Memo No. 45/39.

FORESTRY COMMISSION

PROGRESS REPORT ON FOREST RESEARCH

JUNE 1939

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REPORT ON FOREST RESEARCH

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1. STAFF.

There have been a number of changes in the organisation of the local supervisory staff. The south of Scotland has proved too large an area for the supervision of one man, and has been divided into two districts with a research forester in charge of one district and a research foreman in charge of the other.

An additional district has been formed in England & Wales, comprising Wales and the new experimental area at Hope Forest in Derbyshire. The research foreman in charge is stationed temporarily in the Forest of Dean.

A temporary arrangement has been made between the Commissioners and St. John's College, Oxford, whereby the research forester at Kennington gives part-time supervision in Bagley Wood, In return the College grant us certain facilities.

2. NURSERY INVESTIGATIONS.

(1) Experimental work on the use of different types of soil covering continued during the past year; the latest results emphasise the importance of using the right type of sand or fine gravel. A costing experiment carried out at Tulliallan and Newton nurseries gave the following data: -

(T = Tulliallan and N = Newton in the table)

Type of Covering	Total cost of material and application and weeding £ per acre		Total output of seedlings 1000's per acre		Net Value of seedlings £ per acre		Profit or Loss on Treatment £ per acre	
	T	N	T	N	T	N	T	N
Nursery Soil	22.6	22.4	1,390	2,390	320	570	-	-
Sand	45.4	84.6	1,390	4,280	300	990	- 20	+ 420
Grit (up to ¼")	59.9	73.5	1,640	4,540	350	1060	+ 30	+ 490
Chips (¼" - ⅜")	46.3	61.9	2,390	3,280	550	750	+230	+ 180

The sand and the grit used at Tulliallan were neither of them good covering materials, both containing a good deal of silty matter mixed with the coarser particles. The Newton sand and grit were ideal for the purpose, containing no very fine sand or silt.

The table shows that though the use of imported covering material increased the cost at Newton by about £55 per acre the higher germination due to the use of sand or grit almost doubled the value of the stock, the increase in value being about nine times the cost of the treatment.

It will be noted that the chips gave a greatly improved yield at Tulliallan which much more than covered the cost, but in the same nursery there was a loss of £20 per acre as a result of covering with an unsuitable type of sand. Cost of weeding was found to vary in the two nurseries; at Tulliallan, sand and chips cost little more to weed than the nursery soil; in both nurseries the grit-covered beds cost from two to three times as much to weed as the nursery soil. At Newton the sand and chips were nearly as expensive to weed as the grit-covered beds. The relative weeding costs were taken into account in calculating the result of the various forms of covering used.

These results are supported by a series of experiments in Kennington nursery in which various forms of covering material were tested against Bedford silver sand, which has been for years the standard covering material at Kennington. Bedford sand improved the germination of Sitka spruce, Tsuga, and Lawson cypress by from 50 to 100 per cent compared with washed grit or limestone chippings. Powdered pumice was also tried but proved too light and so too easily removed by wind.

The practical conclusion from these experiments is that in nurseries liable to caking, and for small-seeded species such as Sitka spruce, Tsuga, and Lawson cypress, it may pay to use the

best form of covering material available. An increase in the yield of one year seedlings of the order of 50 per cent is easily obtainable, and the resulting gain then outweighs any initial difference in the cost of the covering material.

(2) Further work on the stratification of seed of Pinus contorta led to a slight break in the series of successful results. The data are as follows:

	Method of Treatment	Production of one year seedlings per lb. of seed
A.	Seed stored dry, sown April 7th	44,000
B.	Seed stratified on January 29th, sown April 7th	24,000
C.	Seed stratified on February 28th, sown April 7th	68,000

A June count showed that the B plots had produced quite as many seedlings as the control but, owing to a severe attack of damping-off, heavy losses were experienced in the plots sown with stratified seed. The losses were much greater in the B plots, where the seed had had the longer period of stratification, and was evidently related to the time of germination. The A plots germinated on May 17th, the C plots nearly 3 weeks earlier, on April 28th, and the B plots another 6 days earlier, on April 22nd. It is remarkable that the relatively small difference of 6 days in the date of germination should have had such a big effect on the severity of attack. The later germinating control plots were virtually unaffected. Treatment with permanganate of potash failed to check the disease to any great extent.

