Memo. No. 66/37.

FORESTRY COMMISSION.

PROGRESS REPORT ON FOREST RESEARCH.

June 1937.

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REPORT ON FOREST RESEARCH.

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1. Staff.

There have been no changes in higher supervision during the year. The number of men working in the Sample Plot Party has been increased from three to four, the additional man being loaned temporarily from one of the Divisions in Scotland. It is proposed to continue this arrangement in future to give training in thinning methods to members of the Commission's field staff. The subordinate staff of the Research Branch consists of 2 Grade I Foresters, 4 Grade II, 4 Foremen, and 3 Gangers.

2. Nursery Investigations.

(1) Green Manuring. Experiments were started in 1933, in three nurseries in Scotland, on the effect of soiling crops upon the subsequent growth of seedlings and transplants. The green crop was oats and tares and for comparison there were some plots fallowed and others cropped with potatoes, different manurial treatments also being given. The individual plots were probably too small and variations were too great to enable any very definite conclusions to be drawn. The most consistently good results were obtained where trees followed a crop of potatoes which had received 20 tons per acre of farmyard manure. Unmanured green crops gave as a rule no better results than a fallow, but at Altonside a green crop manured with farmyard manure gave a very marked improvement in growth.

See table below.

Altonside Nursery.

Production of Good Plants per Unit.

	J.L. 1x1	E.L. 1x1	S.P. 1x2	S.S. 1x2	J.L. 2x0	E.L. 2x0	S.P. 2x0	S.S. 2x0
Fallow	175	320	255	210	405	85	740	100
Unmanured Green Crop	170	350	180	255	495	120	325	765
Manured Green Crop	445	505	420	355	440	225	1125	1700
Manured potatoes	355	465	245	415	380	155	995	1385

During the summer of 1936 a questionnaire on green cropping was issued to all nurseries in England and Wales. The object of this was to ascertain the current practice as regards green cropping. The replies indicated a wide divergence in practice, but a general belief that green cropping was beneficial. A summary of the enquiry has been published in the Commission's Journal.

(2) Manuring. Experiments with different types of peat were continued at Kennington Nursery. Plots treated with peat in 1935 and resown in 1936 showed some fall-off in the size of seedlings produced, though the treated plots still gave rather better seedlings than the untreated controls. Outputs were high in all plots, productions per pound averaging 20,000 in Norway spruce, 73,000 in Pinus contorta, and 103,000 in Sitka spruce. The maximum yield of one-year Sitka spruce seedlings was of the order of 145,000 to the pound of seed sown.

Kennington Nursery has showed signs during the last two or three years of some reduction in fertility, the plants are not, on the whole, as good as they were during the first seven or eight years of the life of the nursery. Apart from a few small areas the nursery has never had any manure beyond a green

crop (usually sown without fertilisers) and it is remarkable that the soil should have maintained its fertility so well. In 1932 a small-scale so-called intensive seedling production experiment was started in boxed-in beds. The object of this was to find out if seedlings could be raised satisfactorily in permanent seed beds. There were two initial soil treatments, in the one bed ordinary nursery soil was used as a control, while in the other a specially prepared mixture consisting of a half and half mixture of broadleaved humus and nursery soil replaced the upper three inches of the bed. The subsequent treatment has been the same for both beds, namely, the seedlings are lifted at the end of the first year, a dressing of farmyard manure at the rate of about 50 tons per acre is applied and a crop of lettuce or beet root taken off. In the following year another crop of tree seedlings is raised succeeded by a further application of dung cropped with lettuce or beet root. The bed sown in 1936 with Sitka spruce had thus received two applications of dung and this was the third crop of the seedlings produced. The points of special interest are (1) the original soil and broadleaved humus mixture continues to give the best results. In the nursery soil the seedlings average $1\frac{1}{2}$ inches in height, with a maximum height of $3\frac{1}{2}$ inches while in the humus-soil mixture the plants average 2 inches in height with a maximum of 5 inches. Production was at the rate of 65,000 per pound. (2) In both beds the plants are markedly better than seedlings raised in unmanured beds in other parts of the nursery. (3) Dr Stewart of the Macaulay Institute analysed samples of the nursery soil bed in the intensive manuring experiment, and also samples from other sections of the nursery. He found the curious result that while the manured soil was much richer in phosphate and potash than the unmanured sections of the nursery, the addition of the very heavy dressings of dung had not increased the organic content of the soil which was uniformly low (2.2% to 3.8%)

throughout the nursery. This must indicate that the Kennington soil is exceptionally active in breaking down organic matter. The improved growth in the humus/soil mixture is probably due to a higher content of organic matter though we have not yet got analytical data to confirm this.

A series of manuring experiments was devised in 1935 by Dr Stewart and laid down in a number of nurseries in Scotland. Applications of 'nil', 'moderate', and 'heavy' dressings of farmyard manure, potash, and phosphate were provided and there were two replications of each combination. Four species were sown, S.S., S.P., E.L., and Sycamore. The plants have now been lifted and assessed and it is remarkable to find no outstanding differences ascribable to treatment. Variations in size appear to be due to other factors than the available nutrients supplied in the manures. This result bears out our general experience with manurial experiments in the nursery. The Kennington experiences suggest that we may have been in too much of a hurry to expect results and that the treatments should be extended over a longer period than two years. An article on manuring with so-called humate fertilisers has just appeared in the American Journal of Forestry and may throw new light on the problem. Some preliminary experiments will be carried out this year with the American method.

