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FORESTRY COMMISSION.

Report on Experimental Work (England & Wales), November 1925.

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PART I - Introduction.

This year the Nursery Investigations in England and Wales were located at two centres, namely the 1925 seedling studies at Bagley Nursery, Oxford, the 1924 seedling studies at Bushfield Nursery, Bagshot and the transplant studies at Rapley Nursery, Bagshot.

It will be recalled that in previous years the nursery experiments in England & Wales were interfered with to a greater or less degree by insect pests, fungal diseases, mice, drought, etc. It has been found at Bagley Nursery that potential enemies are no less numerous than elsewhere. The following insect pests have had to be dealt with, Melolontha vulgaris, Serica brunnea, Rhizotrogus solstitialis, Otrorhynchus sp., Agriotes linneatus, Agrostis and Mamestra spp., Chermes cooleyi and C.strebilobius. A Fusarium sp. and Botrytis sp. were also potential fungal diseases, mice were present and there was a six weeks drought. As the result, however, of continuous supervision which enabled the first symptoms to be noted and the preparation of control measures in advance with the entomologist and mycologist, all these pests were controlled. The damage done was negligible and when any loss resulted the amount was determined with the result that the experiments were not interfered with. In the transplant studies at Rapley Nursery, Melolontha damage was stopped promptly. It is suggested that, in itself, it is a result of some interest to have demonstrated that the admitted difficulties and dangers of nursery experimental work and nursery work in general in the South of England have been overcome.

Soil Conditions.

Bagley Nursery, Oxford.

The nursery is located on Plateau gravel. The soil is a stoney loam, variable in heaviness, in amount of stones and in depth. The depth is 8-12 inches and the soil rests on yellow sand but occasionally clay. The soil conditions increased the difficulties of nursery experiments this year.

Rapley Nursery, Bagshot.

The nursery is located on the Bagshot Sands. The soil in the section used was 6" light, grey, brown sandy loam with a few flints, on 6" grey brown sand with pockets of sandy humus on yellow sandy clay. The soil is well drained and works well at all times. In 1924 the section carried lupins which were dug in. This did not clean the land of couch which had to be removed before the experiments were carried out.

Weather Conditions.

The following Tables give an analysis of the metereological data at Oxford and Bagshot during the periods of the investigations.

Bagley Nursery and Observatory, Oxford.

Month.	Temperatures in degrees F.				Rainfall inches	Mean Humidity %	No. of days 32°F. in screen & under.
	Mean Max.	Mean Min.	Highest	Lowest.			
1925.							
rch	48.0°F.	34.7°	55.6°	24.5°	0.458	83	13
pril	54.0	38.5	63.0	25.9	2.219	76	1
y	62.3	46.1	75.2	34.1	2.677	76	0
ine	70.6	49.7	84.3	41.9	0.066	70	0
ly	72.6	54.2	84.6	46.3	3.887	77	0
igust	68.1	53.6	79.1	46.8	2.340	81	0
ptember	61.4	46.1	70.7	40.9	3.226	79	0

Bushfield Nursery, Bagshot.

Month.	Temperatures in degrees F.				Rainfall inches.	Mean Humidity	No. of days 32°F. in screen & under.
	Mean Max.	Mean Min.	Highest	Lowest.			
1924.							
ctober	56.8°F.	44.5°	69°	27°	3.71	87	2
ovember	50.0	39.7	59	24	2.56	88	4
ecember	47.3	37.2	54	26	4.18	92	5
1925.							
anuary	46.3	35.4	54	24	2.16	92	9
ebruary	47.2	35.3	53	27	3.47	87	10
arch	46.9	32.8	53	22	.89	82	19
pril	53.8	36.6	62	29	1.90	75	3
ay	62.1	43.7	77	33	2.99	76	0
une	71.0	46.5	84	31	0.00	66	1
uly	72.5	51.6	84	43	3.45	75	0
ugust	67.6	51.2	78	42	3.08	81	0
eptember	60.7	44.0	69	35	3.16	78	0
ctober	59.0	42.0	68	30	2.53	88	3

Features of this season were :-

(a) Frosty weather in February and March when the lining out was being done in the Transplant Studies.

(b) A period of low rainfall in March following that work.

(c) A period of high rainfall, particularly in Oxford in May during the sowing season.

(d) A period of drought and high temperatures in June and July. From the 2nd June to 19th July inclusive rain fell on 3 days namely, the 27th June, .06 inches, 4th July .26 inches and 7th July .29 inches.

Seed Data.

As in previous years, the seedling studies were limited to the species which give difficulty in the nursery namely, Douglas fir, Sitka spruce, and European larch. In the race studies a large number of other species were raised. The following Table gives the seed data:-

Species	Ident. No.	Purity %	Germination.					
			Jacobsen.		Hearson		Sand.	
			%	Fresh Seed.	%	Fresh Seed.	%	Fresh Seed.
	Tests March 1925.							
Douglas Fir	25/7	91.9	27	4	17	3	33	-
" "	25/6	94.1	72	1	44	15	53	-
Sitka Spr.	25/16	93.1	83	4	82	2	87	-
Eur.larch	25/10	80.3	31	3	40	2	30	-
	Tests June 1925.							
Douglas Fir	25/7	93.9	19	0	16	6	15	-
Sitka Spr.	25/16	90.8	70	1	80	2	84	-
Eur.larch	25/10	79.3	31	0	35	2	32	-

It will be noted that Douglas fir 25/7 is well below average in quality and is unsuitable for experimental work for which average seed is best. It was issued by Headquarters and used for some experiments before its quality was known.

PART 2 - Nursery Investigations.

(a) Seedling Studies.

1. The Relation between Season of Sowing and Germination and growth

Registered Experiment N.S.No.1

This experiment was carried out with three species, Douglas fir 25/7, Sitka spruce 25/16 and European larch 25/10.

The sowings were made with the perforated zine plates used in the previous year. The nursery technique was that used for such investigations by me in Scotland. The following is data for density and depth:-

Douglas fir	300 seeds per sq.ft.	½" depth.
Sitka spruce	500 " " " "	⅛" "
Eur.larch	500 " " " "	⅛" "

The sowings were made at six seasons between mid-March and June. The unit was 2 plates each 1 sq.ft. There were six repetitions of the 2 plates for each of the six seasons, the plots being arranged in the chessboard manner.