It will be noted that despite a certain amount of loss from damping off short-period stratification (C plots) increased the output by about 50 per cent.

(3) Experiments on density of sowing in both countries led to the conclusion that the standard densities recommended in the Silvicultural Circular No.15 are satisfactory in most years for the spruces and Japanese larch. Thinner sowing than standard produced a larger proportion of the strongest grade of plants but when cost of preparation of ground and weeding are taken into account the balance is in favour of the standard density. On the other hand heavier than normal sowings gave inferior results in most cases. One interesting point is that the proportion of 'cull' plants was very similar in all densities. It appears that no matter how thin the sowing there is an irreducible minimum percentage of inferior plants, probably accounted for in many cases by delayed germination.

The question of the relative merits of drill sowing and broadcast sowing is one which has given rise to a good deal of controversy and at Kennington the density of sowing experiments have been duplicated by the two methods. The results of a P.36 experiment are set out below, the data relating to the standard density of sowing.

Number of Grade I 2 yr. seedlings per pound of seed

Species	Broadcast Sowing	Drill Sowing
Sitka spruce	38,000	16,000
Norway spruce	19,000	19,000
Japanese larch	12,000	16,000

The increased production of Grade I seedlings of Sitka spruce is quite striking. There is some confirmation of this result from more recent experiments which are tabulated below:-

Total outturn of seedlings per pound of seed

Species	Nursery	Broadcast Sowing	Drill Sowing
Sitka spruce	Tulliallan	48,000	34,000
Sitka spruce	Newton	99,000	47,000
Sitka spruce	Kennington	107,000	86,000
Scots pine	Tulliallan	43,000	44,000
Scots pine	Newton	46,000	49,000

The Sitka show a higher total yield from broadcast sowing in every case. The cause of the difference is not apparent, nor is it clear why Sitka spruce should be the only one of the four species used to show such a decided preference for broadcast sowing.

(4) In previous years noneof the attempts made to increase the size of conifer seedlings by applying artificial manures has been very successful but in the last two years trials have been carried out with a dilute solution containing ammonium sulphate, ammonium phosphate, and potassium nitrate, applying the solution at intervals of about 3 weeks, from the beginning of July to the middle of August, to one year and also to rising two year seed beds of European larch, Scots pine and Sitka spruce. At Altonside nursery the manured seedlings were twice the height of the unmanured plants at the end of the second year and much superior both in colour and needle-length In the case of Sitka spruce there was an increased production of long roots, but when samples were sent to Dr Rayner for detailed examination she gave an adverse report, stating that the roots were no better than those of the controls and lacked the proper mycorrhizal structures which characterise healthy plants. At Kennington this

treatment was applied to rising 2 year Tsuga seedlings, some of the plants receiving two and others ten applications during the growing season. When lifted and graded the following results were obtained.

Percentage of Seedlings in each Grade

	Grade I over $3\frac{1}{2}$"	Grade II $3\frac{1}{2}$" & under	Culls
A. Unmanured	32	63	5
B. Manured 2 applications	43	53	5
C. Manured 10 applications	63	32	5

Treatment C. has produced a substantial improvement in the size of the plants. It was observed on lifting these plants that the roots in C. remained active till late in the year and that there was relatively little short-root development. The implications of this are not yet apparent.

(5) The most striking of all the various attempts to produce large one year seedlings of Sitka spruce was obtained last year at Kennington by following up some preliminary experiments carried out by Dr Rayner in P.37 using soil collected from below an oak stand in the New Forest and mixed with hop-waste compost; when Sitka spruce was sown on this mixture of woodland soil and compost, very fine seedlings were produced. At Kennington a boarded seed bed was excavated and filled up in sections with the following soil media:

A. Kennington nursery soil.

B. Kennington nursery soil plus 10 lb. of hop-waste compost per square yard.

C. Soil from an open oak stand in Bagley Wood 'inoculated' with humus from a plantation of Sitka spruce.

D. The same soil plus compost.

Seed of Sitka spruce was sown broadcast on April 26th 1938. The production and growth at the end of the first season are shown in the table below.

