FORESTRY COMMISSION.

ADVISORY COMMITTEE ON FOREST RESEARCH.

REPORT FOR ELEVENTH MEETING.

(JULY 1938)

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REPORT ON FOREST RESEARCH.

June 1938.

1. Staff.

There have been no changes in higher supervision during the year. The arrangement with the Imperial Forestry Institute whereby we have the part-time services of Mr W.R. Day has been continued and is working satisfactorily.

2. Nursery Investigations.

(1) Stratification of Seed. A repetition of the previous year's experiment on the stratification of seed of Pinus contorta again gave positive results. Stratification hastened germination and improved the size of the seedlings. The data for the two experiments are:

Number of 1-yr. Seedlings per lb. of Seed.

	Unstratified	Stratified
1936	13,000	40,000
1937	43,000	73,000

It seems fairly certain that Pinus contorta can be included with Douglas fir and birch as species which can usefully be stratified in sand for a period of 6 weeks to 2 months before sowing. The method has not been tried with fresh seed of either of the conifers because the seed does not arrive in this country early enough for stratification to be practicable.

(2) Date of Sowing. The past season's results were generally in line with previous work. Early sowing, i.e. before the middle of April, gives generally the best results in the case of the larches, spruces, and Douglas fir, both as regards germination and size of seedling. Some curious anomalies are met with, such as a drop of nearly 50 per cent in germination in a sowing of Sitka spruce on March 30th, as compared with the preceding and succeeding fortnights. The conditions responsible for the drop are obscure.

Of all the species used in these experiments Scots pine is the one which appears to benefit least from early sowing and can therefore be sown the latest. Even with this species it is advisable to get the seed in before the middle of May at latest.

(3) Method of Covering Seed. An experiment at Kennington nursery tested three types of covering material, nursery soil, sandy gravel of a type which appeared suitable for seed covering but apparently contained some silt in addition to the coarse sand and small pebbles, and silver sand from Leighton Buzzard a coarse sand containing neither pebbles, silt nor fine sand.

The production in 1000s of 1-year seedlings per pound of seed was:

	Nursery soil.	Sandy gravel.	Silver sand.
Sitka spruce	26	61	112
Japanese larch	12	27	39
Lawson cypress	4	15	35

Although the sandy gravel has given much better results than the nursery soil the yields are still far lower than those obtained by the use of the silt-free silver sand.

A satisfactory form of mechanical distributor has been devised by the Research Officer for Scotland with the co-operation of other officers. The machine is a modification of a commercial type of manure distributor and works very well with coarse materials such as fine gravel or chippings but is less successful with sand. The machine has been adopted in a number of Scottish nurseries and appears to find general approval. At Kennington Nursery yields of 90,000 1-yr. Sitka spruce and 26,000 Japanese larch one year seedlings per pound of seed sown were obtained, using sand applied by the machine for covering.

(4) Depth of Covering The very general use of fine gravel or other coarse-textured material for covering seed suggested the desirability of investigating the question of depth of covering. Experiments were carried out in 1937 in Newton, Altonside and Tulliallan nurseries in Scotland. Results are tabulated below and give the number of seedlings obtained in each treatment.

Species	Nursery	Depth of Covering with fine gravel. 1/16"	3/16"	10/16"
		No. of plants in 1000s.		
Sitka spruce	Newton	7.1	7.3	5.6
	Altonside	8.6	13.5	14.6
	Tulliallan	3.6	8.6	0.3
European larch	Newton	4.0	3.7	4.2
	Altonside	2.9	3.8	4.2
	Tulliallan	2.0	2.2	1.2
Japanese larch	Newton	4.2	4.2	3.9
	Altonside	1.9	4.1	4.8
	Tulliallan	1.2	2.1	0.3
Alnus oregona	Altonside	1.8	5.9	6.1
	Tulliallan	0.9	1.4	0.8
Alnus incana	Altonside	4.6	7.0	6.2
	Tulliallan	0.7	1.5	0.1

Germination was very low in all nurseries. There are considerable variations in yield but a general trend in favour of covering to a depth of about 3/16". Tulliallan has a much heavier soil than the other two nurseries, possibly this may account for the bad results obtained there from the heaviest depth of covering. As regards the other two nurseries the lightest covering is as a rule inferior to either of the deeper coverings.

(5) Wet Weather Sowing. A preliminary experiment in 1936 having given satisfactory results in Tulliallan Nursery, further experiments were carried out in a number of nurseries in Scotland, using sand or fine gravel for covering the seed. With one exception the germination was as good in those beds sown when the ground was wet and the soil would normally be considered in an unsuitable condition for sowing, as in the beds sown when the soil was dry and the tilth good. The exception was in the case of Scots pine in Altonside Nursery where there was an apparent drop of 33 per cent in the out-turn from the sowing in wet weather.

The experiment is still in a preliminary stage and it would be unwise to make much of these results; so far the indications are promising.

(6) Application of Peat to Nursery Soils. The experiments on the addition of dried peat to nursery soil continue to give conflicting results. At Kennington there is no doubt whatever that the peat is beneficial but in most of the other nurseries in England & Wales and in all those in Scotland where peat has been tried the improvement in size and quality of seedling is so small as to be insignificant. It is possible that some of the nurseries where there has been no result may yet show a benefit when the peat becomes more completely incorporated with the mineral soil.

(7) Manuring. A trial was carried out in a number of nurseries on a method of manuring seed-beds by applying so-called liquid humate. This was prepared as follows: A 50-gallon barrel was half-filled with needle litter and humus collected from beneath a forest stand. To the litter was then added 1 lb. of 20 per cent ammonium sulphate, 1½ lb. of ammonium phosphate and 1½ lb. of potassium nitrate, and the barrel filled up with water, stirring vigorously meanwhile. After standing for several hours the mixture was again stirred to bring the finer humus particles into suspension, siphoned off into watering cans and applied at the rate of 3½ gallons per 50 square feet of seed-bed. Applications were made in most cases in the month of July and rather variable results obtained. Spruces improved in colour and in some cases also in growth, though the growth difference was not as a rule very striking. Other species, e.g. ash, birch, beech, grey alder, and larch showed little response. At Kennington birch responded well early in the growing season but by the end of the growing season there was little difference between the treated and untreated plots. At Altonside Nursery in Scotland, where the humate was applied to Sitka spruce, European larch and Scots pine shortly after the seed germinated, the treated seedlings are much the stronger, on the other hand the same solution of artificials applied without infusion with the humus gave equally satisfactory results and it is possible that the humus is unnecessary. On the whole the results of the treatment have not been very striking.

Ash responded well at Kennington to a complete manure comprising lime, and magnesium in addition to potash, phosphate and nitrogen. At the end of two years the treated seedlings averaged 24 inches in height compared with 13 inches in the untreated controls.

(8) Methods of controlling weeds in seed-beds.

The plants in the 1934 weed-control experiment in Scotland having been lifted and finally assessed it is now possible to review the complete series of experiments laid down in 1932, 1933, and 1934. In the first of these years experiments were carried out at Inchnacardoch, Altonside, and at the Royal Botanic Garden, Inverleith; these included trials of scorching with a blow lamp and treatment with solutions of sulphuric acid and copper sulphate. In 1933 Benmore Nursery was added to the series and the experiments were carried out on a larger scale; three species instead of one were sown, and although the use of copper sulphate was dropped the blow lamp and sulphuric acid treatments were increased in number. The data have proved very troublesome to analyse because of the interaction of several factors, notably the output of usable seedlings per pound of seed, cost of the treatment applied, and saving, if any, in the cost of weeding. The method employed by the Research Officer for Scotland has been to reduce the results to the common denominator of cost of raising the 2-year seedlings produced per pound of seed sown, taking all operations into account. Even with this simplification it is quite a formidable matter to present the data and for the purpose of this report it will perhaps be sufficient to tabulate the major results in each nursery and year.

