JOURNAL

OF THE

FORESTRY COMMISSION.

No. 2: FEBRUARY, 1923.

Editing Committee:
R. L. ROBINSON,
A. W. BORTHWICK,
H. A. PRITCHARD,
FRASER STORY.

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INTRODUCTION.

THE length of the interval which has elapsed since the issue of the first number of this Journal is due to the vicissitudes through which State Forestry has passed. As pointed out in the first number, the Journal is intended to afford a means of exchanging opinions and experiences of all members of the Staff. It is not intended that it should become a mere organ for the issue of information from head-quarters. It is hoped, therefore, that, in spite of the pressure of executive work, individual members of the Commissioners' Staff will contribute in larger measure to its pages.

R. L. R.

Research and Experiment: Meeting of Technical Officers, October 26th, 1922.

In connection with the following summary, attention is drawn to the statement on Research and Experiment, published on pp. 24–34 of the Commission's Second Annual Report.

Present: Messrs. Robinson, Pritchard, Fraser Story, Guillebaud, Marsden and Anderson, and Drs. Borthwick, Munro and Steven (Forestry Commission); Sir David Prain (part-time) and Mr. Oliphant (Forest Products Board); Messrs. Hiley and Cartwright (Oxford); Dr. Wilson and Mr. Laing (Edinburgh). Lord Lovat was also present part of the time.

Mr. Robinson stated that the object of the meeting was to review the progress made in experimental and research work during the past year. The scope of that work has been as follows:—

(1) Production: Collection of data relative to rate of growth of timber.
(2) Nursery and plantation work.
(3) Management, care and tending during early stages of growth. Special treatment in thinning to secure maximum rate of growth and maximum production of timber of the right kind and quality.
(4) Protection at all stages against Insects and Fungi, &c.

In order that all present might know what was being done in the way of forest investigations, he had also asked Sir David Prain, Director of the Forest Products Research Board, to give the meeting a short account of that Board's work.

Forest Products Research Board.

Sir David Prain explained the organisation, aims and activities of the Board. He said the Board had appointed Committees to deal with the details of various aspects of its work. These Committees are:—

(*a*) On identification, and structure of timber.
(*b*) On seasoning and general water relations of timber.
(*c*) On preservation of timber and study of losses due to decay.
(*d*) On timber testing.
(*e*) On extractives.

The Board proposed to appoint at least one additional Committee to deal with Paper, Pulp, Cellulose, Alcohol, &c. A preliminary review of the problems involved had revealed the wide extent of the field to be covered and the small amount of knowledge available. It had shown, on the one hand, how often knowledge supposed to be complete is imperfect and had indicated how frequently knowledge that may be complete is not fully understood or generally disseminated. The Board are alive to the fact that there are many problems for which the industries concerned are anxious to have solutions; they are equally conscious that there are some problems possibly capable of solution which industrial interests at present regard as insoluble.

The policy of the Board is to ascertain what work is being done at existing institutions and to take the fullest possible advantages of existing facilities and to avoid the undertaking of any investigation which its members are satisfied can and will be undertaken by any already existing organisation. The Board will at all times endeavour to co-ordinate the results arrived at by its own officers and by other workers.

Sir David Prain further stated that his Board would at all times welcome the submission of problems relative to Forest Products.

Experimental Work.

MR. GUILLEBAUD, in reviewing the experimental work up to the present time, pointed out that it was necessary to employ properly-devised statistical methods, both in planning and interpreting experiments, as experience has shown that the old method of contrasting a single pair of plots in which one serves as the control, while the other serves as the method to be investigated, may not give reliable results, but that both the method under investigation and the control must be repeated several times on adjacent areas of ground.

He then went on to give a short summary of his investigations at Hafod Fawr, the salient features of which are:—(1) The success of Japanese larch at all elevations, and especially in the highest part of the woods; (2) the failure of European larch above about 1,100 feet elevation; (3) the strikingly uneven growth of Norway spruce on all classes of soil and the very long periods in which the trees can remain in the checked stage; (4) the complete failure of Scots pine planted pure in exposed situations; (5) the very promising growth of Sitka spruce on peat and at high elevations.

One very interesting fact recorded was the tendency in Japanese larch to produce surface roots which spread out just under the layers of fallen needles. Further investigation led to the conclusion that these surface roots were active in breaking down and disintegrating the subjacent layer of peat.

DR. STEVEN agreed that for peat areas the Japanese larch and Menzies spruce were good species to plant. They were doing very well on such areas on the west coast of Scotland.

Some discussion took place on the cause of the killing of European larch twigs at Hafod Fawr, and MR. HILEY stated that the cause might be due to *Meria laricis*. MR. LAING stated that he had found that the Japanese larch produces Mycorhiza in a greater variety of soils, including peat, than any other species, with the exception of the Japanese Umbrella pine, *Sciadopitys verticellata*.

MR. FRASER STORY said that his experience of Welsh conditions was that Menzies spruce and Japanese larch did better than other species at high elevations. He pointed out, however, that caution was necessary in drawing conclusions from the existing growing stock at Hafod Fawr; in some of the plantations which were planted on contract by an Altrincham firm, transplants of 5 feet or 6 feet in height were used. MR. ANDERSON pointed out, in confirmation of the ability of the Japanese larch to feed in humus, that he knew a plantation where this species was reproducing naturally under its own shade. LORD LOVAT mentioned that, in his experience, soil was not the only growth factor of fundamental importance. He called attention to the importance of shelter, especially for spruce, and recommended that a careful study should be made of the effect of shelter and nurses on the growth of this species. He also recommended that experiments should be made to test the possibility of using large-sized Menzies spruce transplants, especially on grass lands. Lord Lovat also emphasised the advantages to be obtained by using artificial manures in connection with the growth of soil-cleaning crops.

Nursery Experiments.

MR. MARSDEN, in submitting an abstract of his report, stated that he felt increased confidence in the work, which was due to the adoption of improved statistical methods :—

(1) Covering newly-sown seed in the beds with sand instead of ordinary soil reduced the cost of weeding, and there was no evidence that this method was inimical to germination.

(2) Douglas fir seed soaked in water for 21 days gave better results than when soaked for 7 or 14 days.

In the case of Norway spruce, Scots pine and European larch, experiments this year confirmed those of last year, that the best results were obtained by soaking from 7 to 14 days. Early spring sowing of Douglas fir gave better results than late spring sowing. Experiments made in the previous year with Norway spruce, Scots pine, Douglas fir and European larch, sown in autumn, gave satisfactory results only in the case of the Douglas fir. However, all species, in spite of protection, suffered severely from mice.

(3) Larch, sown thinly and raised under shelter, might be lined out as one-year seedlings so as to produce one-year × one-year transplants fit for planting.

(4) Shelter and early sowing gives larger plants.

(5) Shelter of the seed beds for the first eight weeks after sowing leads to a great increment in production.

(6) Pre-germination or stimulation to early germination has proved to be desirable for Douglas fir and European larch.

DR. STEVEN reported that he had been able to carry out experiments in all branches of the experimental work as laid down in the programme.

1. *Storage of Seed.*—After three years in air, Norway spruce retains its vitality in a high degree, Scots pine retains its vitality to a less extent, Menzies spruce and Japanese larch show an initial falling-off to a considerable extent, but store moderately well. Douglas fir seed falls off rapidly and is not adapted for storing.

2. *Time of Collection of Scots Pine Seed.*—A few years ago the crop of Scots pine seed produced in Scotland, though abundant, was of poor quality. This led Mr. J. Rafn to suggest that the cones had been

collected too early in the season. Cones were collected in September and October, 1921, and in February, March and April, 1922. There was no appreciable difference in the quality of the seed due to time of collection. The seed was, however, more easily extracted from the later collected cones. The extraction was done at Beauly Forest School, and it was suggested that the lower temperature, namely, 70 deg. Fahr., at which extraction was carried out, gave better results than the higher temperatures usual in the trade. From the point of view of facility of extraction, collection should begin about the 1st of December. The cones were collected in five different woods at Beauly, and the age of the mother trees was found to make little difference in the quality of the seed.

3. *Season of Sowing Seed.*—The time of sowing Douglas fir seed should be in the autumn or in early spring, not later than the middle of March.

4. *Methods and Density of Sowing.*—General conclusion was that, of the three methods—broadcast, drill and band—the first gave a smaller proportion of first-grade plants than the other two methods, although the seedlings were less liable to frost lift. In the present experiment the seed beds were 4 ft. in width, the drills were 1¼ in. broad, and bands 4 in. broad, both drills and bands being 4 in. apart. Where broadcast sowing is adopted the density should not exceed 900 two-year seedlings per square yard. In drill sowing 150 to 200 seedlings per drill is a safe average. In the band method 300 to 350 seedlings per band can be grown.

5. *Mechanical Sowing.*—Experiments were made with a Planet Junior seeder, specially modified to sow in bands. Norway and Menzies spruce, Douglas fir, European larch and Corsican pine were sown with very satisfactory results by this machine on a semi-commercial scale at Seaton nursery ; some difficulty was experienced in obtaining a full 4 in. band, and further improvements in the machine are under consideration.

6. *Cost of Weeding in Different Methods of Sowing.*—The difference in the cost of weeding in broadcast, drill and band works out, as yet, very nearly the same, and when the production of seedlings is determined in the spring of 1923, the cost per unit number of seedlings will be determined.

7. *Protection Against Frost.*—A detailed study was made at Beauly by one of the trainees under Mr. Fraser's direction. Temperature records were kept throughout the winter and spring, and comparisons between these records and frost damage clearly indicate that the most dangerous periods occur when frost and thaw rapidly alternate. This year such periods of rapid alternation occurred principally in April, and indicated that protection, at least during the night, should not be discontinued too early in the season. There was little to choose between the various methods of protection—canvas, branches and hardwood leaves, straw between the drills, canvas on netting plus straw—even the best methods are only efficient up to a certain point.

The investigation has shown that protection alone does not completely solve the problem. Investigations into the liability to frost damage in different nurseries and in different parts of the same nursery, will aid in avoiding losses. The production of well-rooted seedlings is desirable, such as can be obtained by methods of early sowing and ensuring as far as possible that the seed beds are well stocked. This will apply more especially to such species as Douglas fir and Menzies spruce.

8. *Undercutting.*—This operation does not give rise to a more bushy root system, nor does it increase root development relative to the shoot. It simply gives smaller plants.

9. *Season .of Transplanting.*—The advantages of being able to extend safely the season of transplanting are many. It has been demonstrated the season for Norway spruce can safely be extended over a considerable period on a commercial scale. Late autumn and winter lining-out does not give good results with Scots pine.

10. *Soiling Crops.*—The use of artificial manures in conjunction with cleaning and manurial crops has proved advantageous. The yield of blue lupine was increased by 30 per cent., while that of mustard was increased from 300 to 400 per cent.

Plantation Experiments.

11. *Season of Planting.*—A series of plots of ¼ acre each has been planted each month since 1920. The first year showed successful results with Norway spruce at Port Clair, South Laggan forests and Fort Augustus. The series for 1922 will be completed in November and the whole results analysed in the summer of 1923. Similar experiments with Menzies spruce and Corsican pine have been started at Inchnacardoch and Culbin respectively.

12. *Age and Type of Plant.*—During the planting season 1921–22, experiments were begun with European larch, Norway spruce, Menzies spruce and Douglas fir. The ages of plants used in each case were (*a*) 2-yr. × 2-yr. transplants, (*b*) 2-yr. × 1-yr. transplants, (*c*) 2-year seedlings.

At Monaughty the loss among Norway spruce, 2-yr. × 2-yr., was 3 per cent., while that among 2-year seedlings was 10 per cent., but, in spite of the higher loss among the seedlings, the survivors are of a better colour and growing more vigorously than the transplants.

13. *Experimental Plantations.*—Experimental plantations were established at high elevations at Achnashellach and Inchnacardoch. The composition was Norway spruce, sheltered in various ways, or .combinations by Scots and Mountain pines and *Pinus contorta.* At Monaughty heather-scirpus ground has been planted experimentally with Norway and Menzies spruce. Similarly, good soil at high elevation (1,800 ft.) at South Laggan has been planted with the same two species. At Culbin an experiment, in 1-acre plots, on two classes of soil, (1) heather-covered sand, (2) heather-rush sand, has been started with nine different species, all of which have rooted well.

Work Done at Oxford.

Mr. Hiley then submitted an outline of his work done in 1921–22.

1. *Treatment of Seed Previous to Sowing.*—From the 1921 sowings, examination in March, 1922, showed that root and stem development were fairly proportional, so that stem growth may be taken as an index in comparing the value of seedlings grown on similar soils.

Treatment of seed by incubation at various temperatures for different periods indicated that incubation for seven days at 20 deg. gave the best results. The comparisons were made with untreated seeds.

2. *Delayed Germination.*—An attempt was made to ascertain whether an artificial check would produce delayed germination. Seeds of Douglas fir were incubated at 21 deg. Cent. for periods of one to nine days. They were then placed on dry filter paper in a dry incubator for varying periods up to seven days, and afterwards germinated on damp filter paper at 21 deg. Cent. The reduction in germination was slight.

3. *Height Increment of Growing Trees.*—Phenological observations were continued on Corsican pine, Sitka spruce and European larch.

4. *Root Pruning.*—This was found to be of no use with 2-year Corsican pine seedlings, but it was less harmful for 1-year seedlings; the best results were obtained by pruning back to 3 in.

5. *Killing Seedlings by Heat Applied at Soil Surface.*—In artificial heating of the soil surface around spruce seedlings the critical temperature at which killing of the seedlings took place was found to be about 47 deg. Cent. When the soil was moist the seedlings could withstand a higher temperature than when the soil was dry.

6. *Experiments on the Growth of Hypocotyl and Radicle.*—Rise or fall in temperature reacted equally on both these organs.

7. *Investigation of Fungus Disease on Ash.*—A disease of the leading shoots of ash in Bagley wood was investigated by Mr. Cartwright, and is believed to be associated with a fungus allied to *Valsa*. The investigation is still in progress.

Discussion.

A discussion on the above reports then took place.

Lord Lovat pointed out that the experimental and research work had shown not only a satisfactory increase in volume, but that already valuable results had been achieved.

The question of transplanting and handling large-sized seedlings, such as those which had been seen during the visit on the previous day to Bushfields, required careful consideration. Attention must also be given to the question of lining out 1-year seedlings.

The experiments and results obtained with the use of artificial manures for green and soiling nursery crops were important, and these experiments should be continued on a larger scale.

Dr. Borthwick pointed out that shelter and forcing might easily be overdone, with the result that the constitution of the plant might be weakened. The appearance of the plants in the nursery beds and lines, their size and numbers, was not the final index of efficiency. It was the behaviour of the stock when planted out in the forest that counted. An endeavour should be made to keep a record of the subsequent growth of specially-treated plants after they leave the nursery.

MR. PRITCHARD considered that some useful information might be obtained by experiments in periodic planting and lining out of Corsican pine.

In order to make sure as to what extent, if any, the age of the seed tree influenced the growth of its progeny, Mr. Pritchard suggested that the subsequent history of the plants raised from old and young seed trees should be followed up in the plantation as well as in the nursery.

Satisfactory results were obtained by undercutting the roots of transplants, and he suggested that this method of treatment should be applied to spruce with the object of obtaining big plants. He mentioned an interesting experiment with Corsican pine seedlings, the roots of which were nearly all pruned off and the seedlings planted with the soil tightly packed round what was left of the root system. The result of this treatment proved to be satisfactory.

DR. WILSON thought that a certain amount of caution was necessary in the use of soiling crops. It was possible to get too much decaying vegetable matter in the soil, with the result that danger from certain fungi might be increased.

In regard to mechanical apparatus used in nurseries, he mentioned that care was necessary in order to avoid any wounding of the plants. Certain transplanting laths had been found to cause damage by gripping the seedlings too firmly, and thus causing a wound which encircled the root collar. The subsequent effect was to produce a swelling above the wound similar to that which may be caused by *Pestalozzia*. A slight modification in the laths overcame this trouble.

MR. STORY pointed out that extra care was necessary in handling seed which had been pre-germinated in order to avoid injury to the radicle.

MR. ANDERSON called attention to the harmful results of too deep planting, and made the interesting suggestion that, where humus layers were likely to increase in depth, spruce might be experimentally planted at a less depth than normal. The suggestion was made relative to a specimen of spruce from Hafod Fawr exhibited at the meeting by Mr. Guillebaud. The plant had been planted apparently at normal depth among heather, but moss and other organic accumulations had collected around the collar of the plant, which in response had thrown out one strong and several other weaker adventitious surface-feeding roots.

Sample Plots.

MR. ANDERSON submitted his annual report on the progress of permanent sample plot work during the past year.

The endeavour was to lay down permanent sample plots of the more important coniferous species in as wide and representative distribution as possible. One hundred and twenty-two such plots had been formed up to date.

MR. ANDERSON suggested a modification in the classification of stems, which was provisionally agreed to, as it was thought that more accurate descriptions of treatment would be obtained thereby. This modified classification alters, of course, the definitions of the thinning grades which are based upon the stem classes, but, in addition, a proposal was put forward by Dr. Steven to introduce a new grade of thinning which should be alternative to the full " C " grade. For the purpose of comparison the existing and the proposed new classifications of stems and definitions of thinning grades are given.

Existing Classification of Stems.—The trees are divided into two main groups under the heading : I. Dominant Stems, and II. Dominated Stems. These groups are defined and further subdivided as follows :—

I. *Dominant Stems.*—These include all trees which form part of the upper canopy, and are divided into the following classes :—

Class 1.—Trees with normal crown development and good stem form.

Class 2.—Trees with abnormal crown development or with bad stem form, including—

(*a*) Trees with oppressed crowns.
(*b*) Badly-formed foregrowth and wolf trees.
(*c*) Other trees with bad shapes, especially forked trees (including, in the case of larch, stems deformed by canker).
(*d*) Whips.
(*e*) Diseased trees of all kinds.

II. *Dominated Stems.*—These include all trees which do not take part in the upper canopy. In this group are included :—

Class 3.—Backward trees still free from top shade.

Class 4.—Suppressed trees standing under the shade of other trees, but still capable of developing.

Class 5.—Dead and dying trees and any trees which have been bent over.

Note.—In the case of larch crops in which canker is usually prevalent to a greater or less degree in all woods, the class 2 (*e*) falls out, and the trees are classified as if they were free from disease, but adding the letter K in the register where there are visible signs of canker.

Existing Definition of Grades of Thinning.

I. *Common Method* (*Niederdurchforstung : Éclaircie par les bas*).

A. Grade. Light Thinning.

Remove class 5 and some of 2 (*e*). *i.e.*, dead, dying and bent-over trees, with a limited number of diseased trees.

The object of such thinning is to obtain data for comparative purposes.

B. Grade. Moderate Thinning.

Remove classes 5, 4, 2 (*e*), 2 (*d*) and part of 2 (*b*).

i.e., dead, dying, bent-over trees, suppressed and diseased trees, whips and the most dangerous and worst-formed foregrowth (if not capable of improvement by pruning).

C. Grade. Heavy Thinning.

Remove gradually all trees of classes 5, 4, 3 and 2, also part of 1.

i.e., all dead, dying, bent-over and suppressed trees, backward trees and defective dominants together with some of the well-developed dominants.

There remain only trees with normal crown development and well-shaped boles, distributed as regularly as possible over the ground, so that each has room to develop its crown normally. At the same time, no permanent break in the leaf canopy can be permitted.

The following principles apply to Grade B. and C. :—

(*a*) In all cases where the removal of a dominant will create a hole in the crop, convenient suppressed or backward trees may be left to cover the soil.

(*b*) The removal of trees with bad crown development or poorly-shaped boles (class 2) is to be carefully conducted with reference to the canopy and development of the whole crop.

II. *Thinning in the Dominant Crop* (*Hochdurchforstung : Éclaircie par le haut*).

D. Grade. Light Thinning in the Dominant Crop.

Remove class 5, a great part of class 2, and some stems of class 1.

i.e., dead, dying trees, bent-over, badly-formed and diseased stems, forked bushy trees and whips, as well as those trees (generally foregrowth) which are spoiling groups of even-growth trees.

The removal of trees with poor boles, and particularly those with forks, if present in large numbers, can be spread over several thinnings in order that the canopy may not be broken to too great an extent.

D. Grade. Light Thinning in the Dominant Crop—continued.

After the first of the several such thinnings, the remaining stems of this kind may be pruned to minimise their power of damaging the rest of the crop.

This grade of thinning comes into consideration chiefly with young crops.

E. Grade. Heavy Thinning in the Dominant Crop.

Remove class 5 and stems from classes 1 and 2.

i.e., all dead, dying, bent-over diseased stems, and all trees which hinder the development of the crowns of these *élite*.

This grade is concerned with the development of definite stems (*élite*), which are to form the final crop.

~~*Proposed New*~~ Revised *Classification of Stems.*

The trees are divided into the following classes :—

Class 1.—*Predominant or Dominant Trees.*

(*a*) Trees with normal crown development and good stem form.
(*b*) Trees with slightly defective stems or crowns.
(*c*) Trees with very defective stems or crowns (including in the case of larch, stems deformed by canker).
(*d*) Whips.
(*e*) Badly-formed foregrowth and wolf trees.

Class 2.—*Co-dominant Trees.*

(*a*) Trees with normal crown development and good stem form.
(*b*) Trees with slightly defective stems or crowns.
(*c*) Trees with very defective stems or crowns (including, in the case of larch, stems deformed by canker).

Class 3.—*Sub-dominant Trees.*

(*a*) Trees with normal crown development and good stem form.
(*b*) Trees with defective stems or crowns.

Class 4.—*Suppressed Trees.*

These are trees standing under the shade of other trees, but still capable of developing.

Class 5.—*Dead and Dying Trees.*

Including bent-over and leaning trees.

Class 6.—*Diseased Trees.*

(*a*) Dominant and co-dominant.
(*b*) Sub-dominant and suppressed.

Note.— The instructions with regard to European larch stands are the same as in the old classification.

Revised

~~Proposed New~~ *Definition of Thinning Grades.*

I. *Common Method* (*Niederdurchforstung : Éclaircie par le bas*).

B. Grade.—Light Thinning : Control.

Remove classes 6, 5, 4, 3 (*b*), 1 (*d*) and part of 1 (*e*).

i.e., dead, dying and bent-over trees, diseased and suppressed trees, whips and the worst-formed foregrowth and defective sub-dominants.

C 1 *Grade. Moderately Heavy Thinning.*

Remove gradually all trees of classes 6, 5, 4, 3, 2 (*b*) and 2 (*c*), and part of 2 (*a*), 1 (*d*). 1 (*e*), and part of 1 (*c*).

i.e., all dead, dying, bent-over suppressed trees, diseased trees and whips, also sub-dominants, the majority of the co-dominants, and some of the worst-formed dominants.

C 2 *Grade. Very Heavy Thinning.*

Remove gradually all trees of classes 6, 5, 4, 3, 2, 1 (*b*), 1 (*c*), 1 (*d*), 1 (*e*), and part of 1 (*a*).

i.e., all dead, dying, bent-over, suppressed trees, diseased trees and whips, also all sub-dominants, co-dominants and defective dominants, together with some of the well-developed dominants.

