FORESTRY COMMISSION

Progress Report on Research

July 1936.

Table of Contents.

1. STAFF.

The most important change during the past year has been the transfer, on promotion to Division 5, of Mr J. Macdonald, Research Officer for England & Wales. Mr Macdonald had been in Research for nearly 12 years and had done consistently good work, and his loss will be severely felt. The newly appointed Research Officer for England & Wales is Mr R.G. Sanzen-Baker who was transferred to the Research Branch in December 1935 as assistant to Mr Macdonald. Having regard to all the circumstances it was considered desirable to come to an arrangement with the Imperial Forestry Institute whereby Mr W.R. Day should be available for silvicultural investigations and for assistance in the experimental work in the eastern half of the country. Mr Day will also give the lectures on experimental methods to the students at the Institute, formerly given by Mr Macdonald.

Mr R.G. Sangster, temporary assistant to the Research Officer for Scotland, left in August 1935 to take up an appointment in Uganda and his place has not been filled. A clerical officer has however been appointed to assist Mr J.A.B. Macdonald with his office work. The subordinate staff consists of 5 Grade II Foresters, 4 Foremen and 2 Gangers.

2. NURSERY INVESTIGATIONS. WORK IN 1935.

(1) Weed Control by the use of the blow lamp and sulphuric acid respectively.

An elaborate experiment was carried out in 1933 in four nurseries in Scotland, using different intensities of burning and different strengths of acid, the time of

application was also varied. The seedlings were lifted and graded in the spring of 1935 and the resulting data analysed. Very variable results were obtained, but the variations were due in part to the 1933 season which was abnormally dry, resulting in a much smaller crop of weeds than usual. In three out of the four nurseries the results were on the whole unfavourable to either method of treatment, as compared with hand weeding. In the fourth nursery, Benmore, which has a fairly rich soil and a wet climate light burning (15 seconds per sq. ft.) on the 7th day after sowing substantially cheapened the cost of raising Scots pine, but with Sitka spruce 7th day burning was not effective while burning on the 10th day gave good results. Prolonged burning (45 seconds per sq. ft.) was disastrous, as was late burning (on the 13th day) in the case of Scots pine. For some not very obvious reason burning gave bad results with European larch, not even the lightest application showing an improvement.

Sulphuric acid applied at the strength of 1 in 110, (1 gallon per 10 square feet of seed bed) 7 days after sowing, reduced the cost of production of the three species at Benmore to from 60 per cent to 80 per cent of that of the controls. Stronger acid (1 in 50 and 1 in 80) was not so satisfactory. The results are summarised in Table 1.

TABLE 1.

P. 33. Weed Control Experiments.

BLOWLAMP

No.	TREATMENT Description		COST as PERCENTAGE of CONTROL											
			Altonside			Benmore			Inchnacardoch			R. B. G.		
	Seconds per sq. ft.	Day	E.L.	S.P.	S.S.	E.L.	S.P.	S.S.	E.L.	S.P.	S.S.	E.L.	S.P.	S.S.
1	Control		100	100	100	100	100	100	100	100	100	100	100	100
2	45	7th	234	125	196	16400	152	727	152	190	162	107	100	117
3	15	7th	141	103	129	210	58	104	65	109	90	90	110	70
4	30	7th	141	203	116	418	65	208	93	114	114	120	110	100
5	45	13th	271	168	196	-	1600	1000	264	354	243	150	90	-
6	15	13th	124	107	171	1980	1202	304	84	81	95	110	81	78
7	13	13th	171	154	193	7600	1945	132	133	109	148	120	76	143
8	45	10th	280	203	317	5460	1283	220	123	162	157	333	100	333
9	15	10th	112	117	112	280	270	84	79	100	76	217	71	113
10	30	10th	180	125	175	510	498	96	93	95	81	377	71	157
Control outturn in thousands per lb.			7.8	8	32.	7.3	2.2	38.	6.3	14.	38.	9.2	9.5	30.
Control cost per thousand useable 2 yr. seedlings.			3/5	2/4	2/-	5/-	11/9	2/1	7/6	1/9	1/9	2/6	1/9	1/11

SULPHURIC ACID.

No.	TREATMENT Description		COST as PERCENTAGE of CONTROL											
			Altonside			Benmore			Inchnacardoch			R. B. G.		
	Strength of Soln.	Day	E.L.	S.P.	S.S.	E.L.	S.P.	S.S.	E.L.	S.P.	S.S.	E.L.	S.P.	S.S.
1	Control		100	100	100	100	100	100	100	100	100	100	100	100
2	1 in 80	Immed.	3142	5800	635	100	146	106	219	139	250	143	110	81
3	1 in 80	7th	322	482	287	154	80	94	125	104	450	110	90	77
4	1 in 50	Immed.	5200	3554	1184	226	407	212	457	353	378	197	119	115
5	1 in 50	7th	18270	580	535	216	321	212	322	130	648	154	115	127
6	1 in 110	Immed.	302	214	242	96	73	82	119	125	242	113	110	+
7	1 in 110	7th	231	156	187	80	61	70	112	96	153	105	110	225
Control outturn in thousands per lb.			6.5	9.9	2.5	8.	3.5	55.	5.5	14.	26.	7.	9.5	27.
Control cost per thousand useable 2 yr. seedlings.			4/1	1/10	2/7	4/2	6/10	1/5	8/-	1/11	2/7	3/3	1/9	2/2

+ Cockchafer.

(ii) Season of Sowing. A series of experiments on season of sowing gave striking results in most of the nurseries concerned. In European larch March sowing produced the largest plants in almost every case. The figures for Fleet nursery in the S.W. of Scotland are the most striking the data being as follows:-

Date of Sowing	March 1-15	March 15-30	April 1-15	April 15-30	May 1-15	May 15-30	June 1-15
Size in inches	8.4	9.2	6.9	5.5	3.6	1.5	1.3

Such a difference in size transcends anything we have achieved by manuring. At Newton the March and April sowings gave plants of 3 - 4 inches in height as compared with 2 - 2½ inches for the May sowings. In the case of Sitka spruce March sowing produced seedlings averaging 2 inches in height at Fleet nursery, while the May sowings gave plants of only half that size. At Kennington Nursery results were as follows:-

	Early Sown (March 12)		Late Sown (May 4)	
	Av. size in.	Yield per lb. 000s.	Av. size in.	Yield per lb. 000s.
Jap. larch	3½	44	2¼	39
Sitka spruce	1¼	80	1	77
Pinus contorta	2	56	1	30

The effect of early sowing upon the size of Sitka spruce was less than in the previous year but was still quite noticeable. The increase in the production of P. contorta as a result of early sowing is a point of interest as this species is rather given to delayed germination.