I. Sulphuric Acid.

Experiments.	Sitka spruce.	European larch.	Scots pine.
	(1) Altonside Nursery.		
P.32	No benefit from use of acid.	-	-
P.33	Dry season and few weeds. Treatment increased costs with all species (Outturns reduced)		
P.34	No benefit from any of the treatments.		
	(2) Inchnacardoch Nursery.		
P.32	-	-	No reduction of cost.
P.33	One weak application of acid applied soon after sowing reduced costs. Remaining treatments unfavourable.	Treatments mostly harmful. Outturns lower.	
P.34	5 pints of 1 in 95 acid applied on 5th day after sowing reduced cost. Remaining treatments unfavourable.	Three out of six treatments gave favourable results. Remainder harmful.	Three out of six treatments gave favourable results. Remainder inconclusive.
	(3) Inverleith Nursery.		
P.32	No conclusive result.	-	-
P.33	5 pints of 1 in 80 acid on 7th day after sowing gave highest outturn and reduced costs.	Four out of six treatments harmful, rest inconclusive.	Two out of six treatments harmful, rest inconclusive.
P.34	Two treatments favourable. Four unfavourable. Best treatment was 3 pints of 1 in 95 acid on 7th day.	Two out of six treatments beneficial. Rest inconclusive. Best treatment was 5 pints of 1 in 80 acid on 5th or 9th day.	Four treatments out of six beneficial. Rest inconclusive. Best treatment was 5 pints of 1 in 80 acid on 5th day.
	(4) Benmore Nursery.		
P.33	$7\frac{1}{2}$ pints of 1 in 110 acid on 7th day gave good results. Costs substantially reduced. High concentrations (1 in 80) unfavourable.		
P.34	3 or 5 pints of 1 in 95 acid on 5th day after sowing very effective in reducing costs. High concentration unfavourable.	5 pints of 1 in 95 acid on 5th day gave good results.	

Summary of results from use of acid. The experiments with Sulphuric acid have given on the whole unfavourable results in three out of the four nurseries. Germination has often been reduced, sometimes disastrously so, and the number of successes is more than counterbalanced by the failures. In the fourth nursery, Benmore, the results with the lower concentrations (1 in 95 and 1 in 110) are sufficiently encouraging to justify experiment on a larger scale. The dosage suggested is 6 pints per square yard applied as follows: Sitka spruce and Scots pine on the fifth day after sowing, European larch on the seventh day after sowing.

II. Blow Lamp Experiments.

Experiments.	Sitka spruce.	European larch.	Scots pine.
	(1) Altonside Nursery.		
P.32 - 34.	With the partial exception of P.32 none of the blow lamp treatments reduced costs of production.		
	(2) Inchnacardoch Nursery.		
P.32	Burning controlled weed growth into the second year and reduced costs.	-	-
P.33	Light burning sometimes but not invariably beneficial. 15 seconds per square yard on 7th to 13th day after sowing gave best results.		
P.34	All burning treatments gave inconclusive or unfavourable results.		
	(3) Inverleith Nursery.		
P.33	15 seconds per sq. yd. on 7th to 13th day gave good results.	15 seconds on 7th day improved outturn and reduced weed growth by 40%.	15 to 20 seconds on 10th to 13th day increased outturn and reduced costs.
P.34	All burning treatments gave inconclusive or unfavourable results.		
	(4) Benmore Nursery.		
P.33	15 seconds per sq. yd. on the 10th day after sowing gave good results.	The seed germinated too quickly and the seedlings were scorched in all treatments.	15 seconds on the 7th day halved the amount of weeding and increased the outturn.
P.34	20 seconds on the 12th day gave good results.	10 seconds on the 8th day after sowing gave good results.	

Summary of Blow LampTreatments. The conclusion from the three years series of experiments is that so far as cost of production is concerned local conditions of soil and weather must determine if the blow lamp should be applied. In a sandy nursery such as Altonside and in a dry season the weeds germinate so slowly that nothing is gained by using the blow lamp. It must also be realised that occasionally there may be a disaster, as in the case of European larch in P.33 in Benmore nursery where the tree seed germinated so quickly that the seedlings were badly scorched. In weedy nurseries, especially in high rainfall areas, given discretion in its use, the blow lamp appears a useful adjunct.

It should be observed that the experimental results were based solely on costs of production, assuming an unlimited labour supply. Where there is a shortage of labour the time element becomes all important, and the greater speed of the blow lamp treatment may make its use indispensable.

(9) Hortomone. Preliminary trials have been carried out with a proprietary preparation called Hortomone A, containing a growth-promoting substance. The species used included cuttings of aspen, poplar, golden privet, and sundry conifers. A small number of the aspen rooted successfully and there was a decided stimulus to the rooting of privet. Poplar struck well both with and without the treatment. All the conifers failed. The work is being extended this year.

(10) Cultivation of Walnut and Poplar. Some remarkably fine two-year walnut seedlings were raised last season at Kennington in well-manured soil, black walnut were up to 7 feet and common walnut up to nearly 5 feet in height. These have been lifted and relined at a wide spacing; a proportion of the plants was stumped before relining.

The new poplar nursery at Mundford near Thetford is turning out well. Stumped one-year old poplar cuttings lined out in P.36 now average from 9 to 13 feet in height, the growth varying with the species.

Poplar cuttings lined out at different spacings in the Fen Row nursery at Rendlesham showed the benefit of wider spacing. The plants grew well, averaging 6 feet in height at the end of the first year. When graded on size and vigour the following data were obtained:

Spacing	Grade I	Grade II	Grade III	Culls	Dead
	percentage of cuttings lined out				
3" x 12"	32	27	18	17	6
6" x 12"	50	31	14	5	-
9" x 12"	50	29	17	4	-

Extending the spacing from 3" to 6" has appreciably increased the proportion of Grade I plants.

A repetition of the previous year's experiment on size of cutting indicated that 8" is the most suitable length for a poplar cutting. The best result is obtained when the cutting is buried in the soil so that the top only just shows above ground-level.

An experiment on the stumping and relining of some aspen transplants which were of very poor form and growth gave good results. Some of the cut-back plants made shoots up to 6 feet in length.

3. Programme of Nursery Investigations 1938.

Project	Nursery
Stratification of seed of Pinus contorta	Kennington
Method of covering seed. .	Tair Onen
Season of sowing	Kennington, Halwill and Tair Onen
Density of sowing	Kennington and Newton
Sowing under wet conditions	Tulliallan, Newton, Altonside
Comparison of drill and broadcast sowing	Newton, Tulliallan
Trial of Hortomone	Kennington, Altonside
Application of peat to nursery soils	Kennington, Altonside, Tulliallan
Manuring	Kennington, Altonside, Tulliallan, Strathyre, Widehaugh, Tair Onen
Raising of Walnut	Kennington
Raising of birch and alder	Tulliallan, Altonside
Comparison of lining-out and bedding out Sitka spruce seedlings	Newton
Large-scale experiment on Green Cropping	Inchnacardoch
Raising of Poplar.	Mundford

4. Progress of Plantation Experiments.

The Research Officer for Scotland has prepared a comprehensive report summarising the Scottish experiments on soil cultivation and preparation for planting, including turf planting, grouping of turfs, hand digging, and ploughing. The following is a summary of this report.

(1) Peat Soils.

(a) Direct planting into the natural surface. In the early days of the experimental work at Inchnacardoch and elsewhere in the west of Scotland many experiments were made with different methods of direct planting. The more

elaborate of these were based on the belief that the roots might penetrate broken-up peat more readily than peat in its natural conditions, hence various forms of pitting, mattock trenching etc. These all failed to produce satisfactory growth on the fibrous peat of the Scottish Highlands. Vertical notching and pitting resulted in the death of the majority of the spruces, while methods of shallow planting designed to place the roots near the surface also failed except in one experiment at Glenrigh, where the natural drainage was good.

It should be observed that results with the direct notching of spruces on the amorphous types of Molinia peat of the Cheviots and Pennines are much less unfavourable to this method. Losses are usually higher than by turf planting, and growth appreciably slower, but provided a reasonable amount of drainage is done it is possible to secure satisfactory plantations by this means; Moorburnhead Plantation is a case in point.

(b) Standard Methods of Turf Planting. These have proved a great advance over direct planting on all types of peat, both as regards reduction of losses on planting and also, as a rule, as regards rate of growth. In some of the experiments, however, turf planting resulted in heavy losses during the first year. This occurred almost exclusively on the fibrous types of peat when planting was carried out before the turfs had time to settle properly and the weather following planting was very dry.