The seed was soaked in tap water for 7 days the water being changed at the end of the 3rd day. The seed was redleaded, The seedlings were sheltered for the periods noted in Experiment No.3.

The following Table summarises the results ;-

Species Quality.	Date of Sowing.	Mean Plant Percentage at -							Mean Seedling Size.
		-	-	30.4.25	14.5.25	16.6.25	16.7.25	6.10.25	
Sitka spruce 81%	25.3.25	-	-	a few.	33%	61%	59%	59% ± 8	1[illegible]
	1.4.25	-	-	nil.	12	54	51	51 ± 1.5	1[illegible]
	17.4.25	-	-	nil.	a few.	66	60	59 ± .9	1[illegible]
	5.5.25	-	-	nil.	nil.	66	60	58 ± 5.2	1[illegible]
	22.5.25	-	-	nil.	nil.	27	28	32 ± 3.1	1"
	11.6.25	-	-	nil.	nil.	nil.	a few.	4 ± .5	½"
		-	-	14.5.25	4.6.25	25.6.25	14.7.25	5.10.25	
Doug.fir 21%	26.3.25	-	-	a few.	14	17	17	17 ± .6	3[illegible]
	2.4.25	-	-	a few.	11	14	14	15 ± .5	3[illegible]
	18.4.25	-	-	nil.	5	11	12	13 ± .6	2[illegible]
	7.5.25	-	-	nil.	8	16	17	18 ± .5	3"
	23.5.25	-	-	nil.	nil.	3	4	6 ± .3	2"
	11.6.25	-	--	nil.	nil.	nil.	nil.	nil.	-
		20.4.25	30.4.25	14.5.25	4.6.25	26.6.25	13.7.25	5.10.25	
Eur.larch 35%	27.3.25	5	14	20	21	21	21	20 ± .9	4[illegible]
	3.4.25	a few	13	21	21	21	20	20 ± .6	4"
	20.4.25	nil.	nil.	12	19	19	18	17 ± .6	2[illegible]
	11.5.25	nil.	nil.	nil.	25	28	26	25 ± 1.2	2[illegible]
	26.5.25	nil.	nil.	nil.	nil.	13	13	13 ± 1.4	1[illegible]
	12.6.25	nil.	nil.	nil.	nil.	nil.	nil.	nil.	-

There was slight damage from Serica brunnea in the second, third and fourth sowings of Sitka spruce and European but in each case the loss was less than 1%.

OBSERVATIONS and CONCLUSIONS.

1. It will be noted that, relative to the percentage of viable seed, the plant percentages are high. Although exceeded in Scotland in the previous year, they are of quite a different order from that obtained in experimental work on these species in England previously. Translated into production per lb. they give :-

x 59% for Sitka Spruce	=	85,550	1 yr. seedlings per lb.
x 18 % Douglas fir	=	11,160	"
x 25 % European larch	=	14,350	"

(Laboratory germination 81%, 21% & 33% respectively).

2. The results for Sitka spruce show that for this season the production from sowings from the 25th March to 5th May is reasonably uniform, thereafter there is a marked fall. The size of seedling decreases with lateness of sowing.

3. The results for Douglas fir are similar. There is a dip in the plant percentage in April, probably due to less favourable weather and soil conditions.

4. The results for European Larch are similar.

2. THE RELATION BETWEEN SUMMER SHELTER & PRODUCTION AND GROWTH.

Registered Experiment N.S. No. 3.

This species was carried out with three species, Douglas fir, 25/7, Sitka spruce, 25/16, and European Larch, 25/10.

The drill method of sowing was used. The seed was soaked 7 days in water, the water being changed at the end of the 3rd day. The seed was redleaded. The following is a note of density and date of sowing :-

Douglas fir	6 grammes of seed per drill sown	23/4/25.
Sitka spruce	1½ " " " " " "	1/5/25
European larch	3 " " " " " "	13/5/25

The unit for each species was a plot of 5 drills unshaded and 5 drills shaded. This was repeated 4 times in the linnear A., B., B. A., etc. method.

The shelter consisted of laths 1" wide spaced ½" apart. It was applied to the plots to be shaded when the maximum temperature in the screen exceeded 60°F for 2 or more during germination and 70° after germination was advanced.

The following table gives the movement of the shelter during this season:-

	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF
/5/ 25	25/5/ 25	3/6/25	24/6/ 25	29/6/ 25	3/7/ 25	5/7/ 25	10/7/ 25	12/7/ 25	28/7/ 25	18/8/ 25	20/8/25.

This season, particularly in June and July, provided an opportunity for the study of this subject.

The following Table summarises the results of the influence of shelter :-

Species	Treatment	Mn. No. of seedlings per drill			Min. size of seedlings.
		18.6.25	29.7.25	9.10.25	
itka Spruce	Unsheltered ...	326± 8.6	221±10.6	213±9.8	1½"
	Sheltered ...	342± 5.9	323± 6.5	315±8.8	¾"
ouglas fir	Unsheltered ...	81± 1.8	51± 3.5	53±3.3	2¾"
	Sheltered ...	41± 1.6	51± 3.2	62±2.7	2½"
uropean Larch	Unsheltered ...	104± 1.9	94± 2.0	93±2.1	3¼"
	Sheltered ...	134± 4.3	128± 4.2	125±4.0	2¾"

These results bring out points of interest. Before discussing these it is necessary to state that the count at the 18th June was too late to give the production before drought an sun losses, as these had begun. A complete count of all plants was thus made to enable the actual loss to be determined Actually on the 18th June a mean number of 37 seedlings were dead in Sitka spruce unsheltered plots; 14 in Douglas fir, and 5 in European larch. In the sheltered plots the losses were

2, 1 & 1 respectively. The losses took place from the 12th June onwards. It may be questioned whether these losses were due to sun, drought damage or pathological causes. There is no doubt on this point. The results and the arrangements of the plots are sufficient answer but in addition the entomologist certified that they were not due to insect damage and specimens were submitted to the mycologist but were not reported on. Later a mean number of 2 plants per drill were lost from serica in the sheltered plots of Sitka spruce and Douglas fir between the dates of the first and second counts, and 4 in the sheltered Sitka spruce between the dates of the second and third counts.