In connection with season of sowing a record was kept last year in 13 nurseries in Scotland as to the number of days in each month when the soil and weather

conditions were such as to permit sowing. The data are set out below.

Nursery	Number of days suitable for sowing.		
	March	April	May
Altonside	17	10	20
Newton	21	9	18
Craibstone	10	10	20
Tentsmuir	23	22	25
S. Strome	10	12	22
Dornoch	10	6	21
S. Laggan	2	9	25
Inchnacardoch	5	13	25
Benmore	11	12	28
Barcaldine	10	15	24
Inverliever	21	19	21
Fleet	25	21	28
Tulliallan	8	8	28

The chief point of interest is the considerable number of days in March on which sowing would have been possible in most of the nurseries. In several of the nurseries there were more suitable days in March than in April. A single season's observations do not count for very much but at least the figures suggest that in some seasons and nurseries March sowing would be quite feasible.

(iii) Manuring Experiments. Following upon the successful trial of heavy dressings of Sorbex and other dried peats in Kennington nursery in the previous year further trials were carried out in about 12 nurseries distributed over Great Britain. The Sorbex was applied to the beds immediately before sowing and it is possible that it was not properly incorporated with the soil. With one or two

striking exceptions the results were negative, germination was reduced in many cases and there was no very marked improvement in root development. At Ampthill in Bedfordshire, however, the improvement in size of plants (S.S. & N.S.) was quite definite and the root systems were also much more fibrous. The experiment is being repeated in a number of nurseries in England, using peat from a Yorkshire source and giving the seed beds time to settle down before sowing.

In Fleet and Tulliallan nurseries in Scotland the effect of applying different amounts of fresh and old farmyard manure was tried, see table below for the results at the end of the first growing season. Species Sitka spruce sown in spring 1935.

Treatment	Tulliallan		Fleet	
	Yield per lb. 000s.	Size in.	Yield per lb. 000s.	Size in.
Control	2.7	1.5	19.0	0.6
Fresh farmyard manure @ 10 tons/acre	2.9	1.5	16.4	0.7
do. 30 "	1.8	1.5	15.0	0.7
do. 60 "	1.8	2.5	15.3	1.0
Old farmyard manure @ 10 tons/acre	2.3	1.5	17.2	0.8
do. 30 "	2.0	1.75	14.4	1.1
do. 60 "	2.8	1.0	14.4	1.25

The effect of even the heaviest applications has been remarkably small and the results are not very consistent. The response to farmyard manure is strikingly different from that of agricultural crops such as wheat or turnips, and points to some fundamental difference in method of nutrition.

(iv) Stratification of Seed. Further tests carried out on Douglas fir seed confirmed the previous year's results as to the benefit of stratification. As regards other species Corsican pine and alder were again stratified without success, while birch showed a very definite response to this treatment, the output of seedlings being raised five-fold. An experiment with old stand of Scots pine (1930 collection) gave results which appear very promising. There were three treatments:

A. Seed dry stored and sown on March 27th.

B. Seed stratified in sand on 30th January and sown March 27th.

C. Seed stratified in sand on February 28th and sown March 27th.

The production of seedlings per lb. of seed was:

A	26,400
B	30,900
C	44,700

Difference between means required for significance = 4500.

Statistical analysis shows that while the longer period of stratification B has given a barely significant increase in germination, the shorter period C has resulted in a very considerable increase as compared with the control.

Previous work has shown that freshly collected Scots pine seed does not respond to stratification and it is interesting to find the stored seed responding to the treatment.

(v) Bedding-out of Scots pine and Sitka spruce. Plants were bedded out (closely lined out) two years ago at Kennington at different spacings. The plants have been lifted and the following results obtained.

Scots pine 1yr 1yr	A	B	C
Density of bedding out as 1 year seedlings	1" apart in the row.	4½ plants per inch of row.	9 plants per inch of row.
Percentage of deaths	4	6	20
Percentage of culls	8	28	31
Percentage fit for planting	87	38	21
No. of plants per square yard of bed, fit for planting	180	375	400

The effect of crowding the plants has been naturally to increase the proportion of culls very considerably, and also, in the case of the highest density, C, to increase the death rate. The percentage fit for planting falls very sharply from A to B. In C only one-fifth of the plants lined-out were fit for planting. The last row of figures gives the result in terms of number of fit plants per unit area bedded out and provides the real justification for the method in emergency. It sometimes happens that surplus seedlings are available but there is a shortage of nursery area for lining them out. As an alternative to destroying the plants bedding-out may be adopted and the experiment shows that quite a high out-turn of useable plants, per square yard, can be obtained, though at some sacrifice in relation to the original numbers. The experiments further indicate that the highest density (9 plants per inch) is not advisable. The optimum density for the bedding-out of surplus plants probably lies between 1 and 4 plants per inch of row.

Sitka spruce 2 yr. 1 yr.	A	B	C	D
Density of bedding-out as 2-year seedlings	1" apart in the rows.	½" apart in the rows.	6 plants per inch of row.	12 plants per inch of row.
Percentage of deaths	0	2	25	62
Percentage of culls	19	27	30	19
Percentage fit for planting	81	48	24	10
No. of plants per square yard of bed, fit for planting	170	240	300	250

It will be noted that with each increase in the density of bedding out the proportion of plants fit for planting is approximately halved. Where economy of space is the chief consideration the optimum density probably lies between 2 and 6 plants per inch.

(vi) Method of covering seed. The importance of using the right type of material for covering small seeds is shown from an experiment with Sequoia gigantea carried out at Kennington.

Type of Covering.	Production of seedlings per lb. of seed.
A. Nursery soil	350
B. Bedford Sand	2,900
C. Limestone chippings	950
D. Broadleaf humus and limestone chippings	450
E. Thames Ballast Sand	850
F. Broadleaf humus and Thames Ballast Sand	650

Bedford sand, which has been used in the nursery in previous years as the standard form of covering, has greatly improved the yield of seedlings. The addition of humus to the chippings and to the Thames Ballast Sand has not proved beneficial.