Soil Medium	Production per lb. of seed	Average size of seedling	Maximum size of seedling
		inches	inches
A. Nursery Soil	90,000	1	$1\frac{3}{4}$
B. Nursery Soil plus compost	88,000	$1\frac{1}{2}$	3
C. Bagley Wood Soil	136,000	$1\frac{1}{2}$	3
D. Bagley Wood Soil plus Compost	116,000	$2\frac{1}{2}$	$4\frac{1}{2}$

The ordinary nursery soil produced a moderate seedling averaging 1 inch in height at the end of the year, the composted Bagley Wood soil however gave a seedling averaging $2\frac{1}{2}$ inches in height, a remarkable result in such an unfavourable growing season.

Dr Rayner has been good enough to examine these seedlings and the following is a summary of her report.

A. Kennington Nursery soil. Root system poor. Roots devoid of normal mycorrhizas. Both short and long roots show a pseudo-mycorrhizal by a fungus of the Rhizoctonia type.

B. Nursery soil plus compost. Root system much more branched than in A: majority of roots non-mycorrhizal but some infection by 'Rhizoctonia'.

C. Woodland soil. Root system fair. A few of the roots have normal mycorrhizas. The majority show infection of the 'Rhizoctonia' type.

D. Woodland soil plus compost. Root system well branched with greater development of sub-laterals. There are many mycorrhizas of the normal type. Relatively little infection by 'Rhizoctonia'.

When the seedlings are two years old they will be lined out and eventually planted on two distinct sites the one a good spruce soil, e.g. a Molinia peat, and the other a difficult soil for spruce, e.g. Allerston or Hope. The relative behaviour of the plants on these two sites should enable us to assess the importance of the mycorrhizal types of young root systems as shown by these four lots of plants at Kennington.

(6) Experiments on the use of peat continue to give discordant results. At Tullialian, where the soil is a clay loam the total germination of Sitka spruce as well as the yield of Grade I seedlings have both been consistently lower in those plots which were treated with peat. Neither time of application of peat nor watering at time of application has affected this result. By way of contrast the use of peat at Kennington has given almost consistently better plants than the ordinary nursery soil and this superiority tends to be maintained after three successive sowings on the same peat/soil mixture. Taking these results in conjunction with various divisional nursery experiments on the use of peat it seems clear that the reaction of a nursery soil to

peat is at present unpredictable. On the evidence available those nurseries in which peat has given good results are much in the minority.

(7) A year or two ago Mr Young got some very definite results at Ringwood Nursery with nitro chalk applied to Sitka spruce seed beds before sowing. This manure greatly improved the size of the seedlings. A repetition at Kennington depressed the germination and resulted in no improvement in the size of the plants.

(8) An attempt was made at Tulliallan to assess the effect of cultivation between the lines of 2 year 1 (rising 2 year 2) transplants of European larch and Scots pine. The data are given in the table.

Height Grade	No. & per cent of Plants in each Grade			
	Not hoed		Hoed	
inches	No.	%	No.	%
3 - 4	90	1.8	48	.9
5 - 6	693	13.8	525	10.0
7 - 8	1234	24.5	1129	21.6
9 - 10	1514	30.1	1608	30.8
11 - 12	900	17.9	1075	20.6
13 - 14	371	7.4	535	10.2
15 - 16	168	3.3	219	4.2
Over 17	57	1.1	86	1.6
Total	5027		5225	

The hoed plants have a slightly larger proportion of plants in the taller grades but the response does not appear to have been marked. Scots pine showed little difference.

(9) A few preliminary experiments have been carried out at Kennington with growth-promoting substances. Hortomone A at the rate of ½ and 1 ounce per gallon of water was applied to cuttings of aspen and London plane. The treatment was carried out in March, the cuttings being soaked for 18 hours in the solution. The percentage success was as follows:

		London Plane Percentage rooted	Aspen
A.	Control	72	7
B.	Hortomone A ½ oz. per gallon	16	10
C.	Hortomone A 1 oz. per gallon	2	5

The plane rooted very well without treatment and the Hortomone was clearly harmful (probably too concentrated). The aspen showed little response to the treatment.