CONCLUSIONS :-

(1) For Douglas fir, it is conclusively shown that shelter even for limited periods when the screen temperature exceeded 60°F during germination has definitely retarded germination, 81 ± 1.8 unsheltered compared with 41 ± 1.6 for sheltered. Later, however, in the period of high temperature there was a heavy loss in the unsheltered plots, a fall from 81±1.8 to 51 ± 3.5, while in the sheltered plots (when the screen temperature exceeded 70°F for more than 2 days) there was an increase from 41 ± 1.6 to 51 ± 3.2. The final figures were 53 ± 3.3 and 62 ± 2.7 respectively. The shelter decreased growth slightly, 2¾" to 2⅛".

The conclusion for this species is that shelter should not be applied during germination unless the screen temperature much exceed 60°F - probably 70°F would be safe. The condition of soil moisture should also be considered.

(2) For Sitka spruce, shelter during germination when the screen temperature exceeded 60°F for two days, did not retard germination. Later in the unsheltered plots there was a heavy loss 326 ± 8.6 to 221 ± 10.6, while in the sheltered plots it was much less -- 342 ± 5.9 to 323 - 6.5. The final figures were 213 ± 9.8 and 315 ± 6.8 for unsheltered

and sheltered respectively. Shelter decreased growth markedly, 1½" to ¾".

The conclusion is that for this species shelter on the principle applied was markedly beneficial as regards production but not growth.

(3) For European larch shelter during germination as applied increased germination to a significant extent, 104 ± 1.9 and 134 ± 4.3 for unsheltered and sheltered respectively. The losses in this species were not marked, namely 94 ± 2.0 128 ± 4.2 for the corresponding treatments. The final figures were 93 ± 2.1 and 125 ± 4.0. The corresponding growth data was 3¼" and 2¾" for unsheltered and sheltered respectively.

The conclusion for this species that shelter on the principle applied was beneficial but principally during germination.

(4) The production was satisfactory. Taking the final sheltered results, the outturn per lb. of seed was Sitka spruce 94,250 1 yr. seedlings, Douglas fir, 4365 and European Larch 19,150.

(5) Taking the five seasons during which this study has been proceeding the 1925 season is the first one since 1921 in which shelter has been markedly beneficial in the Southern England zone.

No. 3. WEED PROBLEMS.

Registered Experiment N.S. No. 21.

This subject was studied rather fully. In the first place, there was a special study of the influence of soil treatments at and before sowing and secondly the relationship between weed growth and method of sowing, density of sowing, season of sowing, shelter and tilth was determined by observations and timing studies in the different experiments on these subjects.

In the experiment on soil treatment the following methods were studied :-

1. Control, no treatment.
2. Covering soil treated with a 1% solution of $CuSO_4$, 1 gallon to 2 cu.ft. of soil, 7 days before use.
3. After sowing and covering, the soil wet down with 1% $CuSO_4$ solution 1 pt. to 1 sq.ft.
4. The seed bed prepared 26 days in advance of sowing. Before sowing the surface hoed to kill germinating weeds.
5. The standard soil covering burnt before use.

Sitka spruce was used as the indicator species as being likely to be sensitive. The density of sowing was 1 lb. to 360 sq. ft. The unit was a plot 3 feet square. It was repeated five times for each of the five treatments, the plots being arranged on the chessboard principle. The sowings were made on the 21st May.

The principal weeds which had to be dealt with were Poa annua, Rumex acetosa and Spergularia rubra.

The following Table summarises the results :-

Treatment	Mn. No. of Minutes of 1 man taken to weed 1 sq. yd. on				Mn.No. of Seedlings per sq.ft.
	30.6.25	22.8.25	22.10.25	Total	
Control	27 ± 1.8	5 ± .8	6 ± 1.0	38	148±10 + 8[x]
Covering Soil treatment with 1% $CuSO_4$	19 ± 1.5	3 ± .5	4 ± .7	26	142±13 + 9[x]
After sowing and covering soil wet down with 1% $CuSO_4$	0	0	0	0	10± 3 + 1[x]
Seed bed prepared 26 days in advance and hoed before sowing.	18 ± 1.4	6 ± 1.0	9 ± 1.7	33	127±19 +10[x]
Burnt soil used for covering	21 ± 1.7	3 ± .2	7 ± 1.3	31	92±13 + 4

x Mn. No. of plants per sq. ft. killed by Serica and not included in the mean.

CONCLUSIONS :-

1. The treatment of the covering soil with 1% $CuSO_4$ has decreased the amount of weeds to a significant degree in the first weeding. There are decreases in the subsequent weedings, but these are not quite significant. The production of seedlings has not been affected.

2. The wetting down with 1% $CuSO_4$ after sowing and covering eliminated weeds but decreased production seriously.

3. The preparation of the seed bed 26 days in advance with hoeing at the time of sowing decreased the amount of the first weeding to a significant extent. The production of seedlings has not been affected significantly.

4. The decrease in the weeding with the burnt soil is not significant. The production of seedlings has been decreased to a significant extent. On burning, the soil lost its structure and did not make a good covering soil. It washed down into the underlying layers.

The following Table give the weeding times per bed of 21 sq. ft. for the 1% $CuSO_4$ treatment of covering soil and controls carried out at Bushfield in 1924. The data obtained in the previous year is added for comparison :-

Species & Treatment.		1924 Weeding			1925 Weeding.		
		Ist.	2nd.	Total	Ist.	2nd.	Total
itka spruce	Bed soil	12 min.	15 min.	27 min.	3 min.	3min.	6 min.
	Humus	43 "	14 "	57 "	5 "	7 "	12 "
	Humus $CuSO_4$	8 "	8 "	16 "	2 "	3 "	5 "
opean larch	Bed Soil	29 "	22 "	51 "	7 "	5 "	12 "
	Humus	45 "	13 "	58 "	11 "	7 "	18 "
	Humus $CuSO_4$	4 "	6 "	10 "	3 "	2 "	5 "

Conclusion :-

1. The influence of the Copper sulphate treatment has persisted during the second season. There has been no adverse influence in growth.

RELATION BETWEEN DENSITY OF SOWING & WEED GROWTH.

An analysis of the data for both broadcast and drill sowings for 3 species showed that there was no relationship between these factors during the first year.

RELATION BETWEEN METHOD OF SOWING & WEED GROWTH.

An analysis of the data for 3 species showed that drill sown beds took longer to weed than broadcast beds. The comparative figures per sq. yd. of 1 man during the first year were 28 ± 1.1 and 22 ± 1. The drill figure includes some cultivation against drought.