(3) Season of Sowing and Method of Covering in Relation to Frost-lift. An investigation was made into frost-lift in relation to soil and sand covering, and to date of sowing on A. soil, and B. soil plus Sorbex peat, at Altonside Nursery. The plots were sown in 1935 and frost-lift occurred as a result of intermittent periods of frost and thaw from December 1935 until March 1936. While Sitka spruce was the species most affected, frost-lift was virtually confined to the beds covered with soil. In the soil-covered beds the losses due

to frost-lift were as follows:-

Date of sowing.	Losses in the soil plots. per cent.	Losses in the soil plus Sorbex plots. per cent.
March 12	Not sown	15
" 22	30	Not sown
April 16	23	11
" 24	44	26
May 7	27	34
" 25	54	27
June 14	81	76
" 27	94	97

It is evident that losses were catastrophic in the very late sowings carried out in June. In the earlier sowings losses ranged from 23 to 54 per cent in the ordinary nursery beds, and from 11 to 34 per cent in the beds treated with Sorbex. Whether the apparent difference in favour of Sorbex is significant is perhaps doubtful. In the case of the grit-covered beds only one plot showed a slight amount of frost-lift. The conclusion is that grit-covering has proved a very efficient means of preventing frost-lift even in late sown beds.

In Norway spruce the losses ranged from 27 to 58 per cent in the beds covered with nursery soil and again only one of the grit-covered beds suffered. In the case of Scots pine and European larch, frost-lift occurred only in the two latest sowings covered with soil.

One other point of interest may be mentioned, as arising out of the 1936 season of sowing experiments. At Fleet Nursery the sowings were carried out on new nursery ground. The ordinary spring sowings gave the usual poor results associated with such conditions, but seed sown in the previous autumn produced excellent seedlings, averaging over $1\frac{1}{2}$ inches in height; the early March sowings also were fairly satisfactory

(4) Stratification of Seed. The two species which have been found to respond to stratification for short periods in sand are Douglas fir and birch. To these can now probably be added Pinus contorta. An experiment at Kennington with seed which had been stored for two years gave the following results:-

Unstratified. Yield of 13,000 seedlings per lb.
Stratified. " " 40,000 " " "

Further tests on new seed of Pinus contorta are being carried out this year.

(5) Wet Weather Sowing. A preliminary experiment in Tulliallan Nursery in 1935 showed that Sitka spruce could be sown in wet weather and produce quite a satisfactory yield of seedlings provided sand or grit was used for covering. The experiment was repeated in 1936 on a larger scale, with replications, and the following yields were obtained:-

	Type of Covering	Yield per Unit S.S.	N.S.	E.L.
Sown in wet weather	Soil	20 ± 10	60 ± 16	4 ± 1
" " dry "	Soil	450 ± 120	180 ± 91	24 ± 5
" " wet "	Grit	830 ± 170	—	—
" " dry "	Grit	750 ± 120	—	—
" " wet "	Sand	290 ± 85	290 ± 51	110 ± 20
" " dry "	Sand	630 ± 100	—	—

The very poor results obtained from sowing in wet weather and covering with soil explain the nurseryman's dislike of sowing when the soil is wet. With the use of a non-caking form of soil covering, however, excellent results can be obtained. The yields from the wet weather sowings of Sitka spruce covered with grit, and of Norway spruce and European larch covered with sand, were actually higher than the yields from the beds sown in dry weather and covered with soil. The yield per pound from the best outturn of Sitka spruce was

about 30,000 seedlings. The plants have yet to be lined out and it is possible that sowing in wet weather may result in a poor type of root system.

(6) Walnut Cultivation. During the last year or two the nursery treatment of walnut has received a good deal of attention at Kennington Nursery. Small plants have not been a success in the field, and some large over-grown plants imported from a private nursery made little or no growth for the first year or two after transplanting. The experimental treatment has largely been concerned with these big plants, and it was decided to resort to stumping, cutting the shoots back to ground level and pruning also the roots. Part of the plants were relined into manured and part into unmanured ground. The spacing was 2 feet by 3 feet. The plants put up strong shoots and at the end of the second season were lifted and sent to Bedgebury. The manured plants averaged 4 feet in height, with shoots of 2 ft. 9 in., and the unmanured plants 3 ft. in height, with shoots of 2 ft. 3 in. The walnuts which had not been cut back had badly-shaped stems and the shoot growth was much less vigorous. There is no doubt that the plants required the space given them in the nursery, as some of the leaves were up to 2 ft. in length.

Stumping has also been carried out with small plants, one year and two year seedlings, of black walnut. The one year seedlings are evidently too small for this purpose and it remains to be seen how the two year seedlings will do. It is quite possible that it may be better to leave the plants for three years in the beds before stumping.

(7) Nursery Treatment of Poplar. A series of experiments on size and type of cutting, depth of insertion in the soil, etc. was carried out at Kennington. The results generally confirmed

the methods employed in poplar nurseries in Belgium and the north of France, and may be summarised as follows:-

1. Cuttings should be made from the lower part of a strong one-year-old shoot.
2. The length should not be less than 7 inches, but there is no advantage in the use of longer cuttings, provided the right type of material is used.
3. Cuttings should be lined out with the tips only just visible above ground and spaced not less than 6 inches apart in the lines.
4. The practice of stumping the plants at the end of the first year and relining at a wide spacing has proved very successful at Kennington. One-year-old shoot cuttings of different species of poplar raised in 1934 were cut back in 1935 and relined in unmanured nursery soil at a spacing of 2 ft. x 3 ft. At the end of the second year in the lines the plants averaged over 9 feet in height and were lifted for planting in the poplar garden at Yardley Forest.