II. *Thinning in the Dominant Crop* (*Hochdurchforstung : Éclaircie par le haut*).

D. Grade. Light Thinning in the Dominant Crop.

Remove classes 6, 5, part of 2 (*a*), 2 (*b*), 2 (*c*), and a great part of classes 1 (*b*), 1 (*c*), 1 (*d*), 1 (*e*), also some stems of 1 (*a*).

i.e., dead, dying and bent-over trees, diseased trees, part of the co-dominant class and a large part of the defective trees, also some well-shaped dominants where these are overcrowded.

E. Grade. Heavy Thinning in the Dominant Crop.

Remove classes 6, 5, and many stems from classes 2 and 1.

i.e., all dead, dying, bent-over and diseased trees, and all trees which hinder the development of the crowns of the remaining *élite*.

Note.—The general remarks are the same for the new as for the old thinning grades, ~~and for economy of space are not repeated~~. omit

Peat Research.

Mr. E. V. Laing then submitted his report on peat research. He said, during the past season, the following factors, likely to cause or contribute to growth inhibition of forest tree on peat soils, have been studied and are still in the course of being studied :—Mycorhiza development in peat and oxidation in peat.

1. *Mycorhiza Development in Peat.*—From the work already done in the present investigation on mycorhiza development in peat, the following points seem to have been established :—

(*a*) It is necessary to distinguish true mycorhiza from false mycorhiza. In true mycorhiza the mycelium forms a dense mat on the root, and the mycelium is more or less irregular and vesicular in appearance. False mycorhiza presents a more or less similar superficial appearance to true mycorhiza, but the web is more diffuse and the mycelium is regular and non-vesicular. This distinction is most evident in the spruces.

(*b*) True mycorhiza is invariably found on trees growing well in peat.

(*c*) False mycorhiza may be found on badly-growing trees. This condition, it is suggested, represents a stage in the development of true mycorhiza, the conditions for the formation of true mycorhiza being absent.

(*d*) A fungus mycelium is usually present in the cortical tissues of tree roots in peat, which is not a mycorhizal fungus, but evidence points to it being capable of developing into a mycorhizal fungus. The presence of this cortical mycelium is correlated with poor growth.

Up to the present, in summing up the evidence, it seems that true mycorhiza is always present on the best-growing trees in peat in the field ; that the development of true mycorhiza is often arrested, and it is suggested that true symbiosis does not exist, but that all the benefit of the union of root and fungus is derived by the fungus.

2. *Oxidation.*—During the summer, from June onwards, experiments have been in progress to test the process of oxidation in peat. The peat supplies for testing were obtained from Corrour, Invernessshire.

Oxidation has been found to be absent altogether in the case of many peats, while others in their natural condition show a fairly high degree of oxidation which can be correlated with good growth.

Air-dried peat shows a high oxidation—higher than most other soils tested. Air-dried peat gives a quicker germination of spruce seed, and taller seedlings at any given age than other soils used.

The water content of the peat influences the oxidation in peat. There is a distinct optimum between 60 to 70 per cent. H_2O content. The exact point not having yet been determined. Certain sands, instead of increasing the oxidation in peat, decrease it. Experiments are still in progress in connection with oxidation.

Mr. R. L. Robinson said that the work upon which Mr. Laing was engaged was of great importance to forestry. What we wanted to know, at the present time was a reliable and simple method of assessing the value of peat soils for planting purposes. The simplest method in practice up till now was the use of the vegetation types as indicators of quality.

Dr. Borthwick said that Mr. Laing had raised an entirely new point in connection with peat mycorhiza. The distinction between true and false root fungi was of considerable importance as the observations made by Mr. Laing seemed to indicate that the symbiotic partnership did not merely depend upon the bringing together of root and fungus. On the contrary, in the case of the false mycorhiza it seemed that the fungus obtained all the benefit and gave nothing in return, in which case it was distinctly harmful and it was therefore of fundamental importance to find out what conditions were necessary for the establishment of true symbiotic union.

In regard to the toxicity of peat, Mr. Laing had made experiments with heather leaf humus, he had found that an extract of old heather leaves had a distinct toxic effect on seedling conifers. The next step was to find out some means of neutralising this poison. Mr. Laing said that ammonium-molybidate by colour reaction shows differences between good and bad peat.

Mr. Robinson asked Mr. Laing if there was a convenient method of determining the acidity of peat as an indication of inferior quality. Mr. Laing replied that degree of acidity could not be taken as an index of quality because sometimes good peat may have an acid reaction.

Dr. Wilson pointed out that mycorhiza vary in different soils. Many conifers may have an internal Mycorhiza when the external mycorhiza is absent. As to the toxic action of certain peats on mycorhiza would the same toxines kill plants without mycorhiza? Whether the mycorhiza fungus could be grown isolated from a root was still doubtful, up to date the Scots pine was the only species among trees from the roots of which the fungus had been isolated and grown separately.

Mr. Hiley asked for information as to how the heather leaf extract referred to earlier in the discussion was made. Mr. Laing explained that the extract was obtained by soaking the dried leaves in cold water.

Mr. R. L. Robinson asked Mr. Laing to consider the possibility of making field scale trials on the results of his work.

Phomopsis.

Dr. Wilson, in submitting his report, said that he had now found *Phomopsis* on six different species, viz., Douglas fir, Japanese larch, European larch, Western hemlock, common silver fir and *Abies grandis*. The Douglas fir was the species most intensively attacked, the next in order of susceptibility being the Japanese larch, especially where *Phomopsis* was abundant on adjacent Douglas firs.

Phomopsis is a conidial stage of an ascomycetous fungus *Diaporthe* as he had proved by artificial cultures. In the attack on *Abies grandis* the fructifications found were in the ascus stage, but the fungus was producing the form of damage typical of *Phomopsis*.

The Japanese larches attacked were 15–20 years old in most cases. This age seems to be the most susceptible period in the life history of the tree. At Jervaulx younger plants were not attacked which led to the idea at first entertained, that the damage was due to pruning.

Mode of Infection.—The attack takes place at lesions before cork formation has had time to close the wound. If the lesion is on a lateral branch the fungus may spread down to the main stem and cause a canker.

Effect of attack.—The leading shoot may be killed back 1 ft. or 15 inches, and if the tree is young it may be killed outright. But if trees older than five years are attacked a new leading shoot may be formed by one of the lateral branches. This, of course, retards growth very much. The disease is very wide spread on trees 8 to 10 years old. Infection may take place through a lateral branch just above ground level, it can spread to the main stem and attack only one side or travel completely round the stem. In the latter case the tree is ultimately killed. On older stems 15 to 20 years the spread of the fungus, on the main stem, is generally limited by the formation of cork layers around the attacked areas which are usually elliptical in form. Subsequently the dead bark is cut off by the closing in of the occluding cork layers.

In Japanese larch similar damage to that on Douglas fir occurs up to 15 or 20 years. The distribution of this fungus in Scotland is very wide, but varies in intensity in different localities. A dangerous feature of this fungus is that it can exist on dead branches. If therefore a wood is littered with dead twigs and branches the fungus is liable to get a firm hold. In some woods inspected, between the ages of 8 and 10 years, it was found that up to 33 per cent. of the trees had been killed out. Losses also occur in the nursery among seedlings and transplants.

At Glentress even after careful cleaning and thinning, 5 per cent. to 10 per cent. of the trees in a 20-year old crop of Douglas fir are still diseased.

In using transplants from the nursery it is often difficult to tell whether they are healthy or not as the period between infection and the appearance of the disease may vary from 9 to 18 months.

It is not yet certain that the disease is the same in all the six species mentioned there may be special races attacking special species. The point is of practical importance as regards the possibility of infection. Dr. Wilson stated that an accessible but isolated experimental area where cross infection experiments could be carried out would be most useful.

As regards remedial measures diseased material cut from a plantation should be at once burned or removed. It was of importance that such material should not be left lying about in the plantation.

Mr. R. L. Robinson called attention to the virulence of the genus *Diaporthe*, species of this genus *D. parasitica* had almost completely wiped out the American chestnut (*C. dentata*) in America.

Mr. Pritchard said the disease was very much like larch canker in many ways and attacked more frequently dominated or suppressed trees.

Mr. Hiley thought the destruction of nursery stock infected with *Phomopsis* would be of little help, as there were so many spores present in the plantation. He asked if all lenticular-shaped patches on Douglas fir were due to *Phomopsis*. Dr. Wilson replied that it would be too sweeping a statement to say that such was the case, but many lenticular-shaped orifices were due to this fungus although fructifications might not be present as they break up very quickly. Mr. Hiley agreed that infection experiments were very important.

Entomological Work, 1921–22.

Dr. Munro gave the following review of his work.

1. *Advisory work.*—The volume of this work is steadily increasing, and the information acquired through it as to losses caused by insect pests and as to the more important causes of loss is of considerable value.

In nurseries the following insects were the chief causes of injury to seedlings and plants :—Cockchafer, *Melolontha vulgaris* ; Cutworms (Agrotid caterpillars), *Pemphigus piceæ* on pine transplants, *Bibio lacteipennis* on larch seedlings, *Psyllopsis fraxini* on ash plants, *Phyllaphis fagi* on beech, and *Saperda populnea* and various Chrysomelid beetles on poplar.

In plantations the following insects were reported as injurious :—

Chermes cooleyi and *C. pini*—Various moths, including *Mamestra pisi* attacking Sitka spruce ; various weevils, *Strophosomus coryli* and *Otiorhynchus picipes* being unusually prevalent in pine plantations, and also *Polydrusus pterygomalis* ; various sawflies including *Nematus laricis* and *N. erichsonii*, the former being very prevalent in the South of England, the latter occurring in numbers near Elgin.

The following insects were reared from seeds submitted for examination :—*Endrosis lactella* from stored seeds of Scots pine and Douglas fir, *Grapholitha strobilella* and *Perrisia strobi* from Spruce cones, the weevils *Balaninus turbatus* and *B. venosus* from acorns and *Megastigmus spermotrophus* from Douglas fir seeds.

Numerous queries were received concerning Furniture beetles (Anobiidæ) in various timber structures, including a query regarding a consignment of American oak and ash infested by one of the powder post beetles *Lyctus planicollis.*

A feature of the year was the abundance of *Tortrix viridana* in the Southern counties of England and the unusual prevalence of the small weevils *Strophosomus* and *Otiorhynchus.*

2. *Experimental work.*—Experimental work was confined to the Pine weevil problem, of which an account is given in another part of the Journal.

3. *Research work.*—The revision of the British bark-beetles was continued. A study of the life-history of the pine root aphis *Pemphigus piceæ* was begun in January. A series of asexual wingless generations were reared on pine roots, but in June all the breeding stock were killed by excessive watering of the pots containing it. It is hoped to renew this work this year. The alternate host of *P. piceæ* is not known and the insect's habits are of some importance and considerable interest.

Larvæ of the fly *Bibio lacteipennis* received from Dr. Steven were reared on spruce, pine and larch respectively. The flies emerged on 12th to 15th May.

Research on the development of the reproductive organs of Hylobius, on its egg-laying habits and on the effects of temperature on these, has already been referred to elsewhere.

Mr. R. N. Chrystal, B.Sc., working on a grant from the Scientific and Industrial Research Department, continued his research on the Chermesidæ, the following is a summary of his results :—

Chermes cooleyi.—The life-history has again been studied and the main results obtained last year confirmed. The winged forms flying from the Douglas fir to Sitka spruce were shown to be true sexuparæ. Two types of larvæ are produced on the Douglas fir " progrediens " type developing directly into winged sexuparæ and " sistens " type producing only wingless summer and winter forms. The sexual generation again consisted largely of males. No galls of *C. cooleyi* on Sitka spruce have yet been discovered.

Chermes pini.—The oriental race of this species on *Picea orientalis* was found abundantly at Kew. The sexuparæ and sexual generations were studied and Marchal's results as regards their behaviour confirmed especially in the case of the males which as in his experience were found to be very rare. Sexuparæ were found on Sitka spruce and gave rise there to sexuales which however died off. Characters whereby these *pini* sexuales could be distinguished from *cooleyi* sexuales occurring with them on the Sitka spruce, were established.

Mr. R. C. Fisher, B.Sc., worked on poplar sawflies and the results of some of his work are contained in the insect section of the forthcoming Bulletin on Poplars. Latterly he has been engaged in research on *Tortrix pronubana* and *Scolytus destructor* as a Research Scholar of the Ministry of Agriculture.

Messrs. Chrystal and Fisher are more engaged in pure entomology than in forest entomology at present, but their work is fundamental and will later yield results of considerable importance in agriculture and forestry. Mr. Chrystal's present research on Chermes already promises results of far-reaching importance, and it is much to be hoped that his work may be completed. Applied science is in its essentials absolutely dependent on pure science and unless pure science work is carried out as a foundation for applied science, progress would soon cease. Much work is done at Kew which has no apparent forestry value but which forms a basis for work which has definite forestry value and it is highly desirable that the combination of pure and applied science studies now in existence may be continued.

Root Growth.

A general discussion then took place upon the advisability of carrying out a comprehensive series of fundamental investigations into tree root growth and action.

It was pointed out that until more accurate knowledge was available concerning the relationship between the root and the soil in which it grows, a good deal of experimental work would necessarily be of a trial and error nature. The main object was to find out the best and quickest methods of enabling the tree to develop a well balanced and symmetrical root system with a plentiful supply of fibres or feeding roots. It was agreed that in connection with root action there was scope for fundamental research.

Road-making in Relief of Unemployment: Forest of Dean and Highmeadow Woods.

1. *Reason for undertaking the work.*—On account of being unable to sell timber, due to the glutting of the markets following the war and the coal strike of 1922, fellings had to be stopped ; there were also instructions from the Office of Woods to cut down expenditure to the lowest possible limit on account of the necessity for economy. This meant the turning off of many hands and, as forestry is classed with agriculture, the men thus turned off were not qualified for unemployment benefit, and it was felt that something should be done to offer work to these men. There was also widespread unemployment among pit-hands on account of the collieries being unable to obtain sufficient orders to keep the pits going. In the working plan that was drawn up for the Forest of Dean there was included a skeleton scheme of road construction which was to be carried out gradually as occasion demanded. This scheme was taken as the basis for the unemployment work, and, in view of the advisability of providing employment, it was decided to carry out the whole scheme at once, although under ordinary circumstances this work would have been spread over a term of a good many years ; for under ordinary circumstances it is not financially sound to make a road until the time comes when there is sufficient material to be felled in the area the road taps to pay the interest on the capital cost plus the upkeep.

2. *Extent of work undertaken.*—The preliminary scheme sanctioned for unemployment relief work was for making 12 roads of a mileage of 18.1 at an average cost of 26.1*s.* per yard, and of metal surfacing two roads of 5.6 miles at an average cost of 10*s.* a yard. The total expenditure working out at £46,830.

The work actually undertaken was the making of 13 roads of a mileage of 18.0 at an average cost per yard of 28.3*s.* and the metal surfacing of 1.4 miles at a cost of 10*s.* a yard. The actual total expenditure worked out at £46,005. For details of cost *vide* para. 7.

The two roads with the largest differences in altitude and with the most difficulties were the Cockshoot and Reddings Roads of Highmeadow ; in the case of Cockshoot there is a rise of 588 feet to be negotiated in 2.2 miles and in the Reddings road there is a rise of 409 feet in the total length of the road (1.96 miles) representing an average gradient of 1 in 24.6.

3. *Procedure and Staff.*—(*a*) *By Contract or otherwise.*—It had first to be decided whether the work was to be undertaken departmentally or by contract. The former method was the one adopted because the work had to be started at once and on as large a scale as possible, and in the case of only one road had a survey been undertaken and that had to be modified considerably ; it would have taken weeks to

carry out the necessary surveys for contract work, and tenders would then have had to be issued and the commencement of the work would therefore have been very much delayed. When the works were sanctioned it was thought that they would only be required for six months, so every week was of consequence. Intimation that the work was to be undertaken was received in the third week of October, 1921, and the first men were started at work on the 11th of the following month. The work was completed on November 30th, 1922.

(*b*) *Supervision of Work.*—This was of some difficulty as the roads were in a tract of country 8 by 4½ miles, and for the sake of providing work as near as possible to the homes of the unemployed it was necessary to scatter the work; for this reason, and so that as many men could be employed as possible, work was carried on with three or four roads at the same time. Although the deputy surveyor set aside more than half of his time for road work it was necessary to appoint an officer to supervise with no other work on his hands; this was done, an officer recommended by the Ministry of Transport being appointed. When there was levelling to be done an assistant in the deputy surveyor's office undertook the work.

(*c*) *Subordinate Staff and Labour.*—A ganger was appointed on each road and paid 2*s.* 7*d.* per day above the labourer's wage. A travelling timekeeper was paid 7*s.* 6*d.* a day. There were also three checkers who kept the labourer's time and checked the metal and other material being brought on to the roads; their wage was 1*s.* 1*d.* above the labourer's wage. It is most important that the ganger should be a good man, a man who knows his work and not only does not fear his men but is tactful with them; it pays well to pay high enough to get a really good man. Under the ganger were sectional leaders, say one to every 10 to 25 men. The leaders got 7*d.* a day above the labourer's wage. It was found necessary to appoint a full time clerk. Wages were paid weekly. The labourer's wage at first was 36*s.* a week, but this came down to 32*s.* 6*d.* per week in the fourth week of April, 1922, and stayed at that figure till the works ceased. The men were taken from the labour exchanges. The number directly employed, taking the average weekly figure for each month was as follows:—

1921—November, 42; December, 103. 1922—January, 443; February, 535; March, 524; April, 494; May, 447; June, 320; July, 285; August, 249; September, 219; October, 160; November, 80.

Besides these men there were those who obtained employment on account of work carried out by contract such as supplying stone by tender.

The men, other than gangers and foremen, were not paid for wet time.

(*d*) *Procedure.*—The procedure found best was as follows:—

The deputy surveyor having decided that a road was to be taken in hand made the preliminary survey with the use of a clinometer and so fixed on the alignment of the road. In fixing on the alignment the chief points to be taken into consideration are:—

(*a*) The road should tap as large an area as possible. To fulfil this condition the alignment should run at the lowest point possible, that is to say in the valleys.

(*b*) As the road is a permanent affair one must steel one's heart and cut through woods of whatever age and however promising.

(*c*) Gradient, curves and drainage about which more is said in para. 4.

(*d*) Cost.

(*e*) The road should lead to the chief market.

Directly the alignment was decided on an assistant took levels of any section of the road where there would be a likelihood of a cutting or embankment; this having been done and the formation level decided on the level section map, the road was pegged out, the height of the embankments and depth of cuttings being shown on the pegs. Levels should be taken and pegs put in whenever there is a change of gradient on the existing ground surface and at any rate at not more than 100 feet apart. At the same time the drainage should be decided on, that is to say, the places where drains are to be put across the road, whether such drains are to be culvert or pipes, and of what diameter, and the places where drains are to be dug alongside the road. These preliminaries having been completed the work was handed over to the officer supervising the road work who would then start labourers on getting the road formation level. While this work was being done the source of supply of stone for pitching was gone into and decided on, and where quarries had to be worked quarrying was started immediately. Where trees have to be removed it should be decided first whether the stump is to be left in the ground or not as there will be a considerable greater expense incurred if the tree is felled first and the stump grubbed afterwards. Stumps should be removed if they are actually under or within a foot or so of the road unless there is an embankment at the spot; they should also be removed where they will interfere with the drainage.

(*e*) *Transport.*—Five and a quarter miles of Decauville track were obtained, mostly from the Disposal Board, with 52 iron cubic yard side tipping skips. The track was of 14, 16 and 18 lbs. to the yard, and its average price worked out at 4.3*s.* per yard. The skips cost £7 each. The track was used to the best advantage, but work had to be carried out in so many places at once that it was a hard matter to make it sufficient, and it was often necessary to transfer a part of the track before one would naturally have done so; in fact it would have been better to have had another mile or so. The track was sometimes put down in the centre and sometimes to one side and just off the roadway, either of these methods has its advantages and disadvantages over the other, but there is not space to go into them, in this report. In some cases the Decauville track led straight from the quarry to the road which was being formed; in some acses stone was brought by rail from the quarry to the Decauville track; and in others the stone, slag or ashes was brought by motor lorry or horse traction from the slag or ash heaps or quarry to the road. Each case had to be gone into on its merits and a decision come to as to the cheapest way of procuring and carrying the stone, but the cost of haulage was a large factor in the decision. Generally the traction by motor lorry or horse traction was by piece work, so much per cubic yard delivered, but piece work was not always possible. The rate per cubic yard carried by motor lorry varied from 4*s.* to 1*s.* 9*d.* The maximum rate was for a distance of six miles and the minimum for a lead of half a mile. A cubic yard averages about 23 cwt. in pitching stone, 8 cwt. in ashes and 21 cwt. in slag. It was often found cheapest to transport the top metalling by cart or motor lorry and especially by motor lorry; this had the advantage over the Decauville in that a handling (into the skips) was done away with. Another advantage is that the running of the lorries or carts makes indentations with their wheels on the part of the pitching where there will be most wear in the future, these indentations have to be filled up with extra metal and the result is that there is good consolidation and extra depth of metal just where it is most required. In fact, generally speaking, the Decauville track was used for moving earth for making the correct formation level (embankments and cuttings) and for bringing the stone for pitching; this having been done the rails were removed, the pitching was rolled and the metalling and ashes were then brought on by motor lorry. For such work and tipping motor lorries are very suitable; the most efficient that we had at work was the Steam Sentinel, which tips up by hydraulic pressure and carries 8 cubic yards at a time; the Sentinel can take its full load along metalled roads at 10 to 12 miles per hour and cost 84*s.* per day with driver, repairs and fuel included (day work). At the beginning of the work two claims were made by the County Council Road Authorities for damage due to hauling over County Council roads; the most serious of these was due to hauling by iron tyred wheels when there was frost in the ground. Afterwards we took care to use motor tractors with rubber tyres only. These claims have been settled and amounted to £271.

4. *Class of Road.*—(*a*) *Breadth.*—The normal breadth of metalled road was 9 feet. The breadth round curves was increased to 12 feet, and if the curve was unusually sharp two more than this. At one exceptional hairpin curve the breadth of the road is 33 feet.

The only reason for adopting 9 feet as the normal width was to lower the expense; the objection to so narrow a road is that there is not room for more than one track, that is to say, where ruts are formed there is no alternative run for the wheels without getting one wheel off the metal, unless broader passing places are made.