RELATION BETWEEN SEASON OF SOWING & WEED GROWTH.

The following Table gives the comparative data :-

SEASON OF SOWING.	NO. OF WEEDINGS.	TOTAL WEEDING TIME 1 man per sq. yd.
26.3.25	4	73 min. ± 6.1
2.4.25	4	79 " ± 6.8
18.4.25	3	42 " ± 4.3
7.5.25	3	34 " ± 4.2
23.5.25	2	17 " ± 1.0
11.6.25	1	14 " ± .8

It is seen that the March - 1st April sowings show significantly greater weeding times than the 2nd April - 1st May, which in turn are higher significantly than the 2nd May - 1st June.

RELATION BETWEEN DIFFERENT TYPES OF SOIL COVERING, INCLUDING HUMUS & LIME MANURING & WEED GROWTH.

An analysis of the data for the 7 treatments in Experiment No. 22 (see later) showed that the weed growth was not influenced. No. 2 lime manuring gave a total seasonal weeding per sq. yd. of 33 min. ± 3.8 compared with 23 ± 2.1 for control. This, however, is not quite significant. The results for the other treatments were uniform.

RELATION BETWEEN SHELTERING & WEED GROWTH.

An analysis of the data of unsheltered and sheltered plots of 3 species showed that shelter had decreased the weed growth but not to a significant extent.

4. THE RELATION BETWEEN METHOD & DENSITY OF SOWING AND PRODUCTION, GROWTH & QUALITY, AS MEASURED BY SUBSEQUENT SURVIVAL IN CONIFEROUS SEEDLINGS.

Registered Experiment N.S. No.4.

An investigation on this subject has been begun with 3 species, Douglas fir, 25/6, Sitka spruce, 25/16 and European larch, 25/10. Two methods of sowing are studied, broadcast and drill and four densities in each. The unit plot is 1 sq. yd. and there are four repetitions for each of the four densities in each method. The plots are arranged in the chess-board method. Germination, evenness of distribution and growth have been excellent. The plants have been protected successfully to date from pests, diseases, etc. The data will be presented when the plants are lifted.

5. TILTH STUDIES.

Registered Experiment N.S.No.22.

The importance of tilth in seedling production has been demonstrated in previous investigations. Improvement was sought along three lines, namely the use of humus, lime and sand. Sitka spruce was used as the indicator species, it being known to be very sensitive to tilth conditions.

The influence of the following treatments was studied :-

1. Control, untreated nursery soil and covering soil.
2. ditto. with quick lime applied at the rate of 1 lb. per 9 sq.ft.(approx. 2 tons per acre) in spring.
3. Nursery soil with humus covering soil(2 parts bed soil + 1 part humus)
4. " " " coarse sand " " "
5. Deep humus mulch & humus covering soil (as above).
6. ditto. with lime as No. 2.

7. Deep humus mulch and coarse sand covering soil.

These treatments were devised to study :-

(a) The influence of lime on surface caking (No.2) and general consolidation of soil (No.6).

(b) The influence of humus (No.3) and coarse sand (No. 4) on surface caking.

(c) The influence of humus on general consolidation.

The consolidation of the soil, an adverse factor experienced in English Experimental work in the past was found on investigation to be due to the misapplying of the treading method of seed bed preparation. This is a useful method on very light dry soils with broadcast sowing but should not be used with other methods of sowing and on other than very light dry soils.

The unit plot was 1 sq. yd. The 7 methods were each repeated 4 times, the plots arranged on the chessboard method.

The Sitka spruce was soaked 7 days, redleaded and sown on 30th May. The density of sowing was 1½ grammes per drill. There were 5 drills per plot.

The following Table summarises the results :-

Treatment.	Mean No. of Seedlings per drill at 28.6.25	11.10.25.
. Control, nursery soil	146 ± 6.2	213 ± 5.9 + 1*
. Nursery soil with lime	43 ± 4.0	95 ± 4.4 + 2
. Nursery soil with humus covering	113 ± 6.5	189 ± 3.9 + 0
. Nursery soil with coarse sand covering	175 ± 7.3	284 ± 10.2 + 2
. Humus mulch and humus covering	39 ± 3.1	174 ± 7.5 + 6
. Ditto. with lime	10 ± 1.0	62 ± 1.2 + 1
. Humus mulch & coarse sand covering	109 ± 6.4	250 ± 7.6 + 4

*Min. number of seedlings per drill killed by serica brunnea.

The following are observations and conclusions on the undernoted points :-

A. The relation between type of covering and the rate of germination.

   (1) The addition of lime in spring has inhibited germination (Nos. 2 & 6). This is markedly significant.

   (2) The addition of humus has inhibited germination (Nos. 3, 5 & 7). The greater the amount of humus (No.5) the greater the inhibition.

   (3) Coarse sand is the only covering giving a significant increase in the rate of germination compared with the control (No. 1)

   The influence of these coverings on the rate of germination (i.e. up to 28/6/25) was not due principally to caking, as little rain fell during the period.

B. The relation between type of covering and seedling production :-

   (1) The spring addition of lime has decreased production markedly.

   (2) The addition of humus (other than 7) has decreased production by a much smaller amount which is just significant. Germination has increased more in the humus plots than in the lime plots between 28/6/25 and October. This is due probably to water retention and the prevention of caking.

   (3) The use of a coarse sand for covering has increased production to a significant degree.

C. The influence of the above treatments on growth.-

   (1) At the end of the first season there is no visible difference in growth.

6. STUDIES ON HARDWOOD NURSERY PRACTICE.

Registered Experiment N.S. No. 23.

The projected experiments on this subject could not be carried out owing to the inability of the Assistant Commissioner for England & Wales to supply the necessary seed.

7. STUDIES ON RACE & TYPE OF TREES.

Registered Experiment N.S. No. 24.

Douglas fir from 4 Canadian origins and 1 U.S.A. origin were sown in 1924 at Bushfield Nursery, Bagshot. They were severely attacked by Melolontha larvae during that season, but they were projected successfully this season and a varying number of seedlings obtained.

The following are notes on the different types. More detailed locality data was given in the 1924 Scottish Report pp. 13-14.

Douglas fir 24/28 U.S.A. presumed from Coast.

A typical coast type seedling. Shoot average length 6" maximum 12". Needle medium green; stem olive to orange green; buds red; terminal buds hidden by needles. This is a well branched plant, the branches being largely second or late growth.