3. Programme of Nursery Investigations, 1937.

The major projects are:

Project.	Nursery.
Stratification of seed. P.C. and Abies grandis.	Kennington.
Manuring.	
Trial of peat combined with artifical manures.	Kennington, Altonside, Tulliallan.
Test of straw compost in nurseries.	Tulliallan & Altonside.
Application of potash salts applied in advance to beds to be sown with N.S. and S.S.	Kennington.
Effect of lime on ash sowings.	Fleet.
Green cropping.	Altonside.
Trial of "humate fertilisers".	Kennington et al.

Project.	Nursery.
Season of sowing. S.S. and P.C.	Kennington.
Advance preparation of seed beds, using grit covering.	Altonside, Tulliallan.
Trial of covering materials on seed beds. S.S., J.L. and L. cypress.	Kennington.
Depth of covering with grit.	Altonside, Tulliallan, Newton.
Comparison of broadcast and drill sowing, using grit covering.	Tulliallan, Newton.
Wrenching of E.L. 1 x 1 transplants.	Edinburgh, Newton.
Wet weather sowing.	Altonside, Benmore, Edinburgh.
Weed control by use of the blow lamp (improved pattern).	Tulliallan.
Weed control, chemicals.	Benmore & Tulliallan.
Raising of Walnut.	Kennington Nursery.
Spacing of Cricket bat Willow and poplar cuttings.	Rendlesham.
Length of poplar cuttings.	do.

4. Progress of Plantation Experiments.

(i) Peat Project. The position has not altered materially since last year but there are some points of interest arising out of recent assessments.

(a) Inchnacardoch. The P.28 plots on the peaty slopes below Craig Ialain are making excellent progress. The heights are shown in the table below.

Species.	Unmanured Controls. Av.Height in.	Slagged Plots. Av.Height in.
Pinus contorta	49	92
Japanese larch	31	93
Mountain pine	29	53
Sitka spruce	13	44
Norway spruce	15	43

The vegetation is distinctly better than that in the Lon Mor area but is of a moderately poor type, and the original P.23 plantation on the same site, planted without turf draining, was an almost complete failure. Pinus contorta is the only species making relatively good growth in the unmanured controls. Pinus contorta and Japanese larch are now established in the manured plots. A minor point of interest is the success of Norway spruce which is keeping up well with the Sitka. Neither of the spruces can make any headway without the manure.

(b) Achnashellach. A block of Japanese larch was planted in Glen Carron in P.32 near the successful P.28 plots of that species. The P.28 plots were very intensively drained, and one of the objects of the later experiment was to discover if a crop could be raised successfully with normal spacing of the drains. The experiment was combined with a test of the effect of doses of 1 and 2 ounces of slag respectively.

The results are:-

Treatment.	Average Height at end of 5 years.
	feet.
Control. - No manure.	2.0 ± 0.10
1 oz. basic slag per plant.	3.5 ± 0.20
2 oz. basic slag per plant.	3.5 ± 0.10

So far the growth of the manured plants has been quite satisfactory and it is interesting to find that the smaller dose of slag has given just as good results as the larger dose. The unmanured plants are very poor.

ii. Upland Calluna Soils. There are no special developments of interest to report at Teindland where growth of all species is slow on the poor soil.

One or two experiments on treatment of heather before planting are beginning to show some results. At Clashindarroch

burning the heather before ploughing and planting has definitely improved the growth of Japanese larch, Sitka spruce and Pinus contorta. The same applies at Allerston with Japanese larch and Sitka spruce, and to a lesser extent at Clocaenog with Sitka spruce though here the ground was turf drained not ploughed. It seems evident that it is desirable to burn off the heather before ploughing.

Root investigations have been carried out at Allerston by the Research Foreman, J. Weatherell, who has done an excellent piece of work.

(1) The pan itself appeared less of an obstacle to the downward growth of pine roots than did the unweathered soil of the A (leached) horizon. Where the ploughing was deep enough to disturb most of the A layer but not quite deep enough to break the pan the roots appeared to have no difficulty in growing through the pan.

(2) In the deep-ploughed area both weathered and unweathered pan was found. There were considerable stretches where the pan was unbroken and unweathered.

(3) Ability to pierce the pan appeared to depend largely on the vigour of the plant which in turn was related usually to the depth of ploughing.

(4) The application of slag increased the number of 'long' roots but did not apparently affect the depth of rooting.

(5) In one plant of Scots pine (a five-year-old tree planted as a two year seedling) 5 primary roots and 6 secondaries penetrated unbroken and unweathered pan.

(6) The deepest-going Scots pine root investigated reached a depth of nearly three feet below the pan and there were many roots from 9 - 16 inches below the pan layer. These roots were apparently still growing downwards andnone of them showed any signs of dying back. This was on the deep-ploughed

ground, in which most of the pan had been broken, and goes to show that the subsoil is not an unsuitable medium for root development.

(7) Six birch trees planted in P.30 were also excavated. These were growing on the 3-furrow shallow ploughing and three of them had received a dressing of basic slag. The roots appeared to penetrate the pan quite readily; manuring increased the total length of roots but not the depth. The maximum depth to which a root had penetrated was 4 ft. 10 in.

(8) Oregon alder showed a much more branched root system than either Scots pine or birch, and the roots kept more to the upper layer of the soil; a few roots, however, penetrated below 12 inches. Three Corsican pine were also examined and a total of 37 roots were found penetrating the pan. The maximum depth reached was 3 ft. 10 in.

These observations are distinctly encouraging. They indicate that the deep ploughing, which is now the standard method of soil preparation at Allerston, does result in a very big improvement in root development, as compared with the earlier type of shallow ploughing and still more as compared with ordinary pitting or notching. The breaking up of the pan appears to be of relatively minor importance; the roots do not seem to find it a serious obstacle provided that there is a good depth of cultivated A (leached) horizon in which the plants can make a start. The tendency of pines, birch, and larch, to deep rooting is a good augury for the ultimate windfirmness of the crop.

iii. Dorset Heaths. An interesting development during 1936 has been the reduction in intensity of the pine shoot moth attack in the pine plantations at Wareham. In 1935 the attack was very bad, and judging from experience in the Eastern Counties it was assumed that it would be even worse in the following year. Actually the infestation died down to a great extent and the trees made a remarkably good recovery.