(vii) Composting of Weeds. A preliminary experiment carried out in Nagshead nursery, Forest of Dean, showed that it is possible to get very active decomposition of nursery weeds in spite of the large amount of soil usually present in the heap. A pit 6 ft. x 10 ft. x 2 ft. deep was dug and a rough shelter constructed with a detachable corrugated iron roof. One half of the pit was filled with weeds the other half being used for turning the mass and partially drying it. The weed used was largely couch from a disused garden as the experiment started too late to obtain sufficient weeds from the nursery. Sufficient material was available by the

middle of September and the roof was removed to allow rain to saturate the heap. A mixture of dried blood and bone meal was dug into the wet heap at the rate of 1½ cwt. of blood and 25 lb. of bone meal per ton of air-dry weed material and the roof was replaced. Within two days the temperature of the mass rose to 135°F. and by the end of the week reached 150°F. It was then watered and turned when the temperature after falling to 110° rose again to 130° and then slowly dropped to air temperature, which it reached in about 3 weeks from the start of the process. The compost was left until April 1936 when it was found on examination to be apparently completely broken down. With minor modifications the method followed that devised by Dr Rayner in her work on composts. The two outstanding features of the Nagshead experiment are the high temperatures attained and the short duration of the process.

The experiment will be repeated this year when smaller quantities of dried blood will be applied as it seems probable that the air dry weight of the weeds was overestimated and consequently too much of the composting medium applied. In the meanwhile experiments are being conducted with the compost.

3. PROGRAMME OF NURSERY INVESTIGATIONS 1936.

The major projects are as follows:

Project	Nursery
(i) Manuring.	
Effect of lime on conifers.	Altonside, Inchnacardoch, Strathyre, Tulliallan.
Trial of Sorbex and other types of peat.	Tulliallan, Kennington, and 6 Divisional Nurseries in England & Wales.
Artificial Manures applied to ash.	Fleet.
(ii) Date of Sowing S.S. and Ash.	Reddings (Div. 7), Fleet.

	Project.	Nursery
(iii)	Effect of sowing in wet weather.	Newton, Tulliallan.
(iv)	Determination of losses in seed beds.	Altonside, Benmore, Fleet, Inchnacardoch, Tulliallan.
(v)	Raising of S.S. in boxes, following the South African method.	Kennington.
(vi)	Inoculation of virgin nursery soil with humus from stands of the species to be used for sowing.	Altonside, Strathyre, Inchnacardoch, Tulliallan.
(vii)	Density of Sowing N.S., S.S., J.L.	Kennington.
(viii)	Stratification of old seed of various conifers and of new seed of Pinus contorta.	Kennington.
(ix)	Nursery treatment of poplar, length of cutting, type of cutting, depth of planting etc.	Kennington and Thetford.
(x)	Raising of walnut, manuring and stumping.	Kennington.

/

4. PROGRESS OF PLANTATION EXPERIMENTAL WORK.

(i) Peat Project. Inchnacardoch. Perhaps the most interesting of the older experiments on the Lon Mor peat bog - peat of the worst Scirpus type - is the eight year-old experiment No. 52 on intensity of drainage. Alternate sections were laid out at 12 feet and 18 feet drain spacings respectively and the planting was on Belgian turfs with slag and soil. The species used were Sitka spruce and Pinus contorta. The Sitka spruce remain in check on both treatments, although the colour is better in the closer draining. The Pinus contorta are now beginning to grow quite strongly

and the effect of the closer drainage is showing up. The position at the end of 1935 was as follows:-

	Average		Tallest Plant	
	Height	Leading Shoot	Height	Leading Shoot
12-ft. drain spacing	5 ft.	10 in.	7ft. 6in.	21 in.
18-ft. " "	4 ft.	7 in.	8 ft.	20 in.

It is encouraging to find the trees growing so well 8 years after planting. The initial dose of 2 ounces of slag given to each plant has presumably been used up and, as the root investigations show that the roots are pushing well outside the area of the turfs, the plants may now be regarded as established.

The Oregon alder planted in P.30 on the shallower slope peat in the original P.22 Block continue to grow satisfactorily and they do not seem to have suffered badly from the May frosts of 1935. The tallest plant is now 13 feet in height though the average is not more than half that figure. Some of the plants have had to be pruned to give light to the Sitka spruce in the same groups. In general the Sitka are much more promising in this area than on the Lon Mor, but the peat conditions are a good deal better.

A number of experiments have been carriedout at Inchnacardoch and elsewhere on the use of the proprietary phosphatic manure known as Semsol. This gave excellent results in a P.28 experiment on the Lon Mor, its effect upon Sitka spruce being more lasting than that of slag. Recent experiments have been less favourable as the use of Semsol has led in many cases to a high death rate in the plants. Until the conditions under which Semsol can be safely applied have been worked out it is proposed to discontinue the use of this manure.

Borgie. The P.30 imitation ploughing plots are beginning to show up well. Both Pinus contorta and Sitka spruce are putting on shoots of 10 to 12 inches in length on what appeared to be a bad type of Calluna-Scirpus peat. Growth is so promising that it would seem worth considering mechanical cultivation of some of the large area of similar ground available.

Achnashellach. The latest asssessment of the P.28 manuring experiment with Japanese larch in Glencarron has given the following results:-

	Slagged		Not slagged	
	Ht. feet.	L.S. inches.	Ht. feet.	L.S. inches
Turf Planted	11.1 ± 0.43	21.1	3.9 ± 0.51	6.1
Direct Notch	5.1 ± 0.42	7.7	2.6 ± 0.59	3.6

The two methods of planting are not directly comparable because the sites though adjacent may not be exactly similar. In the turf planted section the plants in the manured strips are nearly three times the height of those in the unmanured and it is probable that the controls which are in fairly narrow strips are benefiting from the protection given by the tall plants alongside.

Higher up the hill, where conditions are more unfavourable, slagged Scots pine and Pinus contorta average from 3½ to 4 feet in height and are putting on leading shoots of 8 to 10 inches; both these species appear to be now fairly well established. Without slag the plants are still under 2 feet in height and growing slowly. Under the same conditions Sitka spruce are making very slow headway. Controls 7 inches high and 0.8 inch shoots, and slagged 21 inches high and 3.0 in. shoots.