(*b*) *Composition.*—The roadway, except where there was a difficulty of drainage or newly formed ground to contend with, consists of 9 inches of pitching covered with 4 inches of small metal. The small metal was covered by ½ inch or so of ashes or slag dust. In one case where the ground was very wet and a spring under the road, birch poles from 3 inches to 5 inches diameter were put down across the roadway touching one another and then a layer of ashes; on this foundation the stone pitching was placed. On embankments where there is a likelihood of the pitching being pressed into the newly formed ground it is best to put a layer of ashes, slag or small stones down first before the stone pitching. The stones forming the pitching were hand packed. They were either limestone, slag, coal measure sandstone, old red sandstone, or red sandstone conglomerate according to the facilities of each road. These stones are arranged in order of fitness for pitching, limestone being the best and conglomerate the worst. Limestone and good slag are the hardest for wearing, but the sandstones pack closer; the conglomerate is very soft and also does not pack. The small metal was either slag or limestone. The top layer should be of a hard material so as to resist the wear and tear of the wheels; sandstones are therefore ruled out and either slag or limestone had to be used, granite not being available. Limestone is better than slag and there are limestone quarries available in the Dean as well as in Highmeadow, but to save expense slag was used directly it was found that its cost was less than limestone. The Crown owns a large dump of iron slag at Parkend and this was worked to the uttermost; at first a steam stone breaker was used, but after some months it was found cheaper not to use a breaker but to sort out the slag into three classes according to the sizes found in the dump. The larger class was used for pitching, the intermediate class which forms the bulk of the dump for the small metalling and the slag dust for the top most half inch layer or for mixing with the intermediate class. The outturn from this slag heap was 14,322 tons. It was either taken by road straight to the road work or put on rail at Parkend. 1,127 tons of slag for part of one of the roads was obtained from a slag heap at Cinderford. The half inch sprinkling on the small metal was in the case of part of two roads small limestone gravel. Elsewhere it was either slag dust or ashes. At first it was intended to use slag dust and no ashes. but it was found that ashes were the cheaper as they could be obtained from any colliery free. The amount of ashes used for blinding totalled about 3,000 cubic yards. Rolling is an essential in metalled road construction. In the case of newly formed ground the formation level should be rolled before the pitching is done. When the pitching is in position, roll again, and well. Thoroughly roll again when the top layer of small metal is down and lastly a final rolling when the ½ inch surface sprinkling has been carried out. Two to four rollers were used, but by far the best was a 7 ton petrol engine; it worked more smoothly than the steam rollers. Steam rollers cost 37*s*. 6*d*. a day including driver, fuel and repairs. The petrol rollers cost 6*s*. per hour with driver, fuel and repairs. No watering of the road surface was done.

(*c*) *Camber and Gradient.*—A camber of about 1 in 25 was aimed at, the centre of the road being the highest point. It is important that the camber should be obtained on the formation level, and this for two reasons, *firstly*, the proper drainage of the formation level is much facilitated; this is important, the formation level cannot keep dry if it is flat and the road will last longer if the surface that the stones rest on keeps dry. *Secondly*, if the camber is obtained on the formation level there will be no necessity to trouble about the camber when packing the pitching, and it will only be necessary to keep the pitching of an even thickness. Endeavour was made to keep to a maximum gradient of 1 in 15. This was not, however, always possible. In the matter of gradient there are certain points to be kept well in view.

(1) In the case of forest roads the loaded vehicles more often than not go one way only; a steeper gradient can be allowed for carts going down hill with their loads than the reverse; however even for down hill loads a steeper gradient than 1 in 13 should not be allowed if only because the steeper the gradient the more the wear and consequent upkeep and cost.

(2) See that the steeper gradients are in the straight; thus if there is a stretch of road of say 400 yards at 1 in 17 with a curve in it arrange for the curve to be graded say 1 in 20 and for the remainder of the road to be graded say 1 in 15 or 16 with a straight pull. With a team of 3 to 6 horses which is required to manage heavy timber traction it is of importance that the steeper gradients be as straight pulls as possible, it is much harder to pull round a curve.

(*d*) *Curve Radius*.—As a rule, no bend should have a radius of less than 100 ft., and, as already referred to in the last paragraph, it is essential that the gradient at a curve should not be steep. In two cases it was impossible to get a radius of as much as 100 ft. without prohibitive expense. In the one case, a radius of 75 ft. was obtained, and as the loaded wagons would always be going in one direction, a slight downhill grade of 1 in 120 in that direction was arranged for round the curve so that two horses would be ample to take the heaviest load round the corner. In the other case the radius of the curve was 65 ft. only, but by having a gradient of only 1 in 120 and making the road 33 ft. wide round the corner, heavy loads can be taken in either direction without difficulty. In fact, the key to negotiating sharp turns is to have a good gradient and to broaden the road.

(*e*) *Drainage*.—The proper drainage of a road is of great importance to the life of the road. What drainage is required cannot be properly gauged if the road survey and road making is undertaken in the summer in fact, it is of great advantage for the road work to be carried out during the winter, so that the conditions in the wet season can be seen. It is well worth inspecting the line of road during or within an hour or so of the ceasing of heavy or continuous rain, and noting what water has to be arranged for. The geological formation, as well as the configuration of the ground, has much to do with the amount of drains required. The roads under report were in Old Red Sandstone, Carboniferous Limestone or coal measures. In the case of the first two formations the soil and subsoil is so porous that far less drainage was required than in the case of the coal measures. The coal measures, again, varied very much, as there is very quick transition from a sandstone to a clay subsoil. On sloping ground with bad drainage usually a ditch was dug on the upper side of the road at about 2 ft. from the road: the general rule was for the bottom of the ditch to be not less than 6 in. below the bottom of the formation level. On flat ground, where the drainage was bad, a ditch on either side of the road was necessary. On sloping ground with fairly good drainage, or in cuttings where a ditch off the road was not practicable, a breadth of about 10 in. of the formation level on the upper side of the road was dug 3 in. or 4 in. deeper than the rest of the formation level, and in the depression thus formed rubble was placed, and on the top of this the pitching. This rubble ditch should act well for drainage purposes. For ditches leading water across the road, either culverts or earthenware pipes were used; the latter were of 4 in., 6 in., 9 in., or 12 in. diameter, according to need. In some cases iron pipes— which were obtained locally, second-hand were used. Where the earthenware pipes were near the pitching they were given stone coverings, so that the weight of the road would not be on them. The mouths at the upper end of any culvert or pipe should be guarded by iron or wood bars, to prevent choking of the drains by leaves or sticks. These guards should be 4 ft. to 5 ft. away from the drain mouth. 1,540 yards of pipes were laid and about 15¼ miles of drains excavated or cleaned out. For drainage of the formation level *vide* remarks on camber.

(*f*) *Cuttings and Embankments*.—The highest embankment and the deepest cutting were each 11 ft. Before a cutting is decided on a trial hole should be dug to ascertain whether the solid rock will be reached before the required depth is obtained. In some cases it is worth while excavating in the rock, *e.g.*, when the resulting material is suitable for use on the road as pitching or for an embankment wall or culverting. The steepness at which the slope of the sides of the cutting can safely be left depends on the material of which it is composed and on the drainage. For instance, a soil with stone or shale in it will stand with a comparative steep slope. On the other hand, a clayey soil with bad drainage must be well cut back or there will be danger of it shaling off and slipping, especially in wet weather or after a frost. In one case where there was a cutting in a bank of very wet clay the only thing to be done was to build up a dry stone wall to keep the wet clay from oozing down on to the road. Where it is necessary to have a cutting at a bend of the road allowance must be made for the room necessary for the outward swing of the tail of the longest log which is likely to be dealt with. A 60 ft. log was taken as the longest which would be taken along the roads. In the case of embankments, the work was handicapped by the fact that it was so hurried. An embankment should stand 12 months, if possible, before the pitching is laid; but this was, of course, impossible The minimum breadth at the top of the embankment was 4 ft. broader than the breadth of the metalling; that is, not less than 2 ft. broader on each side. The slope of the embankment was that naturally attained by the material as it was thrown from the skips. When the material of which the embankment was formed had not a large proportion of stone in it, it was rammed and in some cases watered at the same time. This consolidation by ramming and watering took the place of the consolidation which would have been effected by time and rain if we had been able to wait. Ramming is especially necessary in the case of clayey soils, which come out in blocks and do not pack close as do sand soils. In holes in the formation level formed by the extraction of the stumps of trees it is very important to ram very thoroughly, as otherwise the soil put in to fill the hole up will set later on and there will be a drop in the road. In the case of one embankment it was found necessary to make a counterfoot for drainage purposes. The two largest and highest embankments were broadcasted with hay seed this autumn so as to get a covering as soon as possible to prevent slipping and erosion.

5. *Cost.*—(*a*) *Total.* In paragraph No. 2, the total cost per average yard of the 13 roads is given. The circumstances of each road varied very much, not only as to the cost of getting the stone to the road, but also as to the amount of work necessary on embankments, cuttings, &c., to get the formation level desired. The cost of the cheapest road worked out at 19·5*s*., and of the two most expensive at 36 and 29·6*s*. per yard respectively. It is not possible to differentiate fully between the different costs, but the following figures are as near as can be obtained from the information available.

(*b*) *Labour.*—The labour bill varied from about 8 to 18·94*s*. per yard, and probably averaged about 11·56*s*. per yard. This labour excludes labour in getting stone except where useful stone was obtained when a necessary cutting was being made.

(*c*) *Transport.*—The cost worked out at an average of 3·78*s*. per yard. This cost included transport of plant from job to job and of stone, slag and ashes along the roads. It also includes the carriage of stone from quarry to road work where the stone was not obtained under a contract for delivery.

(*d*) *Rolling.*—Cost of rolling was ·76*s*. a yard.

(*e*) *Plant.*—The cost of plant works out at 1·21*s*. per yard. This figure includes purchasing price and railway carriage, and a deduction is made from the purchasing price of £1,400, which is a conservative estimate of the price which will be obtained on the sale of plant.

(*f*) *Metal.*—The cost of obtaining and taking to the work pitching stone, small metalling and ashes for blinding works out at about 9·41*s*. per average yard. Over 30,000 tons were handled.

There was one ton of pitching stone per yard of road. The price of this stone, obtained by direct piecework labour at the quarry, varied from 2·12*s*. to 2·75*s*. per cubic yard, loaded into skips. That obtained by contract varied from 2·5*s*. to 7·5*s*. per ton at the quarry. This last figure was only given for a small quantity and before the ropes had been learned.

The price of slag, big and small, was 2·1*s*. per ton, loaded into vehicles at the slag heap.

Ashes were generally free at the colliery ; that is to say, only loading and transport had to be paid for. The cost of loading was 2·5*d.* per ton ; the cost of transport varied according to distance.

(*g*) *Supervision.*—The cost of the Supervising Officer works out at ·26*s.* per yard. His salary was at the rate of £450 a year. No charge has been made for the time spent on the work by the Deputy Surveyor or by his assistant. If these items were charged the cost of supervising would be estimated at ·7*s.*

(*h*) *Summary.*—Cost per yard is as follows :—

	Shillings.
Labour	11·56
Transport	3·78
Rolling	0·76
Plant	1·21
Metal	9·41
Supervision ...	0·26
Total	26·98

L. S. O.

Road-making in Relief of Unemployment : Tintern.

In order to provide work for the relief of unemployment, the sum of £5,500 was expended on roads in the Tintern Woods. Of this sum about £300 only was spent on tools, materials and supervision, the remainder representing wages to those who would otherwise have been unemployed. For this sum, work was undertaken over 13,000 yards of road, of which some 5,400 yards were existing rides and roads requiring extensive repairs, widening or improvement, 3,200 yards of new metalled roads were constructed, and about 4,400 yards of " formation " was completed, ready for metalling.

In every case, except that of the roads where work was restricted to " formation," there will be immediate benefit to extraction facilities, and the roads would have come into a normal scheme of management if and when finances permitted. This would have been, in many cases, at a very problematical date, and the actual advantages now being derived from the work would have been lost.

The alignment of the new roads was undertaken and plans for the improvement of existing ones were prepared by the officer-in-charge, Mr. W. H. Lovegrove, an Abney level and a prismatic compass being the only instruments used. A roads officer (Mr. Robertson) was appointed in entire control of the constructional work, and he supervised the clearing of the timber from the route of the new roads, and the pegging and chaining of the centre-line, curves being laid off by the " tape offset " method where necessary.

In almost all cases, metalling was done piecework, men working in gangs of four to eight and finding their own material. One of the most interesting points regarding the labour employed was the rapidity with which men, having no previous knowledge of the work, learned to erect dry stone masonry. Excellent work was done, and the main difficulty was in driving home to the men the fact that retaining walls should not be vertical, but leaning up the slope at an angle of from 5 to 10 deg. For all work the surface stone of the vicinity was used; in some places this was a sandstone (Old Red), in others a conglomerate. Men either rolled stone down to the roads, from the area round about, or, if necessary, themselves hired horse transport to haul it from some spot (on the road) when it was plentiful.

The two new metalled roads were constructed along moderately steep slopes involving "cut and fill," with retaining wall, over the greater part of their length, few true cuttings or embankments were made, these being avoided by conforming pretty closely to the contours.

Without entering into great detail it is not possible usefully to describe the work done in the improvement of existing tracks, etc. This varied from complete metalling of rides and the making of new exits to the draining and wheel-track-metalling of other rides and semi-abandoned parish roads; the 5,400 yards of this work cost about £1,350, *i.e.*, an average of 5*s*. per yard; actually the cost varied from 20*s*. to 1*s*. according to the work done.

Details of the new metalled roads follow. One road was 790 yards long, and cost about 19*s*. 6*d*. per yard; the other was 2,373 yards in length, and was constructed for 24*s*. 6*d*. per yard. In each case the figure given is inclusive of an apportionment of charges for tools, materials and local supervision, and the higher cost of the second road is attributable to excessive surface water, a greater amount of blasting, and the fact that one very expensive horse-shoe bend (involving a short cutting 15 feet deep) had to be constructed, and that retaining walls, often 5 feet high, had to be built throughout almost the entire length.

Soil, etc.—Although much loose rock was met with, little solid rock was encountered, and blasting was resorted to as the exception rather than the rule. Everywhere stumps (old oak coppice stools) had to be removed; they were generally dug out.

Breadth.—Formation was planned 13 ft. wide, but was for economy reduced in places to 11 ft.; metalling similarly varies from 10 ft. to 9 ft., with necessary increase on corners.

Composition.—Foundation, 6 in. rough pitching (blocks not less than 6 in. thick; surface, 4 in. thick, 2½ in. mesh, broken *in situ*. Soil from roadsides was used for "blinding" the centre (3 ft. wide) for horse traffic. Metalling was anchored at the edges by various means, generally by rough curbing (large blocks) buried 6 in.

Roads were subsequently rolled (6 to 8-ton rollers), although this was not anticipated at the time of their construction; had it been, cross-cuts (see "drainage" below) would have been covered.

Gradient.—Average gradient 1 in 12 in both cases. Maximum gradient 1 in 10 in the one case, 1 in 8 in the other. No reverse slopes.

Curves.—Degree of curvature and width of road adjusted everywhere to permit the passage of a timber-carriage loaded with 60-ft. logs.

Drainage.—No pipe-drains or tiles were employed (to reduce expenditure on material). Streams are carried under the roads in culverts of dry masonry, surface water collected in channels on the upper side of the roads and taken across in open cross-cuts at intervals of about 100 yds. These cross-cuts are strongly built of natural stone slabs chipped to shape, about 12 ins. × 12 ins. × 4 ins., spaced about 6 ins. apart, and coming flush with the road surface, the space between them being paved (to prevent washing) with narrow slabs. Covered cross-cuts would be better, but their cost, if built as dry stone culverts, would be prohibitive, and it was desired to avoid the use of tiles or pipe-drains with the attendant unavoidable expenditure upon material as opposed to labour.

The roads upon which only "formation" work was done were constructed mainly in a compact gravelly sand on gentle slopes; they were 12 ft. wide, and cost on the average 3*s.* per yard, which included a considerable amount of blasting (of boulders) in places.

Where "track-metalling" was done on old tracks, the wheel surfaces were dug out 18 ins. wide and filled with rough metal. This sort of work, done piece-work, generally cost about 3*s.*

For purposes of comparison it may be mentioned that the minimum agricultural wage when this work was done varied from 5*s.* 9*d.* to 5*s.* 5*d.* per day.

O. J. S.

Training of Foremen.

No one, I think, can doubt that some training of foremen is a necessity. The point is that this training, to be worthy of the name, must be so thorough as to ensure that a trained man shall be capable of taking his place in the field with such a degree of confidence as to enable him within a reasonable period to perform the functions of a ganger and ultimately of a foreman in charge of a minor operation under the forester. How suitable training can most successfully be provided is a matter which can, it would seem, be discussed at greater length.

In all, ten forest school men* have so far been allotted to me, one of whom elected to return home within a few hours of reporting to his station for duty. The remainder have proved themselves keen, but inclined to confusion arising from improperly assimilated specialised information, and all the various sins of omission and commission referred to in the article entitled "Training of Foremen" in the first number of the *Journal* have been encountered. Careful supervision and very much patience have been necessary on the part of forest officers and foresters, for almost without exception these men have at first shown themselves lacking in the practical application of general knowledge useful in the field.

* It should be noted that some of the men referred to in the above and succeeding articles were uncertificated students from the apprentices' schools or else trainees from the schools for disabled ex-service men. It was never the intention of the Commissioners that the latter should be prepared to occupy the position of foremen.—*Ed.*

The season has, however, gone far to demonstrate that we can give the men all the necessary training on the practical side in the field.

In addition to the forest school men, I have been obliged to make use of some carefully selected " untrained " men as gangers and foremen. These were mostly older men, and consequently were on the whole much more successful in the handling of their gangs. They were also as keen as one could desire, and even more readily than the younger ex-students evinced proper appreciation of the elementary facts of plant physiology in application to their work. Nor is this so surprising in view of the life experience these particular men have had on the land, the term " untrained " being in their case a relative one only.

It is, of course, most unreasonable to expect the young and inexperienced ex-students successfully to assume control of large gangs of men themselves almost wholly without experience in forest work. Capability in this respect will doubtless come with time in most instances, but in the meantime there is no doubt that the " untrained " foreman I refer to has, in the majority of cases, proved a much more suitable type to rely upon where economy and efficiency have had so closely to be associated.

There are, however, future years to provide for. The type of ganger and foreman we want is, I believe, very generally agreed upon, and surely the best means to ensure real efficiency in the future is some adaption of the apprentice system under which suitably selected youths would be apprenticed for a term of years to approved foresters and thoroughly grounded in the practice of forestry. After, say, two years, summer sessions at the forest schools could be arranged for instruction in the theory of sylviculture, elementary science and land surveying, the apprentices returning to the forest each autumn for the first six months of the forest year. Five years' apprenticeship on these lines, arranged to terminate not later than the apprentice's twenty-first year, should eliminate all suspicion of cramming and equip a young man in a way that no system of theory before practice can ever achieve. Is there a doubt that the old custom of apprenticeship for a period up to seven years did not give a man a knowledge of his trade unattainable in any other way ?

The question of a bonus to the foresters to whom apprentices are entrusted could be given consideration, and apprentices could themselves compete for the privilege of taking an extended forest school course, carrying a higher certificate after the end of their apprenticeship. Such details, however, remain to be thought out.

In my opinion, the men who are to be our future foremen and foresters should be required to show something of their mettle on the practical side before being permitted to devote critical years of their lives to theory. A reversal of this order seems certain to lead a proportion of the candidates into a blind alley with all its disillusionment and disappointments.

W. L. T.

The subject of the above article being of such widespread interest, the Editing Committee were of the opinion that it would be useful to obtain the opinions of the Instructors and Divisional Officers thereon. A copy of the article was accordingly circulated to the officers concerned, and the following comments were received :—

Mr. C. O. Hanson (*Divisions No.* 3 and 4).—I am very much in agreement with Mr. Taylor's remarks and conclusions, especially that for our present work the untrained local ganger is often of far more practical use than the young ex-student. He is, however, almost always deficient in education, and is not capable of taking the position of foreman or forester. For these posts it is essential to have more educated men, not only in forestry but in general education. It is, therefore, essential for the future of the department to train a certain number of men.

My experience of the post-war ex-school gangers and foremen has been as follows :—

(1) Of ex-school men who were supplied to the division over a year ago I have had to deal with seven, of whom only two have proved fit to be promoted to foremen and are likely to make good foresters. It appears to me that the wrong type of man was at first taken into the schools, and it is essential in future either to adopt the apprentice system suggested by Mr. Taylor or to admit only men who have worked in the woods for some years under a forester.

(2) I have lately received gangers who have only just left the schools. It is too early to say anything about them, except that they appear to be more suited to the work than those of the previous year.

With regard to the education given at the schools, I do not think it is sufficiently practical. I find ex-school men often cannot keep tools sharp and in good order, and in planting, for instance, only have knowledge of one planting tool, that used in the school forest from which they come. Many have never used a mattock or Schlich's spade. They are also deficient in practical knowledge of such operations as hedging, fencing and hanging gates. I suggest that to learn such things each student should be attached for a short time to an expert gang of labourers who are doing these jobs in the school forest. I know, however, from practical experience, even in the large Forest of Dean, that it is difficult to arrange this—still, it should be kept in mind.

Then, again, it would be a great advantage if they could be taught the preparation of progress reports, costing returns, and the Commission's system of foresters' accounts, so that they may be capable of carrying on the office work in the temporary absence of the forester through illness or leave.

Taking all things into consideration, I do not think there is much fault to be found with the schools themselves. It is the type of man who has entered the school which wants improvement. Any student who does not show capability after a few months at the school should be dismissed, and under no circumstances should men who fail to get the school certificate be given appointments under the Commission. The men should not be judged by paper examinations only, but by their practical knowledge of field work as well.

Last year an ex-school ganger was sent to collect alder seeds. He came back with a bucket full of *male* catkins ! It should be impossible for such a man (after two years' training) to obtain an appointment.

C. O. H.

Mr. L. S. Osmaston (*Deputy Surveyor, Forest of Dean*).—It is at present laid down that an applicant for going through the forester's school should have put in six months' work in the woods as a labourer. This is far too short. We want as foremen and subsequent foresters those who have done work in the woods ever since they left school; that is to say, youths who have done not less than five years' labourer's work. Now that the number of men required by the Commission is so small, would it not be possible to get enough men of this class ? Promising youths should be noted, and when they have done not less than five years' work in the woods, and have had sufficient education and possess the requisite ability to go through the school course, they will be of the right stamp.

It should certainly be one of the conditions of joining the school that the passed student binds himself to serve the Forestry Commission for not less than three years if called on to do so. I am now laying down this last condition when appointing a man as foreman. The last man who was appointed a few months ago worked in the woods since he left school, passed through the school, came here, did work as labourer and ganger for the first few months after he left the school, and was then appointed to a beat on the condition that he serves the Office of Woods for not less than three years. He has a difficult beat and is doing well. He has a house and garden free, and is paid 8*s*. a week above the ordinary forest labourer's wage, whatever that may happen to be; he is really doing the work of a forester. If it be found that, on account of the Forestry Commission having been in existence such a short time, efficient youths with five years' forest labourer's serivce are not forthcoming, then the number of years' service requisite before entering into the school must be temporarily reduced as may be found necessary, say, two years for 1923, three years for 1924, four years for 1925, and five years for 1926 and onwards.