The last season's growth has somewhat altered the position as regards the more exacting species, such as the spruces, Japanese larch, and Douglas fir. These did not have a good season at Wareham, there was a general yellowing of the foliage and reduction in length of shoots as compared with the previous year. The pines on the other hand made excellent progress, especially those in the manured plots. One point, which is very evident on the ground, is the rapid variation in soil quality, showing the need for the replication of treatment plots. This is brought out in the following table relating to Experiment 17. P.33 which is in two sections, A and B, separatedby about 100 yards. The primary object of the experiment was to test the effect of basic slag upon seedlings and transplants of five species.

Species.	Age of Plant.	Section.	Manured with slag.		Unmanured.	
			Height. in.	Shoot. in.	Height. in.	Shoot. in.
Scots pine	1 x 0	A	14	6.5	5	1.5
	"	B	14	4.0	8	0.5
	1 x 1	A	32	11.5	14	2.0
	"	B	21	10.5	10	1.5
Corsican pine	1 x 0	A	11	6.0	2	0.5
	"	B	9	6.0	2	0.5
	1 x 1	A	22	9.5	6	1.5
	"	B	18	9.0	6	2.0
Pinus contorta	2 x 0	A	26	10.5	8	1.0
	"	B	16	8.0	7	1.0
	2 x 1	A	19	7.5	8	1.5
	"	B	21	8.5	11	3.0
Japanese larch	1 x 0	A	11	3.0	6	1.0
	"	B	11	2.5	4	0.5
	1 x 1	A	33	6.5	9	0.5
	"	B	19	3.5	5	0
Sitka spruce	1 x 0	A	10	2.0	3	0.5
	"	B	10	2.5	3	0.5
	2 x 0	A	14	3.0	7	0.5
	"	B	11	2.0	6	0.5

In most cases the plants have grown better in Section A than in Section B. Seedlings are on the whole well behind the transplants while the stimulus due to the slag is very marked even in Pinus contorta, a species which usually manages to grow fairly well without any manuring. The most rapid growth is shown by the 1 x 1 transplants of Scots pine, though the Corsican pine are not far behind.

Dr Rayner's P.33 plots are now even more striking than they were last year, the best composts have produced very fine seedlings which show no sign of any fall-off in rate of growth. In 1936 Dr Rayner prepared further supplies of the two most successful composts, C.1 and C.5, made from straw and hop waste respectively, and these were dug in at the rate of 2 lb. per patch, or approximately $2\frac{1}{2}$ tons per acre. Other plots were treated with basic slag and there were plots of transplants. The C.P. sown in the patches treated with hop compost have grown outstandingly well. Basic slag has not had time to produce much effect, but results should be visible before the end of this growing season. The contorta have not shown the same response to the compost as the Corsican.

Lawson Cypress continues to grow well and a further plot of this species is being planted.

iv. Thetford Forest. A recent assessment of the P.28 species plots shows the importance of locality in this area. Two blocks were planted in the same year one at Olly's in the south of the Forest and the other at Lynford 4 to 5 miles to the north. While the pines have done almost equally well in both areas Douglas fir and European larch have made good growth at Olly's but almost failed at Lynford. Frost has been the chief factor in producing this result. See table below:-

Locality.	Species.	Average Height. feet.	Average Shoot. in.	Longest Shoot. in.
Olly's	Scots pine	8.0	18	36
Lynford	"	7.0	14	33
Olly's	Corsican pine	8.0	18	34
Lynford	"	7.5	18	30
Olly's	Douglas fir	13.0	30	60
Lynford	"	3.0	8	35
Olly's	European larch	9.0	16	48
Lynford	"	3.5	9	32

There is a number of other experiments at Thetford dealing with Douglas fir and European larch in which various treatments have been tested, such as size of plant, method of soil cultivation, method of planting, hoeing etc. In general the results tally much more nearly with those at Lynford than at Olly's. Owing to recurrent frost and drought failures have been excessively heavy, and no solution to the problem of establishment has been found. The one fact which does stand out is the importance of using strong, well-rooted transplants. Experiments with beech planted in the open have been even less successful, frost and drought destroying the plants. The attempts to introduce beech under older Scots pine have largely failed owing to drought and damage by deer, hares, etc. Last year weather conditions were more favourable and many of the surviving plants made good growth. The weather is clearly the most important factor in the Thetford area; given two successive years after planting, free from either late frost or prolonged drought during the growing season, and the problem of establishing beech or Douglas fir would be relatively simple. Unfortunately such favourable conditions seem to be rare and the planting of any species except pine is hazardous.

v. Chalk Soils. The alders are the best of the nurse crops tried at Buriton, and Oregon alder appears to be the most successful species of alder. Growth is, however, curiously irregular; for example three out of four P.30 plots of Oregon alder in the same experiment average 14 feet in height and canopy is closed, in the fourth plot the height is only 7 feet, there are many blanks, and the plot is virtually a failure. There is no apparent explanation for the poor growth in this plot.

Beech seedlings and transplants were introduced into some of the alder plots in P.33. The following table summarises the results to date.