A good deal of Japanese larch has been planted in later experiments at Achnashellach, and Hybrid larch has also

been tried. Both larches are doing well wherever slag has been used and where there is a certain amount of shelter. The upper slopes of this forest are evidently very exposed and on some of the higher ground the larch are developing a bushy habit.

Beddgelert. Experiment 7 P.28 on a deep and mostly poor peat bog illustrates very well the importance of vegetation type in relation to the use of basic slag. This was a manuring experiment in which 5 manurial treatments were applied. The main type is Scirpus-Eriophorum but there is also a patch of Aira and other grasses with Scirpus. The results of the latest assessment are set out below.

Treatment	Scirpus-Eriophorum.		Grass-Scirpus.	
	Height. in.	Shoot. in.	Height. in.	Shoot in.
Control	16 ± 2.3	1.1 ± 0.3	59	11.1
Soil	14	0.8	47	8.3
Magnesium limestone	16	1.4	52	9.7
Horns and hoofs	16	1.4	48	8.7
Sulphate of potash	15	1.0	56	10.7
Basic slag 2 oz.	43 ± 1.8	6.0 ± 0.1	54	9.4

On the Scirpus and Eriophorum type the plants are still, after 8 growing seasons, in check on all plots except those receiving basic slag. The slagged plots have made steady growth and appear to be satisfactorily established. On the better, grassy, type the slag has evidently been without effect, the plants in all treatments are growing well and none of the differences is significant.

In general Sitka spruce are recovering remarkably well at Beddgelert, and there seems to be relatively little

ground on which unmanured plants check for more than 6-7 years.

Summary of the peat experimental work.

A survey of the various peat areas in which experimental work has been carried out leads to the conclusion that each area has its own peculiarities and that without the experiments no one could have foretold how the several species would react in each case. The stage now reached may be briefly summarised as follows:-

(1) Method of Planting. Turf planting is unquestionably superior to direct planting. On the poorer peat types all species do better when planted on turfs. As to the best form of turf, whether the thick turf planted by the Belgian spade or the thin turf planted by side notch, there is scarcely sufficient evidence to make a definite statement, on the whole there does not seem to be much difference between the results.

(2) Draining. Depends on the rainfall and type of peat but must be intensive on the poorer peat types.

(3) Manuring. The only safe as well as effective manure so far thoroughly tested is basic slag.

The response to manuring and the necessity for its application seems to depend on the locality and the type of peat. Probably in all localities there is no benefit from applying manure to 'flushed' peat, i.e. peat through which fresh water is flowing. At Beddgelert though the undrained vegetation is very rich in Scirpus most of the peat appears to respond fairly quickly to drainage and Sitka spruce eventually - after 8 to 10 years on the poorer vegetation types - begins to get away. The use of slag in this area is primarily an economic question because the cost of the slag must be set off against the shortening of the rotation.

Kielder. The same remarks apply in general.

Inchnacardoch, Glen Righ and Achnashellach. The experiments have not been established long enough for the evidence to be quite conclusive but all the indications tend to show that basic slag is essential for successful establishment.

Borgie. Manuring probably essential for establishment.

(4) Species. Beddgelert and Kielder. Sitka spruce appears to be undoubtedly the best species. Norway spruce does equally well (though not so fast growing) on the good types of peat such as Juncus, tussocky Molinia, and similar flushed peats, in sheltered situations, but is much inferior on exposed sites and on the poorer peat types. Pinus contorta either grows too fast and is not stable (Beddgelert), or is crippled by black game (Kielder).

Glen Righ and Achnashellach. Japanese larch is the outstanding species. Sitka spruce appears hopeless without manure and very doubtful with it (except possibly on the better types of slope peat). Pinus contorta has perhaps scarcely had a complete trial and might do better than the larch on the more exposed sites but under average conditions is not likely to be as good.

Inchnacardoch. Pinus contorta is a very promising species on the flat deep peat bogs. Sitka spruce seems likely to fail as a first crop except under the most intensive methods of manuring and draining. Japanese larch is fairly good on the slopes but has not been fully tested on the flat bogs. Alnus oregona is distinctly promising as an advance crop on the sloping ground.

Borgie. In contrast to the other Scottish area Sitka spruce seems quite a promising species. Pinus contorta and Scots pine are also growing well.

(ii) Upland Calluna Soils. Inchnacardoch.

Experiment No. 16 P. 26 is very interesting for the light which it throws on the effect of introducing Scots pine among Sitka spruce on a site unfavourable to the latter species. In P. 23 12 plots were planted with Sitka spruce on a dry bank above the Fort Augustus - Auchterawe road. This was a season of planting experiment, one plot being planted each month. The take was good in all plots but on most of the area the plants went into check. The topography is somewhat varied consisting largely of steep dry ridges and slopes carrying a Calluna-Erica cinerea vegetation (Type 1). A proportion of the area is somewhat better spruce ground, being flat, and carrying a herbage of bracken scattered thinly among grass and heather (Type 2). A third type consists of partially flushed, sheltered ground with strong bracken, grasses and some heather (Type 3).

After three growing seasons the spruce were completely checked in growth on Types 1 and 2 but showed some signs of movement on Type 3. It was then decided to interplant alternate plots with pines as follows: 1 plot with Mountain pine, 1 plot with Pinus contorta and 4 plots with Scots pine. Planting was carried out in P.26. The pines developed well, and the Scots pine are now from 9 to 14 feet in height.

On the poorest ground (Type 1) the spruce is still more or less in check, 13 years after planting, but where the Scots pine was introduced the trees began to get away in 1933 (8 years after bringing in the pine) and now the spruce in the mixed plot are mostly out of check and beginning to go ahead.

On the somewhat better ground (Type 2) the pure spruce have grown slowly but steadily, at an average rate of about 4 inches a year. In the Scots pine mixture the

spruce began to grow more rapidly in about the fourth year after the pine was planted and from that date went rapidly ahead. In 1935 the spruce leading shoots averaged 20 inches in length in the mixed plots, as compared with only 5 inches in the pure plots.

The spruce on the best ground (Type 3) have also reacted surprisingly well to the admixture with Scots pine. The trees in the mixed plots are 4 feet taller than those in the pure plots though at the present time they are growing at nearly the same rate.

The data are set out below.