Another attempt was made to strike cuttings in a cold frame during the growing season, using two plant hormones, Indolyl-acetic acid and Naphthalene acetic acid. Two frames were used, in one the rooting medium consisted of 10 inches of sand over turfs over large stones, while in the other a 10-inch layer of sand was placed over one foot of well-firmed horse manure. The cuttings were taken with a heel, and the heel clear cut with a sharp knife. The percentage of plants which either developed roots or formed a callus from which roots may develop later is shown in the following table:

Species	Sand over turf and stones		Sand over horse manure					
	Control		Control		Indolyl-acetic acid		Naphthalene acetic acid	
	Callus formed	Rooted	Callus formed	Rooted	Callus formed	Rooted	Callus formed	Rooted
	%	%	%	%	%	%	%	%
Elm	49	11	33	23	23	30	17	20
Plane	0	0	0	15	0	30	0	60
Norway spruce	51	20	0	0	0	0	0	0
European larch	11	33	27	17	13	13	0	0

The relatively good proportion of 'takes' in the best treatments of the conifers is interesting but the most encouraging results are those for the elms in which it has been possible to root or develop callus on from 50 to 60 per cent of the cuttings in a period of two months (August to October). This is of obvious importance in connection with the raising of stocks from disease-immune trees. There is some indication that Indolyl-acetic acid has increased the rooting of the elm cuttings.

3. SUMMARY OF NURSERY EXPERIMENTS CARRIED OUT IN 1939.

Project	Nursery
Woodland Nurseries. Comparison of growth of several species on natural soils (with and without compost), and in ordinary nursery soil.	Drummond Hill, Buriton, Bagley Wood, Tair onen, Kennington, Tulliallan.
Manuring.	Fleet, Tulliallan, Kennington.
Stratification of seed of Thuya and Lawson cypress.	Kennington.
Density of Sowing Scots pine.	Fleet, Tulliallan, Newton, Kennington.
Comparison of Broadcast and Drill Sowing.	Tulliallan and Kennington.
Seed bed covering.	Fleet, Tulliallan, Newton, Widehaugh, Kennington.
Salvage of held-over seedlings by pruning and wrenching.	J.L., E.L., S.S., and S.P. at Altonside, Newton, Tulliallan, Kennington.
Control of Frost-lift.	Tulliallan.
Composting weeds with potassium permanganate.	Kennington.
Divisional Green Manuring Experiment.	Ringwood, Tair onen, Fairoaks, Buriton, Lynford, Widehaugh, Delamere, Tulliallan, Fleet.

4. PROGRESS OF PLANTATION EXPERIMENTS.

Peat Soils. During the past few years slagged Sitka spruce on the shallower Scirpus-Calluna peats at Inchnacardoch, Borgie, and Glenrigh Forests have made encouraging progress. About 4 years after planting, i.e. when the main stimulus due to the slag was over, growth slowed down considerably and there were some indications of check; but now (from 9 to 11 years after planting) there has been a decided resumption of growth and the prospects are much more promising, especially where the spruce were planted in mixture with other species, such as Pinus contorta or Oregon alder.

At Achnashellach slagged Japanese larch of P.28 have been brashed and a first thinning is almost due.

Growth of Sitka spruce and Pinus contorta has been so promising on the hand-dug (imitation ploughing) plots at Borgie that the North Division plough was sent up there recently and several acres ploughed experimentally. This ploughing has been very successful in spite of rather unfavourable conditions due to frost followed by a quick thaw and a fall of snow. The furrows turned out very cleanly to a depth of 10 - 12 inches and the tractor showed no tendency to slip or get bogged in the peat, except occasionally in a small completely-ploughed plot. Most of the area was ploughed with furrows 5 feet apart but there was also a section with furrows 15 feet apart to compare with normal turf draining and planting. The peat in this area was about 18 inches in depth, and the vegetation, Scirpus with dwarf Calluna. Part of the ploughed ground will be planted with blocks of pure Sitka spruce and Japanese larch, part with mixtures of S.S./P.C. and N.S./S.P. and part with a group mixture of S.S., P.C., J.L., S.P. and grey alder.