Douglas fir 24/22. Craigellachie, B.C. Mean annual rainfall 30 - 32 inches.

Shoot average length 2½", maximum 9"; needle colour dark bluish green; stem grey green; buds reddish brown; terminal bud prominent. There are a few branches second growth.

Douglas fir 24/23. Shuswap Lake, B.C., similar to 22, but rainfall 24 - 25 inches.

Shoot average length 3¼" maximum 9"; needle colour medium green; stem colour variable olive green to red; buds red to reddish brown; terminal buds either prominent or hid; a little second growth.

Douglas fir 24/24. Louis Creek, B.C., Rainfall under 20 inches.

Shoot length average 4", maximum 9".

Needle colour medium to light green; stem olive green to red; buds red to reddish brown; terminal buds prominent or hid; very little second growth, little branching.

Douglas firm 24/25 - Salmon River, Rainfall 17".

Shoot length average 3", maximum 6"; needle colour dark bluish green; stem grey to reddish green; buds reddish brown; terminal buds generally prominent; very little second growth.

In ~~the~~ my original ~~of my~~ 1924 working Plan on this subject, one of the purposes of such investigations was stated to be the supply of material for related pathological studies. Dr.Munro has already found the need for such material in connection with Chermes cooleyi.

During this season the following race studies were started. There is nothing as yet to report :-

European Larch, seed of 12 origins including the Tyrol, Silesia and Scotland.

Pinus Contorta, seed of 3 origins, partly School of Forestry seed.

Pinus ponderosa seed of 2 origins.

Japanese species, 8 different species or races.

PART 2 - Nursery Investigations.

(b) Transplant Studies.

8. Relationship between Season of Transplanting, Corsican pine and losses and growth.

Registered Experiment NS. No.13.

This is a continuation of the study begun in the season 1922-23. Transplantings were made with both 1-yr and 2-yr seedlings at 6 seasons between December and May. The unit plot was 4 rows of 50 plants repeated 6 times and scattered at eash of the six seasons.

The seedlings both 1-yr and 2-yr were raised in Rapley Nursery on 9-12" grey sandy loam on a very soft iron pan on sand. The density in the seed bed was 59 per sq.ft. for the 1-yr seedlings and 83 per sq.ft. for the 2-yr seedlings.

The following Table summarises the results:-

Season of Lining Out.	Percentage Loss at		
	15.5.25.	25.6.25.	28. 9. 25.
year seedlings.			
3. 12. 24	.75%	-	2.0 ± .26
3. 1. 25	.25	-	1.0 ± .26
3. 2. 25	.40	-	1.2 ± .22
3. 3. 25	.25	-	.8 ± .20
2. 4. 25	.20	-	1.0 ± .22
2. 5. 25	0.	17.0	18.0 ± 1.20
year seedlings.			
3. 12. 24	3.40	-	10.0 ± .98
3. 1. 25	4.10	-	6.0 ± .60
3. 2. 25	1.25	-	3.0 ± .42
3. 3. 25	.40	-	1.2 ± .22
2. 4. 25	.10	-	14.0 ± 1.74
2. 5. 25	0.00	35.0	70.0 ± 2.10

With regard to growth there is no visible difference in size and quality in the different seasonal transplanting from December to April. At the end of the first growth, the rising 2-yr 1-yr were larger than the rising 1-yr 1-yr. This difference is now less because a larger proportion of the latter have made a second growth.

Observations and Conclusions.

1. The losses in the 1-yr 1-yr stock are less than in the 2-yr 1-yr. This is most marked in the less favourable seasons.
2. In the 1-yr 1-yr stock there is no significant difference in the losses from December to April inclusive (March .8% loss is lowest). May has a higher loss which is markedly significant.
3. In the 2-yr 1-yr stock each difference is significant, May very much so. (The lowest loss is March 1.2%).

It may be considered useful to summarise the results obtained at Rapley during the period 1922-25:-

Year and Class of Stock.	Percentage Loss from transplanting in -						
	November	December	January	February	March	April	May.
1-yr stock							
1.1922-23	7.0	9.0	11.0	10.5	34.0	-	-
2.1923-24	13.0	16.0	13.0	12.0	14.0	52.0	
3.1924-25	-	2.0	1.0	1.2	.8	1.0	18.0
Mean	10.0	9.2	8.3	7.9	16.3	26.5	-
2-yr stock							
4.1923-24	49.0	31.0	14.0	18.0	47.0	45.0	-
5.1924-25	-	10.0	6.0	3.0	1.2	14.0	70.0
Mean	-	20.5	10.0	10.5	24.1	29.5	-

Conclusion:

1. During this period, although the results have varied, January and February linings out have given low losses consistently, in both classes of seedlings.

No.9 The relation between spacing of transplants and losses, growth and subsequent survival.

Registered Experiment N.S.No.18.

This investigation was carried out with the undernoted six species. The plants were graded to give average plants. The following is relative data:-

Species.	Seed Ident. No.	Age.	Nursery of Origin.	Seedbed Soil.	Shoot length limits	Seedbed Density.
Scots pine	22/45	2-yr	Rapley	Sandy loam.	2½" & 5"	76 pr.sq.ft.
Corsican "	23/31	2-yr	"	"	1½ & 3"	83 " " "
Norway sp.	23/5	2-yr	Swinley	Clay "	4 & 7"	128 " " "
Sitka sp.	22/20	2-yr	Bushfield	Sandy"	4 & 8"	72 " " "
Eur.larch	24/10	1-yr	Swinley	Clay "	3 & 6"	90 " " "
Doug.fir	22/19	2-yr	Bushfield	Sandy"	6 & 12"	70 " " "

The unit for each species and treatment was a plot of 4 rows each 8' long. It was repeated 6 times in scattered plots.

The spacing between the lines was 10" with variations of 1", 1½", 2" and 3" within the lines. The notch system was used and the work was carried out in February and March beginning with Douglas fir and finishing with Norway spruce. The soil conditions of the lining out site are described in the introduction.