	Pure Sitka spruce		S.S. plus S.P.		Pure Scots pine	
	Height ft.	Shoot in.	Height ft.	Shoot in.	Height ft.	Shoot in.
Type 1.						
Bare calluna Erica cinerea moraine slopes and ridges.	1.7 ± 0.25	2 ± 0.6	2.9 ± 0.5	7 ± 1.4	9.3	20
Type 2.						
Scattered bracken over grasses and Calluna.	4.2 ± 0.13	5 ± 0.6	8.8 ± 0.38	20 ± 3.0	13.0	25
Type 3.						
Strong dense bracken over grasses and Calluna.	8.9 ± 0.97	19 ± 2.6	13.3 ± 1.4	26 ± 3.4	14.2	24

Clocaenog. Experimental work in this forest was started in P.32 and as the ground is high lying and exposed progress is bound to be relatively slow. So far, of the species tried, Pinus contorta has made the best growth, but Sitka spruce has done rather unexpectedly well considering the conditions. Japanese larch is satisfactory and in one drainage experiment appears to be responding to a close spacing of the drains. Much of the heather at the higher

elevations in this forest is old and rank, and the question arose whether it was desirable to burn it off before planting. Experiment 7 P.33 was laid down to investigate this point. Three types of heather were included namely tall (18" - 2'), medium (12") and short (1" - 3"). All plants received one ounce of basic slag at the time of planting. The growth after three growing seasons is shown in the table below.

Species.	Tall Heather.	Medium Heather.	Short Heather.
	Average length of P.35 leading shoot in inches.		
Japanese larch	7.5	5.6	5.4
Pinus contorta	6.3	5.5	4.9
Sitka spruce	6.9	4.5	3.7

All three species show the best growth in the tall heather, the improvement being greatest in the case of Sitka spruce.

Use of broadleaved trees. Birch and alder, which have been planted experimentally in all the upland Calluna areas, have done outstandingly well wherever basic slag has been applied. On most of the soils these broadleaved species are still more dependent than the conifers on the initial impetus to growth supplied by the basic slag. Of the various species of alder, Alnus oregona appears to be the best except in localities subject to severe late frost. The following data from experiments at Teindland and Allerston illustrate the response of this species to manuring with basic slag.

	Average Height in feet.		Average leading shoot, inches.	
	Manured.	Unmanured.	Manured.	Unmanured.
Teindland, P.32	4.3	0.8	15	2
Allerston, P.34	3.5	2.0	15	1.5

The plants which have not received basic slag are making no progress and seem likely to die.

Examination of the root systems of some of the manured plants at Allerston has shown that the main roots are penetrating into the lower, undisturbed layers of the soil. The success of the alder on these poor acid soils may be of great significance in the future. If they continue to thrive, the action of the roots should help to aerate the soil and to increase its effective depth while the leaf-fall will improve the humus conditions and promote a more favourable type of decomposition.

(iii) Dorset Heaths. During the past year a severe outbreak of pine shoot moth has developed. Scots pine and Pinus contorta are the principal victims, but even the Corsican pine have not escaped damage.

The following data for a P.32 experiment on the direct sowing of pines indicate the progress made during the past four growing seasons.

Species.		Unmanured Control.	Slag.	Bonemeal.
Pinus contorta	Mean Height, in.	5.4	12.1	18.6
	Mean Shoot, in.	3.2	6.7	9.3
Pinus radiata	Mean Height, in.	4.7	13.5	19.6
	Mean Shoot, in.	1.2	4.9	6.8
Pinus pinaster	Mean Height, in.	9.0	23.3	25.2
	Mean Shoot, in.	3.8	9.9	10.6
Corsican pine	Mean Height, in.	2.5	3.0	-
	Mean Shoot, in.	0.9	1.4	-
Scots pine	Mean Height, in.	5.5	9.9	6.0
	Mean Shoot, in.	2.1	5.9	2.8

Both slag and bonemeal have much improved the growth of most of the species. It is interesting to note that the unmanured control sowings of P. contorta and P. pinaster are now beginning to make a move.

In the same year a manuring experiment was carried out with transplants of Scots pine, Corsican pine and Pinus contorta, applying 1 oz. of slag to each plant in the treated sections. The manured and unmanured plots now form a remarkable contrast. The Scots pine and P. contorta controls are stunted, with short needles, and very few of the plants are getting away, in the slagged plots on the other hand all the plants are growing vigorously, putting on shoots of from 6 inches to 18 inches. The Corsican pine controls are better than those of the other species but the manure has again given a great stimulus to growth.

On the evidence of these plots, and having regard to the danger from the pine shoot moth it would seem probable that manuring with basic slag would be an economic operation at Wareham.

Lawson Cypress continues to do well. The plants in the P.33 plot of this species now average 22 inches in height and are growing at the rate of about 6 inches per annum.

(iv) Thetford Forest. The May 1935 frosts, which were very intense at Thetford, did a great deal of damage throughout the experimental plots. This is not wholly regrettable because of the many points of interest which have since emerged. For example, the experiments on size of plant of beech, larch, and Douglas fir show most clearly the superiority of the large plants of 18 in. to 2 ft. in height as compared with the small plants under 12 inches.

Another point of interest is the stage of flushing of the plants at the time of the frost. The Douglas fir at Olly's Farm, for example, practically escaped damage because most of the trees had not flushed when the frosts came. Elsewhere this species was badly damaged having already flushed.

The experiments on the introduction of beech under Scots pine have fared very badly. Under light canopy, e.g. Scots pine of up to 8 feet in height the trees were mostly killed by the combined effect of frost and drought, while under the taller pine root competition has been a serious factor in the last few dry years and losses have been very heavy.

The alder and birch nurse crops are doing moderately well but are not yet tall enough for the introduction of tender species such as beech or Douglas fir.

In general the weather conditions during the past few years have been most unfavourable to the frost tender species. The results of the experiments amply justify the policy of relying chiefly upon the pines for afforestation in the Thetford area.

An experiment on 1-year seedlings of Scots pine and Corsican pine planted in P.35 gave an excellent take of the Scots pine, but failures in the Corsican ranged from 60-75 per cent., the deaths occurring in the May drought after the plants had begun to flush.

(v) Chalk Soils. Friston Forest. Seven plots were laid down in P.33 to determine the necessity for weeding the rank grass growing up among the beech which had been planted 2-3 years previously. The May 1935 frost caught all the experiments and with only one exception damage was just as bad in the unweeded as in the weeded plots, showing that even a dense covering of grass is no protection against a frost of this severity. Down to the end of 1934 the rate of growth and percentage of failures were much the same in both weeded and unweeded plots and there was no evidence that the plants had suffered from the neglect of the weeding.