Upland Calluna Soils. In the previous report some data were given as to the effect of pine admixture upon the growth of Sitka spruce on ploughed ground at Teindland. The data related only to total height but during the past year the 1937 shoot growth has also been assessed and the following data obtained: - The leading shoots of the Sitka spruce in the mixed plots averaged 2.1 inches longer than those in the pure plots, with a standard error of the difference of only 0.26 in. The effect of slag on the growth of the Sitka spruce in the mixed plots is now, after 10 years, showing up very clearly: - Mean length of the 1937 leading shoot of Sitka spruce in the slagged plots 4.6 inches, in the unslagged plots 1.1 inch. Difference, 3.5 inches with a standard error of 0.28 in. The data as regards percentages of checked plants are also quite striking, in the unmanured plots over half the Sitka spruce plants are still in check, while where manure was given over 95 per cent of the plants are out of check. These results are of special interest because of the long time that has elapsed since the slag was applied, in ten years every trace of the phosphate will presumably have been leached out from the soil but the effect on the plants appears to be lasting. Root excavations show that by applying phosphate long-root formation is markedly stimulated and as conditions gradually improve owing to enclosure and drainage the manured plants with their bigger root systems are presumably able to recover more quickly than the plants which got no manure. The effect of the slag thus seems to be physiological rather than merely manurial, which greatly enhances its value on these poor soils. In the same experiment at Teindland the Tsuga have picked up remarkably in the last few years and some of the slagged plots are

almost forming canopy. In P.37 one or two of the Sitka spruce plots were recultivated (rough dug) between the rows of trees, the plants showed an immediate response in length of needle.

There is a large experimental area on Wykeham comprising some of the poorest land at Allerston forest. The experiments cover a wide range of objects, but the most interesting deal with method of soil preparation, choice of species and effect of artificial manures.

One of the most interesting experiments at Allerston is No. 6 P.28 at the north end of the area running up to the escarpment. This was given six different forms of soil preparation and was planted with four different species; it also includes three strips treated with basic slag. The soil treatments were as follows: -

A. Complete ploughing.

B_1. Three furrow ploughing.

B_2. Three furrow ploughing - slagged after planting.

C. Single furrow ploughing. Trees planted in the furrow. (This was the early Divisional method.)

D. Patches picked up and stirred with a long-bladed pick. One tree planted in each patch. (This was the later Divisional method.)

E. Explosive charges were fired at a spacing of 15 ft. x 21 ft. Trees planted at the usual spacing into undisturbed soil between the explosion cavities.

F. Trees notched into the natural surface. (This may be regarded as the absolute control method.)

Section B was the only treatment to receive basic slag.

The species used are Sitka spruce; Scots pine; a 50/50 mixture of Sitka spruce and Scots pine; Corsican pine; and Japanese larch.

The ploughing was done by an ordinary tractor-drawn agricultural plough; the work was consequently shallow, and the pan was only reached here and there in the full and 3-furrow ploughing.

The experiment was fully assessed at the end of 1937 when the plantation was 10 years old.

The following is a summary.

(1) Complete Ploughing

Species	Average Ht. ft.	Average Ht. in.	Average length of leading shoot in 1937 in.
Scots pine (pure)	4	8	13
" (mixed)	5	2	13
Corsican pine	4	3	11
Sitka spruce (pure)	2	2	1.8
" (mixed)	2	5	4
Japanese larch	4	11	13

Note. - Three out of the four species are growing almost equally well. Only the Sitka spruce is backward; this species is improving in the mixed plots but is making little progress where planted pure. The pines and Japanese larch can be regarded as successfully established.

(2) Three furrow Ploughing

Species	Average Ht. ft.	Average Ht. in.	Average length of leading shoot in 1937 in.
Scots pine (pure) (without slag)	3	11	11
Scots pine (pure) (with slag)	4	10	12
Scots pine (mixed) (without slag)	4	3	11
Scots pine (mixed) (with slag)	5	3	13
Corsican pine (without slag)	3	10	11
Corsican pine (with slag)	5	1	12
Sitka spruce (pure) (without slag)	1	9	1.4
Sitka spruce (pure) (with slag)	2	8	3.4
Sitka spruce (mixed) (without slag)	2	5	4.1
Sitka spruce (mixed) (with slag)	3	3	6.6
Japanese larch (without slag)	2	10	8
Japanese larch (with slag)	4	0	10