	Beech Seedlings.			Beech Transplants.		
	Losses per cent.	Height in.	Shoot in.	Losses per cent.	Height in.	Shoot in.
Planted in Grey Alder	50	10	3.5	30	23	8.5
Planted in Oregon Alder	55	16	6.0	25	32	13.0
Planted in open	35	11	4.0	35	21	7.0

The chief results are, firstly, the better take and much faster growth of the beech transplants than the beech seedlings, and secondly, the good growth of the beech transplants in the Oregon alder plot, where the plants have established themselves really well and with relatively few failures. The Oregon alder were the only plants which were tall enough in P.33 to provide any appreciable degree of shade and I think the lesson is that the introduction of beech should be delayed until the alder are not less than 10 to 12 feet in height and are able to give an appreciable amount of shelter.

A similar experiment in the following year gave opposite results as regards the use of seedlings and transplants of beech, the seedlings being in this case the more successful type of plant.

Ash were planted into one of the grey alder plots in P.33 but show great variation in growth evidently related to soil conditions. The ash did well where the alder grew successfully, but are very poor where the alder have failed.

	Ash planted in P.33.			
	Av.Height	Av.Shoot	Tallest plant	Longest shoot
	in.	in.	in.	in.
Grey alder P.31				
Sub plot 1.a	34	13.5	80	38
" 1.b	20	1.5	28	5
" 1.c	27	7.5	49	26

Sub plot 1.a adjoins a shelter belt and ash are making good growth also in the open next to the shelter belt. The grey alder now average 10 feet in height in the best plots and have formed canopy.

Further plots of grey alder were planted in a different part of the forest in P.32 but have not done well. Whether the poor results are due to the weather conditions following planting or to soil factors is a question requiring investigation.

Two experiments carried out to test the value of screefing off the turf before planting beech showed conclusively the necessity for screefing on this type of land. Losses were much higher in the unscreefed plots and subsequent growth has been poor.

vi. Loam and Clay Soils (Hardwoods).

(a) Poplar. A number of the poplar experiments at Yardley and Selby Forests have been assessed. The Yardley plots are disappointing, none of the special methods hitherto employed having proved successful. It is possible that the dry summers of 1933 - 35 have affected the growth and that the plots may improve given more favourable weather conditions. In the current planting season manurial treatments have been given for the first time and the ground has also been intensively drained. It will be some time before the results of this work become apparent.

The Selby experiments have not been much more successful than those at Yardley, nursery manuring with farmyard manure has given disappointing results. It seems evident that heavy nursery soils are unsuitable for the raising of poplar. The mounding up and hoeing of checked poplar in the forest has not led to any significant improvement.

(b) Walnut. Some largeplants of Juglans regia and Juglans nigra were given special treatment in Kennington nursery, part being stumped and relined and part relined without being cut back. The stumped plants made good growth in the nursery and both lots were planted out at Yardley in P.35 and at Bedgebury in P.36. At Yardley the stumped plants have made excellent growth, the shoots averaging 12 - 15 inches in P.36 while the untreated plants made little new growth and suffered considerably from die-back. The differences were less pronounced at Bedgebury where both types of plants made good growth in the first year.

(c) Oak. Weeding experiments at Alice Holt, Rockingham and the Forest of Dean suggest that the composition of the vegetation is the important factor. Wherever the herbage is mixed the oak will usually get through in the long run, but

weeding often becomes essential when one species or type of weed is dominant e.g. coarse grass, bramble, bracken, or oak coppice.

As a whole the oak plots are getting away well and have recovered satisfactorily from the 1935 frost. In most areas one-year seedlings have grown better than comparable plots of direct sowings.

Of the nurse species tried at Drayton in Rockingham Forest, Alnus oregona is the best. The five-year-old plants are now 6 - 7 feet in height and putting on very good shoots. Lawson Cypress has done well in two plots but failed in the third owing to frost.

(d) Ash and Sycamore. The hoeing experiments with ash and sycamore at Tintern continue to show a response as a result of the hoeing. The ash groups which were hoed in 1935, the year of planting, were divided into two series of plots half of which were hoed in 1936 and half left unhoed. The results are as follows:-

	Average Height. ft.	in.	Av. shoot growth in 1936. inches.
A. Control	2	2	1
B. Hoed first year only	3	9	16.5
C. Hoed first and second years	4	2	23.5

The plants in B & C were sturdy with large terminal buds but the plants in C had distinctly darker green and larger leaves than those in B. The B plots are beginning to grass over and may fall-off more definitely in growth this year. A point of special interest is the fact that the unhoed, control, plants, which put on quite good shoots in the first year have now gone into check.

Sycamore also have responded to hoeing though the improvement is less marked than in the case of ash. Shoot growth in the hoed plots has been just double that of the unhoed plants - 22 in. as compared with 11 in.

5. Summary of Plantation Experiments carried out in P.37.

(i) Peat soils. Test of manurial action of basic slag of varied grade and solubility. (In co-operation with the Basic Slag Committee). At Glen Righ Forest with Japanese larch.

Trial of copper salts at Inchnacardoch.

Application of phosphate to plant roots by means of a puddle composed largely of ground mineral phosphate. - Achnashellach.

Mixed plantation of Sitka spruce with alder and birch. - Kielder.

(ii) Upland Calluna Soil. Preliminary trial of Alnus sitchensis at Teindland.

Trial of copper salts at Teindland.

Formation of a mixed plantation of pine, larch, and alder on ploughed ground - Teindland.

Use of straw compost - Teindland.

Planting out of compost-treated plants - Allerston and Harwooddale.

Trial of the French Plant-roll Machine - Teindland and Allerston.

Direct sowing on moorland seed bed treated with Dr Rayner's hop waste compost - Allerston.

(iii) Dorset Heaths. Trial of direct sowing in patches on ploughed ground. Patches treated with compost prepared by Dr Rayner from sawdust - Wareham.

(iv) Chalk Soils. Planting of plot of Oregon alder - Buriton.