The frost damage suffered by the other experiments at Friston varied with the elevation. In the valleys

frosting was intense even birch being slightly touched but on the slopes above 125 feet elevation all shoots over 2 feet above ground level escaped damage.

Buriton Forest. Here again the extent of frost damage was closely related to the elevation, and on the higher land the frost level appeared to be only 12-15 inches above the ground. The ash and beech introduced among alder escaped damage for the most part and are making satisfactory growth. In an experiment on method of planting beech it is interesting to note that the plants notched direct into the grass were badly frosted while those notched into a screef escaped serious damage.

(vi) Loam and Clay Soils (Hardwoods). Frost affected the majority of the hardwood areas and in consequence not many measurements have been taken. In general the growth of oak is satisfactory apart from the heavy clay soils of Northamptonshire where progress is very slow. In the P.32 species experiment at Drayton Oregon alder are now up to 5 feet in height and are fine sturdy plants. Lawson cypress, Scots pine and Pinus contorta though only half the height of the alder are also healthy and vigorous. Neither oak nor ash has moved. If the growth of the Oregon alder is maintained this species may be distinctly useful for improving the condition of these heavy clay soils. Another possible tree is the Serbian spruce which seems to start rather more quickly than Norway spruce and was much less badly damaged in the May frost. Of other species tried, the larches and hemlock spruce have done badly while Thuya is slow in getting away.

The hoeing experiments on ash in Division 7 continue to give interesting results. A new experiment was started in P.35, on a fairly steep slope near Tintern. Ash transplants were planted in groups, some of which were hoed

twice during the growing season. The plants escaped the May frosts and by the end of the growing season the shoots of the plants in the hoed groups were nearly double the length of those in the controls (7.9 in. as compared with 4.4 in.) This is the first experiment on the hoeing of ash to show a definite response in the first growing season. In previous experiments the response has been delayed until the second or third season after planting.

5. Summary of Plantation Experiments carried out in 1935/36.

(i) Peat Soils. Experiments on the planting of tough peat knolls have been carried out at Bennan, Borgie, Inchnacardoch and Nevis Forests. Draining experiments have been started at Dornoch, Glenrigh and Scootmore.

(ii) Upland Calluna Soils. A draining experiment has been planted at Teindland.

At Harwooddale plots of common alder have been laid down and varying amounts of basic slag applied.

Corsican pine has been planted at Allerston both pure and in mixture with birch.

A species experiment has been laid out at Clocaenog on Calluna moorland below the Shooting Box; the species included Thuya, Abies nobilis, Cupressus nootkatensis and Pyrus intermedia.

(iii) Dorset Heaths. Plots of birch and of three species of alder have been planted at Wareham, experimental work at Allerston and Harwooddale having shown that these trees can root deeply in podsolised soils and so may improve the soil conditions. A further trial has also been given to Lawson Cypress.

An experiment on the top dressing with basic slag of Sitka spruce in check at Wareham has been carried out.

(iv) East Anglian Heaths. Test of different methods of cultivation and of planting beech in Queen Mary's Avenue in the King's Forest.

(v) Chalk Soils. A further trial of Pyrus intermedia as a nurse species for beech at Buriton.

(vi) Loams and Clay Soils (Hardwoods). Stumped plants of Juglans nigra have been planted at Yardley. Hoeing experiments on walnut at Bedgebury and Tintern.

Mixtures of hardwoods and conifers and establishment of an advance crop of alder at Fleet.

Field extension of ash manuring at Fleet.

(vii) Other.

Extension of Nursery root pruning at Clashindarroch.

Grazing experiment at Newcastleton.

Spacing experiments in various forests.

Extension to proveniance plots at Clashindarroch, Lael, Findon, Inchnacardoch and Nevis.

6. Progress of Special Investigations.

(i) Season of Peeling Pit Props. An investigation was carried out in the Forest of Dean to obtain information on two points: (a) whether the seasonal factor is important in relation to peeling, i.e. whether props peel more easily when cut in the spring or early summer, when the sap is running, than in the winter, (b) whether winter-felled props peel more easily if left lying in the woods until the spring, and then peeled. The investigation was carried out with a

considerable range of species (all conifers), and the tool used for peeling was a draw knife. It was found that poles of the size involved peeled equally easily at all seasons, hence there is no object in confining the work to the spring and summer months.

(ii) Douglas fir in the Thetford District. The field work under this head has been completed but the writing-up has been delayed by the transfer of Mr J. Macdonald to Division 5.

(iii) Chermes cooleyi on Douglas fir. It is proving unexpectedly difficult to demonstrate in actual figures the check to height growth and volume increment resulting from the attack of Chermes cooleyi on young Douglas fir plantations. Climatic factors, which also affect increment, are difficult to assess, and it seems probable that individual trees are attacked and make recovery in different years. As far as general observations go there has been a marked lessening of attack during the last year or two in North Wales.

It is proposed now to keep selected trees under annual observation as this seems to be the only valid means of correlating intensity and duration of attack with the rate of growth.

(iv) Reassessment of Oak Rot. The first assessment of oak rot in the Forest of Dean was carried out in 1931/32 when 100 trees in each of 19 plots were felled, cross-cut, and the volume of decayed timber measured. In April 1936 three of the same plots were selected and a similar number of trees felled and cross-cut in each plot. In each area there was an apparent diminution in the number of trees wholly free from decay and two out of the three plots showed

an increase in the volume of rotted timber. The data are being analysed statistically to ascertain whether the apparent increase is significant.

(v) Meteorological Stations. Observations were continued at the stations at Benmore, Parkend, and Thetford. Unfortunately the plots were very badly damaged by the May 1935 frost, as almost all the plants had flushed by the middle of that month. Arrangements have been made to introduce a plot of Scots pine into each station in order to have the species which is not subject to the recurrent damage from spring frosts.

(vi) Pruning. The experimental pruning of young conifers has proceeded according to plan and the following species have been included: Scots pine, Corsican pine, Sitka spruce and Douglas fir. Examination of plots pruned in 1931 shows no apparent bad results from quite drastic live pruning of Douglas fir, Corsican pine and Norway spruce. The relation between the amount of space for crown development and the rate of occlusion of the pruned wounds is very apparent, the age of tree also plays an important part. The younger the tree and the more space available for crown expansion the quicker occlusion takes place. In some young and vigorously growing Douglas fir at Tintern many of the wounds have occluded in the first growing season. On the other hand in an older stand and with trees which are somewhat crowded most of the wounds are scarcely showing any signs of closing over after 5 growing seasons. In Douglas fir occlusion is better in the upper part of the stem than near the ground; this is doubtless the result of the faster radial growth below the live crown.