Note. - A glance at the 'average height' data shows that the manure has in every case improved height growth, increases being of the order of 25 to 50 per cent. The shoot growth on the other hand indicates that the unmanured pines are

now growing strongly and the inference is that the manure was unnecessary in the case of these species. The combined effect of admixture with pine and the application of slag is very apparent in the Sitka spruce. In the pure, unslagged, plots the average shoot is 1.4 inches while in the mixed, slagged, plots the shoots average $6\frac{1}{2}$ inches. Of the two factors, the admixture with pine appears to have had the greater effect.

The unslagged Japanese larch are a long way behind the slagged plants in height but seem to be now growing fairly strongly.

One other point of interest is that, comparing this with the previous table, it is evident that growth has been better on the fully ploughed plots than on the 3-furrow ploughing. (The slagged sections of the 3-furrow ploughing must be disregarded in making the comparison because there was no slag applied to the completely ploughed plots.)

(3) Worked Patches.

Species		Average Ht. ft.	Average Ht. in.	Average length of leading shoot in 1937 in.
Scots pine	(pure)	3	5	8
Scots pine	(mixed)	3	9	9
Corsican pine		3	1	8
Sitka spruce	(pure)	1	4	0.9
Sitka spruce	(mixed)	1	4	1.4
Japanese larch		2	5	4.0

Note. - Compared with the previous tables relating to ploughed ground there is a considerable reduction in vigour of growth. This is most evident in Sitka spruce and Japanese larch. It will be observed that there is little evidence of any improvement in the growth of the Sitka spruce in the mixed plot, this contrasts with the beneficial effect of the mixture on the ploughed sections.

(4) Single Furrow Ploughing
Explosive Charges
Notch planting without any preparation of the Soil

The results obtained from these three methods do not differ materially from the data given above for the Prepared Patches. On the average the growth is slightly poorer but the differences are doubtfully significant. The complete data for all treatments are given in the table below for two selected species.

Treatment of Soil	Scots pine (mixed plot) Av. Ht. ft.	in.	Av. Shoot in.	Sitka spruce (mixed plot) Av. Ht. ft.	in.	Av. Shoot in.
Complete Ploughing	5	2	13	2	5	4.0
3-furrow Ploughing (without slag)	4	3	11	2	5	4.0
3-furrow Ploughing (with slag)	5	3	13	3	3	6.6
Single furrows, planted in the furrow	3	6	9	1	2	0.9
Worked Patches	3	9	9	1	4	1.4
Explosive Charges	3	7	9	1	3	1.0
Notch planting	3	5	8	1	2	0.9

Note. - Perhaps the most remarkable point about the above table is that the pines on the uncultivated strips are making relatively such good growth. The notch planted strips are not appreciably inferior to the vastly more expensive method of worked patches.

The Kielder experiments are of interest in connection with the use of basic slag. There are considerable stretches of peaty ground carrying a vegetation consisting mainly of Calluna. The types vary from Calluna/Molinia to Calluna/Scirpus and it was anticipated that on this herbage Sitka spruce would respond freely to basic slag. Actually the response has been relatively slight, the reason being that the unmanured controls have grown unexpectedly well.

In the last year or two black game have been very destructive on the later experiments on the main block at Kielder. Scots pine and Pinus contorta have suffered especially severely but the damage has been quite bad even on Sitka spruce.

Japanese larch started well in the slagged plots but now show signs of exposure.

At Clocaenog Forest in North Wales the position is very similar to that at Kielder, the vegetation is rich in

Calluna although the subsidiary species are different, and it was expected that the unmanured Sitka spruce would check badly. Actually the check has been remarkably slight and basic slag has not improved growth to any great extent.

At Hamsterley a block of moorland adjoining the existing experiments is to be ploughed up and a small area planted this year, leaving the remainder for planting in P.40.

Dorset Heaths. A curious disease has appeared on Pinus contorta and Pinus insignis in this area. The needles do not develop properly and are much thickened and distorted, ultimately the shoots die. A similar disease is common on Pinus insignis in some parts of Australia where it is known as fused needle but has not been reported from any other country until this outbreak occurred at Wareham. Fortunately the disease shows no signs of affecting Corsican pine which continues to be the best species at Wareham.