L. S. O.

Mr. A. L. Felton (*Parkend School*).—There is much to recommend the suggestion to apprentice selected youths to approved foresters, where they will get the atmosphere of forest life far better, I consider, than in a school, and where they will have a better opportunity of meeting with small points in a forester's life which otherwise may be overlooked. I think it will be agreed that, however a man is trained, he does not really get a grip of things until he has met with them in actual life. The apprentice would also have a better opportunity of dealing with outside labour. Here he has mainly only student labour to control, which is far different, though I should have thought that the better type of student would have quickly found his feet in this respect when he leaves the school. Dividing the practical and theoretical work I believe also would have good results; the men could then concentrate their mind fully when the time came for their theoretical training, and, provided the teaching was carried out judiciously, there should be little chance for overcrowding their brains.

This system of training should also do much towards overcoming the idea that so many students get that when at school they are something different from other men, and also, once having gained the certificate, they are fit for a higher-paid position than the Commission can offer. My experience has been that the better educated and superior student at the end of his course either tries for a position abroad or in private employ, in preference to working for the Commission, solely from a money point of view; the result is that many of the best men are lost, and only inferior men go to the Commission. It is meeting with this type which, no doubt, gives the impression that the students leave a school with a confused mind resulting from improperly assimilated specialised information, although it is hard to realise, as only elementary theory is dealt with. The apprenticeship of selected men would also ensure the right type of man being trained, though it is questionable whether many youths would be willing to agree to so long an apprenticeship as five years (not too long, in my mind). If they did, it would be a proof that the man was of the right type and really keen on forestry. In either case, whether the men are to be trained under the apprentice scheme or under the present system at a school, I would suggest that before accepting a man for training he should sign an undertaking that he would work for the Commission for a given period, if his services are required. No doubt this may have the effect of lowering the number of applicants for training, but it would do away with the unfortunate idea that the certificate fits the student for a better-paid position than the Commission can offer, and would ensure that only keen men willing to work their way up are trained. Finally, I think it would be a great help to instructors if Divisional Officers could find time, among their other arduous duties, to intimate, through the Education Officer, any main points where the students fail, so that such points could receive special attention.

A. L. F.

Mr. A. D. Hopkinson (Chopwell School).—I agree very largely with what Mr. Taylor says, particularly with the desirability of giving practical training to lads before they are admitted to the Commission's schools. The ideal method of training, in my opinion, would be to take boys as soon as they leave school, when fourteen or fifteen years of age, and allocate them to certain foresters for three or four years' apprenticeship. The boys should be very carefully chosen, and should be country-bred. As far as my experience goes, it is practically impossible, except in very exceptional cases, to make a successful forester out of a townsman. The sons of foresters, gamekeepers and such like should be given preference, and they should only be put under foresters of known ability and who are willing and keen to have them and train them. Wherever possible, the boys should be recruited in the neighbourhood of the forest where they are to be trained, in order that they may, at any rate for a year or two, live at home. I do not think one forester should have more than two or three apprentices allotted to him at one time.

It should be clearly understood that the forester takes trouble to teach his apprentices and put them on to all the different operations which have to be performed. For this extra trouble he should receive a small remuneration per annum. Only those apprentices who acquit themselves well during their period of apprenticeship should be permitted to enter a school. Then boys should be encouraged to read simple technical books and to attend, where possible, evening classes for the improvement of the general education. They should be paid the ordinary rate of wages for lads of their age, and perhaps given a bonus when finally passed as fit to enter a school. This method would give an opportunity for " weeding out " those that did not appear as if they had the making of good foresters in them, and thus ensure a considerably higher standard in the men leaving the schools. As far as I can judge, the standard of apprentices now undergoing training has fallen considerably when compared to those who were trained just after the war. Greater care should be taken in the selection of the trainees, and the existence of the Commission's schools should be more widely known than is at present the case.

The method which has been outlined above cannot, of course, be put into full operation at once, but it might be gradually worked into by taking on a lot of older lads now and giving them one year's apprenticeship, another lot about a year younger and commencing thus on a two years' apprenticeship, and so on.

A. D. H.

Mr. F. Scott (*Northern Division*).—The need for a special course of training for foremen has not been felt in this division, nor is it considered likely that the necessity for such training will arise. Men engaged as foremen or promoted to this grade have been drawn mostly from private estates. All had some years of experience as working foresters, and several had been in charge of squads. A few have not been very satisfactory and have been reduced, but generally this type of man has, when his prejudice against " red tape " has been overcome, given every satisfaction. In the intial stage of our work the skill and endurance of these men was put to a severe test, owing to the inexperience of the labour available.

Efficiency in the practice of forestry can only be acquired by actual participation in the work. Class-room training may make a man more observant, but it cannot teach him how to use his hands, and the first essential in a foreman is that he must be able to perform any operation in connection with his work, and at the same time he must be capable of teaching others. Tact and firmness in the handling of a gang are of the very highest importance, but these are qualities which theoretical training cannot, unfortunately, confer. A foreman's duties require of him, primarily, that he should be able to carry out instructions, the methods by which he is to proceed being laid down to him. The field or the forest will prove his best school in this connection.

It would be unfair to express an opinion based on the limited experience of the ex-student type of foreman afforded here. One man, with previous experience of leadership, has gained well-merited promotion in a comparatively short time. Most ex-students now completing their training would appear to suffer a serious disadvantage in that they complete their course at an age at which they are too young to gain the respect, as leaders, which older men would secure without effort.

Theoretical training should, I think, begin when the foreman, is seen to be capable of promotion to a higher grade. Foresters should as a rule, be recruited from the ranks of the foremen, and, on promotion, should be given a forest school course. Every encouragement should, however, be given to men of all grades to rise in the service. With W. L. T., I agree that the apprentice system produces the best men. The experience should cover all branches of the work, including saw-milling, but while I approve of giving scope for improvement in general education at this stage, say, by attendance at evening classes, I consider that a full five years of practical work will be required to produce a thoroughly efficient forester. From among the men so trained a sufficient number of those capable of taking the lead will always be found.

F. S.

Mr. J. F. Annand (*North-Eastern Division*).—The chief cause of the lack of efficiency in the work of some of the foremen who have been taken direct from the schools has, in my opinion, simply been the men's want of experience. It is not surprising that the results have not been uniformly satisfactory. The men have either been too young or, as in the case of ex-Service men, they have been drawn for training from civil occupations other than forestry, and they have had too little time or opportunity of acquiring the requisite knowledge and practice of the actual work they have been called upon to do. In this division a few of the outstanding men from the forest school have done exceedingly well, but most of them, at the outset, have only been moderately successful. Our best foremen (and foresters also) are those who have had several years' training in practical work on well-managed private estates where a good deal of planting had been done. These men have served no regular apprenticeship, but they have had the opportunity of taking part in all practical work alongside experienced estate workmen and usually on more than one estate. I think this is preferable to a long apprenticeship in one place. In any case, there would seem to be no need for the apprenticeship to start at so early an age as 15 or 16 years. Boys of 15 very often have not fully decided what occupation they intend to follow, and it does not appear desirable that the Forestry Commission, at any rate, should undertake responsibility for specialised training in forestry for boys of this age. Many of them would almost certainly transfer to other and better-paid employment. Boys of 15 can, as a rule, live more economically at home, and if they are in a neighbourhood where they can get forestry work, this work should count in a qualifying period. If taken on as apprentices by the Forestry Commission they would have to be subsidised, as they could not earn enough to pay for board and lodging.

It is suggested, therefore, that a youth who desires to train as a forester should have had two years or more practical work on an estate before proceeding to a forest school or university. He should be not less than 17 or 18 years of age, and, as regards his general education, should preferably have passed a higher-grade examination. He could then go to the forest school for two years (perhaps summer sessions, as suggested by Mr. Taylor) for instruction in natural science, forestry, surveying, etc., returning each winter to practical work either on private estates or on the Commission's areas, as may be arranged. At the end of the second summer session, scholarships or exhibitions might be made available for those desiring it, and likely to be able to qualify for a University diploma or degree, which should qualify for appointment as higher-grade foresters or district officers. Those not desiring or not considered suitable for further theoretical training should be eligible for appointment as probationer foremen under head or first-grade foresters, or for similar appointments on private estates.

The practical training of youths in squads by themselves is not considered so valuable as that of working singly in squads of experienced workmen. The work on private estates is more varied than that on most of the Forestry Commission's areas in their present undeveloped state, and that is why it is considered so desirable that part of the preliminary practical training should be on private estates.

If the class work at the forest school is to be confined to the summer months, as suggested, it might be necessary to extend the period of training over three summers. The annual out-turn appears to be too high for present requirements in any case. Private owners would, in my opinion, take ex-school men more readily if part of their practical training had previously been on private estates.

J. F. A.

Mr. J. M. Murray (South-Eastern and Western Division).—I have read Mr. Taylor's article with great interest. If certain minor details are excepted, I can find myself in complete agreement with the views expressed. The pre-war system of apprenticeship for three years, followed by changes to other estates as a journeyman, produced a good forester who knew his work and had the shrewdness that only practical experience of the work can give. The system was improved, to my mind, by the late Professor Sir Isaac Bayley Balfour, who started a course for young foresters at the Royal Botanic Gardens, Edinburgh. Probationers were chosen from applicants who were not over 25 years of age and who had had three years' experience of forestry work on approved estates. The course consisted of evening lectures on the various sciences on which forestry is dependent. Work was provided in the Arboretum, where the men were trained to distinguish the various trees and shrubs, and were given considerable experience in the handling of plants. At the end of the three years' course a certificate was given showing the proficiency of the probationer in his work and studies.

The main difficulties in this system of training were (1) the limited number of men that could be taken on, and (2) many of the men had not done any bookwork since leaving school, and occasionally they took ill to starting again. The second difficulty is one which will occur in a system of training that demands practical experience first and theory afterwards, but the danger of this is lessened if the apprentices are given opportunities of attending lectures on various subjects connected with forestry. Such opportunities were formerly provided by the county lectures of the Agricultural College in Scotland.

The following system of training might be adopted :—

(1) A number of suitable apprenticeship centres could be formed, and evening lectures to the apprentices at these places might be given. The attendance of continuation classes might be enforced, unless it could be shown that there were good reasons for non-attendance. A forest museum should be formed at each training centre.

(2) Entrance to the forest school should be gained by examination. This school should be so situated that the practical work can be maintained during the two years' school course, and the aim should be to evolve a thoroughly practical forester with sound elementary theoretical knowledge.

In this division there have been foresters and foremen with very many kinds of training. So far, the most satisfactory men have been those who were country bred, who started work on a good estate, preferably one north of the Forth, and who, after at least three years, undertook a course of theoretical training. With one or two exceptions, men with only a school training have found themselves in occasional difficulties in planning work. In every instance they have been lacking in ideas in timber utilisation. Where the schoolmen were of the right kind they applied themselves to their work, and in the course of a very short time became good managers.

It may not be out of place to say here that the intensity of training that any man will undertake is generally governed by the personal advantages he is to gain. These advantages may be spiritual or worldly. In these days we fear the welfare of the spirit is much dependent on the world, and unless the monetary advantages to the foreman are to be sufficient, the provision of theoretical training involving any sacrifice will be useless.

J. M. M.

Mr. J. Fraser (*Beaufort School*).—The safest general guide in directing the future policy of education of foresters and foremen is probably the Report of the Interim Authority. When attention is given to the personnel of the existing service it is evident that the system in view in that report is at all events a practicable one. It appears that ability to carry out the required work and not any specified type of training should be the guide in selecting men and that while for the purposes of pay and administration grades must be distinguished these grades should not be regarded as insurmountable barriers to progress. Every attempt should be made to allow a man to advance in the service so far as his abilities allow him. What is rather indefinitely termed practical knowledge must occupy its proper position when deciding what prominence is to be given to practical instruction. Practical knowledge is acquired only by practice and at the outset it is well to state that the greatest difficulties will arise not from lack of practical knowledge or technical instruction, but from lack of general education in its widest sense. The guidance and active co-operation of divisional officers is necessary not only for the work in the training centre, but for the further education of the men ; the instructors can guide only for a short distance and it is natural to expect that divisional officers will require to carry out a large part in the general educational scheme. In Scotland the advice and active assistance of the divisional officers have been freely given, and suggestions offered by them have proved most helpful. The suggestions offered here are only personal opinions, but it is felt that the measures suggested would meet the approval of these divisional officers.

Men whom it is intended to train specially for the service of the Commission should preferably be selected from men who are already in the service of the Commission, and should be men who by their work have already proved themselves likely to be of value to the Commission. If possible, probable entrants should be so placed in the service that for a time at all events, they are able to avail themselves of any evening class instruction that is provided by the Education Authorities. Men should be encouraged to attend classes in English and Elementary Mathematics. Lack of ordinary school education should not necessarily exclude men from the forest schools ; a small number of men older than the existing prescribed age class would serve a very useful purpose in the forest schools. Favourable consideration for provision for attendance at these schools might be given in the cases of perhaps two men per school per year. It has been pleasant to notice that certain men with limited school education have made good progress mainly by their own efforts.

Men who are selected for attendance at the schools should in the first instance be selected for a period of one year only. During this year indoor instruction might be usefully directed to elementary botany, surveying, forest mensuration and the other subjects prescribed in a general manner in the existing scheme. The nature, the extent and value of the outdoor instruction would in large part be determined by the position of the training centres. It is desirable that as many as possible of the men in the service of the Commission in the junior grades should be given a course of this kind and it is felt that it should be possible to arrange for that without heavy expenditure. In favourable circumstances, it is felt that the expense per man might not exceed £35.

A further period of training of one year might be given to selected men; the training might be on the lines already prescribed by the Commission, or the procedure offered might be adopted. At the end of the year of instruction in the schools one man per class might be granted a scholarship which would be sufficiently large to defray training expenses of all kinds at one of the Universities. The men who would be suitable for this course would be few and one or two years might pass without selecting any man for this course. The course to be followed at these higher training centres might be prescribed within wide limits but graduation in strictly technical degrees should be discouraged. In Scotland, at all events, any deficiency in early education in school would not prevent a man overcoming difficulties connected with entrance examinations. The existing distribution of working centres would allow a selected man to be employed where by evening study these difficulties could be overcome.

The position of the forest schools depends largely on the procedure that would be adopted with regard to training after the first period. Men who have passed through one year of training at the schools should be given opportunities to gain such experience as is normally got by forest apprentices. As it is probable that for some time, at all events, experience in utilisation work will not be available for all, in operations conducted by the Commission an arrangement might be made for definitely placing men in suitable situations and a scheme of co-operation with landowners might be arranged. In return, a fixed number of landowners' nominees might be provided for in the forest schools. It should be possible by arrangement between divisional officer,s experimental officer and instructors to conduct the management of practical operations at the forest schools so that these schools might be of real value for short courses of instruction for men who have already passed through the one year course. It is clear that, for this purpose a reasonable degree of certainty of permanency of arrangement and a fairly wide field of operations are necessary.

The general lines that have been suggested above do not make any demand for special educational facilities that are not already provided for. Each of the three main suggestions can be adversely criticised and details of each suggestion require careful discussion but it is contended that :—

The man who is willing to work has the opportunity of rising in the service; the discontented man cannot complain that any other man in the service receives more favoured conditions :

Provision is made for acquiring practical experience by practice :

A small number of highly trained men specially suitable for highly specialised work necessary in connection with forest operations will be available and the unfocussed view of extreme specialisation will be corrected :

The total costs of education to the Commission will be reduced.

J. F.

Recent Work on the Pine Weevil.

The Pine Weevil (*Hylobius abietis*) problem still occupies the attention of the Forestry Commissioners.

The extensive areas of Scots pine felled during the war while they have in many cases afforded land and opportunity for planting operations have also served to increase the weevil population throughout the country and have created problems which must be faced to ensure successful planting.

The *Hylobius* problem is no new one. It attracted the attention of the famous German foresters Ratzeburg, Altum and Von Oppen in the middle of the last century and even to-day it is in Germany one of the most important problems in the domain of Forest Zoology. In Britain too, the Pine Weevil has been attracting attention and it may be worth while to review the work that has been done recently in this country and in Germany with regard to its control. In the first place, it should be noticed that even to-day the life-history of *Hylobius* under varying climatic and forest conditions is not thoroughly known.

In 1912, Grohmann, a Forstmeister in Saxony, appeared to have obtained a fairly accurate and reliable knowledge of the life-cycle of *Hylobius*. (*Tharandter Forstliches Jahrbuch*, Vol. 64, 1913). He found that eggs laid in June gave adult beetles in August of the following year, *i.e.*, fifteen months later, and that eggs laid in September did not give rise to adult weevils until twenty-one months later, in June of the second year.

He stated, however, that soil, climate, latitude and altitude were important factors affecting the duration of the life-cycle (*i.e.*, from egg to adult) and more recently Professor Escherich of Munich found that while thirteen to sixteen months was the usual duration of the life-cycle in some instances, three to four months sufficed (*Forstwissenschaftliches Centralblatt*, 1920). He, too, stresses the importance of soil and climatic factors and Wulker, one of his research workers, expresses the opinion that the date of egg-laying may be important in determining the length of the life-cycle.

In Britain, comparative studies of the period of duration of the life-cycle in different districts have not been made, but comparison of records of observations made by myself at Bagshot in Surrey and at Montreathmont Moor in Forfarshire, show that in the south the life-cycle is gone through more rapidly than in the north. This indicates that in the south *Hylobius* can increase more rapidly in numbers than in the north and that more intensive trapping is required in the south and in sunny warm areas than in the north and in colder districts.

On the whole then, it may be assumed for practical purposes that from fifteen to twenty-one months is the average period of duration of the life-cycle of *Hylobius* but that shorter periods may occur and should be expected in southern and in warmer districts.

With regard to the mode of egg-laying of *Hylobius* recent observations made in the field during the past three years and experiments begun this year at Kew show that the weevil has a marked preference for portions of stumps, roots of fallen branches below soil level as egg sites. The experiments at Kew further showed that small logs buried to a depth of three inches in the soil and completely covered by it to that depth were sought out by the weevil, but a log buried eighteen inches deep was not utilised for egg-laying unless connecting with the soil surface by an adjoining and contiguous log slanting upwards.

These experiments are still in progress, but they throw interesting light on the doubtful value of such measures as creosoting and burning stumps or burying stumps with a layer of soil. Such measures can easily be rendered useless, for it is evident that the mere passing of a cart or the dragging of a log over a root may expose it (such exposed roots must be familiar to every forester) and afford access for the female weevil.

The Kew experiments, together with observations made in the field, also showed that egg-laying continued from May to August in most districts, *i.e.*, Suffolk, north to Elgin, but was begun in April and continued till September in Surrey. In this connection, log traps (*i.e.*, short logs about 2 ins. across partly buried in the soil on "the slant") proved a most useful guide to the movements of *Hylobius*.

At Bagshot, Surrey; Rendlesham, Suffolk; Montreathmont Moor, Forfarshire; and the Culbin Sands, Elgin, the first appearance of the weevils in the spring and the first dates of egg-laying were determined by examining their logs, and so, too, in the autumn log traps prepared in June and early July contained eggs, but similar traps prepared later contained no eggs. Such traps afford great assistance in deciding whether the weevil is present in numbers in an area. At Montreathmont Moor, long before the young plants were touched by the weevils, numbers of weevils were being found in the test-traps, and there is no doubt that such traps are always worth the small cost and trouble involved in preparing them.

The movements and habits of the adult weevils have received attention in the Commission's experiments. At Bagshot observations were made on a pine felling during winter and spring, but no adult weevils were found until March 15th, when they began to appear under branches and stems lying on the ground. At this date such branches and stems showed no gnawed patches, but a week later all branches and stems showed gnawed patches on the lower surface, and on the soil small heaps of bark dust were found. After a little practice it was found that each gnawed patch indicated the presence of a weevil under the log or branch, and in this way numbers of weevils were obtained which otherwise would have been overlooked. In such cases, the weevils were found in the soil hidden by pine needles, bits of bark and moss, or even an inch or two below the soil in a small recess apparently made for retreat.

The habits of the weevils observed at Bagshot suggested a series of experiments, which were conducted in the laboratory at Kew during March, April and May.

Weevils collected at Bagshot were placed in three large breeding cages containing a layer of soil $1\frac{1}{2}$ to 2 ins. deep. Scots pine transplants were supplied as food, and later one or two pine branches laid on the soil served for breeding ground.

When introduced to the cages, where the temperature during the day ranged from 43° to 47° F., the weevils disappeared into the soil within an hour's time and remained there. On the following days one cage was placed near the fire to raise the temperature, while the other cages were used as controls. At 49° F. the weevils began to appear above the soil, and when the temperature rose to 65° all had appeared above the soil and showed great activity. Several paired, and all nibbled at the food plants. In the control cages kept at 45°, the weevils remained in the soil. Subsequent experiments on these lines gave similar results, and it was found that between 49°-50° the weevils became active, and at 60° flew about the cages. On 11th April, low temperature experiments stopped owing to the warmer weather prevailing, when even out of doors the temperature reached 58° F. On this date the first eggs were found, and egg-laying continued until 27th May, when the experiments closed.

These experiments were confirmed, in their general results, by observations in the field. Thus in April and May at Bagshot the weevils were actively feeding, while in Forfarshire and Elgin during the first fortnight in May the weevils were only beginning to be active, the first weevils being found in Forfarshire on May 3rd. From that date onwards in the Forfarshire area the weevils appeared in increasing numbers, 3,000 being trapped by 27th May.

In Elgin, on the Culbin sands, *Hylobius* was just beginning to appear on 8th May. On logs and branches lying on the ground gnawed patches were found, and a few weevils taken. On the next day fresh "frass" was observed on some young pine planted in autumn, and one weevil was found. Isolated self-sown pines showed fresh traces of weevil injury, and under one such pine 52 weevils were found in the soil. Under an older pine, some 20 ft. high, 62 weevils were taken in the soil by Messrs. Annand, Mackay and myself.

These experiments and observations are of considerable interest. They indicate that *Hylobius* winters in the soil, probably feeding in mild weather, and that the first few warm spring days are the signal for its leaving its winter quarters and beginning its reproduction.

Experiments on the movements and dispersal of *Hylobius* were carried out in the Forfarshire area already mentioned. The main objects of these experiments was to ascertain how far such obstacles as drains or ditches, rough heather, burned moorland and roads deterred the dispersal of adult weevils.

The method of experiment was to mark by a lasting paint a number of adult weevils, set them free, and watch for their occurrence in the traps or on plants in various parts of the area. 1,000 weevils were painted and liberated on 3rd July, but unfortunately it has not been possible to determine how many of these weevils have been recaptured, for the following reasons. The paint in many cases got rubbed off or chipped off, except in the punctures on the wing covers, but there it was not sufficiently conspicuous to be seen without using a lens, and consequently it is certain that a number of marked weevils which were recaptured were destroyed without being recorded. Further, as marked weevils were turning up in the traps until the experiments closed in August, it is evident that others may still be at large and will not be seen again until next year.