The following Table summarises the results :-

Species.	Percentage Loss in Spacings of -			
	1"	1½"	2"	3"
Norway sp.	0 %	0 %	0%(.3)^x	.4%
Sitka sp.	.1	.5	.1(.4)^x	.2
Doug.fir	1.4	1.5	.8	1.5
European larch	.6	.8	.3	.8(1.2[illegible]
Scots pine	2.9	4.4(4.7)^x	4.3	3.1
Cors.pine	2.0(2.3)^x	3.6(4.5)^x	2.8(5.6)^x	1.0(1.6)^x

x The figures in brackets give the losses when the plants killed by Melolontha larvae are included.

Observations and Conclusions.

1. It will be noted that the losses are low (0% to 4.4%) and uniform throughout the different spacings.

2. As regards size of stock, this can only be determined accurately when the stock is lifted, but in Norway spruce, Sitka spruce, European larch, Scots pine and Corsican pine there is no marked difference in size in the different spacings. In Douglas fir the two ~~under~~ wider spacings have on the whole larger plants than the two closer ones. In the latter species also the needles are shorter and paler in colour in the two close spacings.

3. As regards symmetry and strength of branching, there is a progressive decrease from the 3" to 1" spacing, in all species except Corsican pine which has not a well developed system of branching. It is not marked however until the 1" spacing is reached.

It is considered that the only true assessment of the results of such an experiment is the subsequent development of the plants when planted out. For this purpose an Experimental Garden where such work could be done under control and supervision is an immediate necessity.

No.10. The influence of the Grading of Seedlings on losses, growth and subsequent survival.

Registered Experiment N.S.No.19.

This study was made with the same six species and lots as before. The following system of grading was applied to the seedlings:-

Grade 1. Seedlings one half the maximum shoot length and over, excluding exceptionally large plants and exceptions noted in Grade 3.

Grade 2. Seedlings less than one half the maximum shoot length with the exceptions noted in Grade 3.

Grade 3. Culls, badly rooted, suppressed, drawn, weakly, damaged and diseased seedlings.

This worked out with the different species as follows:-

Species.	Grade Description.		
	Grade 1.	Grade 2.	Grade 3 culls.
pine	4" & over	Under 4"	Cause of culls:- Imperfectly ripened lammas shoots, 2 or more leaders, suppressed and severe Lophodermium attack.
can pine	2" & over	Under 2"	2 or more leaders, suppression and severe Lophodermium attack.
y spruce	5" & over	Under 5"	Multiple tops, a few badly rooted and suppressed.
spruce	5" & over	Under 5"	Very small seedlings, multiple tops and cockchafer damage.
ean larch	$3\frac{1}{2}$" & over	Under $3\frac{1}{2}$"	Principally very small plants.
las fir	7" & over	Under 7"	Botrytis, suppression, multiple tops.

The following grades were studied, the scale and lay out being as for Experiment No.18. The spacing was 10" x 2"(except iv)which was 6" x $1\frac{1}{2}$" and the work carried out between February and March.

(i) Grade.1.

(ii) Grades 1 and 2 i.e. only culls excluded.

(iii) Grade 2.

(iv) Grade 3 (bedded).

The following Table summarises the results:-

Species.	Percentage Loss in			
	Grade 1	Grades 1 & 2	Grade 2	Grade 3
rway spruce	.3%	.7%	1.0% ± .3	2.2% ± .4(2.4)[x]
tka spruce	0.	.1	.0	2.8 ± .5
uglas fir	1.0	.9	1.8 ± .4(2.2)	13.9 ± .9
ropean larch	0.	.6	.8 ± .2	6.3 ± .6
ots pine	2.1	3.3	11.7 ± 1.3	43.1 ± 1.2
rsican pine	1.5(2.9)	.4(1.0)	2.1 ± .3(3.7)	27.9 ± 1.6

[x] The figures in brackets give the losses when the cockchafer plants are included.

<u>Conclusions</u>:-

1. In Norway spruce, Sitja spruce, Douglas fir and European larch, there is no significant difference in the losses in Grade 1; Grades 1 and 2 and Grade 2. In Scots pine and to a less extent in Corsican pine the losses in Grade 2 are higher than in Grades 1 and Grades 1 and 2.

2. The losses in Grade 3 in all species are higher, markedly so in Scots pine, Corsican pine and Douglas fir.

3. There is a more or less well marked decrease in average size from Grade 1 to Grade 3.

4. In this experiment also an experimental garden is a necessity to enable the plants to be studied after planting.

PART 3. Planting Investigations.

1. The Relation between Season of Planting and the losses and growth of Corsican Pine.

Registered Experiment P.S. No. 501.

In the autumn of 1924, a new series of monthly plantings was laid down at Wangford, Thetford Chase, to continue the 1923-24 series. This new series consisted of two parts, Part I, monthly plantings from December 1924 to May 1925 and Part II, September 1925 to May 1926.

The soil is a deep, yellow sand on chalk. The herbage is sparse bracken, Festuca ovina, a little Carex arenaria and abundant lichen. The elevation is 100 feet and the site is moderately exposed from the prevailing wind.

Part 1 consists of 6 monthly plantings of 30 rows of 50 plants each, in 6 scattered series. The stock was 2yr.-1yr. Corsican pine raised at Wangford Nursery. The following Table gives the results at 30th September 1925.

	Dates of Planting.					
	16.12.24.	16.1.25.	12.2.25.	16.3.25.	15.4.25.	15.5.25.
Mn. Loss %	16	16	22	20	28	70
Probable Error	± 1·2	± ·9	± 1·8	± 1·4	± 1·8	± 2 ·1

Conclusion:-

1. It will be noted that from December to March inclusive, the losses do not show significant differences. April has a higher mean loss but this is barely significant, May has a very much higher loss.

It may be considered useful to summarise the results obtained to date on this subject:-

Place a Year.	Mn. Loss % from Plantings in December.	January.	February.	March.	April.	May.
Cannock, 2yr.lyr. 1922-23.	14 ± 6	23 ± 1·2	29 ±1·5	32 ± 1·1	56 ±2·0	71 ±1·4
Allerston, lyr.lyr. 1923-24.	24 ± 1·5	26 ± 1·8	24 ± 1·7	22 ± 1·7	23 ±2·7	43 ±2·6
Wangford, 2yr.lyr. 1923-24.	35 ± 1·5	14 ± ·9	36 ±1·4	62 ± 1·5	52 ±1·9	46 ±1.7
Wangford, 2yr.lyr. 1924-25	16 ± 1·2	16 ± ·9	22 ±1·8	20 ± 1·4	28 ±1·8	70 ±2·2
Mean Loss %	22	20	28	34	40	58

The conclusions are:-

1. Season of planting has an important influence on losses
2. The actual results depend on the site, the weather conditions and the nature of the stock.
3. It has been shown that, on the average, winter planting particularly during December and January, gives much lower losses than spring planting.