It is not often that Scots pine shows a major response to basic slag, but this is certainly the case in a P.34 experiment (No. 23) on ploughed ground. In the unmanured control plots losses averaged 23 per cent as compared with only 6 per cent in the slagged plots. The average growth at the end of 5 growing seasons was: Controls, Height 9 inches, leading shoots 1.9 inches. Slagged plots, height 30 inches, leading shoots 12 inches.

Dr Rayner's P.36 experiment was assessed last Winter. The following table shows the position after three growing seasons

	Corsican pine		Pinus contorta	
	Av.Ht. in.	Av.Shoot in.	Av.Ht. in.	Av.Shoot. in.
Direct Sowing, Unmanured	2	0.4	1	0.1
Direct sowing, with basic slag	6	4.6	7	5.0
Direct sowing, with straw compost	10	6.7	7	4.4
Direct sowing, with hop-waste compost	18	10.5	12	7.7
Transplants, unmanured	6	2.5	7	2.1

Manuring with hop-waste compost has had a remarkable effect upon the growth of the Corsican pine, the seedlings are three times the height of the basic slag treatments and are making vigorous growth. It is also interesting to note that the slagged sowings are as tall as the 2 yr.-1 transplants and are putting on better shoots.

About 12 tons of hop waste were obtained in 1938 from a local brewery and successfully composted at Wareham under Dr Rayner's supervision. The compost was used for various experiments on direct sowing including Sitka spruce, Norway spruce and Corsican pine. The most important of these was a 2-acre costing experiment on ploughed ground, in which seed patches were prepared at four feet apart, 2 lb. of compost dug in to each patch, and subsequently sown with Corsican pine seed which was covered with local soil. The total cost including compost worked out at the very high figure of over £13 per acre. The experiment has been repeated this spring with somewhat simplified methods and the cost very considerably reduced.

Thetford Heaths. The series of plots dealing with the introduction of beech under Scots pine of varying heights and ages have improved greatly in the last two growing seasons. The improvement is most noticeable wherever there is a break in the pine canopy; under the full shade of the pine the beech are alive but stunted, with small leaves and slender buds. It seems clear that beech is very intolerant of shade in this area; this is unfortunate for the object of this series of experiments because it means that the pine must be drastically thinned at such an early age that most of the thinnings will be unusable and consequently this method of establishing beech becomes very expensive. The absolute necessity of protecting the beech from grazing by deer, hares

and rabbits is another point which has emerged in the course of the investigation. The intolerance to shade of beech at Thetford is probably not a question of insufficient light but rather of lack of moisture and nutrients, due to the competition of the pine roots.

The assessment of two P.30 experiments comparing the use of large and small plant material of various frost-tender species throws an interesting light on the problem of establishing such species at Thetford.

Experiment No.	Species	Losses in Large Plants	Losses in Medium and Small Plants	Average Height after 7 growing seasons: Large Plants	Average Height after 7 growing seasons: Small Plants.
		%	%	in.	in.
8	Beech	70	80	-	-
	D. Fir	25	35	-	-
	J. Larch	45	55	-	-
	E. Larch	20	55	-	-
13	Beech	40	90	23	8
	D. Fir	25	75	72	32
	E. Larch	40	70	48	36

With the exception of the Douglas fir in Experiment 8 losses in the small plants range from 55 to 90 per cent. The large plants have made a much better showing on the whole and, as the figures given for Experiment 13 indicate, the Douglas fir and larch are now getting out of danger from frost. The beech data illustrate the exceptionally difficult problem which this species presents at Thetford.

Chalk Soils. Further examination of the experimental plots at Buriton has shown that of the three main blocks which were planted consecutively in P.30 to P.32, the first two are not situated on typical chalk sites but are on a belt covered with a thin deposit of clay with flints. This deposit provides better growing conditions than the true chalk and is responsible for the success of the alder nurse plots. It is

perhaps an open question whether the better growth of all species on the clay with flints deposit is due to the better soil or to the fact that at the time of planting the ground had only recently gone out or arable cultivation and there was not the same dense growth of grass as on the true chalk. Whatever the factor may be it is quite clear that results obtained on clay-with-flints over chalk are not applicable to the chalk soils lacking that deposit. Hence the failure of many of the attempts at Buriton and Friston to establish alder as a nurse, which has been so puzzling in the past.