As regards the effect of turf planting upon rate of growth, on the poorer types of pseudo-fibrous peat, e.g. Calluna-Scirpus, growth after the first few years may be little better than in the case of direct notching. In both cases the result is a complete state of check, but the

turfed plants, so far, remain for the most part alive, while those planted direct gradually die. On this type of land the effect of manuring with basic slag is greater than any improvement that can be effected by method of planting.

(c) Experiments on Methods of Turf Planting. A number of experiments carried out on the poorer peat types at Inchnacardoch and Achnashellach may be mentioned here very briefly. Nothing was gained by planting on turfs taken from the lower levels of a deep peat bog as compared with surface peat. Draining and laying out the turfs three years in advance of planting was not helpful at Inchnacardoch. No advantage resulted from putting a planted turf on top of another turf in which a cavity had been formed, the object being to improve aeration. Experiments on the lifting of badly checked spruce on fibrous peat were generally unsuccessful, losses were very high and relatively few of the plants recovered. The most intensive treatment, consisting of lifting the checked plants, applying basic slag and putting in new drains, has been a success, but it is questionable if it would not be better to replant de novo using standard turf planting.

The most interesting of the special methods of turf planting employed is the system of group planting tried at Inchnacardoch and Glenrigh where three turfs are placed round a central planted turf. Such concentration of the turfs combined with the more intensive drainage alters favourably the vegetation and promotes the growth of the trees. This result points the way to ploughing as the probable solution of the problem of the afforestation of the poorer peat soils (fibrous and pseudo fibrous types).

(d) Dug-over Peat. Owing to lack of the necessary implements it has been impossible to experiment with ploughed-up peat of the type found in the Highlands. Imitation ploughing (turning over the peat by hand) has been carried out at Borgie where 1½ acres of deep Calluna-Scirpus peat were dealt with in this manner. After 7 growing seasons the average heights of the trees were as follows:

Sitka spruce	4 ft. 10 in.
Pinus contorta	4 ft. 10 in.
Scots pine	3 ft. 2 in.

All the plants received the usual dose of basic slag. This result on a definitely bad type of peat is quite encouraging although, as there was no ordinary turf planting carried out alongside as a control, it is difficult to say exactly what part the cultivation has played. The nearest turf planting is about a mile away on the opposite side of the valley and though the ground is not dissimilar, it is unsafe to make a comparison.

Hand digging has also been carried out on a number of Scirpus-Calluna knolls carrying a thin skin of fibrous peat. There are experiments at Nevis, Bennan, Borgie, Inchnacardoch, Blackcraig and Glenrigh Forests, all of which were carried out in P.35 and P.36. The results have been generally unfavourable as compared with direct planting or planting on replaced turfs, the feature of the dug-over areas being the very heavy death rate which occurred in the first season after planting. These knolls present a special problem owing to the tendency of the disturbed soil to dry out during a summer drought.

Summary. The experimental work provides definite evidence justifying the adoption of the standard method of turf planting on peat soils. The method is equally applicable whether the species is Sitka spruce, Japanese larch,

Scots pine or Pinus contorta. On the poorer types of peat the success of the turf group and imitation ploughing methods (in conjunction with basic slag) in improving the natural vegetation points to intensive cultivation as a possible solution of the problem of these peats. Half the battle will be won if grasses can be brought in to replace the heather and Scirpus, and the surest way of effecting such a change is to turn over the surface peat as completely as possible. The addition of basic slag will probably be necessary in most cases.

(2) Upland Calluna Soils.

The most important series of experiments in Scotland is in the large experimental area at Teindland. On this compacted and naturally ill-drained, impoverished soil the effects of cultivation are usually very well-marked. A P.28 experiment contrasts the growth of three species planted A. by direct notching into the undisturbed soil and B. on mounds, the latter involving a considerable amount of local soil cultivation as well as locally improved drainage. The results are as follows (after 10 growing seasons):

Species		A. Direct Notch		B. Mound Planting	
		Unmanured	Manured	Unmanured	Manured
Japanese larch	(Mean Height. in.	23	40	36	67
	(per cent of losses	43	31	21	7
Scots pine	(Mean Height. in.	22	35	32	43
	(per cent of losses	26	7	23	15
Pinus contorta	(Mean Height. in.	16	36	27	52
	(per cent of losses	33	17	25	16

Growth of all species planted by direct notching without basic slag has been painfully slow. An average total height of less than two feet in ten years is not much of a result. Mound planting clearly improves matters though

it is worth noting that the heights of the unmanured mounded plants are less than those notched in direct, but with manure. In this experiment the combination of mound planting and manuring with basic slag has given much the best results. That drainage is an important factor on this Teindland area is well illustrated by a P.26 experiment with Scots pine. Whereas the plants on the undrained ground averaged only 15 inches in height after 12 years, those planted between drains averaged 27 inches (range 17 to 35 inches) while those put in along the drain sides averaged 40 inches (range 27 to 55 inches).

In P.27 and P.28 a fairly elaborate ploughing experiment was carried out in the same experimental area at Teindland. There were three methods of ploughing, i.e. full ploughing, double-furrow ploughing and double-furrow ploughing with a subsoiler, following the plough. The plough was specially constructed for the work and was drawn by three horses. Considering the nature of the soil and the numerous boulders it did very good work but its performance was certainly much inferior to that of the modern tractor-drawn ploughs. Even where the subsoiler was used the iron pan was seldom reached or broken.

A variety of species and mixtures was tried, including mixtures of Sitka spruce and Norway spruce with Pinus contorta and mountain pine, these will be referred to later in this report. For the present purpose it will be sufficient to give the data regarding the growth of Scots pine and Pinus contorta, both species which, where planted direct, without cultivation, have made little progress. Ploughing was carried out in P.27 and half the area was ploughed in that year and the other half in P.28.

The average heights in inches of the unslagged plants of the two species, at the end of P.37, are as follows:

	Scots pine		Pinus contorta	
	P.27	P.28	P.27	P.28
	in.	in.	in.	in.
Full ploughing (no slag	43	50	34	60
Full ploughing (slagged	57	51	38	77
2-furrow ploughing (no slag	50	32	42	52
2-furrow ploughing (slagged	58	46	41	75
2-furrow ploughing subsoiled (no slag	54	27	38	69
2-furrow ploughing subsoiled (slagged	68	53	47	83
Mean ... (no slag	49	36	38	60
Mean ... (slagged	61	50	42	78

The data show no consistent trend as regards the effect of the three methods of cultivation and it was quite apparent on the ground that this is due to local soil variations. The effect of slag has also been rather variable. The stimulus has been greatest on the poorest sites and so has had a levelling-up effect; this is particularly noticeable in the case of Scots pine of P.28 ridge ploughing. The Pinus contorta used in the P.27 planting were apparently a poor lot, the P.28 plants giving a much better result.

If we compare the growth of the P.28 Scots pine with that of the P.28 Pinus contorta the difference is not very great, and it is possible that in ten years' time there will be little to choose between the two species as regards height growth. The experiment did not include a direct planted control but there is sufficient evidence on the area as a whole to leave no doubt as to the beneficial effect of the ploughing.

In P.29 a large-scale ploughing experiment was carried out, covering an area of about 10 acres within the reserved Compartment at Teindland. Mound planting

(incidentally a very expensive method of soil preparation) was contrasted with shallow cultivation by horse plough, there being two methods: Three Furrow ploughing planted at normal spacing, and Complete ploughing planted in closely spaced groups. The species used was Pinus contorta, half the plants were put in in P.29 and the remainder in P.30.

The results are summarised in the following table:

	P.29 Planting. Average height after 9 growing seasons.		P.30 Planting. Average height after 8 growing seasons.	
	Unmanured.	Manured with basic slag.	Unmanured.	Manured.
	in.	in.	in.	in.
Planting on Mounds	35 ± 5.3	55 ± 7.9	34 ± 6.2	51 ± 5.4
Three furrow ploughing	32 ± 2.4	72 ± 4.8	35 ± 2.4	61 ± 4.0
Complete ploughing (planted in groups)	34 ± 8.3	80 ± 2.9	36 ± 6.9	67 ± 9.1

Without manure growth has been relatively slow and and there is nothing to choose between the three methods of soil preparation. With manure the trees can reasonably be regarded as established and there is a distinct indication that the more intensive cultivation provided by ploughing has been beneficial. The high standard errors reflect the very variable growth of the trees, probably in a few years' time when canopy has formed the plantation will even up and differences between the initial treatments may show up more clearly.