(v) Loams and Clay Soils. Hoeing of ash and sycamore - Tintern.

Planting of large walnut - Tintern and Bedgebury.

Start formation of Poplar Garden - Yardley.

(vi) Other.

Provenance plots of:-

Hybrid larch - Drummond Hill, Clashindarroch, Harwooddale.

European larch - Drummond Hill, Clashindarroch, Mortimer.

Japanese larch - Drummond Hill, Clashindarroch, Achnashellach, Harwooddale.

Pinus contorta - Clashindarroch, Achnashellach, Teindland.

Scots pine - Findon, Monaughty.

Norway spruce and Sitka spruce - Nevis, Kielder.

Spacing plots (replicated) of European larch - Clashindarroch.

Extension of plants root pruned in the nursery - Clashindarroch.

Extension of nursery experiments on the lining out and bedding out of Norway spruce and Sitka spruce ... ... - Newcastleton.

Underplanting of European larch sample plot with Beech, Tsuga, Douglas, Thuya, and Nothofagus procera ... ... - Haldon.

Trial of Ailanthus glandulosa and Platanus acerifolia ... ... - Llanover.

6. Progress of Special Investigations.

(1) Pruning. An experiment on degree of pruning has been started in a Scots pine plantation at Edensmuir.

Further trials with different pruning implements have been carried out in the Forest of Dean.

(2) Progress of Plantations in industrial Areas. Mr Day and Mr Sanzen Baker have examined plantations in Llanover and Llantrisant Forests as well as in other smoke-affected districts. The objects of the investigation were to determine the causes of the unsatisfactory state of many of the plantations and to determine the best species for these areas. An interim report has been submitted from which it appears that incorrect choice of species has been one of the principal causes of the trouble. Partly owing to the mining operations and partly owing to the nature of the soil the lower slopes of the hills are very dry and these slopes and still more the valley bottoms are danger zones from the point of view of late frosts. In the past the mistake has been made of planting frost-tender and exacting species such as Douglas fir, European larch and Sitka spruce on these sites. The success of the plantations has been further prejudiced by heavy weed growth, use of poor plants, and often unsatisfactory planting. Honey fungus and Fomes have also played a destructive part in the former coppice areas on the lower slopes.

Messrs Day and Sanzen Baker have been unable to find much direct evidence as regards the action of the industrial fumes and they are not inclined to consider these as an important factor. The species that have done well at Llanover are Japanese larch, Corsican pine, Scots pine, Sitka spruce and Norway spruce on the higher slopes, and, in recent plantings beech. One interesting point is the relative success of the Intermediate form of Douglas fir from the Upper Fraser River; these have stood the conditions much better than the coastal Douglas.

(3) Progress of Poplar Plantations in Commission Forests. Mr Day and Mr Sanzen Baker have carried out a survey of the principal blocks of poplar planted on Commission land. Root examinations have been made and the form of root system developed

has been worked out. The methods used in forming the new poplar garden at Yardley are in part the outcome of this enquiry. A report on the investigation is expected shortly.

7. Measurement of Permanent Sample Plots.

Two interesting sample plots were established in a 31-year-old mixed crop of Douglas fir and Corsican pine which was growing on blown sand adjoining Culbin Forest. The Douglas fir are 34 feet in height, about 2 ft. higher on the average than the Corsican pine. This represents the slowest growth of Douglas that we have met in the sample plot work. One of the plots has been thinned to favour the Douglas fir while in the other it is hoped to obtain a final crop of Corsican pine but including a small proportion of the best of the Douglas fir.

The four sample plots of Japanese larch at Hafod Fawr were remeasured last year. These lie at elevations ranging from 750 ft. to 1480 ft. above sea-level and the height growth varies inversely with the elevation. It is satisfactory to find that the plots at the higher elevation are putting on the relatively good increments of about 120 cubic feet per acre per annum.

The Japanese larch plot at Highclere was measured for the fifth time. It is now 41 years old and is the oldest sample plot in the country of this species. There are 200 trees standing per acre with a mean quarter girth of 8 inches and height of 63 feet. In spite of the repeated heavy thinnings crown development is relatively poor (crown per cent only 27). Height increment is improving again after a period of slow growth round about 1925 and possibly associated with the drought of that year. The height increments have been as follows:-

Period	1916-22	1922-27	1927-32	1932-36
Increment (feet)	9	3	4	6

A plot of Douglas fir at Kildrummie, Aberdeenshire is interesting for the evidence it affords on recovery from attack by Chermes cooleyi. The infestation began in 1926, and for a time the trees were almost completely defoliated. The plot has now recovered from the attack. The height and basal area increments were:-

Period	1921-26	1926-31	1931-36
Height increment (feet)	10.5	6.5	9.5
Basal area increment (sq. ft.)	12.3	3.0	8.7

8. Botanical Research.

(i) Mycorrhiza Research. Dr M.C. Rayner. The current laboratory investigations include (1) manuring experiments with Scots pine sown in Wareham soil. Some of the pots include the composts which have given such striking results in previous pot experiments and in the field. There are other pots to which are added the equivalent mineral nutrients contained in the composts, and another series contains cow manure. The object of the experiment is to meet the criticism that the improvement in growth may be due to the mineral nutrients contained in the composts.

(2) The addition of varied quantities of cellulose to three soils, ex Wareham, Oxshott, and New Forest, respectively, Scots pine being used as indicator.

(3) The addition of an inoculum of native European larch humus to pots containing soil from Wareham and the New Forest, pots sown with European larch.

(4) Test of the comparative qualities of two composts, C_1 and C_7 made from straw. Sown with Scots pine, Corsican pine and Pinus contorta on a mixture of Wareham soil and the respective compost.