In spite of these drawbacks, the experiments with marked weevils have given interesting although necessarily incomplete results. To my mind, the most striking result obtained was that marked weevils were taken in traps in the immediate vicinity of their point of release all through the experiment. This indicates that the weevils remained in or near one spot throughout the summer and that their wanderings are in some circumstances strictly limited. The maximum recorded distance travelled by the weevils from the point of release was about 800 yards, or less than half a mile. While it does not follow that *Hylobius* never travels farther than this distance, it should be mentioned that short-distance flights are the rule rather than the exception in the insect world, that is, where flight is unaided by wind. The occurrence of *Hylobius* at the lantern of the Isle of May lighthouse, recorded by the late Wm. Evans in the *Scottish Naturalist* for April, 1915, must be regarded as exceptional, and the Montreathmont experiments serve, I think, to show that the opinion often expressed that *Hylobius* seeks out new breeding-grounds considerably distant from its own must be received with caution.

The above experiments showed beyond all doubt that ditches, rough heather, burned land and roads offer no serious obstacle to *Hylobius*.

A feature of the weevils' movements at Montreathmont was that there was a definite movement to and from the standing woods. Weevils flew from these woods to the felled and planted area and *vice versa*. Thus those marked weevils which travelled farthest were trapped at the edge of a standing pine belt, and there was a definite movement on the part of the painted weevils in that direction which was contrary to that of the prevailing wind.

Taken as a whole, the experiments and observations made during the past two years in the natural history of *Hylobius* seem to me to justify some change in the view commonly taken of this pest. Too much attention has, in the past, been given to the felled area. While it is undoubtedly true that felled areas of pine form extensive breeding ground for *Hylobius*, the trouble does not start there, but in the standing pine woods. Observations made throughout the country during the last three years confirm this view, and as far as organised forestry is concerned it is to the weevil conditions in our standing woods we must look if we are to combat *Hylobius* efficiently.

Experiments have also been made by the Commission in combating *Hylobius*, and the results obtained from these experiments may be of value to executive officers who are faced with the pine weevil problem. In the first place, it may be stated that such measures as burning the felled area and charring, creosoting or burying the stumps on it, and even the custom of barking stumps, are too costly and of too little practical use to be worth while. All of them neglect the fact that the majority of the weevils lay their eggs in subterranean portions of the stumps and roots.

Measures aiming at protection of the plants by smearing or painting them with lime and linseed oil and other dressings were proved by experiment as having little effect. The treatment required frequent renewal and these measures are not worth their cost. The same applied to the use of a lead arsenic poison spray tested in Bedfordshire and there is no doubt that measures directly aiming at the collection and destruction of the adult weevils are the most likely to give results.

The most important recent contribution towards the practical control of *Hylobius* is that of Forstmeister Grohmann in Saxony. He devised a type of trap which supplied both breeding and feeding ground for the weevil and was intended to attract it and induce it to lay its eggs in the traps which could be destroyed instead of in the stumps which could not be removed. The construction of Grohmann's type of trap has been described in Leaflet No. 1 of the Forestry Commission, and there is no reason to doubt that the type is an efficient one. On the other hand, all that Grohmann claims for it has not been realised. His chief claim for the pit-trap contrasted with the log or billet-trap is that it encourages the natural enemies of *Hylobius*. Among these he cites blind-worms and lizards, bugs, spiders, ants, centipedes, wood-lice, staphylinid beetles, wire-worms (*Elater* beetles), ground beetles and ichenumon flies. While it is true that some or even all of these animals may occur in pit-traps there is still no evidence to show that any of them are highly important enemies of *Hylobius*. Furthermore, ground beetles, staphylinid beetles and ichneumon flies do also occur in or on log traps and in my experience Grohmann's pit-trap is justified on other grounds. It lasts longer than the log-trap, is more attractive to the weevils and can be left for long periods (three to six months) without any attention. It is especially suited for protection purposes but is less suited for use where an outbreak already exists.

In experiments conducted by the Commission in 1920, it was found that trapping of the weevils by means of bark and sawdust traps was $2\frac{1}{2}$ times as efficient as hand-picking and much cheaper. In one of the experiments, however, this was not borne out in the early part of 1921, but subsequent experience has shown that under most conditions, trapping is superior to hand picking of the weevils from the plants, and, in fact, at Montreathmont Moor in 1922, the weevils were so readily taken in the traps that very few plants were even attacked and hand picking would not have been possible while the traps remained.

At Rendlesham, Suffolk, and on other areas the drought of 1921 rapidly dried up the bark traps in use and log traps were substituted. These proved efficient, and as they are often more easily obtained than bark-traps, last longer than these, and are easily handled, they were used exclusively in the 1922 experiments.

The 1922 experiments were conducted at Monthreatmont Moor through the courtesy of Mr. Annand. Similar experiments were also made by him at Monaughty, Elgin and on the Culbins. These experiments were designed not only to give information as to the movements of *Hylobius*, but to provide protection as far as possible for a planted area of 240 acres. The main breeding grounds of *Hylobius* consisted of a small group of stumps of pine in the midst of the planted area; an extensive felling to the south of that area and cuttings in a belt of pine to the west of the area caused by a windbreak.

Log traps consisting of portions of pine stems 4 ft. long and about 3 ins. in diameter at the thick end were first prepared in the autumn of 1921. These were examined in February and showed no evidence of the weevils presence. In April, they still showed no signs of weevil, but on the 3rd of May the first weevils appeared in the traps and their occurrence rapidly became more frequent until by the end of May, over 2,000 had been trapped. Trapping continued throughout the summer and when collection ceased on 28th September over 26,000 weevils had been destroyed.

The total cost of trapping including cutting of logs for traps, carting and laying them and collecting of the weevils was approximately £41. No plants were lost through weevil on the whole 240 acres, and the protection cost may be placed at 3*s.* 6*d.* per acre. The result of the experiments is therefore satisfactory; the crop was protected and in addition, a number of useful observations were made and new facts added to our knowledge of *Hylobius*.

A word of caution is, however, necessary with regard to these experiments. In the first place it is certain that further protection will be necessary next year and secondly, it is by no means certain that such complete protection as was obtained this year can always be ensured. The summer of 1922 was, on the whole, cold and wet and not favourable to activity on the part of the weevil which probably on that account sought shelter in the traps more than it might have done in warmer weather. On the other hand, the experiments suggest that systematic trapping is effective and that there is justification for further experiments to improve the system of trapping now in use. If, as the recent experiments and observations suggest, the standing woods are the normal habitat of *Hylobius*, attention should be given to the weevil conditions in these woods. If prior to felling the number of weevils in the woods to be felled can be reduced to a minimum that ought to prevent any considerable amount of egg-laying taking place in the stumps and roots after felling. Experiments to ascertain whether such a means of control is practicable are evidently desirable and will probably be undertaken in the near future.

So far, no mention has been made of control of the weevil by parasites. Our knowledge of the parasites of *Hylobius* is still very scanty and the prospects of controlling the weevil by the encouragement of its natural enemies are so far not very promising. In addition to a number of predaceous beetles of the family Carabidae the following are the insect enemies of *Hylobius*, so far known :—*Bracon hylobii* Ratyeb, *Bracon brachyceros* Thoms., a braconid species still undetermined and the ichneumon *Ephialtis tuberculatus*. *B. hylobii* and *B. brachyceros* are recorded by German writers, the other two parasites are British records. Of the two known British parasites the braconid is the more important. It is widely distributed and often occurs in considerable numbers. Its life history and relation to *Hylobius* have been described by the writer (*Proc. Roy. Phys, Soc. Edinb.*, Vol. XXXVI)

The ichneumon *Ephialtis tuberculatus* is less widely distributed and less common where it occurs than the braconid. It is chiefly known as a parasite of caterpillars.

Through the courtesy of the Board of Agriculture for Scotland, experiments on the artificial introduction of the bracon above mentioned in to a felled area were tried in 1915. Owing to unfavourable weather and to the small number of parasites set free, and as it was subsequently discovered that the parasite was already present in the experimental area, no results were obtained from these experiments.

In addition to these insects enemies of *Hylobius* two other animal parasites have been described, an eelworm (*Altantonema mirabile* Leuck) and a protozoan (*Gregarina hylobii* Fuchs). The first of these was wrongly described by Fuchs as *Tyleuchomorphus* and is cited as such in Leaflet No. 1. Neither of these parasites is, according to Wulker (Zeitschr. f. Ang. Ent. Bd. VIII, Heft. 2) of any practical importance and he sums up his discussion on the parasites of *Hylobius* with the suggestion that the mode of life of *Hylobius* is unfavourable to control by parasites and that the braconids offer most hope in this direction and these only if they can be artificially increased in numbers

Once *Hylobius* has been reduced in numbers in our standing woods the parasites will play a useful role in keeping it in check.

One other important enemy of *Hylobius* deserves mention. Both larvæ and adults are attacked by a fungus, identified by Dr. Butler, of the Imperial Bureau of Mycology, as *Sporotrichum globuliferum*. The fungus appears as a white fluff on the larvæ and beetles and on the latter often forms a ruffle-like collar round the thorax.

It also attacks *Hylastes ater* and appears to be common in the South of England. Whether this *Sporatrichum* can be used in combating *Hylobius* has not been determined. In some cases it may prove of value and experiments to test it in the field are desirable. Laboratory tests with such entomogenous fungi are often very favourable but in the field such successful results are rarely obtained.

To sum up the present position of the Pine Weevil problem, it may be said that trapping is still the most hopeful means of control, that log and pit traps appear to be the most useful types of trap and further that attention should be given to the weevil conditions in standing woods.

J. W. M.

The Green Spruce Aphis.

During the past two years reports have been received by the Commissioners concerning defoliation of the Sitka spruce by the Green Spruce Aphis, *Aphis* (*Myzaphis*) *abietina* Walker, and recent reports received from Mr. Scott, of the Western Division (Scotland) show that this insect is in certain districts causing serious injury to various spruces. The Commissioners wish to call the attention of officers and foresters to this aphis, and the following notes on the signs of aphis attacks may be found helpful.

Theobald (*Annals of Applied Biology*, Vol. I, 1904) first called attention to the various signs of *Aphis abietina* attacks. "In *P. sitchensis*, the damaged needles soon fall and complete defoliation results. In *P. excelsa*, the needles turn brown, but the majority hang on, and the tree looks as if it had been scorched by fire. Young *P. excelsa* do not present the same appearance as old ones when attacked, the needles instead of turning brown are mottled, where the aphis sucks yellow spots appear, and this lasts through the winter."

Yellow blotches on the needles are usually the first sign of the aphid's presence, but as winter advances complete defoliation of the Sitka spruce and browning of the common spruce trees takes place, and attacked trees can be recognised from a considerable distance away. The aphides themselves are usually most in evidence in autumn and winter, when the wingless forms are found. They are typical "greenfly," and may be found in large numbers situated on the needles. Winged forms appear from May to August. No sexual generation has yet been found. It may be expected to occur on some other plant than spruce, but this intermediate host is not known. Detailed descriptions of the various known stages of the aphis will be found in Theobald's paper.

The natural enemies of the Green Spruce Aphis are ladybird beetles, especially the small beetles of the genus *Scymnus*, various hover-fly larvæ (Family Syrphidæ) and, as Theobald has shown, the long-eared bat. Hymenopterous parasites appear to be of minor importance, but spiders are especially useful.

The Commissioners are anxious to obtain more information regarding this aphis, with special reference to its distribution and prevalence. Any information regarding the occurrence of the aphis, together with particulars of the injuries caused by it and of the general soil and forest conditions prevailing, would be welcomed. Even when the aphides are found injuring spruce it is not always certain that they are the sole cause of injury, and the presence or suspected presence of bad soil conditions or of fungus attack should be noted. Severe aphis attacks may be followed by bark-beetle attacks. The bark-beetles which may follow spruce aphis are *Pityogenes chalcographus*, *P. bidentatus* and *Hylastes cunicularius*. The first two attack the stem and branches, especially at the branch whorls. *P. chalcographus* is more a spruce dweller than *P. bidentatus*, but it, so far as is known, is confined to the Dunkeld district of Perthshire. Both these beetles make star-shaped tunnels. *Hylastes cunicularius* closely resembles the Black Pine Beetle, *H. ater*, described in Leaflet No. 4, but it breeds in spruce and not in pine.

Spruce aphis outbreaks are usually intermittent. In England the chief outbreaks have occurred in 1846, 1913 and 1921, but with the extensive planting of spruce they may become more frequent. Up to 1914 the aphis was not recorded from Scotland. These aphis outbreaks are of real importance under our present forest conditions, and it is hoped that officers and foresters may be able to assist in acquiring information regarding an insect which may at times be ranked as one of our serious pests of spruce. Queries and information regarding the aphis should be addressed to the entomologist at the Royal Botanic Gardens, Kew.

J. W. M.

The Cockchafer Problem.

During the past ten years the results of several researches dealing with the cockchafer have been published in Europe. Of these the most important are Decoppet's work in Switzerland, Zweigelt's in the Bukowina and in Lower Austria, and Escherich's in the Bienwald (Rhine Palatinate). Decoppet and Zweigelt have dealt chiefly with the occurrence and distribution of the cockchafer, and Escherich with the application of control measures.

Decoppet's monograph is based on observations systematically carried out over a period of seventy-five years, from which it has been established that there are definite cockchafer years, that is, years when the insect is unusually abundant, and that such years occur regularly. The interval is three years, and this period also represents the duration of the life-cycle from egg to adult. Cockchafer years, however, do not occur at the same time in all districts, and the Swiss recognise three different cycles.

Thus, in the Basle district cockchafer years occur when the numerals of the year are exactly divisible by 3 (*e.g.*, 1917, 1920, 1923) ; in Berne when the year numeral divided by 3 leaves 1 over (*e.g.*, 1918, 1921, 1924) ; and around Lake Constance, when the year numeral divided by 3 leaves 2 over (*e.g.*, 1916, 1919, 1922). These are the three main cycles in Switzerland, but in the higher valleys the cockchafer years are separated by four-year intervals, corresponding with a lengthening of the life-cycle. Decoppet points out that while cockchafers are found every year they are seriously injurious only in cockchafer years, and that the periodicity of the cockchafer's occurrence is an important practical point. A knowledge as to which regime occurs in his district enables the forester to anticipate cockchafer attacks.

There has been considerable discussion as to how the various cockchafer cycles have been brought about, but at present nothing certain is known. It seems, however, that at some time, in the Basle district for example, the season had been unusually favourable to the cockchafer, so that an unusually large number of eggs were laid or hatched, and that in the two years following the conditions were not favourable to hatching and one brood of cockchafers dominated the locality.

In explaining the occurrence of two periods for the life cycle, a three-year one in the plains, and a four-year one in certain high valleys, Decoppet suggests the existence of two cockchafer races, a lowland and a highland. Zweigelt questions this theory, and expresses the view that the local climatic conditions are the cause of the disparity in the periods of development.

Zweigelt's conclusions, if confirmed, should be most valuable. In the Bukowina and in Lower Austria he believes that in districts where the average temperature for the year is 44° F. and below, the cockchafer is of little importance, but that where the average year's temperature is 46° F. and upwards, the cockchafer is a serious pest. Zweigelt further considers that the summer temperature is more important than the winter temperature, and his charts showing the occurrence of cockchafer in the two districts studied indicate that where the July temperature reaches 64° F. and upwards the cockchafer is much more troublesome than in those districts where the July temperature is below 62° F.

The work of Decoppet and Zweigelt is fundamental, and represents a new and important line of enquiry. If, as a result of their researches, the forester can prepare for a cockchafer outbreak, he can much more effectively deal with it than is possible in this country at present.

In Britain the period of development of the cockchafer is known to extend over four years, and in the north of Scotland it may take longer. At present, however, definite information is lacking as to the occurrence of cockchafer years. Beetles and grubs are found every year, but whether there are years when unusually severe attacks occur, and whether such attacks are periodic and regular, has, so far as the writer is aware, never been definitely determined. Information on these questions is highly desirable, as it will have an important bearing on control measures against cockchafer. Experience in Switzerland, Denmark, Germany and Austria shows that periodic swarms of cockchafer are the rule, and that in the intervening years losses due to cockchafer are small. Accordingly, all measures aim at the suppression of the chafer in its swarm years, and it is possible that that course will pay in Britain. If a swarm year has occurred in 1920 it is evident that another will occur in 1924, and the forester ought to prepare for it. This leads to the question of control measures.

Briefly, control measures may be divided into three groups: those which are directed against the adult cockchafer before egg-laying, those which aim at deterring or preventing egg-laying by treating the soil, and those which are directed against the grubs.

On the Continent and to a small extent in England, the collection of adult cockchafers by beating them off the trees in the early morning has been practised. According to Escherich, this measure has proved most effective in the Rhine Palatinate, and is extensively practised in Central Europe. In Britain the cockchafer does not occur in such enormous numbers as on the Continent, and this may account for the infrequent use of this method, although Miss Ormerod records the collection of 80 bushels of cockchafers on a single farm by beating them from the trees.

Of the measures designed to prevent egg-laying, two deserve mention In the Bienwald it was found that quick-lime and naphthalene spread over the nurseries prevented the beetles from egg-laying. Quick-lime, however, has the disadvantage that it rapidly slakes in wet weather and loses its deterrent value. Naphthalene has also the disadvantage that it may affect seedlings. There are, however, several grades of naphthalene on the market, and experiments will determine whether the risk of injuring seedlings may not be reduced by using a more refined form of naphthalene.

Measures directed against the grubs of the cockchafer appear to be more in favour in this country than measures against the adult. They may be classified as follows:—

(*a*) Digging up of the grubs.

(*b*) Trapping of grubs by trenches or by sods or turves.

(*c*) Destruction of the grubs by the digging into the soil of noxious substances, such as gas-lime and naphthalene.

(*d*) Destruction of the grubs by fumigating with carbon bisulphide and other gases.

(*e*) Destruction of the grubs by means of entomogenous fungi.

The attention of workmen should be drawn to the opportunity which is frequently afforded of killing the grubs where ground is dug over in the nursery and elsewhere.

The use of gas-lime and naphthalene is governed by circumstances, as nursery stock may be injured by these substances. The hoeing of naphthalene into the soil between rows of plants such as raspberry canes and strawberries has been found effective in horticulture, and experiments in this direction offer hopes of success in the forest nursery.

Volatile substances such as carbon bisulphide are costly. Experiments on the use of carbon bisulphide and chlorpicrin against cockchafer are being conducted by the Ministry of Agriculture's Plant Pest Branch, and it is hoped the results of these may shortly be available.

The use of entomogenous fungi on a large scale against cockchafer grubs was first advocated by Professor Giard in 1893, when he and Le Moult discovered that the fungus *Isaria densa* Fr. (*Botrytis tenella* Sacc.) was an important enemy of both the adult chafer and its grubs. After a series of laboratory experiments by Giard, Le Moult, who was then directing cockchafer control in various French cantons, carried out a number of field experiments, which Giard has described. These were unusually successful, but another series conducted by the eminent Swiss agriculturist Dufour were disappointing. Decoppet, Escherich and Zweigelt consistently state that the use of fungi is unlikely to prove of practical value in controlling cockchafer. They admit the excellent results obtained by this means in the laboratory, but state that no such results can in our present state of knowledge be obtained in the field. This, indeed, appears to be the general opinion of both mycologists and entomologists, but the whole question has been raised again by the appearance, in a French journal, recently of an article on "the cockchafer and its parasite," by Le Moult, in which he avers that as recently as March and April of last year he obtained from one of his experimental plots established in 1893 fifty or sixty mummified grubs killed by the fungus, and that the cockchafer had definitely been controlled by that fungus and at times almost completely exterminated.

This sudden reappearance on the scene of Le Moult has raised a host of questions regarding his experiments, but until his recent claims are either endorsed or refuted they must be received with caution.

To sum up the present position of the cockchafer problem, it may be said :—

1. That information regarding the occurrence of swarm years in Britain is much to be desired, and could probably be obtained through forest officers in charge of nurseries.
2. That experimental work on the value of naphthalene as a deterrent against egg-laying and as noxious to the grubs, when hoed or dug in, is worthy of consideration.

3. That the possibility of using fungus infections to destroy grubs in the soil requires further investigation.

With regard to the first point, it would help the Commissioners in their enquiry if sample lots of cockchafer grubs, together with any data regarding their possible age and first appearance, could be sent to the entomologist at Kew. Specimens of adult beetles from the North of Scotland would also be of interest. Two species of cockchafer occur in Britain, *M. vulgaris* and *M. hippocastani*. The first is southern, the second northern in its distribution. *M. vulgaris* takes four to five years to develop, *M. hippocastani* probably five or even six, and any information which would help to determine the occurrence and distribution of the two species would be welcomed.

J. W. M.

The Silver Fir Chermes.

The Silver Fir Chermes, *Chermes (Dreyfusia) nüsslini* Bomer, is one of the most serious enemies of the silver fir in this country, and it is no exaggeration to say that its prevalence has been responsible to a very great extent for the failure of the common silver fir (*Abies pectinata*), as well as other species of the genus *Abies* in Britain. In view of this fact, an investigation is now being carried out at Kew under the combined auspices of the Department of Scientific and Industrial Research and the Forestry Commission, into various aspects of the Chermes problem, and it is hoped to make a complete study of the silver fir species.

In order to facilitate the work of enquiry and render the final results more complete, it is very desirable that we should receive information from as many sources as possible, and with this object in view the officers of the Commission and others who may be interested in this question are requested to supply, if possible, information and material as follows :—

(1) Where silver fir plantations may be found in Great Britain, including information regarding such points as species, age, locality and silvicultural conditions.

(2) Information relating to the immunity of any species of *Abies* from Chermes, and to the recovery of any species from attack.

(3) Specimens of infested branches, together with data regarding age of tree, soil conditions (if possible) and extent of infestation.

(4) Information regarding origin of plants in infested plantations.

Communications may be addressed to Mr. R. N. Chrystal, Forestry Museum, Royal Gardens, Kew, Surrey. Any information which can be given along the lines suggested above will be most gratefully received and acknowledged.

R. N. C.

Note on Pan Formation.

In the last two years a number of articles have appeared in the German forestry journals dealing with the subject of pan formation. The views expressed may be briefly summarised as follows ;—

1. Pan formation is mainly confined to coarse grained sandy soils poor in mineral foodstuffs. The immediate cause is the action of soluble humic acids (colloids) upon the mineral constituents of the soil dissolving these only to be reprecipitated in a lower stratum of the soil.
2. Apart from the mineral poverty of the soil, relatively high rainfall is the principal predisposing cause. High rainfall acts directly and indirectly. Directly by washing the humic compounds out of the surface layer of the soil, and indirectly by encouraging the growth of heather, which appears to produce the most potent type of humic acid of any form of vegetation.
3. The harmful effect of pan formation upon tree growth is liable to be exaggerated. In the East of Prussia, where the rainfall is only 20 ins., some of the pan-bearing soils bear much better crops than adjoining areas where the pan is absent. Swedish foresters also report similar cases. Here the limiting factor is moisture, and the presence of the pan keeps the atmospheric moisture from sinking beyond reach of the tree roots.

In North-West Germany, *e.g.*, the Luneburger Heide, a typical heather tract, pan is of very irregular occurrence, and large areas are completely free from it. Further to the north-west, in Schleswig-Holstein and Denmark, and to the south in the Black Forest, pans are present over large areas and are often very massive.