The effect of cultivation comes out perhaps most definitely in Experiment 36 P.29 at Teindland. Here Scots pine and Pinus contorta were planted in groups some of which were dug-over, representing complete cultivation, while in others the plants were put in on the natural unbroken surface.

Half of the groups were manured with basic slag (2 ounces per plant), the other half being left as unmanured controls.

		Average Heights of Plants in inches after 9 growing seasons.	
		Uncultivated	Cultivated
Scots pine	(No slag	13	28
	(Slagged	16	53
Pinus contorta	(No slag	20	26
	(Slagged	29	63

The outstanding results are from the slagged and cultivated groups of both species as compared with the uncultivated, unmanured controls.

It is clear that cultivation alone is insufficient to produce satisfactory results on this very poor land.

One further experiment is of interest as bearing on the problem of the cultivation of these poor wet Calluna heaths. The experiment was based on the experience of the Danish Heath-reclamation Society which supports the use of intensive cultivation before planting the forest trees. The cultivation extends over a period of years during which at least two agricultural crops are harvested. In 1933 plots were laid down at Teindland in which two treatments were tested: A. the surface was broken up by a single ploughing, and B. the soil was intensively cultivated by twice ploughing and twice cultivating. The experiment differed from the Danish practice in that no agricultural crops were taken (this was done in a later small-scale experiment).

The results, at the end of 5 growing seasons, are as follows:

	Single Ploughing		Intensive Cultivation	
	Losses per cent	Average Height.	Losses per cent	Average Height.
		in.		in.
A. Without Slag.				
Sitka spruce	30	9	11	8
Japanese larch	71	10	48	6
Birch	45	12	36	7
Oregon alder	100	0	100	0
B. With Slag.				
Sitka spruce	8	23	0	22
Japanese larch	40	25	2	36
Birch	27	26	4	16
Oregon alder	6	75	7	117

The data are remarkable from several points of view. Intensive cultivation without any manuring has not helped at all except to reduce to some extent the proportion of failures in the first three species. Oregon alder died out completely in both forms of soil cultivation. As regards growth, all species are in check and it is interesting to find birch making such a poor showing on the intensively cultivated ground.

Where basic slag was applied both Sitka spruce and Japanese larch are showing signs of growth, particularly the larch on the intensively worked sections. Birch is only relatively better than on the unmanured plots and clearly finds the conditions unsuitable. Oregon alder has done by far the best of the species tried, the slag has converted a

complete failure into a 95 per cent take and the plants have attained the very considerable height of from 6 to nearly 10 feet in five years.

The other poor Calluna area in which experiments on soil cultivation have been carried out over a period of years is in Yorkshire, at Allerston and Harwooddale. At Allerston the effects of cultivation are well marked, although, as the soil conditions are less unfavourable than at Teindland, growth of pines on the uncultivated ground are relatively better.

Experiment 6. P.28 shows the effect of shallow ploughing compared with planting into a screefed patch of uncultivated soil. No slag was applied.

Growth after 10 years.

	Screef-planting.		3-furrow ploughing.		Full ploughing.	
	Av.Ht.	Av.Shoot	Av.Ht.	Av.Shoot	Av.Ht.	Av.Shoot
	in.	in.	in.	in.	in.	in.
Scots pine	41	8.5	47	10.6	56	12.8
Corsican pine	32	7.5	46	10.6	51	11.4
Sitka spruce	14	0.9	29	4.1	29	4.0
Japanese larch	16	2.7	34	8.2	59	12.8

The Scots pine in the screef-planted controls without slag are nearly as tall as the same species on fully ploughed and slagged ground at Teindland. Ploughing has, however, quite appreciably increased the rate of growth. The effect of cultivation is more marked on the Corsican pine , full ploughing nearly doubling the height of the plants. Ploughing has brought the Sitka spruce out of check but the most striking difference appears in the Japanese larch, and it will be noted that on the fully ploughed ground

the plants average about 5 feet in height, as compared with only 1 ft. 4 in. in the screefed patches.

From P.31 onwards at Allerston the ground was broken up with a heavy plough drawn by caterpillar tractor, giving much deeper cultivation than in the earlier experiments. A direct comparison of the two methods of ploughing is not possible owing to soil variations, the shallow ploughing being on the poorest ground. The growth of pines on the deeply ploughed land is very satisfactory, and there is a distinct tendency for growth to improve with the intensity of cultivation, i.e. the plants are better on the fully ploughed ground than where the ground has been ridged up by double-furrow ploughing at $4\frac{1}{2}$ feet apart. On the other hand, at Wareham, where the introduction of ploughing has led to a remarkable improvement in the early growth of the pines, ridge ploughing generally gives better results than full ploughing.

Conclusions on the cultivation and planting of poor Calluna soils. As on all other types of soils it is dangerous to generalise too broadly as to the effect of cultivation on the poor Calluna heaths. Results vary with the locality and species, but at least it is true to say that cultivation by digging or ploughing effects a general improvement in the conditions for tree growth. The hardy, unexacting pines benefit as a rule less obviously than such species as Sitka spruce, Japanese larch, birch, or alder. On the poorest type of land, e.g. the top of Teindland, cultivation alone is insufficient to produce satisfactory growth even of the pines; basic slag must be added to give the plants a proper start. The more exacting species, Sitka spruce, Japanese larch, etc. cannot be grown at all without cultivation and slag, their ultimate fate is still

in the balance, because there is always a risk of second check before canopy is formed.

On the better Calluna soils, such as Allerston, the pines respond well to cultivation but, given good plants and good planting, as well as a favourable planting season, may ultimately make a satisfactory plantation without such treatment. Growth is, however, always more irregular than on ploughed ground and usually failures are higher. It is with the more exacting species that cultivation becomes all-important. If, as appears very probable, the production of many of the Calluna areas can be increased by including a proportion of spruce with the pine, ploughing is an essential preliminary for the successful establishment of the mixture.

Pine-Spruce Mixtures on Upland Calluna Soils.

A survey has been made of those experiments in which mixtures of pines and spruces occur. Many of these are too young for the pine to have any influence and in some cases the pines have failed to develop owing to damage by Black game or to unsuitable planting methods. Where the pine have grown satisfactorily and have reached a height of not less than 3-4 feet there is evidence of a definite improvement in the rate of growth of the spruce. Data from experiments at Teindland, Allerston, and Inchnacardoch and Kielder are summarised below.

(a) Teindland. Experiment 16 P.27 and 23 P.28 on shallow ploughed, poor upland Calluna ground. The plots summarised in the table all received an application of basic slag, and

the data represent in each case the mean of 6 plots.

Average heights in inches of plants after 12 and 11 growing seasons respectively:

	Norway spruce mixed with (a) P.contorta	(b) P.montana	N.S Pure	P.contorta in N.S.plots	P.montana in N.S.plots
P.27	19	21	17	42	42
P.28	23	28	18	75	38
	Sitka spruce mixed with (a) P.contorta	**(b) P.montana**	**S.S Pure**	**P.contorta in S.S. plots**	**P.montana in S.S.plots**
P.27	38	35	29	41	41
P.28	45	39	35	86	38

There are several interesting points in the above table. In the first place the spruces have benefited in every case by admixture with pine, but whereas Norway spruce appears to have done relatively better in mixture with mountain pine than with Pinus contorta, the reverse is the case with Sitka spruce. Secondly, three out of the four species (mountain pine is the only exception) have grown better in the P.28 experiment; the ground was all ploughed in P.27 and possibly the delay of a year before planting has been beneficial; the difference is most marked in the case of Pinus contorta. Thirdly, Sitka spruce has grown nearly twice as fast as Norway spruce on this poor ground.

(b) Allerston. Experiment 6. P.28 on shallow ploughed, poor upland Calluna soil, not slagged. The data represent in each case the mean of 18 plots, after 10 growing seasons.