2. <u>On the Use of Large Sitka Spruce.</u>

<u>Registered Experiment P.S. No. 508.</u>

A preliminary experiment on this subject was carried out at Cynwyd Forest, Division No. 2. The results cannot be considered conclusive owing to delays damaging the 3' plants. The following is a note of the losses to date:-

Sitka Spruce 1 foot high ... 15% loss.
" " 2 feet " ... 6% "
" " 3 " " ... 69% "

A number of existing experiments were inspected and recorded during the divisional visits. These were noted in the appropriate reports.

November 1925.

REPORT ON EXPERIMENTAL WORK

SCOTLAND.

NOVEMBER 1925.

INDEX TO ANNUAL REPORT.

1924-25.

A. NURSERY EXPERIMENTS.

EXPERIMENTS CONNECTED WITH GERMINATION.

Experiment 4b dealing with the effect of the Treatment of seed before sowing upon the germination in the nursery was completed.

A new experiment, No. 33, specially undertaken, in order to ascertain if there was any connection between size of seed and germinative capacity in the case of Larch, was also completed.

Experiment 4b. On Treatment of Seed before Sowing, with Iodine and Water.

Object. To throw further light upon the effect of soaking seeds of conifers in water for varying lengths of time and in Iodine solution, and to ascertain, more especially whether, in the case of European Larch, seed soaked for 1 day in Iodine Solution gave a better germination than seed soaked for 1 day in water alone.

Results expected.

Owing to apparently contradictory results obtained by Steven and Hiley, who have both already carried out work with the same object in view, in the case of Larch, no definite views were held as to the probable results.

Plan of Experiment.

The method adopted for investigation was, in the main, that used by Steven in Experiment 4a of 1924. Se-d of Sitka Spruce and European Larch were used. The treatme s applied were :-

1. Soaking for 7 days in tap-water at room temp. Water ch nged once
2. " " 24 hours " " " " ".
3. " " 6 " " " " " " and thereafter for 18 hours in saturated Iodine Solution.
4. Soaking for 24 hours in tap-water at 50°C. and allowed to cool during that time.

Treatments 2 and 3 were the important ones. Treatment 4 was added as Steven had included that in his experiment, but not the soaking for 24 hours in water at room temperature.

The experiment was carried out in Inverleith Nursery and the unit consisted of 500 seeds sown by the perforated plate method, so that every seed was evenly spaced and at uniform depth. Soaking was so timed that all treatments could be sown simultaneously and not on separate days. Only 4 series of 4 plates each could be sown in one day. A total of 10 series for each species was sown, with 1 plate for each treatment in each series.

The Sitka Spruce were sown on 7th, 8th and 9th April and the Larch on 21st, 22nd and 23rd April. Weather conditions were uniform over the period in the first case, but the first four Larch series were sown on a dry day and the remainder in wet weather. The beds were prepared on the first day of sowing in both cases and were not stirred up later.

Seedling counts were made on 21st May, 3rd June, 2nd July and 3rd Sept. for Sitka and on 21st May, 3rd June, 17th June and 3rd Sept. for Larch. Much more frequent counts would have been a decided advantage, as carried out by Hiley, for it is impossible to ascertain the complete germination otherwise, owing to seedlings dying off as fresh ones appear, the two sets cancelling one another out.

Results Obtained.

Nothing abnormal occurred to interfere with the experiment, an attack of Cut-worm coming too late to throw out the counts. (See Appendix I for complete data)

Sitka Spruce. 1. Compared with 1 day's soaking in tap-water at room temp.,,soaking in Iodine Solution did not increase the number of seed, which germinated in the nursery.

2. Soaking in water at 50°C. resulted in a slight increase in germination as compared with water at room temp.

3. Soaking in water at room temp. for 7 days caused an appreciable increase in the number of seed which germinated in the nursery and in the rate of germination.

European Larch. 1. Seed soaked in tap-water for 24 hours and seed soaked in Iodine Solution for 18 hours, following 6 hours' soaking in tap-water, behaved in precisely the same manner when sown outside.

2. Seed soaked for 7 days in tap-water gave a lower germination in the nursery than any of the other treatments.

3. Seed soaked for 24 hours at 50°C. and allowed to cool showed no significant difference in germination from seed soaked for 24 hours at room temp.

Reliability of Results.

This should be high as every precaution was taken to render possible the elimination of atmospheric and soil influences and as nothing abnormal occurred. The extremely close agreement obtained in the case of Larch between the 24 hours water and Iodine treatments, is clear from the following figures:-

	SERIES I to IV. Sown 21st.				SERIES V to VIII. Sown 22nd.			
Date of Counts.	21/5	3/6	17/6	3/9	21/5	3/6	17/6	3/9
24 hours in water	29.95	33.25	34.40	36.10	26.75	29.85	30.90	32.85% of seed sown
18 " " Iodine and 6 in water.	30.95	33.65	34.65	36.50	26.25	29.65	30.95	34.45
	SERIES IX & X. Sown 23rd. April.							
in water	19.70	24.60	26.20	29.70 % of seed sown.				
in Iodine.	20.70	24.50	25.40	28.50 % " " "				

The greatest variation occurs from series to series but there is hardly any difference at all between treatments.

In the case of Sitka Spruce, the final counts for the three groups of series were :-

	SERIES I to IV. sown 7th April.	Series V To VIII. sown 8th April.	Series IX and X. sown 9th April.
Water for 24 hrs.	35.05	25.45	22.8%
Iodine Teeatment.	32.75	26.25	22.3%

The figures also show good agreement between treatments in spite of a marked fall off from one group of series to another.

Agreement of Results with Other Investigations.