Of all the species tried as a nurse on the chalk downs the most reliable are unquestionably the two pines, Scots and Austrian. Of these Scots pine is rather faster growing in early youth but has the disadvantage of very course branching, Austrian is more compact in habit and the foliage is denser and so the trees give greater protection. The best way to plant these pine as nurses for beech has not yet been found. The method adopted in the Buriton plots, in which the pines were planted at 7 feet x 5 feet leaving the beech to be introduced at a later date, is now obviously unsatisfactory, and other methods will have to be tried.

Loam and Clay Soils (Hardwoods). The species plots on the heavy clay of the Drayton section of Rockingham Forest have recently been assessed. The data illustrate the relatively slow growth of oak, compared to that of pines and other conifers. Thus in Experiment 1 P.32, after 6 growing seasons, the following average total heights were found:

Species	Mean Height
	in.
Oak	13
Lawson Cypress	25
Norway spruce	22
Scots pine	39
Pinus contorta	36
European larch	36
Oregon alder	84

Oregon alder is clearly the outstanding species as regards rate of growth.

The experiment was repeated in the following year when two series of plots were formed one on old (felled woodland) and one on old pasture. The two make an interesting contrast.

Species	Mean Height on		Mean Shoot in 1937 on	
	Old Woodland	Pasture	Old Woodland	Pasture
	in.	in.	in.	in.
Oak	14	8	4	-
Lawson Cypress	30	13	9	7
Thuya plicata	26	16	7	5
Norway spruce	30	9	14	1
Scots pine	36	23	10	6
Pinus contorta	38	25	13	6

On the old woodland all the above species, except perhaps the oak, are well established and making good growth. On the grass land the spruce are having a severe struggle to become established and even the hardy pines are making but slow headway. It is not intended to imply that the two sites are comparable in all respects except as regards the presence or absence of former woodland, but the same order of difference in rate of growth on old woodland and on pasture land is found generally on these heavy Northamptonshire clays.

A P.30 experiment on origin of oak illustrates the way in which rate of growth may depend upon origin of seed. The following table sets out the average height at the end of nine years of the two fastest and the two slowest growing origins of Sessile and Pedunculate oak.

Origin	Average height	Difference required to be significant.
Sessile Oak		
France	3 ft. 11 in.)	
Heaton, Devon	3 ft. 4 in.)	
		11 inches
Gwydyr	1 ft. 9 in.)	
New Forest	1 ft. 4 in.)	
Pedunculate Oak		
Haugh Wood, Hereford	3 ft. 7 in.)	
Riddington, Northants	3 ft. 6 in.)	
		11 inches
Watton, Norfolk	2 ft. 5 in.)	
Mortimer, Hereford	1 ft. 6 in.)	

The local Dymock oak came about midway in the series in the sessile, and towards the top in the pedunculate. It is interesting to note that the fastest and the slowest growing pedunculate lots came from different woods in Herefordshire, thus it seems that the rate of growth of the offspring depends upon the individual trees, or stand, from which the seed is collected rather than any major climatic factor.

An ash hoeing experiment at Ffosydd orles appears to indicate that a sufficient stimulus to growth is given by hoeing the interior of the ash groups twice during the first growing season. Little is gained by hoeing outside the trees in the groups or by hoeing in the second year as well as in the first. Hoeing within the groups only (6 ft. x 6 ft.) cost £3.18.0. per acre for 2 hoeings, hoeing outside groups (12 ft. x 12 ft.) cost £10.10.0. per acre, also for 2 hoeings. These costs include screefing for planting.

Walnut plantations at Bedgebury and Tintern, formed with large plants raised in Kennington nursery, have proved disappointing; the shoots have died back on the majority of the plants in spite of careful planting, hoeing, and manuring. We seem to be still a long way from solving the problem of how to establish walnut on old woodland sites. On the other hand spring frosts have been very severe during the past few years and a succession of favourable seasons might bring about an improvement.