	Sitka spruce.				Scots pine in Sitka spruce Plots
	Pure		Mixed with Scots pine.		
	Av.Ht.	Av.l. shoot	Av.Ht.	Av.l. shoot	Av.Ht.
	in.	in.	in.	in.	in.
No Slag	21	1.4	29	4.1	51
Slagged	32	3.4	39	6.6	63

The effect of the pine mixture is less apparent in the mean heights of the Sitka spruce than in the current leading shoots. The difference in colour of the needles is very apparent on the ground and it is probable that the spruce in the spruce pine mixtures will now grow rapidly ahead of those in the pure plots.

(c) Inchnacardoch. Experiment 16. P.27. This experiment has already been written up by Mr J.A.B. Macdonald in the Scottish Forestry Journal, published in October 1936. The experiment started in P.23 with a series of season of planting plots with Sitka spruce planted by direct notching. The ground was rather variable and three distinct soil types are now recognised. In P.27 alternate plots were inter-planted with Scots pine and in 1935 an assessment was made of the relative growth of the spruce in the pure and the mixed plots on each of the three vegetation types. The spruce were then 13 years old and the pine 9 years old, from the date of planting.

Vegetation Type		Sitka spruce Mixed with Scots pine	Sitka spruce Pure	Scots pine in S.S. plots
Dry and exposed Calluna/Erica cinerea slopes	Height	2.9 ft.	1.7ft.	9.3 ft.
	Shoot	7 in.	2in.	20 in.
Sparse bracken, grass, and Calluna	Height	8.8 ft.	4.2ft.	13 ft.
	Shoot	20 in.	5in.	25 in.
Strong dense bracken, grass, and Calluna	Height	13.3 ft.	8.9ft.	14.2 ft.
	Shoot	26 in.	19in.	24 in.

In each type the pine admixture has improved the growth of the spruce in a very marked degree. This is good pine ground and the pines started away without any check. The spruce in the mixed plot on the poorest ground put on an average shoot of 7 inches in 1935, which compares with

only 2 inches in the control. It is also remarkable that the pine admixture should have had such a great effect on the development of the Sitka spruce on the good, dense bracken, type.

(d) Kielder (Smales). Experiment 6. P.27, planted on turfs on Calluna-Molinia-Eriophorum peat. Assessed in 1937, i.e. after 11 growing seasons. The data are given in inches and represent the means of two plots.

	Sitka spruce		Scots pine in S.S. plots.
	Mixed with Scots pine	Pure	
	in.	in.	in.
Average height	66	54	51
Average leading shoot	8.5	6.4	9

In this example also there is an indication of improved growth of the spruce in the mixed plots.

(e) Forest of Deer. The following note was prepared by Mr J.A.B. Macdonald on an interesting case of a pine-spruce mixture in the Forest of Deer. The Sitka spruce were introduced four years after the pine.

"A visit was made on 18th April, 1938 to a ridge top in Forest of Deer where the Chairman had observed Sitka spruce coming on well among Scots pine. The area is in Compartment 10, P.27, at a height of 410 feet; but as there is little high ground intervening between this and the sea - 10 miles away - exposure is severe. The underlying soil is granitic, and there is a 10 in. covering of black, humose material which in the slightest hollows is definitely peaty in texture. The area was old woodland containing Norway spruce, Scots pine and some

European larch. Apparently the Scots pine had started reasonably well, but before they had grown much above the level of the herbage many of them were very badly blasted and quite a number died. Sitka spruce were introduced on turfs in 1931 to beat up gaps.

A measurement made this year gave the following heights in inches for Sitka spruce and Scots pine on -

(1) a Calluna/Nardus type:-

S.S. 19, 11F, 17F, 13F, 12F, 13, 20
7F,22, 19. Average: 14 inches.

S.P. 15, 14, 21, 19, 16, 20, 16, 16,
15, 20. Average: 17.2 inches.

The Scots pine were very badly blasted and in most cases the leading shoots had been killed. The Sitka spruce marked "F" showed signs of frost damage.

(2) On a Calluna/Aira flexuosa/mosses association, the heights in feet were:-

S.S. $4\frac{1}{2}$, $5\frac{1}{2}$, $4\frac{1}{2}$, $5\frac{1}{2}$, 2F, 4, $3\frac{1}{2}$, $5\frac{1}{2}$
$4\frac{1}{2}$, $3\frac{1}{2}$. Average: 4.3 feet.

S.P.3,$1\frac{1}{2}$, 2, $1\frac{1}{2}$, 2, 2, $2\frac{1}{2}$, 2,
2, $1\frac{1}{2}$. Average: 2 feet.

The Scots pine were badly browned on the N/NW side, but were not blasted to anything like the same extent as on the Calluna/Nardus type of ground.

(3) On an Aira flexuosa/Calluna/Galium saxatile site, the Scots pine had done much better, heights in feet being:-

S.S. $3\frac{1}{2}$, $1\frac{1}{2}$, $1\frac{1}{2}$, 3, 4, 5, 4, $6\frac{1}{2}$,
4, $1\frac{1}{2}$. Average: 3.5 feet.

S.P. 7, 5, 6, 5, 3, $3\frac{1}{2}$, $4\frac{1}{2}$, 3,
$3\frac{1}{2}$, $4\frac{1}{2}$. Average: 4.5 feet.

Each Scots pine tree in this group had an entire leading shoot, and none of the Sitka spruce had been blasted.

It appears, therefore, that only in the Calluna/Nardus types have the Scots pine failed. It was found that this vegetation type occurred in very slightly concave parts of the ridge, where undoubtedly drainage was impeded.

A search showed that sphagnum species occurred in these shallow depressions, also Juncus squarrosus. A distinct pan was found at 10" below the surface in one such hollow and the underlying subsoil was definitely gleyed. It is interesting to find that both blasting and frosting occurred together in these partially waterlogged patches and not at all on the slope, or where the surface was convex as in samples (2) or (3)."

Observations on Pine-Spruce Mixtures.

The evidence from the above experiments and observations appears to justify the use of mixtures of pine and Sitka spruce on those wet Calluna types where experience has shown that spruce is liable to check for a number of years before getting away. The plot in the Forest of Deer also shows that use can be made of a slow growing pine crop to bring in Sitka spruce and that these will benefit from the shelter provided by the pine.

The exact part played by the pine in the mixed plots is not fully understood. The pine presumably have a sheltering effect in the earlier stages. Later on the (usually) faster-growing pine will bring about earlier suppression of the heather and other vegetation which must help the root development of the spruce. Ultimately especially on upland Calluna soils in which the pan has been disturbed by ploughing the deeper rooting pine will certainly tend to a more effective penetration of the soil besides contributing to the stability of the crop in the event of wind storms.

Dorset Heaths.

The Lawson Cypress plot at Wareham continues to make excellent growth. Examination by Dr Levisohn of the roots shows that this tree forms only an endotrophic type of mycorrhiza which appears to develop quite normally on trees of this species planted in the Wareham soil.

Corsican pine, direct sown in P.36 in patches treated with hop-waste compost, have grown phenomenally, at the end of the second year many of the seedlings were over a foot in height, germination was so good that the patches have had to be drastically thinned.

Loam and Clay Soils.

The hoeing experiments at Tintern with ash and sycamore showed an interesting development at the end of the 1937 growing season. The unhoed controls have begun to make good growth, and the difference between the hoed and unhoed plots is now much less striking. If the improvement in the unhoed plots continues it will be doubtful if hoeing can be economically justified, at least on ground that is really suitable for ash.

At Dymock half of each of the unweeded plots in the P.30 oak weeding experiment were completely cleared of coppice and other weed growth. Owing to the dense growth the work proved very expensive, costing nearly £7 per acre. Much of the coppice was over 10 feet in height and it was remarkable to find how many of the oak seedlings had survived. In the fully weeded plots there was an average of 15 plants per 6 feet of row. This compares with 10 plants in the unweeded but now completely cleared plots. On paper a stocking of 5 plants per running yard, or one every 6 inches, is more than ample to produce a good crop. Actually the position is not so favourable because the plants in the unweeded plots are

very weakly owing to the prolonged competition with the weed growth. How these weakly plants will respond to their freedom remains to be seen. In any case it is clear that oak seedlings cannot be left unweeded for eight years if the vegetation consists of vigorous coppice, gorse, and broom. The remaining half of the unweeded plot will be allowed to grow on to see if any of the seedling oak succeed in pushing their way through the weed-growth.