It is in these areas of high rainfall and relatively low summer temperatures that pan formation is most serious. Where the layer is near the surface and too thick for the roots to penetrate, the pines are unable to anchor themselves by means of their taproot and develop a shallow rooting system which offers little resistance to wind.

More important, however, than the effect on the root system (pines have a way of forcing their roots through very thick hard pans) is the effect upon the soil. Pan is usually confined to flat or gently sloping land, and its presence offers a great obstacle of drainage into the subsoil, with the consequence that the soil becomes waterlogged, the heather association gives way to bog plants such as *Erica tetralix* and *sphagnum*, and unless the land can be drained there is only a miserable future ahead of tree growth. Forstmeister Fencht, in an article on Scots pine in Northern Schwarzwald, quotes instances of excellent growth of both Scots pine and Silver fir on well-marked pan, but in both cases there was no raw humus layer on the surface of the soil; it is where there is a combination of raw humus on the surface and pan below that the poorest growth is found. He concludes that the great thing is to prevent the accumulation of raw humus.

There appear to be two main ways of dealing with pan formation which are supplementary. In the first place, the land must be drained and the pan broken through. When the pan is brought to the surface it quickly breaks up, and then contains a valuable store of available food material. If cost permits, the pan fragments should be placed round the base of the adjoining plants on the top of the soil after these have been planted. Secondly, beech should be introduced among the pine. If pure pine is planted, the needles will form fresh raw humus and the pan formation will be continued perhaps in an aggravated form. The introduction of beech helps to decompose the pine needles and to keep the soil active and in good condition.

Subsidiary measures recommended are (*a*) to dig the plant holes deep enough to break through the pan, and (*b*) to mix the soil taken from the plant holes with quicklime or chalk.

One writer recommends that the pine should be allowed to grow to a height of 6 ft., and then a small number (about 200 plants per acre) of beech should be uniformly distributed over the area, the pits dug for the beech to be well manured with lime, phosphates, potash and possibly even nitrogen. According to this method, the Scots pine would not receive any manurial treatment.

W. H. G.

Note on Larch—Beech Sample Plots in Switzerland.

Professor Engler, of Zurich, recently supplied particulars of three interesting sample plots at 1,800 ft. above sea-level near Zurich, which were measured for the first time in January, 1920. The figures have been converted into English units of measurement (quarter-girth). The following are brief particulars of the sample plots :—

Plot 1. Pure beech. Age, 92 years. From natural regeneration.

Plot 2. Mixed European larch and beech. Age of beech, 92 years. From natural regeneration. Age of larch, 88 years. Planted.

Plot 3. Larch underplanted with beech. Age of larch, 89 years. Age of beech, 50 years.

		Plot No. 1.	Plot No. 2.	Plot No. 3.
Height (ft.)	Larch	—	113	117
	Beech	104	103	73
No. of Stems per Acre	Larch	—	64	106
	Beech	166	115	247
			179	353
Mean Q.G. (ins.)	Larch	—	13	13½
	Beech	9½	9½	4¾
Basal Area (sq. ft.) ...	Larch	—	75	137
	Beech	105	73	39
			148	176
Form Factor	Larch	—	0·443	0·419
	Beech	0·529	0·525	0·489
Timber Vol. per Acre (cu. ft.)...	Larch	—	3,770	6,770
	Beech	5,965	3,845	1,395
			7,615	8,165

The principal points of interest are as follow :—

(1) The great height of both species, showing the soil to be of very good quality.

(2) The remarkable uniformity in the size of the beech in Plots 1 and 2, which enables a reliable comparison to be made between the two plots.

(3) The great increase in the volume production due to the presence of the larch in Plot 2.

(4) The heavy stock of larch carried in Plot 3 and the large size of the trees.

(5) The fact that under what must be a fairly dense larch canopy in Plot 3, the beech have a mean height of as much as 73 ft. and have contributed 1,400 cubic feet to the total volume.

(6) The high form factors of both the beech and the larch.

W. H. G.

Results of Direct Sowing in the Forest.

The experiments described below were for the most part improvised last year, when it became apparent that there would be a large surplus of seed from Canada and the Continent. The measure of success is sufficient to encourage us to go on with sowing, especially on light soils. It is clear, however, that the technique of the work is capable of great improvement, and local officers are urged not only to keep under close observation the experiments already made but also to supplement them with additional small scale experiments in directions which they consider promising. Seed will be made available for the purpose.

The transition from successful experiments to large scale sowing in a given district ought to be gradual, and owing to difficulties with seed years can rarely be complete. Experience at Rendlesham, where sowing has been carried out since 1919-20, indicates that in the case of pines three seasons must elapse before real confidence can be felt. In the first season the seedlings are small, not very robust in appearance and subject to many casualties. In the second season they grow very little in height, but bush out and present a firmer resistance to enemies, while in the third year they put forth a vigorous leader 6 ins. to 12 ins. long, and present generally a far healthier appearance than young transplants planted in the forest in the year of sowing.

It is only natural to assume that seed sown *in situ* will produce healthier trees than nursery stock, and for that reason it is preferable to sow rather than to plant. The questions which we have to answer first are can we make a success of sowing a given species on a given type of ground, and can we achieve that success at a price which, everything considered, gives better economic results than planting ?

R. L. R.

Direct sowing experiments were carried out in 1921-22 with Douglas fir, Norway spruce, Scots, Corsican, Calabrian and Maritime pines and oak. In all, 878 acres were sown in England and Wales and Scotland; of these nearly 500 acres were sown in the London Division (No. 5).

The seed was sown for the most part in May, 1922, though in certain areas the work did not commence until June. Most of the seed was red leaded before sowing. The results will be considered under the separate species.

Douglas Fir.—Area sown in England and Wales, 156 acres in 12 localities; in Scotland, 25 acres in four localities. The quantity of seed sown varied from $\frac{1}{4}$ lb. to 8 lbs. per acre; the seed was of very poor quality—about 30 per cent. germination—and the light sowings of less than 2 to 3 lb. per acre all failed.

The areas selected were mainly in the west of the two countries, the exceptions being one on the Culbin sand dunes in N.E. Scotland and at Bramshill in Berkshire. The majority of the sowing areas were on fairly steep northerly slopes. At Bodmin both north and south slopes were sown, and while the sowing on the north slope was fairly successful, the south aspect gave a complete failure. Of the remaining successful areas Fedw Hendry and Coed-y-Wern (Gwydyr Forest) had north aspects, while Achnashellach faced to the south. The Bramshill area was flat.

The soils were mostly loams with a covering of bracken, bramble and grass. At Coed-y-Wern the germination was best on the scree slopes, where there was scarcely any mineral soil. At Culbin the soil consisted of pure sand with a covering of moss and clumps of heather.

The soil preparation consisted in the majority of cases in removing the turf in patches 5 to 6 ft. apart, and loosening the soil with a mattock (a Dutch hoe was found a useful tool at Coed-y-Wern and Fedw Hendry). The seed was usually sown broadcast in the patches and covered by hand. The average cost was £1 7*s.* 6*d.* per acre, ranging from 10*s.* per acre at Culbin up to £2 10*s.* per acre at Llandover and Rheola.

The initial germination was relatively good at Coed-y-Wern, Fedw Hendry, Bramshill, the north slope at Bodmin and at Achnashellach and very poor in almost all the remaining areas; over 41 acres no seedlings at all appeared. Much damage was reported in some areas from mice. Most districts reported severe losses since germination due in some cases to sheep and rabbits, and in others to unexplained causes, slugs being suspected. The records as to the present condition of the sown areas are not always complete, but it would appear that out of the total area of 156 acres only 68 acres (in six localities) have as much as 70 per cent. of the patches occupied with seedlings the average number of seedlings per occupied patch ranging from one to three (six at Bramshill). In the remaining sowings the failure was either complete or at most only 5 per cent. of the patches contained seedlings.

It is clear from the above account that the greater part of the Douglas fir sowings have been a failure, though it is possible that some of the seed may germinate this year (1923). Late sowing and low quality of seed were probably mainly responsible for the poor results.

Norway spruce.—Area sown in England, 4 acres in three localities, in Scotland 21 acres in six localities. The seed was of very high quality; the quantity of seed sown varied from 1½ to 10 lb. per acre, averaging 4 lb. In England the three areas sown were confined to Somerset and Devon but in Scotland the localities selected were well distributed over the country.

The soils were mostly heavy, either loams or clays with a covering of either Molinia with other grasses, or heather. The soil preparation and method of sowing differed in the two countries. At Halwill the land was ploughed and the seed sown broadcast, at Haldon the land was sown in ploughed strips and at Quantock the seed was sown broadcast on old forest land and the seed raked in. In Scotland the seed was sown in patches 3 ft. to 6 ft. apart. At Monaughty (Asliesk) where the soil was waterlogged the land was drained and the seed sown on Mounds. The cost ranged from about £1 10*s.* at Haldon and Tweedenhead (4 acres) to £6 10*s.* at Monaughty (6 acres) averaging £3 13*s.* per acre. The high cost at Monaughty was due to very thorough cultivation of the patches which were made 18 in. to 24 in. square.

The initial germination was good except in three areas (4 acres) and the subsequent losses were small in all districts; at Tweedenhead these were ascribed to frost-lift. The only failure was reported from Haldon in Devon (2 acres) where the sowing was affected by drought, the remaining areas are well stocked, *e.g.*, at Halwill where there are estimated to be 121,000 plants per acre and at two Monaughty areas where there are only 2 per cent. of the patches without seedlings with an average stocking per patch of 40 to 50 plants. With the exception of Haldon the number of occupied patches is not less than 85 per cent. in any area. These experiments can be regarded as very successful.

Scots pine.—Area sown in England and Wales, 381 acres in 11 localities, in Scotland 1 acre in one locality; the quantity of seed sown ranged from ¼ lb. (in South Wales) to 2½ lb. per acre. The quality of the seed was apparently low in most cases. Of the whole area all except 32 acres were in Division 5.

The sites selected were mostly flat sandy areas carrying a vegetation of either ling or grass (Molinia preponderating). Twenty-two acres sown at Llanover in South Wales were an exception in this respect, here the sowing was on a steep north-west slope at 800 ft. elevation and the soil was a deep loam bearing a crop of dense bracken. At Rendlesham the greater part of the area had been burnt over so that the land was bare of surface growth. The soil preparation consisted in removing the surface turf in patches 4 ft. to 5ft. apart, slightly stirring the soil below and sprinkling the seed over the bare patch; the seed was then firmed in with the foot, usually without further covering. At Rendlesham a nick was made with a spade and the seed placed in the nick; this resulted in many cases in too deep covering of the seed, the seedlings dying off shortly after they had pushed through the soil.

The average cost was 12*s*. per acre (ranging from 6*s*. to 40*s*.). The initial germination was very poor in half the areas sown, due mainly to thin sowing with old seed or seed of low quality, and also to attacks by birds and mice. The remaining six localities showed a high initial germination (50 to 80 per cent.), but losses were heavy in most districts. The most successful areas were 30 acres at Elvedon and 50 acres at Wokingham where the losses after germination were only 10 per cent., in the remainder the losses were from 60 to over 80 per cent. Late sowing followed by drought was considered responsible in most cases, but much damage was also done by birds (partridges, pheasants, pigeons, larks and finches). As already stated much of the loss at Rendlesham was attributed to too deep sowing. At Bramshill the initial germination was 70 per cent., but the seedlings were almost entirely wiped out by a fungus which was described as attacking the roots. The average number of seedlings in the occupied patches over all the sowings is from two to four.

The reports show that in 143 acres in four districts the germination was a complete failure, there were 137 acres in five districts with from 30 to 40 per cent. of occupied patches, 52 acres in two districts with 60 per cent. of occupied patches and only 50 acres where the percentage of occupied patches was as high as 80, the last named area being at Elvedon. The results, taken as a whole cannot be regarded as satisfactory.

As regards future experiments, earlier sowings are recommended, and also treatment of the seed with Corvusine before sowing instead of with red lead, the latter having proved of little value against birds or mice.

Corsican pine.—Area sown in England and Wales 90 acres in four localities, in Scotland 11 acres in two localities. With one exception seed of high germinative capacity was used, the quantity sown was 1 to 2 lb. per acre. The Scottish areas were at Tentsmuir and Culbin, the English sowings were confined to Division 5. Sandy soils were selected for the experiment and the seed was sown in patches as described under Scots pine at an average cost of 11*s*. 8*d*. per acre (7*s*. 10*d*. to 22*s*.)

The initial germination was good (except at Tentsmuir where old seed was used), but the losses were fairly heavy (20 to 55 per cent.) owing to late sowing followed by drought and also to some extent to attacks by birds and mice. In four areas totalling 60 acres the percentage of occupied patches is from 60 to 80 per cent., at Elvedon there are 40 acres with 90 per cent. of occupied patches. In all these areas the patches are well stocked with seedlings. The only failure was that of one acre at Tentsmuir referred to above. The Corsican pine sowings can thus be regarded as very fairly successful.

Calabrian pine.—A small area ($1\frac{1}{4}$ acres) was sown at Allerston in Yorkshire on moorland soil. The seed was sown in patches in last year's plough furrows and gave a fair germination, but damping off killed many seedlings and the remainder were pulled up by grouse.

Maritime pine.— Forty-five acres were sown in England in five localities confined to the London Division. The seed was of excellent quality, from 1 to 3½ lb. were sown per acre in patches 4 to 5 ft. apart at an average cost of 14*s*. 6*d*. per acre (7*s*. 10*d*. to 22*s*.). The soil was sandy and the vegetation similar to that described under Scots pine.

The initial germination was very good and subsequent losses were almost negligible except for 7 acres at Woolmer where a loss of 60 per cent. was reported ; the cause of loss was not given. In the remaining areas the number of occupied patches is from 80 to 95 per cent., and the number of seedlings per patch from 5 to 10. At Tangham some of the plants are as much as 6 in. in height, but the general average is about 3 in. These results show that Maritime pine plantations can be readily and cheaply established by direct sowing.

Oak.—Direct sowings of oak were made over 30 acres at Brackley and 116 acres at Apethorpe in Northants. The soil was clay, soil covering not recorded. At Brackley a notch was cut in the soil about an inch deep and five or six acorns which had been red-leaded were inserted. The cost was 7*s*. per acre. Owing to late sowing and drought scarcely any of the seed germinated ; it is possible that it may come this year.

At Apethorpe part of the seed was sown in plough furrows at a cost of 10*s*. per acre and part in pits 18 in. square, worked to a depth of 12 in., at a cost of £1 10*s*. per acre. Seventy per cent. of the seed germinated, but losses amounting to 40 per cent. subsequent to germination were caused by game.

It is estimated that only half of the total number of patches is occupied by seedlings. The average number of the plants per occupied patch is three and the size from 2 in. to 6 in.

It is perhaps too early to pronounce definitely upon these areas, but it is clear that where the stock of game is high the chances of success are not great.

Summary of results.—In spite of the very late season of sowing successful results have been achieved on a considerable scale with three species :—Norway spruce, Corsican pine and Maritime pine. The Scots pine and oak sowings have failed to a great extent owing to losses subsequent to germination, while in the case of Douglas fir the failure was probably due mainly to the use of too small quantities of seed of low germination and to late sowing.

W. H. G.

Register of Identification Numbers.

The order of arrangement is as follows :—

Serial number (preceded by the last two numbers of the forest year in which supplies were received) ; quantity ; species ; crop year ; origin ; vendor.

FOREST YEAR, 1921.

21/1 756 lbs. ; *Pseudotsuga Douglasii* ; 1920 ; U.S.A. (Reputed Washington) ; C. H. Manning Sons.

21/2 73 lbs. ; *Larix europaea* ; 1920 ; Italy (Cavalese) ; J. Stainer.

21/3 366 lbs. ; *Picea excelsa* ; 1920 ; Germany (Eberswalde) ; Faupel Bros.

21/4 167 lbs.; *Pinus sylvestris;* 1920; Scotland; Howden & Co.

21/5 35 lbs.; *Pinus sylvestris;* 1920; England (Tangham); own collection, extracted Bentley.

21/6 20 lbs.; *Pinus sylvestris;* 1920; England (W. Bilney); own collection, extracted Bentley.

21/7 50 lbs.; *Pinus sylvestris;* 1920; England (New Forest); own collection, extracted Bentley.

21/8 12 lbs.; *Pinus sylvestris;* 1920; England (Swaffham); own collection, extracted Bentley.

21/9 7 lbs.; *Pinus sylvestris;* 1920; England (Weyborne); own collection, extracted Bentley.

21/10 33 lbs.; *Pinus sylvestris;* 1920; England (Wimborne); own collection, extracted Bentley.

21/11 2 lbs.; *Pinus sylvestris;* 1920; England (Wokingham); own collection, extracted Bentley.

21/12 6 lbs.; *Pinus sylvestris;* 1920; England (Woolmer); own collection, extracted Bentley.

21/13 5 lbs.; *Pinus sylvestris;* 1920; England (Maiden Bradley); own collection, extracted Bentley.

21/14 5 lbs.; *Pinus sylvestris;* 1920; England (Alice Holt); own collection, extracted Bentley.

21/15 4 lbs.; *Pinus sylvestris;* 1920; Wales (Dolavon); own collection, extracted Bentley.

21/16 4 lbs.; *Pinus sylvestris;* 1920; England (W. Runton); own collection, extracted Bentley.

21/17 157 lbs.; *Pseudotsuga Douglasii;* 1920; (Reputed U.S.A.); E. de Hurst.

21/18 71 lbs.; *Pinus laricio* var. *Calabrica;* 1920; Italy (Calabria); Italian Government.

21/19 90 lbs.; *Pinus laricio;* 1920; Cyprus; Cyprus Government.

21/20 21 lbs.; *Pinus sylvestris;* 1919; Scotland; own collection, extracted Kingswood.

21/21 10¾ lbs.; *Pinus sylvestris;* 1920; Scotland (Erchless and Fairburn); own collection, extracted Howden & Co.

21/22 7½ lbs.; *Pinus sylvestris;* 1920; Scotland (Beaufort); own collection, extracted Howden & Co.

21/23 8¾ lbs.; *Pinus sylvestris;* 1920; Scotland (Culburnie); own collection, extracted Howden & Co.

21/24 7½ lbs.; *Pinus sylvestris;* 1920; Scotland (Bonar Bridge); own collection, extracted Howden & Co.

21/25 12 lbs.; *Pinus sylvestris;* 1920; Scotland (Strathconon); own collection, extracted Howden & Co.

21/26 2 lbs.; *Pinus sylvestris;* 1920; Scotland (Glamis); own collection, extracted Smith and Meldrum.

21/27 8½ lbs.; *Pinus sylvestris;* 1919; Scotland (Beauly); own collection, extracted B. Reid & Co.

21/28 1½ lbs.; *Pinus sylvestris;* 1919; Scotland (Deeside); own collection, extracted B. Reid & Co.

21/29 17 lbs.; *Pinus sylvestris;* 1920; Scotland (Morayshire); own collection, extracted B. Reid & Co.

21/30 6 lbs.; *Pinus sylvestris;* 1920; Scotland (Kincardine); own collection, extracted B. Reid & Co.

21/31 32 lbs.; *Pinus sylvestris;* 1920; Scotland (Speyside); own collection, extracted B. Reid & Co.

21/32 30 lbs.; *Pinus sylvestris;* 1920; Scotland (Altyre); own collection, extracted B. Reid & Co.

21/33 3 lbs.; *Pinus sylvestris;* 1920; Scotland (Cluny); own collection, extracted B. Reid & Co.

21/34 4 lbs.; *Pinus sylvestris;* 1920; Scotland (Logie Coldstone); own collection, extracted B. Reid & Co.

21/35 13 lbs.; *Pinus sylvestris;* 1920; Scotland (Deeside); own collection, extracted B. Reid & Co.

21/36 31 lbs; *Pinus sylvestris;* 1920; Scotland (Jedburgh); own collection, extracted Smith and Meldrum.

21/37 9 lbs.; *Pinus sylvestris;* 1920; Scotland (New Luce); own collection, extracted Smith and Meldrum.

21/38 100 lbs.; *Pinus sylvestris;* 1920; Scotland (Morayshire); E. Wiseman.

21/39 18 lbs.; *Pinus sylvestris;* 1920; Scotland (Innes Estate); C. M. Black.

21/40 10 lbs.; *Pinus laricio;* 1920; Mediterranean Isle; B. Reid & Co. (ex J. Stainer).

21/41 2 lbs.; *Pinus laricio;* 1919; Corsica; B. Reid & Co. (ex Rafn).

21/42 4½ lbs.; *Pinus montana* var. *uncinata;* 1920; Scotland (Glentress); own collection, extracted Smith and Meldrum.

21/43 5 lbs.; *Larix europaea;* 1918; Scotland (Loch Broom); own collection, extracted Kingswood.

21/44 185½ lbs.; *Larix europaea;* 1920; Scotland (N.E. Division); own collection, extracted Smith and Meldrum.

21/45 7½ lbs.; *Pseudotsuga Douglasii;* 1920; Scotland (Beaufort); own collection, extracted Howden & Co.

21/46 26 lbs.; *Pseudotsuga Douglasii;* 1920; Scotland (N.E. Division); own collection, extracted Smith and Meldrum.

21/47 6 lbs.; *Pseudotsuga Douglasii;* 1920; Scotland (Kinnordy); own collection, extracted B. Reid & Co.

21/48 4½ lbs.; *Picea excelsa;* 1920; Scotland (Atholl); own collection, extracted Smith and Meldrum.

21/49 1 lb.; *Picea omorica;* 1920; Serbia; Gift, Landowners Co-operative Forestry Society.

21/50 358 lbs.; *Fagus sylvatica;* 1920; Scotland (Beaufort); own collection, cleaned Howden & Co.

21/51 10 lbs.; *Fagus sylvatica;* 1920; Scotland (Invergarry); own collection, cleaned Howden & Co.

21/52 1,298 lbs.; *Fagus sylvatica;* 1920; Scotland (N.E. Division); own collection; cleaned Craibstone, 1921.

21/53 2 lbs.; *Acer pseudoplatanus;* 1920; Scotland (Craibstone); own collection.

21/54 6 lbs. ; *Ulmus montana ;* 1920 ; Scotland (Tulliallan) ; own collection.

21/55 1 lb. ; *Betula verucosa ;* 1920 ; Scotland (Glen Righ) ; own collection.

21/56 ½ lb. ; *Alnus incana ;* 1920 ; Scotland (Borgie) ; own collection.

FOREST YEAR, 1922.

22/1 112 lbs. ; *Pinus maritima ;* 1921 ; France (Landes) ; Vilmorin-Andrieux.

22/2 100 lbs. ; *Larix europaea ;* 1921 ; Italy (Tyrol : reputed Pusterthal) ; A. Grunwald.

22/3 762 lbs. ; *Larix europaea ;* 1920 ; Italy (Tyrol : Cavalese) ; J. Stainer.

22/4 111 lbs. ; *Larix europaea ;* 1921 ; Switzerland (Engadine : alt. 4,000–5,000 ft.) ; J. J. Roner.