The field experiments at Wareham have already been mentioned. Those at Allerston have given very similar results Seedlings of Corsican pine raised on the Moor in beds treated with hop waste compost are definitely better than those raised in Wykeham Nursery. In previous experiments there was no improvement in growth as a result of adding compost to ordinary nursery soil and it remains a puzzle why the addition of compost to very poor moorland soil at both Wareham and Allerston should produce stronger seedlings than can normally be produced in a nursery. The difference may possibly be due to a greater mobilization of nitrogen in the natural soil as a result of the action of the compost. In Dr Rayner's view the organic composts act "as a means of bringing about change of direction of the biological activities responsible for humus decomposition." This change results in the formation of a "substrate favourable to root growth, mycorrhiza development, and general nutrition in the young trees". There is also a possibility that specific growth-promoting substances are present in individual composts.

(ii) Dr E.V. Laing - Root Development of European larch Seedlings. The investigation has been brought to a close, the three years allotted to the work having elapsed. The issue of a report has been delayed owing to the illness and subsequent death of Professor Borthwick.

9. Research on Forest Soils.

Dr A. Muir of the Macaulay Institute has submitted a preliminary report on his survey of the forest areas near Huntly. Two Scots pine sample plots near Strachan, Kincardineshire, have been sampled and the work of testing the uniformity of the soil in these plots is in progress.

Dr Muir has recognised the following types of soil as occurring in this area:-

1. Brown Forest Soils (aclimatic): (a) Basic igneous rocks and drifts in all well drained positions. (b) Drifts from other rocks on well drained moderately steep slopes.

2. Brown Forest Soils with gleyed C horizon: On basic igneous parent materials.

3. Flush Soils: Mainly on basic igneous parent materials, but occasionally on others. Depressions with outlet.

4. Podzolised Soils: Mainly on rocks and drifts other than basic igneous, but one or two examples on basic igneous drift have been found. Mainly well drained slopes and flat sites.

5. Peat Podzolised Soils (up to 50 cm. peat): On all except basic igneous parent materials. Slopes and flat sites.

6. Peat Gley Soils: On all parent materials. Depressions.

7. Peat - over 30 cm. in depth. Confined mainly to the Clashindarroch area in depressions and on higher ground.

These groups form the basis of the classification but in practice most of the main types require further subdivision either on the parent material or on morphological differences, e.g. presence or absence of hard pan in the group of podzolised and peat podzolised soils. In certain cases the vegetation provides a suitable basis for subdivision, e.g. the Brown Forest Soils under Calluna Heath or under juniper and grasses. Analytical data are provided for all the main types.

By the end of this summer the whole of the Clashindarroch and Bin Forests will have been mapped by Dr Muir and the vegetation surveyed independently by Dr G.K. Fraser. It is proposed to have a final inspection of the area to correlate the survey with the allocation of tree species for planting.

10. International Union of Forest Research Stations.

The meeting of the above Union in Hungary was attended by the Chairman, Dr Muir, and myself. Paper-reading sessions were held in Budapest and other towns and visits were made to the principal areas in which research was being conducted. Conditions were very different from those in this country but it was interesting to find that the study of the natural vegetation was as helpful in determining the choice of species as it has proved to be with us. Root excavations were also an important line of research in Hungary.

11. Entomology.

Pine-shoot Beetle. Mr H.S. Hanson, who has been working on this pest for some years, submitted a full report on his work which showed that although much useful progress had been made further information was required on matters relating to practical control. In particular a survey was necessary to determine the relative incidence of the two species Myelophilus piniperda and Myelophilus minor and also more extensive tests of various methods of trapping. It was decided that Mr Hanson should carry out a general survey, this survey to be combined with experiments with trap stems and on the disposal of thinning material. The greater part of this work should be completed by April 1938.

Pine Weevil. The experiment on the trapping of weevil in pine woods before felling has been continued in the New Forest and data will be collected from trapping operations during the current season.

Pine Shoot Moth. Several thousand parasites of the pine shoot moth were bred out at the Farnham House Laboratory from material obtained from Austria. The parasites were liberated in Wareham and Rendlesham Forests. Difficulty was found in synchronising the liberation of the parasites with the emergence of the moth and it is possible that the parasites were freed a little too soon. It is not yet known whether the parasite has succeeded in establishing itself in these two forests.

Oak Leaf Caterpillar. Mr Brown has prepared a comprehensive report on his observations on the caterpillar epidemics in the Forest of Dean. There is much interesting matter in this report which should be useful as a basis for further entomological research. Mr Brown puts forward two reasons for the fact that pure oak woods suffer more seriously from defoliation than mixed woods.

(1) The pure woods carry a smaller population of insectivorous birds.

(2) The survival of the most abundant parasite (Pimpla maculator) of the Tortrix depends, in some degree at least, upon the availability of secondary host caterpillars feeding mostly on plants other than oak. Mr Brown also found that the survival through the winter of Pimpla maculator is favoured by the occurrence of conifers in the oak areas, this parasite apparently preferring to hibernate on conifer needles.

The relative immunity of the sessile oak is apparently due mainly to the fact that the buds flush earlier than pedunculate oak so that the lower branches are in full leaf before the caterpillars are ready to descend from the upper part of the crown. In the pedunculate oak when the caterpillars are active the leaves are only just developing so a smaller number of caterpillars may do a larger amount of damage.

Chafer Larvae. Experiments on the control of chafer larvae by the use of soil insecticides or repellants have not given conclusive results. Here and there they seem to have been effective but often it has been impossible to claim any real measure of success. Meanwhile the damage in the nurseries continues and the need for a fresh line of approach appears evident. The conclusion has been reached that before we can hope to get much further we must know more about the distribution of the chafer in our nurseries. This is work for a trained entomologist and it has been decided that Mr Brown shall give his whole time to the survey.