An experiment on age and type of sycamore showed that two-year seedlings are less satisfactory as planting material than transplants. The data are as follows:-

Type of Plant.	Height at time of Planting. in.	Average Height after 6 growing seasons. ft.
2 x 0	11 - 14	5.0
1 x 1	11 - 14	7.5
1 x 2	15 - 25	10.0
2 x 2	36 - 54	9.9

The tall 2 x 2 plants remained in check for the first 3 - 4 years but then began to grow fast. The smaller transplants grew well from the start, the sturdy 1 x 2 plants giving the best result.

5. Summary of Plantation Experiments carried out in P.38.

Peat and Tough Peat Knolls.	Group planting of S,S., P.C., J.L., S.P. and Oregon alder on peat at Inchnacardoch, Achnashellach and Borgie.
	Introduction of S.S. under P.28 P.C. at Inchnacardoch.
	Trial of sowings on peat knolls, using compost, at Glenrigh and Inchnacardoch.

Upland Calluna Soils.	Trial of French Plant-roll machine at Langdale End. Raising of Scots pine by direct sowing with compost on the moorland at Allerston.
	Introduction of various species under P.29 P. contorta at Teindland. Group planting of P.C., Hyb. L., S.P. and G.A. with birch on ploughed ground at Teindland.
	Small-scale trial of hand digging at Hamsterley.
Calluna Heaths.	Trial of various species of pine at Findon. Costing experiment on the direct sowing of Corsican pine (with compost) at Wareham. Experiments on the raising of Sitka spruce and Norway spruce by direct sowing, using compost, at Wareham.
	Trial of different composts prepared by Dr Rayner, also of amount of compost required at Wareham.
East Anglian Heaths.	Methods of planting beech and soil cultivation at King's Forest. Thinning and brashing of S.P. over beech at Thetford.
Chalk Soils.	Methods of planting beech at Friston.
	Planting of Scots pine as a nurse for beech at Friston.
	Trial of broom sowing on various sites at Friston.
	Introduction of beech into pine and alder plots at Buriton.
Loam and Clay Soils.	Planting of walnut, ash and Sycamore at Tintern. Trial of manuring and hoeing.
	Addition of further trees to Poplar Garden at Yardley.

Origin of Seed.	N.S. and S.S. at Newcastleton and Nevis. P.C. at Achnashellach, Clashindarroch and Allerston.
	E.L., J.L. and Hyb. 1. at Clashindarroch.
Miscellaneous.	Underplanting with beech of J.L. sample plot at Alice Holt.
	Planting out of E.L. plants wrenched in the nursery - Clashindarroch.
	Trial of Dr Laing's method of delaying flushing of E.L. at Clashindarroch.

6. Progress of Special Investigations.

(1) Pruning. Pruning plots, comparing different intensities of pruning, have been established in Douglas fir at Inverliever and Monaughty, Norway spruce at Inverliever and Drummond Hill, Sitka spruce at Inverliever, and Scots pine at Edensmuir.

In order to obtain material for a study of the effect of live pruning upon the spruces a circular was issued to the Divisions asking for groups of 5 trees of each species to be pruned in as many forests as possible. Fifty-two such groups have been formed, 27 in Scotland and 25 in England & Wales. Of these 21 are Norway spruce and 31 Sitka spruce.

(2) Progress of Plantations in industrial Areas. A well-documented report has been prepared by Mr Day and Mr Sanzen Baker on the plantations in Llanover and Llantrisant forests, and in other smoke-affected districts. It is proposed to discuss the report at a conference to be held by the Chairman in the autumn.

(3) Progress of Plantations on Chalk Soils.
Work on this problem is continuing but has been held up by the amount of other work in hand.

(4) Poplar Cultivation. A report on the recent poplar plantations of the Commission is in preparation. Two members of the Imperial Forestry Institute recently visited and reported on poplars planted in Combley Forest in the Isle of Wight. A considerable variety of poplar species and hybrids had accidentally been introduced and the result is a medley consisting largely of inferior forms of poplar. The report raises the question whether a veto should not be placed on the raising and planting of any type except the true black Italian poplar, Populus serotina. This would not affect the experimental planting of promising varieties.

(5) Study of Root Development on ploughed ground of the poor Calluna Heath Type. Further work has been done on the root development of alder and birch on the ploughed ground at Allerston. The depth of rooting was found to vary considerably, thus, out of three 8-year-old common alder plants examined two grew mainly in the upper soil layers, but the third tree sent down three major roots which reached depths of from 2 feet to 4 feet below the surface. Three plants of grey alder of the same age were examined, two of these had formed relatively feeble root systems, the third sent down a major root to the remarkable depth of 6 feet 5 inches below the surface, and practically the entire root system was in the C horizon, below the pan layer. It may be mentioned that the pan was not broken in this case by the ploughing, the roots got down through

a crack formed by the planting spade. It seems surprising that there should be sufficient aeration in the soil below the pan to permit of such vigorous root activity.

Three 5-year-old birch plants were also examined. None of these was particularly deep-rooting, the roots seldom penetrating deeper than 18 inches to 2 feet below the surface, but there was a greater development of secondary and tertiary roots than in the case of either the common or the grey alder.

Oregon alder showed a vigorous root development, mainly confined however to the leached soil above the pan.

7. Measurement of Permanent Sample Plots.

The Sitka spruce plot, E.41, in the Long Combe, near Minehead, was re-measured during the year for the sixth time. In the 15 years since the plot was established the number of trees has been reduced from 1,650 to 420 per acre, the mean height has risen from 33 to 72 feet and the mean quarter-girth at breast height from 3¼ inches to 7 inches. The standing volume is now, at 28 years of age, 4,700 cu. ft. quarter-girth per acre, and a total of 2,300 cu. ft. has been removed in thinnings.

A number of Corsican pine plots were re-measured during the year on the Highclere, Dunster and other estates. These mostly consist of pairs of plots in which light and heavy thinning are contrasted. In each case the advantage as regards rate of volume production appears to be on the side of the heavy thinning. The Highclere plots 59 and 60, in particular, form a good comparison. These plots were 19 years old and 35 feet high in 1932 when they were established. They had then a stocking of about 1,800 stems per acre. In four thinnings the stocking has been reduced

to 850 trees in the lightly thinned B grade plot and 280 trees per acre in the D grade plot. The dominant trees average 67 feet in height in both plots. Comparative data are tabulated below.

	Mean No. Stems per Acre.	Quarter-girth at 4ft.3in.	Crown per cent.	Volume Quarter-girth per Acre. cu. ft.	Total Volume of Thinnings. cu.ft.	Periodic mean annual Increment. cu.ft.
B. Grade ..	850	5¾	33	4,420	340	230
D. Grade ..	280	8	42	3,360	1,600	285

The difference in crown per cent. in the two plots is quite marked and the volume increment is appreciably higher in the heavily thinned plot.

New plots were established in pure Scots pine and Corsican pine in the Binsness Woods near Culbin.

During the summer of 1937 the Sample Plot Party spent six weeks on a Trial Census of Woodlands, visiting two districts in Scotland and two in England.

8. Botanical Research.

(1) Mycorrhiza. Dr M.C. Rayner and Dr I. Levisohn, Bedford College. Experiments on the sowing of seed of pines and other conifers on soil treated with compost prepared by Dr Rayner from hop-waste have shown that there is a striking difference between the effect of the compost when applied to soil that has been under an agricultural regime and its effect on natural moorland or heath soil. For example the addition of compost to new nursery soil (formerly under grass) at Widehaugh Nursery near Hexham resulted in no improvement in the growth of Corsican pine.

When the 1-year seedlings were examined by Dr Rayner she found no mycorrhizas present in either the treated plants or the controls; both lots of plants showed the typical symptoms of uninoculated nursery soil. On the other hand, seed of the same origin sown on moorland soil at Allerston, after treatment with the compost, developed into quite normal plants, with a profuse development of "balanced" mycorrhizas. Seed sown at Allerston without compost produced much poorer seedlings with only scanty mycorrhizas. It would appear that, in the moorland soils so far examined, mycorrhizal fungi are present but the plant has difficulty in forming normal mycorrhizas; there is some inhibiting condition present. Application of compost, or alternatively, but less satisfactorily, basic slag, removes the inhibiting condition and permits normal mycorrhizal development. Pari passu with normal mycorrhizal development goes satisfactory growth of the plants.