22/5 1,981 lbs. ; *Larix europaea;* 1921 ; Italy (Tyrol : reputed Pusterthal) ; A. Grunwald.

22/6 102 lbs. ; *Picea excelsa ;* 1921 ; origin unknown ; A. Grunwald.

22/7 5 lbs. ; *Pinus sylvestris ;* 1921 ; France (Hagenau, Alsace) ; A. Gambs.

22/8 22 lbs. ; *Larix europaea ;* 1921 ; Silesia (Liebenthal) ; A. Gebauer.

22/9 46 lbs. ; *Larix europaea ;* 1921 ; Italy (Tyrol, Vintschgau) ; Wallpach-Schwanenfeld.

22/10 10 lbs. ; *Pinus cembra ;* 1921 ; origin unknown ; Wallpach-Schwanenfeld.

22/11 212 lbs. ; *Pinus laricio ;* 1921 ; Corsica ; J. Pantalacci.

22/12 1,126 lbs. ; *Pinus laricio ;* 1921 ; Corsica ; J. Grimaldi.

22/13 54 lbs. ; *Alnus incana ;* 1921 ; Germany ; C. Appel.

22/14 663 lbs. ; *Picea excelsa ;* 1921 ; Germany ; C. Appel.

22/15 2 lbs. ; *Picea alba ;* 1921 ; U.S.A. (Maine) ; T. J. Lane.

22/16 10 lbs. ; *Pinus ponderosa ;* 1921 ; U.S.A. (Pacific Coast) ; T. J. Lane.

22/17 10 lbs. ; *Thuya gigantea ;* 1921 ; U.S.A. (Washington) ; T. J. Lane.

22/18 10 lbs. ; *Sequoia sempervirens ;* 1921 ; U.S.A. (Pacific Coast) ; T. J. Lane.

22/19 4,000 lbs. ; *Pseudotsuga Douglasii ;* 1921 ; Canada (Lower Fraser Valley, British Columbia, considerably West of Hope) ; Canadian Government.

22/20 3,000 lbs. ; *Picea sitchensis ;* 1921 ; Canada (Queen Charlotte Islands, British Columbia) ; Canadian Government.

22/21 47 lbs. ; *Larix europaea ;* 1921 ; Italy (Tyrol, Pusterthal) ; Wallpach-Schwanenfeld.

22/22 300 lbs. ; *Picea excelsa ;* 1921 ; Germany (Black Forest) ; J. Rafn.

22/23 750 lbs. ; *Larix europaea ;* 1921 ; Switzerland (Alps, alt. 2,000 ft.) J. Rafn.

22/24 10 lbs. ; *Pinus montana* var. *pumilio* ; 1921 ; Origin unknown ; Wallpach-Schwanenfeld.

22/25 100 lbs. ; *Tsuga heterophylla* ; 1921 ; Canada ; Canadian Government.

22/26 3 ozs. ; *Larix europaea* ; 1921 ; Poland (Chelm Mountains) ; Polish Government.

22/27 110 lbs. ; *Pinus laricio* ; 1921 ; Corsica ; P. Spinosi.

22/28 220 lbs. ; *Pinus laricio* ; 1921 ; Corsica ; O. J. Rossi.

22/29 966 lbs. ; *Pinus laricio* ; 1921 ; Corsica ; J. M. Dumas.

22/30 96 lbs. ; *Larix europaea* ; 1921 ; Reputed Silesia ; A. Grunwald.

22/31 476 lbs. ; *Pseudotsuga Douglasii* ; 1921 ; U.S.A., American Forestry Association.

22/32 80 lbs. ; *Pinus insignis* ; 1921 ; New Zealand ; Cooper.

22/33 164 lbs. ; *Pinus sylvestris* ; 1921 ; England (Aldershot military area) ; own collection, extracted Bentley.

22/34 61 lbs. ; *Pinus sylvestris* ; 1921 ; England (Elvedon estate) ; own collection, extracted Bentley.

22/35 146 lbs. ; *Pinus sylvestris* ; 1921 ; England (Pyestock Wood and military areas, Fleet) ; own collection, extracted Bentley.

22/36 144 lbs. ; *Pinus sylvestris* ; 1921 ; England (Culford Estate, Bury St. Edmunds) ; own collection, extracted Bentley.

22/37 59 lbs. ; *Pinus sylvestris* ; 1921 ; England (felled and scattered trees, Crowthorne) ; own collection, extracted Bentley.

22/38 138 lbs. ; *Pinus sylvestris* ; 1921 ; England (Frensham plantations on heath) ; own collection, extracted Bentley.

22/39 55 lbs. ; *Pinus sylvestris* ; 1921 ; England (Sir Percy Wyndham's plantations, Rogate) ; own collection, extracted Bentley.

22/40 351 lbs. ; *Pinus sylvestris* ; 1921 ; England (Lynford Estate, Mundford) ; own collection, extracted Bentley.

22/41 101 lbs. ; *Pinus sylvestris* ; 1921 ; England (Brookwood cemetery and military areas) ; own collection, extracted Bentley.

22/42 160 lbs. ; *Pinus sylvestris* ; 1921 ; England (Cockley Cley Estate, Swaffham) ; own collection, extracted Bentley.

22/43 29 lbs. ; *Pinus sylvestris* ; 1921 ; England (felled trees on Commission's area, Crowthorne) ; own collection, extracted Bentley.

22/44 54 lbs. ; *Pinus sylvestris* ; 1921 ; England (young Scots pine areas, Alice Holt) ; own collection, extracted Bentley.

22/45 50 lbs. ; *Pinus sylvestris* ; 1921 ; England (military areas, Greatham) ; own collection, extracted Bentley.

22/46 137 lbs. ; *Pinus sylvestris* ; 1921 ; England (Woolmer Forest) ; own collection, extracted Bentley.

22/47 81 lbs. ; *Pinus sylvestris* ; 1921 ; England (Bramshott, Ludshott Commons and Mr. Whittaker's estate) ; own collection, extracted Bentley.

22/48 18 lbs. ; *Pinus sylvestris* ; 1921 ; England (Brandon Park estate, Brandon) ; own collection, extracted Bentley.

22/49 15 lbs.; *Pinus sylvestris*; 1921; England (West Runton district); own collection, extracted Bentley.

22/50 10 lbs.; *Pinus sylvestris;* 1921; England (Whitehall, Headley and White estates, Bordon military areas); own collection, extracted Bentley.

22/51 8 lbs.; *Pinus sylvestris;* 1921; England (Commission's area, Hindhead); own collection, extracted Bentley.

22/52 4 lbs.; *Pinus sylvestris;* 1921; England (Royal Pavilion plantations, Aldershot); own collection, extracted Bentley.

22/53 3 lbs.; *Pinus laricio* var *Austriaca;* 1921; England (Royal Pavilion plantations, Aldershot); own collection, extracted Bentley.

22/54 3 lbs.; *Pinus laricio;* 1921; England (Royal Pavilion plantations, Aldershot); own collection, extracted Bentley.

22/55 3 lbs.; *Pinus sylvestris;* 1921; England (Glynley estate, Pevensey); own collection, extracted Bentley.

22/56 9 lbs.; *Cupressus macrocarpa;* 1921; England (Glynley estate, Pevensey); own collection, extracted Bentley.

22/57 6 lbs.; *Pinus sylvestris;* 1921; England (military area, Camberley); own collection, extracted Bentley.

22/58 1 lb.; *Pinus maritima;* 1921; England (military area, Camberley); own collection, extracted Bentley.

22/59 8 lbs.; *Pinus maritima;* 1921; England (Fleet plantations); own collection, extracted Bentley.

22/60 10 lbs.; *Pinus pinea;* 1921; England (Lord Selborne's estate, Greatham); own collection, extracted Bentley.

22/61 1 lb.; *Pinus laricio;* 1921; England (Lord Selborne's estate, Greatham); own collection, extracted Bentley.

22/62 3 lbs.; *Pinus laricio;* 1921; England (Dunster); own collection, extracted Bentley.

22/63 2 lbs.; *Pinus sylvestris;* 1921; England (Station plantations, Privett, Basing Park); own collection, extracted Bentley.

22/64 3 lbs.; *Pinus sylvestris;* 1921; England (Mrs. Gooch's plantations, Godalming); own collection, extracted Bentley.

22/65 2 lbs.; *Larix europaea;* 1921; England (Eggesford); own collection, extracted Bentley.

22/66 2 lbs.; *Pinus maritima;* 1921; England (Woolmer Forest); own collection, extracted Bentley.

22/67 1 lb.; *Pinus laricio;* 1921; England (felled areas, Crowthorne); own collection, extracted Bentley.

22/68 14 lbs.; *Pinus sylvestris;* 1921; England (military woods, Normandy, Guildford); own collection, extracted Bentley.

22/69 1 lb.; *Pinus sylvestris;* 1921; England (Ashdown Forest); own collection, extracted Bentley.

22/70 228 lbs.; *Pinus laricio;* 1921; Corsica; Grimaldi.

22/71 205 lbs.; *Pinus laricio;* 1921; Corsica; Dumas.

22/72 136 lbs.; *Pinus laricio;* 1921; Corsica; Dumas.

22/73 14 lbs.; *Pinus sylvestris;* 1920; Scotland (S.E. Division); own collection, extracted Tulliallan.

22/74 4½ lbs.; *Pinus sylvestris ;* 1921 ; Scotland (Firpark Wood, Carnwath) ; own collection, extracted Tulliallan.

22/75 55 lbs. ; *Pinus sylvestris ;* 1921 ; Scotland (Charterhall Wood Duns) ; own collection, extracted Tulliallan.

22/76 145 lbs. ; *Pinus sylvestris ;* 1921 ; Scotland (Altyre Wood, Forres) ; own collection, extracted Tulliallan.

22/77 63 lbs. ; *Pinus sylvestris ;* 1921 ; Scotland (Drynie Wood, Kessock) ; own collection, extracted Tulliallan.

22/78 51½ lbs. ; *Pinus sylvestris ;* 1921 ; Scotland (Boblainy Wood, Beauly) ; own collection, extracted Tulliallan.

22/79 14 lbs. ; *Pinus sylvestris ;* 1921 ; Scotland (Swinnie Bean, Jedburgh) ; own collection, extracted Tulliallan.

22/80 37 lbs. ; *Pinus sylvestris* ; 1921 ; Scotland (Tulliallan, Kincardine-on-Forth) ; own collection, extracted Tulliallan.

22/81 11 lbs. ; *Pinus sylvestris ;* 1921 ; Scotland (Mulbuie Wood, Muir of Ord) ; own collection, extracted Tulliallan.

22/82 1 lb. ; *Pinus sylvestris ;* 1921 ; Scotland (Loch Talla, Aberfeldy) ; own collection, extracted Seaton.

22/83 35 lbs. ; *Pinus sylvestris ;* 1921 ; Scotland (Donside) ; own collection, extracted Seaton.

22/84 180 lbs. ; *Pinus sylvestris ;* 1921 ; Scotland (Morayshire) ; own collection, extracted Seaton.

22/85 28 lbs. ; *Pinus sylvestris ;* 1921 ; Scotland (Innes) ; own collection, extracted Seaton.

22/86 28 lbs. ; *Pinus sylvestris* ; 1921 ; Scotland (Forfarshire) ; own collection, extracted Seaton.

22/87 2¼ lbs. ; *Larix europaea ;* 1921 ; Scotland (Monaughty) ; own collection, extracted Seaton.

22/88 20 lbs. ; *Larix europaea ;* 1920 ; Scotland (Deeside) ; own collection, extracted Forfar (Smith & Meldrum).

22/89 1 lb. ; *Larix europaea ;* 1921 ; Scotland (Mulbuie Wood, Muir of Ord) ; own collection, extracted Tulliallan.

22/90 3¼ lbs. ; *Pinus montana* var. *uncinata ;* 1921 ; Scotland (Dawyck, Stobo) ; own collection, extracted Tulliallan.

22/91 ¼ lb. ; *Pinus montana* var. *uncinata ;* 1921 ; Scotland (Eshiels, Peebles) ; own collection, extracted Tulliallan.

22/92 66 lbs. ; *Abies nobilis ;* 1921 ; Scotland (Benmore, Kilmun) ; own collection, extracted Tulliallan.

22/93 20 lbs. ; *Pinus laricio ;* 1920 ; Reputed Calabria ; Ben Reid & Co. (ex Stainer) gift.

22/94 1 lb. ; *Pinus ponderosa ;* 1921 ; U.S.A. ; Ben Reid & Co. (ex Katzenstein) exchange.

22/95 1 lb. ; *Pinus Jeffreyii ;* 1921 ; U.S.A. ; Ben Reid & Co. (ex Katzenstein) ; exchange.

22/96 1 lb. ; *Pinus insignis ;* 1921 ; France ; Ben Reid & Co. (ex Vilmorin) ; exchange.

22/97 2 lbs. ; *Pinus montana* var. *uncinata ;* 1921 ; France ; Ben Reid & Co. (ex Vilmorin) ; exchange.

22/98 1 lb. ; *Pinus sylvestris ;* 1921 ; Scotland (Ballochbuie) ; H.M. the King.

22/99 3 lbs.; *Hippophae rhamnoides;* 1921; origin unknown; Ben Reid & Co. (ex Vilmorin); exchange.

22/100 1 lb.; *Robinia pseudacacia;* 1921; origin unknown; Ben Reid & Co. (ex Vilmorin); exchange.

22/101 2,200 seedlings (2 yr.); *Hippophae rhamnoides;* 1919; France; Ben Reid & Co. (ex Vilmorin); exchange.

22/102 9,700 seedlings (2 yr.); *Acer pseudoplatanus;* date unknown; origin unknown; Ardgoil Estate.

22/103 4,000 seedlings (2 yr.); *Acer pseudoplatanus;* date unknown; origin unknown; Ardgoil Estate.

22/104 3,000 seedlings (2 yr.); *Acer pseudoplatanus;* date unknown; origin unknown; Garscube Estate.

22/105 7,000 transplants (2 + 2); *Fagus sylvatica;* date unknown; origin unknown; Ben Reid & Co.

22/106 8,700 transplants (2 + 2); *Larix europaea;* date unknown; origin unknown; Breadalbane Estate (probably ex Rafn).

22/107 15,500 transplants (2 + 1); *Larix europaea;* date unknown; origin unknown; Breadalbane Estate (probably ex Rafn).

22/108 5,000 seedlings (2 yr.); *Larix europaea;* date unknown; origin unknown; Breadalbane Estate (probably ex Rafn).

22/109 600 plants (12"/24"); *Picea sitchensis;* date unknown; origin unknown; Breadalbane Estate (probably ex Rafn).

22/110 2,000 plants (6"/9"); *Picea sitchensis;* date unknown; origin unknown; Breadalbane Estate (probably ex Rafn).

22/111 Seedlings (2 yr.); *Pinus laricio;* date unknown; origin unknown; Smith & Meldrum.

22/112 152,500 seedlings (2 yr.); *Pinus laricio;* date unknown; origin unknown; W. Wiseman (ex Otto Bottisher).

22/113 4 plants (16"/24"); *Picea Breweriana;* date unknown; origin unknown; Haggerstone Estate.

22/114 220,000 transplants (2 + 1); *Pinus sylvestris;* date unknown; origin unknown; Aireton.

22/115 200,000 transplants (2 + 1); *Pseudotsuga Douglasii;* date unknown; origin unknown; Aireton.

22/116 100,000 transplants (2 + 1); *Pinus sylvestris;* date unknown; origin unknown; Little & Ballantyne.

22/117 66,000 seedlings (2 yr.); *Larix leptolepis;* date unknown; origin unknown; English Forestry Association.

22/118 22,600 transplants (2 + 1); *Pinus sylvestris;* date unknown; origin unknown; Slocock.

22/119 283 bushels; *Quercus pedunculata;* 1921; England (New Forest); own collection.

22/120 31½ bushels; *Quercus pedunculata* and *Quercus sessiliflora;* 1921; England (Dean Forest); own collection.

22/121 1 bushel; *Quercus pedunculata;* 1921; England (Selby); own collection.

22/122 4 bushels; *Quercus pedunculata;* 1921; England (Gwydyr); own collection.

22/123 7 bushels; *Quercus pedunculata;* 1921; England (Wigmore); own collection.

22/124 7 bushels ; *Castanea vesca ;* 1921 ; England (Haldon) ; own collection.

22/125 16 bushels ; *Quercus pedunculata* and *Quercus sessiliflora ;* 1921 ; England (Quantocks) ; own collection.

22/126 19 bushels ; *Castanea vesca ;* 1921 ; England (Dunster) ; own collection.

22/127 1 bushel ; *Castanea vesca ;* 1921 ; England (Eggesford) ; own collection.

22/128 128 bushels ; *Quercus pedunculata* and *Quercus sessiliflora ;* 1921 ; England (Rendlesham) ; own collection.

22/129 130 bushels ; *Quercus pedunculata* and *Quercus sessiliflora ;* 1921 ; England (Swaffham) ; own collection.

22/130 55 bushels ; *Quercus pedunculata* and *Quercus sessiliflora ;* 1921 ; England (Brackley) ; own collection.

22/131 7 bushels ; *Quercus pedunculata* and *Quercus sessiliflora ;* 1921 ; England (Apethorpe) ; own collection.

22/132 13½ bushels ; *Quercus pedunculata* and *Quercus sessiliflora ;* 1921 ; England (Frensham) ; own collection.

22/133 221 bushels ; *Quercus pedunculata* and *Quercus sessiliflora ;* 1921 ; England (Culford and Norwich) ; own collection.

22/134 46½ bushels ; *Castanea vesca ;* 1921 ; England (New Forest) ; own collection.

22/135 40 bushels ; *Castanea vesca ;* 1921 ; England (Bere) ; own collection.

22/136 70 bushels ; *Castanea vesca ;* 1921 ; England (Dean Forest) ; own collection.

22/137 6½ bushels ; *Castanea vesca ;* 1921 ; England (Delamere) ; own collection.

22/138 ½ bushel ; *Castanea vesca ;* 1921 ; England (Vaughan) ; own collection.

22/139 20 bushels ; *Castanea vesca ;* 1921 ; England (Quantocks) ; own collection.

22/140 5 bushels ; *Castanea vesca ;* 1921 ; England (Elvedon) ; own collection.

22/141 121 bushels ; *Castanea vesca ;* 1921 ; England (Frensham) ; own collection.

22/142 6 bushels ; *Fraxinus excelsior ;* 1921 ; England (Dean Forest) ; own collection.

22/143 3 bushels ; *Fraxinus excelsior ;* 1921 ; England (Thornthwaite) ; own collection.

22/144 23 bushels ; *Fraxinus excelsior ;* 1921 ; England (Allerston) ; own collection.

22/145 3 bushels ; *Fraxinus excelsior ;* 1921 ; England (Eggesford) ; own collection.

22/146 1½ bushels ; *Fraxinus excelsior ;* 1921 ; England (Apethorpe) ; own collection.

22/147 14 bushels ; *Acer pseudoplatanus ;* 1921 ; England (Thornthwaite) ; own collection.

22/148 ½ bushel ; *Acer pseudoplatanus ;* 1921 ; England (Eggesford) ; own collection.

22/149 2 bushels; *Acer pseudoplatanus;* 1921; England (Apethorpe); own collection.

22/150 2 bushels; *Acer pseudoplatanus;* 1921; England (Frensham); own collection.

22/151 2 bushels; *Acer pseudoplatanus;* 1921; England (Culford and Norwich); own collection.

22/152 ½ bushel; *Pyrus aucuparia;* 1921; England (Rothbury); own collection.

22/153 12 bushels; *Carpinus Betulus;* 1921; England (Apethorpe); own collection.

22/154 103½ bushels; *Fagus sylvatica;* 1921; England (Culford and Norwich); own collection.

22/155 200,000 seedlings (1 yr.); *Larix europaea;* 1921; origin unknown; W. Smith & Son (ex Stainer).

CURRENT LITERATURE.

Indian Forester, January, 1922.

A Dissertation Upon Forest Finance is an interesting article for officers with a mathematical mind. It attempts to prove that compound interest should not be allowed in working out the financial results of a normal forest. Calculations of the financial rotations in India have indicated the advisability of adopting short rotations. The object of the article is to disprove these conclusions.

The Conversion of Coppice and Coppice with Standards to High Forest is interesting and advocates a method very similar to the system now in force in the Tintern Woods (Ambert's system).

Indian Forester, April, 1922.

Officers who use Brandis' Hypsometer will find some supplementary tables for use with this instrument, certain errors in the original tables having been discovered.

Indian Forester, July, 1922.

La Méthode du Controlle for Selection Forests (F. W. Champion) explains the methods of managing selection forests in Switzerland by means of an intensive study of the periodic increment. The article is interesting, but the method is far too elaborate for present use in British woods.

Artificial Reproduction (Trowscoed), begun in the June issue, continued and concluded, deals with nursery work, direct sowings, planting and the tending of plantations in India. It contains remarks which are of interest in our afforestation work.

A Short Criticism of a Dissertation upon Forest Finance (S. A. Vahid) continues the discussion begun in previous numbers.

Indian Forester, September, 1922.

Storage of Conifer Seed.—Figures are given showing the results obtained by Mr. C. R. Tillotson, of the United States forest service, in storing conifer seeds of six species in various containers, over a period of 10 years. The original figures were published in the *American Journal of Agricultural Research* for November, 1921. Put shortly, it was proved that by far the best way of storing conifer seeds is to put them into air-tight bottles. (For large quantities, no doubt, air-tight tins would prove satisfactory.)

C. O. H.

Illustrated Canadian Forestry Magazine. July, August, September, 1922.

These numbers contain much that is of interest, especially the notes on the increasing use of aeroplanes for forest protection and reconnaissance and, even in British Columbia, as an aid to administration, but there is little information of any real and direct value to members of the Commission's staff; the following quotation from a speech of Abraham Lincoln which occurs in the September number would, perhaps, bear repetition:—" In this and like communities public sentiment is everything. With public sentiment nothing can fail, without it nothing can succeed. Consequently, he who moulds public sentiment goes deeper than he who enacts statutes or pronounces decisions."

O. J. S.

American Forestry. July, August, September, October, 1922.

The contents of these numbers are mainly of a popular character and are rather of interest than of great practical value. An interesting article in the August number deals with the evolution of the look-out station for fire protection in the United States, whilst a more instructive but elementary article treats of the parasitic enemies of trees and plants.

The September number contains, under the head " Forestry as a Business," a brief discussion of forest taxation—" Annual " versus " Yield "—and sets out arguments against the remission of taxes on State-owned forests.

Interesting points culled from the above publications are to the effect that last year one commercial enterprise having no primary interest in forestry (viz., a Pennsylvania coal mining concern), planted no less than 130,000 trees for pitwood; that the oldest Sequoia in the world is estimated to be 4,000 years old, and is 29·6 ft. in diameter; that there is a strong movement afoot in the U.S.A. for the standardisation and simplification of the terminology dealing with grades of lumber. (It is to be hoped, at least, for the benefit of our successors, that the latter movement will rapidly and effectively spread to this country).

O. J. S.

Australian Forestry Journal.