It is possible that parasites may play an appreciable part in the control of chafer and Dr Thompson hopes to secure a research student to work on this problem at Farnham House Laboratory.

Chermes cooleyi on Sitka spruce. Dr A.E. Cameron has published a paper on the occurrence of cooleyi galls on Sitka spruce in Scotland. None has yet been found in England & Wales in spite of a few false alarms. There appears to be no reason for anxiety about this pest.

Pine Sawfly. The Farnham House Laboratory investigated an outbreak of pine sawfly at Brendon Forest in Somerset. The intention was to liberate an introduced parasite, Microplectron fuscipennis, with a view to controlling the pest. Examination of sawfly cocoons collected in July 1936 showed that there was already about 90 per cent parasitism by a native parasite Microcryptus basizonius. It was evident that at this stage in the outbreak, which had been developing for six or seven years, nothing was likely to be gained by the introduction of a new parasite. However, as the Microplectron were available they were liberated and the results will be ascertained in due course.

Polygraphus on Spruce. Two outbreaks of this bark beetle have been discovered in the Eastern Counties of England. Norway spruce, scattered among broadleaved trees, has been the subject of attack and many trees have been killed. Polygraphus is known as a pest of minor importance in Germany and it does not appear likely to be a menace to spruce areas in other parts of the country.

12. Vole Disease.

A vole census was carried out in the autumn at Newcastleton, Glenfinart, Glenbranter, and Corris Forests. Voles were numerous in several parts of the Border Country and in part of North Wales, but were very scarce in Argyll.

The most important result of the pathological work has been the discovery of tuberculosis in voles collected from different centres in England, Wales and Scotland. The disease is found attacking the lungs and tissues of the back. It has been definitely identified as a mammalian strain but it is not yet certain if it conforms to the human type or to that occurring in cattle. It is not known if the disease is a recent phenomenon or if it existed in previous years but was undetected. In any case the discovery is of great importance in connection with the spread of tuberculosis.

13. Mycology and Pathology.

Frost Investigation. Mr Day and Mr Peace have prepared a full report on the damage caused by the late frosts of 1935. The meteorological and other factors involved are also discussed in this report, which is now in the Press for publication as a Forestry Commission Bulletin.

Heart-rot of Conifers. Mr Peace has now completed his survey. He has visited many woodlands on private estates as well as in the Commission's operations. A report will be published shortly.

Elm Disease. The survey carried out in the autumn threw some fresh light upon the northern extension of the disease. Infected trees have been recorded from Northumberland, and the range of the attack in Lancashire and Durham is greater than was first thought.

The disease was late in appearing in 1936, but during August and September die-back was observed on large numbers of previously healthy trees and there was thus a considerable extension of the disease. The rate of spread is still curiously irregular. In some areas, despite abundant sources of infection, progress has been slight, while in other areas the disease has suddenly increased in intensity. Worcestershire is an example of a county in which the disease has flared up in recent years.

Dr Walter, an American pathologist who has been studying the disease over here, has found large numbers of fungal fructifications between the wood and the bark of recently killed trees, and also in the galleries bored by the bark beetle. Cases have also been seen when local outbreaks have started in the neighbourhood of piles of elm limbs, the disease having been spread by beetles breeding in the bark of the limbs and migrating to healthy trees near by. These observations indicate the importance of removing diseased material as promptly as possible.

The immune strain of Ulmus foliacea is being propagated.

Damping-off in Nurseries. There was little damping-off last year in the nurseries. The experiments on control are being repeated this year at Chopwell and Tulliallan.

Watermark Disease of Cricket Bat Willow. Work on this disease is proceeding along two lines, control by administrative action in the County of Essex, and a scientific study of the method of spread of the disease. The authorities in Essex are taking more active steps to administer the Watermark Disease Order, and it is proposed to spend nearly £1000 on this work in the current season. One whole-time inspector and two temporary inspectors have been appointed by the County Council.

Dr W.J. Dowson of Cambridge University is in charge of the investigation on the means by which the disease is conveyed from infected to healthy trees. It will be recalled that in 1936 the Commissioners provided a grant enabling the appointment of an entomologist, Mr McC. Callan, to assist Dr Dowson in the field. This grant was not sufficient to cover the work for the whole season and the investigation was further financed by a grant from the Agricultural Research Council. The results of the work done last year were not wholly conclusive and application was made for a further grant for the current year to enable Mr Callan to extend his observations over a second season. After consultation with the Secretary of the Agricultural Research Council it was decided that the Commissioners should finance this work, and a Grant of £180 has been provided as a final contribution.

14. Utilisation.

Further examination of pruned timber, and also analyses of unpruned logs have been carried out by Mr G.H. Donald of the Forest Products Research Laboratory. Having regard to the stage now reached it is doubtful if much can be gained by proceeding further along these lines, and it would seem better

to wait until material is available from the experimental pruning carried out in the Forest of Dean and elsewhere. The chief need at the moment is to extend the scope of the pruning experiments, more particularly as regards the advisability of pruning live branches of the spruces.

The growing importance of the plywood industry has led to a decision of the Laboratory to investigate problems connected with plywood. The use of home grown timber for this purpose is a matter of direct interest to the Commission.

15. Fundamental Research.

A special meeting of the Advisory Committee on Forest Research was held in December 1936 to consider how provision could be made for fundamental research arising out of forestry problems. An agreed report was drawn up, copies of which have been sent to the Secretary of the Agricultural Research Council. Further action awaits discussion between the Commissioners and the Agricultural Research Council.

W. H. G.