Agricultural treatment of a soil, including permanent pasture, appears to destroy the mycorrhiza-forming fungi but experience has shown that these can be restored by lining-out a single crop of conifer seedlings from any established nursery. In this connection a verbal communication from Mr Frank Scott is of interest. He found at Tair Onen Nursery that seedlings of Lawson cypress are an exception to the general rule in that they do not inoculate the soil as do the commoner species, such as pines, larches, spruces, etc. This is presumably linked up with the different type of mycorrhiza formed by Lawson cypress, to which reference has already been made.

Although an ordinary coniferous seedling crop does inoculate a grassland soil and enable seed to be sown

successfully in future, Dr Rayner has evidence that conditions are not the same as in a natural soil which has been improved by the application of compost. There is a lack of balance in the mycorrhizal structures of the plants of most of the common species, raised in an ordinary nursery. This is evidenced by the presence of intense intra-cellular infection by the fungus. In the normal mycorrhiza of such a species as Corsican pine there is a fungal mantle round the short roots and a hyphal network between the cells, but little or no invasion of the cells by the hyphae. On the other hand in the average forest nursery the hyphae are found invading the cortical cells of the roots and it is to this intra-cellular invasion that the term "unbalanced" is applied. To what extent this condition of the roots is injurious is not yet certain. Mycorrhizas are known to be annual structures and a single year in a new and favourable habitat may be sufficient for the plant to develop a normal type of mycorrhiza. There is, however, some evidence to show that seedlings raised on natural soils, and with balanced mycorrhizas, have a better constitution and are able to withstand adverse locality conditions better than the comparable, nursery-raised plant.

(2) Dr E.V. Laing - Root Development of young European larch. Dr Laing has submitted a report on his recent investigations on European larch. The report stresses the difference in behaviour of larch, as regards root development, from that of other coniferous species such as pine and spruce. Whereas the roots of other species were found to be growing actively at the end of March, the European larch roots were dormant. The contrast

is the greater when it is remembered that the larch flushes its short shoots much earlier than any of the other conifers. Root extension does not as a rule take place in larch until the long shoots begin to develop. Meanwhile the plant is dependent for its water supply upon the existing root system. In the case of a plant which has to be moved, special precautions are obviously necessary; the plant should be lifted and handled with great care to preserve as many of the small roots as possible, and good planting and careful firming are indicated in order to bring the small roots in as close contact as possible with the mineral soil.

When larch of two different seed origins were compared (namely Scottish and Swiss from the Munsterthal), it was found that the roots of the Scottish plants began to grow much earlier than those of the foreign origin. On 16th May the Scottish larch were showing strong root extension when the Swiss larch were still inactive.

Dr Laing found that the roots of seedlings begin to develop actively much earlier than those of transplants. The advantage thus held by the seedlings appears, however, to be more than counterbalanced by the smaller root system of the seedling, and the fact that most of the secondary roots are near the root collar. In transplants there is a better distribution of the secondary roots over the lower part of the root system, and this fact, combined with the more bushy root development, presumably accounts for the better results given as a rule by transplants when put out into the forest.

Although these observations and general experience alike point to the importance of early planting of larch, sometimes delay is unavoidable, and planting has to be done later than is desirable. Dr Laing has carried

out some interesting experiments on the treatment of plants after lifting. He found that flushing could be delayed by burying the plants completely in soil for not longer than one month. The burying was done as follows:- a pit 12 ft. x 3 ft. x 15 in. in which the plants, after untying the bundles, were laid flat and covered with about 6 inches of soil. The soil was a well-drained clay-loam. The plants were buried on the 26th February and planted one month later, when the buds were found to be swelled, with the tips of the needles just showing. After planting, the plants quickly flushed and soon caught up those which had been planted in February; there were no losses and the plants grew well.

Another experiment of perhaps more general application was the heeling-in of the plants in the ordinary way and then covering them with a box with air spaces, tightly packed with straw, left between the boards for ventilation. The cover remained on until 11th May when the plants were found to be partially flushed. Growth started immediately on planting and soon overtook the February-planted controls. There were no losses among the plants which had been shaded, while in those which were lifted from ordinary lines and planted out on the same date in May the failures were very heavy. These experiments require repetition on a more extensive scale but they suggest that it may be possible, by delaying flushing, to tide over the danger period between the flushing of the short shoots and the development of new roots.

A method of planting which Dr Laing has found very successful on a dry site is to insert the young trees in the bottom of shallow continuous trenches somewhat resembling the turf drains prepared on peat soils. Such a method has its dangers as the collection of water in any local wet spots is fatal to the plants.

9. Research on Forest Soils.

Dr G.K. Fraser of Aberdeen University has been appointed to the Staff of the Macaulay Institute as from October, 1937. A report on his investigation of humus types on Calluna heath is in course of preparation.

Dr A. Muir has completed a survey of the soils of the Clashindarroch and Bin Forests. An independent vegetation survey was carried out by Dr Fraser and the work has now been collated and a joint report prepared. The report will be completed by Professor H.M. Steven with a section describing the current choice of species on the main soil types which have been recognised.

As a result of discussions held in Aberdeen during the past year it has been decided that greater progress is likely to be made by a detailed study of soils which carry a tree crop than by proceeding with extensive surveys of waste land. It is proposed to make use of some of the sample plot areas for this purpose and an endeavour will be made to correlate rate of growth with the data obtained from examination and analysis of the soil. The survey work will not be entirely dropped but its scope much reduced; the soils of Rothbury Forest in the North East (E) Division have been selected for study this year.

Dr A.B. Stewart has continued his analytical work on nursery soils, and is also collaborating with the Research Officers in planning and assessing nursery manuring experiments.

10. Entomology.

Chafer Grubs. - During the past year Mr J.M.B. Brown carried out a fairly comprehensive survey of the more severely infested nurseries of the Commission. The object

of the survey was partly to determine which species of chafer were present and partly to attempt to correlate local factors with the occurrence of the pest and the amount of damage done. As regards distribution of species Mr Brown found serious damage by Melolontha more or less confined to the south of England and the counties in the west Midlands, with one outlying nursery in Durham. Rhizotrogus was rare outside the eastern half of England, and is nowhere a serious pest at present. Phyllopertha was most abundant in Wales and the north-west of England. The distribution of Serica appeared to be wholly erratic; it occurs over a wide range of conditions in Great Britain and seems to be practically independent of temperature and rainfall variations.

A good deal of useful information as to the breeding and feeding habits of the chafers was obtained in the course of the survey, but this requires to be amplified by the more detailed research which is now in progress.

Mr Brown concludes that "with a knowledge of the species of chafer present and of its life history, an allowance of at least twenty per cent of the nursery each year as fallow, and a little intelligent anticipation, it seems that much of the damage could be obviated."

In addition to Mr Brown's work, research on a parasite of the Melolontha larva is in progress at the Farnham House Laboratory. Dr Walker, who is working on this problem, is in receipt of grants from the Carnegie Trust and from the Forestry Commission. The parasite in question is a Tachinid named Dexia rustica. This lives in a funnel formed from the skin of the chafer grub. The funnel grows from the point at which the parasite enters the grub and is clearly visible through the skin as a small

blackish orifice. A single chafer grub may contain up to 16 parasite larvae and as many as 5 or 6 parasites may issue. Little is known as yet as to the extent to which the grubs are parasitised in our nurseries. A parasitism of 5 per cent. was recorded from Fairoak Nursery at Tintern, while at Nagshead Nursery in the Forest of Dean an average figure of 23 per cent. was obtained. In certain sections at Nagshead the parasitism was as high as 50 per cent. It is hoped to obtain further data during the coming season.

Pine Beetle. - Mr H.S. Hanson has been actively engaged during the past year on a survey of pine woods throughout the country. Thinning experiments have been carried out and a large series of billet and trap stems laid down. The latter work has proved that the rough-barked billet with the bark intact is much superior to any of the other types of billet tried. In Scotland there was a heavy infestation of some of the trap stems by Pissodes pini, and this beetle may be of more importance in standing woods than has hitherto been suspected. The major experimental areas have been linked up by a series of nearly 100 sets of felled pine stems distributed throughout Great Britain. These are giving much useful information regarding the various species of bark beetles and their parasites and predators. Some species which have hitherto been considered very rare are found to be widely distributed and fairly common, while others have a very limited distribution.