7. Measurement of Permanent Sample Plots.

Thinnings and remeasurements were carried out in 32 permanent sample plots and a mixed plot of Abies grandis and Sequoia gigantea at Leighton Park, Welshpool, was marked out and measured. A pruning experiment was also established in a block of Norway spruce adjoining plots 85-88 at Bowmont in Roxburghshire.

At the request of the Director of the Rothamsted Experimental Station detailed measurements of a larch/spruce plantation and a stocktaking of the hardwood area were carried out in Knott Wood, Harpenden.

Of the remeasured plots the most interesting are the replicated series of Norway spruce plots at Bowmont in Roxburghshire, and the Abies grandis at Novar.

The Bowmont plots were established five years ago and are now 25 years old. The number of stems per acre ranges from 1,000 in the very heavily thinned D grade plot, to 2,300 in the lightly thinned B plot. The basal area increments per acre show a rise from the light to the very heavy thinnings as may be seen from the following data.

Grade of Thinning.	Current annual increment per acre in square feet.
B	9.43
C	10.13
D	10.68)
LC	10.65)

The difference between any pair of means must exceed 0.63 to attain significance. It follows that the D and LC grades have put on significantly more increment than the B grade while the difference between the C grade and the D and LC grades are almost significant. The C grade is also definitely superior to the B grade. It remains to be seen whether the trend will be the same at the next measurement.

The Novar Abies grandis plots form a well-contrasted pair. The plots are 35 years old and the trees a little over 70 feet high. The lightly thinned B grade plot carries a stocking of 1,020 stems per acre with a volume of 9,800 cubic feet (true volume underbark). The heavily thinned D grade plot has a stocking of only 345 stems per acre, and a volume of 5,000 cubic feet. The current annual volume production is closely similar in the two plots (550 cu. ft. per acre in B and 500 cu. ft. in D) indicating that, in spite of the heavy thinning in the D grade plot, the growing space is still being efficiently used. In the B plot the crowns are now visibly showing the effect of the dense stocking, and the live crown per cent is only 35 as compared with 47 per cent in D. The trees are still growing in height at the rate of 2-3 feet per annum.

8. Botanical Research.

(i) Mycorrhiza Research - Dr M.C. Rayner. Dr Rayner is continuing her investigation into tree mycorrhiza. Supplies of humus from natural stands of Sitka spruce in Canada have been received in good condition and inoculations have been made both in the nursery and in plots in the forest.

Further pot experiments with the special composts show that the effect of these does not primarily depend upon their content of inorganic food stuffs but upon the biological changes induced in the soil. The Wareham plots, which are now in their fourth year, form a very striking series and the best of the compost-treated plots of Pinus contorta are remarkably strong and vigorous. Certain of the composts have proved consistently more effective than others.

(ii) Dr E.V.Laing - Root development of European larch seedlings. The observations made in 1934 in regard to periodicity of root expansion have been confirmed. Root extension does not begin in the north until about the middle of May, i.e. long after the short shoots have flushed. Field experiments with larch of different seed origin showed that the larch of Scottish origin was much less sensitive to late planting than Tyrolese larch. This is shown in the following table.

Date of Planting.	Average losses per cent.	
	Scottish larch.	Foreign larch.
Before 19th April	-	14
After 19th April	-	64
Before 19th May	4	-
After 19th May	42	-

An experiment on method of planting also gave results of interest. The methods were -

A. planted on the natural surface.

B. planted on ridges.

C. planted in shallow troughs (drains).

The greatest losses occurred among the plants planted in the natural surface and the fewest losses and best growth in the plants in the shallow drains. Thus the method which succeeded best with larch was the converse of the turf planting process which has proved so successful with spruce on wet or peaty soils.

9. Research on Forest Soils.

Dr Fraser has carried out some preliminary Mitscherlich tests of heath soils using Scots pine as the indicator species. The results have not yet been written up but the method appears promising. Dr Fraser has also assisted Dr Muir by making a vegetation survey of the Balloch and Bin areas in connection with the latter's soil survey. Dr Muir hopes to complete shortly his survey of the Huntley area and a preliminary report has already been prepared. The Macaulay Institute for Soil Research are continuing to collaborate in the problem of the fertility of nursery soils. Some preliminary results should soon be available.

10. Empire Forestry Conference in South Africa.

The Chairman and the Chief Research Officer attended the fourth Empire Forestry Conference held in South Africa in 1935. The principal points of silvicultural interest were

(1) the highly successful nursery practice, the plants being raised in small tins or boxes in a soil mixture consisting of natural (uncultivated) soil inoculated with humus from forest stands in the locality, with addition of further organic matter and artificial manures, if necessary.

(2) Intensive cultivation of the soil both before and after planting.

(3) The degree of thinning necessary for the very fast growing pines, which are the trees chiefly used for afforestation.

11. Entomology.

Pine-shoot Beetle and Pine Weevil. Mr H.S. Hanson of the staff of the Farnham House Laboratory has completed the initial study of these insects in the New Forest and is writing up the work with special reference to methods of control. A preliminary report, in which Mr Hanson has endeavoured to assess the relation of the factors of the locality to the liability to beetle attack, has already been received. The question of continuing the detailed investigation of the pine beetle and its parasites and predators will be deferred until Mr Hanson's main report has been received and considered.

Mr Brown has been studying the effect of the beetle attack upon the form of the trees, and endeavouring to distinguish between injuries resulting from the pine shoot moth and the pine beetle respectively. He has come to the conclusion that it is not possible to distinguish between the two injuries unless the damage is of very recent origin. Mr Brown has also made some investigations in young pine plantations at Rendlesham Forest in Suffolk. Strips were pruned in some of the compartments and the material left lying on the ground and the question was whether this material would breed beetle. It was found that a small number of beetles had bred in the pruned branches but that the amount of damage caused was negligible.

Pine Weevil. The experiment started last year on the trapping of weevils in standing woods in the New Forest is being continued according to plan. Considerable numbers of weevils were caught in the traps laid under the trees.