April.—In view of the present tendency in this country, it is interesting to note that the planting of *Pinus insignis* in Australia was originally at a spacing of 8 ft. by 8 ft. to avoid incurring the cost of unremunerative thinnings.

May.—Relative approximate value of wood transformed into various products :—

If the value of a certain quantity of wood be taken, in the forest, as unity, then—

As fuel it is worth	2 units.
As mechanical pulp	2½ ,,
As sulphite pulp	5 ,,
As paper	12 ,,
As wood pulp yarn	15 ,,
As artificial silk	50 ,,

July.—Includes comparative yield tables for Douglas fir in (*a*) Washington and Oregon, (*b*) Prussia, and (*c*) Denmark, with a short, comparative sylvicultural analysis in which the writer emphasises the need for thinning this species, and ascribes to lack of thinning the lower yield observed in natural forests, though from a brief scrutiny of the tables it would appear that at (*e.g.*) 30 years of age, there are more trees per acre in the thinned than in the " natural " stands.

O. J. S.

Forestry in Uganda.
Forestry in Kenya Colony.

Reports prepared by Professor R. S. Troup, at the request of the Colonial Office. These reports review the whole situation in these colonies and embody definite and extensive recommendations for the betterment thereof.

O. J. S.

Zeitschrift für angewandte Entomologie. Vol. VIII, Part 2.

This journal was founded in 1914 by Professor Karl Escherich of Munich as the organ of the German Association for Applied Entomology. The number under review is the first so far received by the Commissioners. In addition to original articles on malaria and on insects affecting agriculture and viticulture, it contains two articles of interest in forestry. The first, on the parasites and enemies of *Hylobius* by G. Wülker of Frankfürt, gives an interesting account of an eelworm parasite of the weevil and a brief review of the work of Fuchs, Escherich and Munro on its insect parasites. The author concludes that parasites offer little hope in the artificial control of the weevil, the Braconid parasites being the most likely to prove helpful. The paper is interesting in that it indicates that in Britain we know more of the life-history and practical value of the Braconid parasites of *Hylobius* than do the German workers, an encouraging thought.

The second article bearing on forestry deals with experiments in the control of cockchafer by exploding vessels containing chlorpicrin and other volatile or gaseous poisons in infested soil. The explosions were effective in that they blew up the various insect larvae occurring in the soil, but the spread of the resulting gases was faulty, and none of the larvae found after the explosion was injured. The failure of the experiments is attributed to the failure of the gases liberated to penetrate the surrounding soil and to the capacity of cockchafer larvae for resisting these noxious gases.

Forest Protection through Bird Protection.—Freiherr von Berlepsch (State-authorised Model Research Station for Bird Protection) sends the following notice to the Editor :—

" The caterpillar attacks in Hainichwalde, situated to the north of Eisenach, are very severe again this year. The beech over many extensive areas were completely defoliated by thousands of caterpillars of the Pale Tussock Moth (*Dasychira pudibunda*). In the previous year the plague ended after pushing southwards and westwards on the borders of Seebach forest, the research area of the State recognised bird-station of Freiherr von Berlepsch. Only the trees on the outer border of this area, which has for many years been preserved by careful and successful bird protection, showed signs of attack. Whether, as has been repeatedly confirmed and was, in fact, also observed last summer, the tits fed their broods on the destructive moths, or whether the interruption of the beech forests by the open country at Oppershause and by the coniferous woods round it, was the deciding factor is still an open question.

The outbreak has now extended south and west, through the Seebach forest and beyond, and has on every side caused many extensive defoliated patches in the Kammerforster range. Seebach forest, like its neighbours, has also been invaded by the moths. Here, however, only a limited number have been able to lay eggs, as they have—as already noted—been caught and destroyed by the numerous birds. In Seebach forest, accordingly, signs of attack are to be seen only on isolated tree-tops, and the whole bird-protection area stands out again, as in 1905* and 1914, as a green island amid the stretch of defoliated forest around. Usually the contrasting conditions approach to within 100 metres distance of one another. Interested observers cannot fail to be convinced by examination of the existing conditions."

J. W. M.

Zeitschrift für Forst und Jagdwesen, December, 1921.

Impressions of Bärenthoren.—Bärenthoren is one of the most interesting forests in Germany owing to the original sylvicultural methods practised there. In 30 years the owner of this private forest has improved both soil and growing stock out of all recognition, and, in consequence, Bärenthoren has become the Mecca of the German forester.

The forest consists of Scots pine growing on poor sandy soil in an area of low rainfall. The great improvements have been effected in three ways : (1) Abolition of clear felling. (2) Leaving all small material lying on the ground after cleaning or thinning—contrary

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* This was a *Tortrix viridana* outbreak *vide* Hiesemann in *Losung der Vogelschutzfrage.*

to all expectations, this did not increase the fire losses nor lead to insect outbreaks—the rotting of this material enriched the soil in humus and greatly increased its productive capacity. (3) Annual fellings over the whole forest, cultural in the young woods and regenerative in the older stands.

Before the treatment was started the soil was covered with lichen and heather, and the soil was wholly devoid of humus. Now the vegetation has entirely changed, a rich herb flora has come in, and natural regeneration is abundant all over the area.

When the trees have a sufficient length of clean stem (40 ft. to 50 ft. at 50 to 60 years at Bärenthoren) fairly heavy thinnings are made in the upper canopy, and eventually the best stems are more or less isolated. Regeneration sets in as soon as the crown thinnings begin, but is kept for a considerable time under the canopy of the old crop and only gradually freed. Beech is planted among the young pine with the object of obtaining a mixed forest. Where regeneration is complete, a number of the best trees are allowed to grow on for a second rotation.

Eventually—this stage has not yet been reached at Bärenthoren—the Scots pine and beech are to be regenerated together.

The author stresses the importance of the early cultural operations and of the gradual introduction of the regeneration, and maintains that unless these are carried out with the same care as at Bärenthoren, the later stages, *i.e.*, the retention of standards for a second rotation and the successful regeneration of the second crop cannot be achieved.

Beech and Oak in Relation to Rain and Lightning.—The author points out that any beech tree grown under forest conditions may be considered to resemble a water catchment area: thus the water is collected by the crown and flows down the side channels represented by the twigs and branches on to the bole which forms the channel for the main stream. The ascending habit of the beech, together with the density of its foliage, is responsible for this phenomenon. If the flow of water down the bole of a beech tree is watched during a heavy storm, it will be observed that the water, on reaching the ground, sinks immediately into it and no pool is formed; closer examination reveals the existence of spaces in the soil round the roots caused by the swaying of the tree in the wind. By means of these spaces the water readily reaches the finer absorbent roots. One consequence of this peculiarity of the beech is that the spaces between the trees in a closed beech wood are relatively dry, most of the rain water having passed down the tree boles to the roots in the manner described. The writer considers that this mainly explains the lack of vegetation under a beech wood, pointing out that wet hollows in beech woods where the shade is quite intense often carry a strong growth of vegetation similar to that occurring in oak woods. The behaviour of the oak in relation to rain is entirely different from that of the beech. Owing to the spreading form of the oak branches and the rough fissured bark which covers them, there is no tendency for the water to be collected and passed down to the main stem as in the beech, and rain falling is distributed to the soil more or less uniformly from the whole area of the crown. This difference between the two species explains certain phenomenon often met with when oak and beech are mixed together; in the early stages the oak frequently grows as fast or faster than the beech, but later on, when the crowns begin to spread out the oak, especially on dry soils, falls off in growth and may be dominated by the beech, the explanation being that the beech crowns rob the oak of much of the water falling as rain. The beneficial action of the beech, on the other hand, when used for underplanting oak, may be largely attributed to its property of conducting rain water to the lower levels of the soil in which the roots of the oak ramify.

The different properties of the two species in relation to rain has also a bearing on their respective behaviour during thunderstorms; an old proverb says that in a thunderstorm you should avoid the oak and seek the beech, and it is a fact that beech trees are rarely struck by lighning. It is probable, however, that electricity is often discharged down beech trees without damaging them, thanks to the stream of water flowing down the branches and main stem, which serves as an efficient lightning conductor. The oak, on the other hand, owing to its lack of any conducting stream of water during the rain which usually accompanies a thunderstorm is frequently struck with violent and disruptive effect. Incidentally, the writer pronounces a caution against relying too much on the proverb; a good lightning conductor such as the beech is not necessarily a safe place under which to shelter during a storm.

Note on Forestry and Unemployment in England.—Forstrat Müller gives a translation of an article on Forestry and Unemployment which appeared in *The Times* of November 3rd, 1921, and adds the following comment: "Tenacious and persevering though the English may be, this task (the creation of forests as a partial means of reducing unemployment) is beyond their strength and capacity. This cry of alarm in *The Times* will remain unheard like many a similar appeal. We, for our part, may congratulate ourselves that in one single respect we are ahead of our late enemy, and we are determined to maintain and increase the heritage left us by our fathers."

W. H. G.

Zeitschrift für Forst und Jagdwesen, February 1922.

Results of Experimental Planting of Scots Pine of different Origin in the Oberförsterei of Chorin.—Seed was obtained from the following twelve sources, and sown at Chorin in the years 1907 and 1908 :—

1. Inverness-shire, Scotland—Countess of Seafield's Estate.
2. Haute Loire, France.
3. Allenstein, East Prussia.
4. Campine, Belgium.
5. Rheinpfalz, Bavaria.
6. Kliewenhof, Kurland, Russia.
7. Chorin, Brandenburg, Prussia.
8. Ural, Russia.
9. Bulgaria.

10. Sweden.
11. North Hungary.
12. West Hungary.

Chorin is situated north of Berlin, in the Mark Brandenburg, the climate is continental in type, and fungus diseases, Lophodermium in particular, do much harm, especially in the southerly races.

The plantations formed from these twelve lots of seed are now 14 to 15 years old, and the differences in growth, etc., which were well marked during the first two years, have gone on increasing, and it is now possible to say definitely that a ten-year period is sufficient to determine whether a given race of Scots pine is or is not suited to the locality into which it has been introduced.

Dr. Kienitz goes into considerable detail in describing the behaviour of each of his races in respect of such factors as rate of growth, colour and length of needles, type of branching, fungus, and insect pests, etc.

To sum up very briefly the results. The East Prussian seed gave the best results in every respect in rate of growth, form and immunity from disease, seed from Brandenburg and Belgium coming next in order of merit; the southern races give the worst results. The Scottish plants were, with the exception of the French, the smallest of all in height (5ft., as compared with 10 ft. for the East Prussian plants at the end of 10 years planted), the branching also was coarse and inferior to the narrow crowned East Prussians, but it is interesting to find that they come next in order to the East Prussians and the Belgians in respect of immunity from disease and from late frost.

Kienitz puts forward a strong plea for further research on the same lines, and draws the following main conclusions from his results :—

(1) In a Scots pine area native seed should be used for regeneration.

(2) Any Scots pine wood contains trees of very different forms, some good from the point of view of the forester and some very bad. As these forms are to a large extent transmissible to the offspring, the forester should remove all badly shaped trees during the thinnings and should collect his seed only from those trees of the best type.

(3) In areas where Scots pine is to be grown, but where existing woods of Scots pine are lacking, care must be taken to select the most suitable race for afforestation. Locality and soil conditions are important. Scots pine which on one type of soil will produce straight, clear stems, on another type may produce forked and coarsely branched trees. Kienitz recommends the use of the native seed in the natural Scots pine areas in the Mark Brandenburg, but for the extensive areas of former broad-leaved forests in Brandenburg the smaller crowned East Prussian strain should be used. For the Lüneburger Heide and North-West Germany seed from good stands in the north of the Mark Brandenburg and in Pommern and East Prussia should be used. For

Schleswig-Holstein, seed might also be obtained from Scandinavia. In middle Germany, in so far as native supplies are inadequate, seed should be brought from the mountains of South Germany.

Regeneration of Beech and Spruce in the Harz.— Much of this article is devoted to an attack on the prevailing method of regeneration—whether natural or artificial—in large blocks. The writer advocates the strip or group method of regeneration for beech, both strips and groups to be of very small extent; he is also in favour of earlier and heavier thinnings, with a view to encouraging regeneration before the trees are fully mature, and considers that early thinning tends to increase the frequency of seed years. With proper sylvicultural treatment there should be no difficulty in obtaining beech regeneration. Spruce is always regenerated artificially in the Harz, but in many areas there should be a speedy return to natural methods.

The writer distinguishes two climatic regions, Northern Harz, with a high rainfall and lower mean temperature, and Southern Harz, where the rainfall is lower and temperature higher. In the Northern Harz the soil under the spruce woods is covered with moss, which prevents the roots of the seedlings from reaching the mineral soil, and natural regeneration is therefore scanty and difficult, but by exposing the mineral soil regeneration can be obtained. In the Southern Harz the result of opening up the old crop is to produce a covering of weeds and grass among which the spruce seedlings are able to hold their own.

The writer draws the following conclusions :—

(1) In the more favourable climatic regions of the Harz, natural regeneration of spruce woods can be easily carried out. The needle-strewn soils do not produce mosses where the stands are opened up, but sweet grasses and herbs which can be kept in check by means of lateral shade, the result of making small openings in the crop.

(2) In all districts of the Harz, spruce regenerates itself easily where a beech admixture keeps the soil loose and free from weeds.

(3) In all districts of the Harz, spruce will seed itself and grow vigorously, provided the roots can penetrate into the mineral soil. In the more rainy and colder Northern Hartz natural regeneration can be obtained, even where the soil is covered with moss, by removing the moss. Local considerations as to cost will determine the practicability of this method.

(4) Peaty soils and soils overgrown with coarse grass can only be brought under spruce by means of planting. Ball plants alone should be used.

(5) The object of management must be to keep the felling areas very small and to abandon clear felling as far as possible.

Meeting of the Empire Forestry Association, November 16th, 1921.— A note by Forstrat Müller is based on an article which appeared in

The Times on the following day. Herr Müller adds the following characteristic remarks: "Able, enterprising men, are taking the greatest pains to impress their people with the importance of forestry, in the hope that the British Realm may become self-supporting in this important natural product. It is doubtful if they will succeed. The English clearly lack the love, mingled as it is with something of mysticism and sentiment, of the Germans for their forests. To this innate spirit is due the call to our young men to adopt a career which offers few prospects of wealth, and to which, none the less, devoted work and self-sacrificing care are given. Without this conception, based on a fundamental attitude of mind which is wholly independent of such mundane considerations as forest mensuration, utilisation, compound interest calculations, etc., we should be in as parlous a plight as the English."

W. H. G.

Zeitschrift für Forst und Jagdwesen, March 1922.

The Regeneration of Mixed Stands of Scots Pine and Spruce in Lithuania.—This interesting article describes a Lithuanian forest consisting mainly of a mixture of Scots pine and spruce in very varying proportions, which until recently was worked exclusively on the clear felling system, although the existence of abundant seedlings in open spaces and under the old trees clearly showed that natural regeneration was feasible. Shortly before the war, however, a severe storm wrought great havoc in the woods, especially among the spruce, and in the gaps so caused natural regeneration everywhere appeared. The writer discusses the condition of the forest in relation to the Dauerwald system as practised at Bärenthoren, and concludes that the selection type of felling practised at Bärenthoren would be out of place over the greater part of his area mainly because working plan considerations require the fellings to proceed slowly, and the result of fellings by single trees would be that the more shade-bearing spruce would colonise the ground to the exclusion of the Scots pine. He finds the solution in the strip method of felling, working on a small scale with a large number of strips in each block. Where the gaps caused by the storm are so numerous that the wood is, as it were, riddled with them, the groups of young growth are enlarged according to the methods of the group system, removing at first all the old spruce so as to further the Scots pine regeneration. In other places the condition of the stands favours the formation of a two-storied wood consisting of Scots pine above and spruce below, the two species eventually to be regenerated together. The conditions in this Lithuanian forest are thus favourable for the introduction of more than one system of regeneration, the condition of the crop determining which system to apply. The writer pleads for great latitude in forest management, urging that a forester should not be tied down by his superior to regenerate his forest according to any definite system, whether strip, group, selection or any combination of these, but should be allowed a free hand to use one or all of these systems in the same wood as actual conditions dictate.

Carbon Dioxide and Increment.—The writer commences by quoting various German authorities to the effect that carbon dioxide is an important limiting factor for vegetable growth, and in particular a statement recently made in this Zeitschrift that the maximum volume increment of forest trees is only then attained when the quality of carbon dioxide available is greater than that normally present in the air. He then proceeds to show that in order to produce the carbon dioxide required for one year's increment of wood on a hectar of a 45-year-old Scots pine crop of Quality Class III, six million cubic feet of air are required, and this involves the complete renewal of the air in the wood once every 5 days during the growing season. The writer regards the decomposition of vegetable matter beneath the trees as the principal source of CO_2, and holds that any sylvicultural measure tending to increase the supply of decaying organic material is of enormous importance to the growth of the trees (the partial pressure of CO_2 in the atmosphere surrounding the trees being the main limiting factor). It seems, however, somewhat curious that the writer makes no reference to the normal process of respiration as a means of supplying CO_2 to the air. The main conclusions of the article fall into line with the objects of the renowned " Dauerwald " system, *i.e.* : (1) frequent light thinnings in the dominant crop, leaving the twigs to decompose in the ground ; (2) stimulation of the micro-organisms in the soil, partly by mixed crops and partly by means of judicious thinnings ; (3) to break up the continuous overhead canopy given by even-aged stands through the introduction of a more selection type of felling.

W. H. G.

Zeitschrift für Forst und Jagdwesen, April 1922.

Parasitic Action and biological Control.—In answer to a criticism by Herr Knoche, Professor Escherich in this article defines his general attitude towards the control of pests by means of their parasites and makes some interesting observations as to possible means of lessening the frequency of epidemic attacks in the future. Referring to the introduction of *Liparis dispar* and *Liparis chrysorrhea* into the United States, he regards the immense damage that these pests have caused as due to the fact that they were introduced into a new environment and without the insects which in Europe are parasitic upon their larvæ.

In natural conditions there is normally a state of equilibrium between an insect and the parasites which prey upon it, but any great change in the environment, and in particular in the food supply of the insect, may upset the equilibrium ; and while the change may be favourable to the insect in question it may be unfavourable to its parasites. In such circumstances, epidemics may be expected. The writer refers to the artificial cultivation of vines, and points out that the association of enormous numbers of plants in close proximity on soil kept carefully free from weeds means an entirely new environment for the insects feeding upon it as well as for their parasites. He suggests that more heed should be paid to the latter and that, in particular, plants which serve the parasites as intermediate hosts should be planted between the vines. In forestry the mass planting of single species unquestionably has provided an entirely new environment and favoured the spread of pests which, while present in natural forests, are kept in check there by the normal equilibrium existing between the pests and their parasites under long-established natural conditions. By returning to more natural conditions such as uneven-aged and mixed forests, it is probable that more favourable conditions will be provided for the re-establishment of equilibrium and consequently epidemic attacks should be of less frequent occurrence.

Finally, Professor Escherich hints that it is not impossible that among the vast numbers of larval parasites occurring in America, one may be found which would put quite a different complexion on the methods of control of cockchafer larvae as practised at present in Germany.

General Principles of Management.—The article consists in the reproduction of a memorandum addressed by the Prussian State Forest Department to the officers in charge of State Forests in the North-West German Plain. The memorandum is dated February 19th, 1922.

The memorandum states that numerous soil investigations have shown that in the wet climate which characterises the North-West German Plain, and in particular, North Hanover and Schleswig-Holstein, great accumulations of raw humus have formed under crops of pure conifer pure beech and in mixed forests of beech and Scots pine. In many places these accumulations are leading to the formation of peat and also to the impoverishing of the surface layers of the soil and the presence of pan below. The soil deterioration is worse on the very poor and also on the very heavy soils, and where several coniferous crops have followed each other on the same land. These evils can only be counteracted by sylvicultural measures, and in the first place by a radical change in the composition of the crop. The future principle of management must be the conversion of the existing woods to mixed stands, the species being so selected as to favour the decomposition of the humus. These mixed woods may have the most varied composition, but broad-leaved trees must always play the leading part in them. Almost all the native broad-leaved species must be introduced, according to the quality of the soil. Of the conifers, Larch, Silver fir and Douglas fir are the most important species, then spruce, and last of all, Scots pine and Weymouth pine. Mixtures of beech and Scots pine or of beech, Scots pine and spruce, also pure plantations of conifers or mixtures of Scots pine and spruce, must no longer be the object of management wherever there is a tendency for the accumulation of raw humus.

It is the duty of the forester not merely to have an accurate knowledge of his existing woods but to know in what directions his management is leading him and whether his prescriptions are tending towards soil improvement or soil deterioration. For this purpose in all forests where soil deterioration is present the forest officer is to dig soil pits in stands of different ages and composition and to describe the condition of the soil. The soil descriptions are to be filed separately with a tracing showing the position of the pits in the forest. At each revision of the working plan fresh pits are to be dug adjoining the existing pits, and the state of the soil redescribed and filed together with the former descriptions.

Areas cleared of trees are to be replanted as a rule with Scots pine, among which Larch, Douglas fir, birch, oak and white alder are to be introduced ; the Scots pine are to be removed gradually with the object of obtaining mixed stands of broad-leaved trees and conifers (excluding the Scots). Such woods are to have a short rotation (60 up to 80 years at the most). Pure spruce woods are to be kept well thinned in the upper canopy and clear felled at an early age and replanted with the above mixture of trees. Pure Scots pine woods are also to be thinned severely and eventually beech Silver fir, and larch introduced by sowing in patches under a thin canopy of the old trees. The Silver fir is stated to be an especially useful species in the area under consideration (no mention is made of the Chermes danger). The accumulation of raw humus in stands of pure beech is a serious obstacle to regeneration ; where the humus cannot be disposed of, it should be removed in strips and other species introduced among the beech seedlings which appear in the cleared strips. In the wet climate of the North-west German plain the mixing of the humus with the mineral soil below by means of harrows or grubbers has proved unsuccessful as a means of dealing with accumulations of humus. It is expressly stated that the above instructions are intended as an enunciation of general principles, and that full freedom is left to forest officers in applying them to local conditions.

This article has been abstracted in some detail because of its interest from the standpoint of British forestry. It would appear that over a considerable area in North-west Germany the existing forestry system is to be revolutionised, pure and mixed coniferous forests giving way to mixture of broad-leaved and coniferous trees of a type with which we in this country are only too familiar. Whether the German foresters will be more successful with such apparently indiscriminate mixtures than we have been in the past remains to be seen ; it is possible that a visit to a typical English private estate would cause the writer of this memorandum to modify his views as to the desirability of such mixtures.

W. H. G.

Ministry of Agriculture Miscellaneous Publications, No. 35.

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Report on a Test of Hedge and Stump-clearing Devices.—This well-illustrated report is the first of a series which it is proposed to prepare upon methods and devices used for specific agricultural operations.

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Tables are given showing the detailed results of the test.

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At Forestry Museum, Royal Botanic Gardens, Kew :—

Munro, J. W. ...	...	Entomologist.

England and Wales.

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Guillebaud, W. H.	...	District Officer (Experiments and Statistics).

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