Polygraphus on Norway Spruce. - An outbreak of the bark beetle Polygraphus polygraphus was discovered by Dr Chrystal on large Norway spruce on an estate near Halesworth in Suffolk. Other attacks were later reported

from Holkham and from Melton Constable, both in Norfolk. The damage was very considerable, many trees having died and others evidently being much weakened. Polygraphus has not previously been recorded in this country but is well known in Germany where, however, it is regarded as a relatively minor pest. Mr Hanson, who visited the Holkham and Melton Constable outbreaks at the end of January 1938, reported that the dominant spruce were recovering and that any new attack appeared to be confined to suppressed trees or to trees which had already been seriously weakened. On the whole there does not seem much cause for alarm.

Chermes cooleyi on Sitka spruce. - There is still no definite record of the occurrence of Chermes cooleyi on Sitka spruce in England or Wales. There was a very heavy infestation of egg-laying females on Sitka spruce in Glenrigh Forest in the autumn of 1936 but a recent examination of the trees showed that few galls were produced and these only on the lower branches. There is again this year a considerable infestation on the Sitka but this is almost confined to the less vigorous trees. Healthy vigorous trees show no sign of infection, even where they are growing in close contact with Douglas fir. At present there is clearly no need for alarm about this pest.

Use of Hylarsol for the Control of Pine Weevil. - In recent years extensive use has been made in German forests of an arsenical preparation, called Hylarsol, as a means of preventing damage from pine weevil. Hylarsol is a powder which is made up with water into a liquid spray with which the plants are coated, using a special twin-nozzle spraying lance. The powder is made by Messrs Schering, Ltd., of Berlin, and costs about 8d per lb. From 8 to 12 lb. are

required to spray one acre of new plantation, the cost including labour and materials ranging from 12s. to 18s. per acre. In the case of a severe infestation two sprayings are requiredduring the first growing season, so that the total cost will be of the order of 25s. to 35s. per acre. Very intensive billet trapping may amount to about 30s. per acre but as a rule trapping costs are considerably below this figure.

German reports on the use of Hylarsol are almost uniformly favourable and the method is coming more and more into general use in State as well as private forests. In this country two provisional trials were carried out in 1936, but owing to delay in obtaining the material the spraying was not done at the optimum season. In 1937 more extensive experiments were arranged in Divisions Dean and E. Scotland. These gave on the whole inclusive results. The protection given in Scotland was not sufficiently complete to enable trees to be planted immediately after a mature pine crop was felled and it is not proposed to experiment further with Hylarsol at the moment.

11. Research on Vole Disease.

The following observations have been taken from the last Annual Report of the Bureau of Animal Population at Oxford.

The main objects of the investigation are to record quantitatively the three to four year fluctuations that occur in British vole populations, to analyse their changing 'structure', and discover the causes of fluctuation, including the mortality that happens on such a large scale in certain years. Field methods of trapping have been developed which give reliable data as to changes of numbers in a given district. The current year is expected to be a peak year in Argyll, and in other areas

also voles appear to be on the increase.

One of the chief problems in connection with damage to young plantations is to find out why voles often reach equally high numbers in two areas, and only attack trees on one of them. The answer is probably to be sought in a quantitative study of the ground vegetation considered as a reserve food supply.

A laboratory stock of voles continued to be maintained at Oxford and a number of experiments have been carried out on the effect of food factors etc. on growth and health.

During 1937 1700 post-mortem examinations were made on voles sent from various field stations in Great Britain and on voles bred in the laboratory at Oxford. A disease closely resembling tuberculosis was found in many of the trapped voles. It appears to be caused by an undescribed Mycobacterium, possibly a new type of M. tuberculosis. Twenty two per cent of the trapped voles examined were infected, but the mortality due to the disease appears to be relatively low.

12. Mycology.

Elm Disease. - The disease continues to spread and each year some fresh centres of intense infection are discovered. In 1937 two local outbreaks were found in Bedfordshire. In one or two areas the progress of the disease has been followed up annually for a number of years by recording a limited number of trees. A group at Foulden, in Norfolk, is a case in point:- 95 trees were examined in 1928 and all were free from disease. In the following year 4 trees were diseased. In 1930 two out of the four trees had

recovered, i.e. did not show any fresh signs of die-back, but there were 13 new infections. At the end of 1937 six out of the 95 trees had died, 19 trees were diseased, 21 were "recoveries" and 49 were as yet unattacked. This is a good illustration of the relatively slow progress of the disease in many localities.

Plants obtained from a resistant elm seedling raised in Holland were heavily inoculated at Oxford with the fungus (now known as Ophiostoma ulmi). Only two of the plants showed any external symptoms, and in those the slight initial wilting disappeared completely after a few weeks. It is hoped soon to have a good stock of plants of this elm.

Inoculation tests carried out by the American pathologist, Dr Walter, point to the relative immunity of Ulmus stricta Wheatleyi, and there is also some field evidence to the same effect. This elm has been planted fairly extensively in England; if it proves resistant the ravages of the disease may be less serious than is sometimes feared.

Butt Rot of Conifers. -- The survey carried out by Mr Peace showed that the only fungus of major importance concerned was Fomes annosus. The principal species affected are the larches and spruces, pines being resistant except when past maturity. The disease is definitely worse on land previously under trees, but is also liable to be severe on old arable land. It is not as a rule bad on land which was previously moorland, or under grass. Larch is more liable to rot on light land than on heavy, and there is also more rot in areas of low rainfall.

Stereum sanguinolentum. - Some small Scots pine pitprops which failed unexpectedly in a mine in Scotland were sent to the Forest Products Research Laboratory for examination and proved to be infected by Stereum. This fungus is common as a saprophyte but under certain conditions seems capable of spreading from the decaying side branches into the stem. Evidence of rot caused by Stereum has also been found in Norway spruce cut for telegraph poles and in a small number of larch. This is not an easy fungus to detect as the amount of staining is usually slight and is often confined to the upper part of the stem. Mr Cartwright of the Forest Products Research Laboratory obtained evidence that the fungus gets in usually after felling, and he considers that it can be controlled by proper methods of stacking.

Poplar Canker. - A few years ago a number of poplars were sent from Oxford to be planted among heavily cankered Populus trichocarpa on Hayling Island. Of these only P. nigra italica, P. regenerata and P. serotina have remained free from canker. P. robusta, P. generosa, P. marilandica and P. candicans have all been attacked. P. robusta and P. marilandica are usually resistant.

Disease of Norway Spruce at Comlongan. - A disease attacking 30-year-old Norway spruce at Comlongan, near Dumfries, was investigated. Many of the trees are dying back from the tops; but examination showed that the roots are quite healthy. Two fungi, Hormonema dematoides and Phoma acuum, have been isolated from dying needles, and a third, Phomopsis Pseudotsugae, from dying shoots. Inoculation experiments are to be carried out.

Die-back of Douglas Fir in the New Forest and at Dovey.- A curious case of the sudden death of a group of large Douglas fir in the New Forest and other cases of die-back of young Douglas fir in Dovey Forest have been investigated. Material from both areas yielded, on culturing, the same fungus, Phomopsis occulta. In this country, P. occulta has only been recorded as a saprophyte, but in the United States it is said to be parasitic on conifers. Mr T.R. Peace, who is at present on a visit to North America, hopes to obtain first-hand information regarding this disease.

Frost. - Scots pine plants of various seed origins were used in a series of refrigerator experiments in the spring of 1937. It was found that plants raised from Scottish seed were, on the whole, hardier than those from seed collected in England.

Frost-lift. - In refrigerator experiments the best materials for covering seedbeds to prevent frost-lift have been moss, peat moss litter, and Sorbex peat. Granite chips and grit, which have given good results in nurseries in Scotland, were not satisfactory in these experiments.

13. Utilisation.

The creosoted telephone poles of Norway spruce and Sitka spruce which were not accepted by the Post Office for service trials have been erected at Kershope Forest. The poles will be kept under observation and it is hoped that the trial will prove successful. Spruce poles are used in various parts of the Continent for carrying telegraph or telephone wires and there appears no reason why they should not be used for that purpose in this country, at any rate in case of emergency.