A further trial of different types of traps was carried out last year in Pound Hill Inclosure in the New Forest. The bark traps proved on the whole less effective than the billets although in the previous experiment bark traps gave the best result. To be fully effective the bark traps require

renewing every 2 - 3 weeks, while the billets last for 5 - 6 weeks before they have to be replaced.

Pine Shoot Moth. A first attempt was made in 1935 by Dr W.R. Thompson to introduce from Austria an egg parasite of this pest. The parasite in question, Copidosoma geniculatum, does not occur in this country but is considered to be of considerable importance on the Continent. Unfortunately the arrangements for collection in Austria broke down and only a small amount of material was received. The parasites were bred out at the Farnham House Laboratory and liberated at Puddletown in Dorset where a serious outbreak of pine shoot moth is in progress; owing to the small number of parasites available the introduction is not likely to be successful. In the current year further funds have been provided by the Commissioners and it is hoped to obtain a much larger supply of material from Austria. The parasites bred out will be liberated at Rendlesham.

Oak Tortrix. Last year Mr Brown reported that there were indications that the severe outbreak of 1932 - 34 was subsiding in the Forest of Dean and in particular that the high percentage of parasitised pupae collected from several areas in 1934 gave promise of control by the parasites. The severe May frosts in 1935, which destroyed much of the foliage on trees in the valleys and on the lower slopes, also caused heavy mortality to the caterpillars, the percentage parasitism, however, also declined, and it seems probable that the severe weather in May either killed many of the parasites, or at least affected their breeding. In general the indications are against any considerable defoliation in 1936.

Chafer Larvae. With the co-operation of Imperial Chemical Industries experiments on the chemical control of chafers were conducted in Old Pale Nursery, Delamere Forest,

allotted by them to Mr Day to enable him to investigate and report on the frost damage. Questionnaires were sent out to all field officers and large numbers of detailed observations were made. These have been analysed by Mr Day and Mr Peace and it is proposed to publish their report in the form of a Bulletin.

Butt rot of Conifers. Mr Peace has visited a number of plantations in England and Scotland and has obtained numerous specimens of butt rot occurring in different species. A variety of fungi have been isolated but Fomes annosus appears to be the only fungus of real importance except in over-mature stands. So far as the enquiry has gone the occurrence of rot does not appear to be correlated with any simple locality factor nor with the previous utilisation of the land, except that there appears to be a greater tendency for rot to occur on land which was formerly under trees.

Elm Disease. Mr Peace made a short survey of part of the affected areas in England and also visited the laboratories in Holland where the disease is being investigated. Arising out of the latter visit a small number of an apparently immune strain of elm have been presented by the Elm Disease Committee in Holland and it is proposed to make further tests on the disease resistance of the plants. In addition trees of the same strain have been purchased from Dutch nurserymen and will be used for propagation in this country.

The United States Department of Agriculture have sent over two of their technical officers, an entomologist and a mycologist, to study the disease in England and we can anticipate interesting results from this intensive attack on the problem. One interesting discovery is that the fungus is widespread in trees which show no visible signs of attack.

Damping-off in Nurseries. A trial of a number of specifics, including Potassium permanganate, Cheshunt compound, Uspulun and Hortosan A, is being carried out this spring in Tulliallan Nursery.

Poplar Canker. A number of centres of the disease in Belgium and Germany were visited in 1935 and the opinion originally put forward that the poplar species vary in susceptibility was confirmed. There appear also to be a number of organisms concerned. So far attempts at inoculation with supposed pathogenic organisms have proved very unsatisfactory.

Ink Disease of Chestnut. The Japanese chestnut, Castanea japonica, which was stated by French mycologists to be resistant to the disease, has been proved to be highly susceptible, at any rate in the young stage.

Frost-lift. Some preliminary experiments on frost-lift have been carried out in the refrigerator at Oxford and frost-lifting of inanimate objects have been successfully induced.

Watermark Disease of Cricket Bat Willow. The Watermark Disease is interesting as being the only instance in this country of attempted control of a fungus disease affecting a timber tree. In Essex, the County Council is administering an Order requiring the felling of diseased trees, and there is already some evidence to show that the policy has been successful, i.e. in the few areas where it has been vigorously applied. The efforts made to administer the Order have been somewhat half hearted, with the result that the progress of stamping out the disease in Essex is much slower than was hoped. Partly with the object of encouraging the local authorities to administer the Order more effectively, and partly in order to assist the scientific investigation of the

disease a grant has been made to provide an entomologist to assist Dr W.S. Dowson of Cambridge. Dr Dowson, who is a lecturer in mycology at Cambridge, has been studying the disease with the assistance of Mr J. Bryce, botanist to the East Anglian Institute of Agriculture at Chelmsford.
Dr Dowson has confirmed the bacterial origin of the disease, the bacillus concerned (Bacterium Salicis) having been named by Mr Day who worked on the disease some years ago.
Dr Dowson considers it very probable that the disease is spread by insect agency, and in particular by a midge, Rhabdophaga saliciperda. The immediate need is for field studies of the disease by a competent entomologist with the object of determining the insects responsible for spreading the bacterium, and of working out their life histories. The grant of £125 given by the Commissioners has enabled the appointment of Mr E. McCallan, and will carry the investigation on until September of this year. It is possible that the Essex County Council may decide to finance the work after September but the Chairman made it clear that no further assistance could be expected from the Commissioners until the local authorities made the existing Order effective.

14. Utilisation.

The Forest Products Research Laboratory have continued the examination of pruned material supplied from pruning experiments and sample plots and analyses of unpruned logs have been carried out to determine the economic results of varying degrees of pruning. Mr G.H. Donald of the Laboratory has published an interesting paper on the interim results in the April 1936 number of the Quarterly Journal of Forestry.

An endeavour was made to obtain some information on the relative value for the manufacture of mechanical pulp of Norway spruce grown on peat and mineral soils in different parts of the country. Samples were delivered to the Laboratory and despatched to Messrs Lloyd's pulping factory at Sittingbourne in Kent. The report received was not satisfactory as it dealt only with the external appearance of the timber and the firm appeared to be unwilling to carry out actual pulping tests on the material supplied. After consideration it was decided to allow the matter to drop as far as the pulping tests were concerned but the Laboratory prepared an interesting report on the rates of growth, density, etc. of the several consignments.