Miss Helen Gray carried out some tests with pot-grown seedlings from Larch seed treated with Water and Iodine, amongst other things. The results are given in the Trans. of the R.S.Arboricultural Society, 1923, Vol. XXXVII.Pt 1. Her figures show complete similarity between the 1 day soakings in water and in Iodine solution, as follows:-

	Germination.							Proportion of viable seed germinated at end of	
	12	14	16	21	26	37	54	14 days	21 days.
	days after sowing.								
Cold water	3	21	30	43	46	46	47	.5	.9
Iodine Solution (Both 24 hours)	2	18	33	43	45	47	47	.4	.9

Steven carried out experiments in 1923-24, which showed that seed of Douglas Fir, Sitka Spruce and European Larch when put into tap-water for 6 hours and then into a saturated iodine solution for 18 hours gave a slight increase in comparison with untreated seed, but no appreciable difference compared with seed soaked in water for 7 days: That soaking in water at 50°C. for 1 day was less effective than iodine: That soaking in water at 80°C. was very harmful.

Hiley, as the result of more intensive experiment showed in 1924, that iodine treatment is not better than soaking in water at 10 to 15°C. for 1 day nor to soaking in water for 7 days.

The results obtained this year would appear to confirm all the previous conclusions, at least in the case of Larch. There are some discrepancies in the case of Sitka Spruce, which may be due to the different methods of experiment.

Important Indirect Results obtained.

(1). The most striking result obtained was the marked difference in the germination throughout the different series, especially with Sitka Spruce. In treatments 2 and 3, the tendency was to fall from Series I to X and in treatments 1 and 4, the reverse was true. This would indicate either (a) Variation in soil fertility along the seedbed, or (b) Variation in the physical condition of the soil, due to delays of 1 and 2 days in sowing after preparation, of (c) Variation in atmospheric conditions or (4). Varying effects on the seedcoat itself of the soaking, subsequent drying for 1 day or less later, and subsequent moistening again in the soil.

As the differences are not gradual from Series I to X but occur suddenly after series IV and VIII, the first alternative is improbable. Any of the others are however, possible and this would suggest that a special study of soil conditions at time of sowing and possible control of same might be worth while and that laboratory experiments into the effect of alternate wetting and drying of seed upon germination, might be useful.

Differences due to one or other of these three causes may amount to as much as 10%, considerably higher than any difference likely to be brought about by use of chemical treatment.

(2) Losses after germination.

In the case of Sitka Spruce, the death-rate over all 4 treatments, so far as it could be ascertained from the limited number of counts was as follows:-

Treatment.	% of total germinated seed.	% of the seed sown.
1.	13.86	4.63
2.	9.46	2.37
3.	10.23	2.56
4.	9.12	2.28

These figures illustrate the importance of noting losses in an experiment of this kind. In some cases, the seedlings had only enough energy to push through the soil. They then died off. In other cases, soil fungi accounted for several and later on Cut-worm removed a few. Quite a number appeared with no chlorophyll and soon died off.

For the two best treatments in the case of Larch, the nursery germination was 33.8% and that of the best plate of 500 seed, 39.2% as compared with the test figure of 38%. In the case of Sitka, the respective figures were 31.99 and 41.20 as compared with a test figure of 53% .

Practical Value

This experiment conclusively shows that soaking of Larch or Sitka Spruce seed in saturated Iodine Solution for 18 hours is not better than soaking in water at room temperature for 24 hours.

It also indicates that a study of the control of the physical condition of seedbeds should lead to useful results. From the point of view of experimental practice, it also indicates that similar experiments would give better results, if more frequent counts were made and every seedling removed as it appears.

It suggests that research into the nature of the seed-coats of various species and their response to various treatments might be of value.

B.3.

Experiment 33. On the Relationship between Size of seed and Germinating Capacity of European Larch.

Object. To ascertain whether there is any correlation between size of seed, germinating capacity and size of seedling in a sample of European Larch in view of the fact that it has been stated that some seedsmen are in the habit of intentionally mixing small seed with large.

The experiment is not yet finally completed but definite results have already been obtained in regard to the relationship between size of seed and germinating capacity.

Results Expected. It was expected that the larger seed would be better than the smaller and would produce better plants.

Plan of Experiment. A fair sample was taken from the seed supplied and the seed therein were separated by eye into 3 sizes, termed XA, XB and XC, the first being the largest. All impurities were very carefully removed. Samples were sent of each size to the B.O.A.S. seedtesting station. At the same time seed of each size were sown in Inverleith nursery. The perforated zinc plate method was used, but the unit consisted of 120 seed, sown in 2 rows of 60 each at a uniform depth of ¼". There were 10 series of 3 units each, one unit for each size; all sown in one day, series after series. The seedlings were counted 5 times from 22nd May to 3rd Sept. and all losses noted as far as possible.

An attack of cut-worm arrived too late to disturb the counts.

Results Obtained.

Size.	Av.Wt.per Seed.	Av.Length of seed.	Germination%. Lab.	Nursery.	Losses in the Nursery in % of seed sown.	of seedlings.	Seeds per 1000
XA.	10048 gm.	About 4mm	28½%	22.33%	4.58%	20.52%	78
XB.	.0037 "	" 3.25"	27½%	12.34	2.83	22.82	288
XC.	.0027 "	" 2.5mm	5½%	3.54	1.33	37.20	634
Means	.0032 "		13% in 10 days				

Clearly in this case, the larger seed have a better germination both in the laboratory and in the nursery. The difference in germination in the laboratory between sizes A and B is small, but is very marked in the nursery, indicating that many of the smaller seed may have enough energy to burst the seed-coat but not to push through the soil. This at once reveals a weakness in the method of seedtesting.

The results of the experiment may conveniently be summarised as follows in terms of 10,000 seeds:-

In a sample of 10,000 seed
there were 780 seed of av.length of 4mm and av.wt of .0048 gms. A.
2880 " " " " 3.25mm " " " .0037 " B.
6340 " " " " 2.5 mm " " " .0027 " C.

Of these, according to the test, the following were viable
222 of the largest size,
792 of the next size,
349 of the smallest size,

Actually in the nursery, the following number germinated,
174 of size A.
355 of size B.
227 of size C.

Losses incurred in first-year seedlings reduced the numbers to
138 of size A.
274 of size B.
143 of size C.

A Total of 555 seedlings which is equivalent to 5.45% of the whole amount of seed sown.

If the smallest size of seed could have been separated out beforehand, 11.25% would have been obtained from the total sown.

Seed, however, are bought by weight and in 100 lbs of the sample dealt with, there were 38 lbs of seed of the first two sizes, 46 lbs of size 3 and 16 lbs of impurities, mostly small pieces of cone scales.

If the seed could be so treated that all impurities and all seed of size 3 were removed, 10 lbs of the cleaned seed would contain 1,143,000 seeds as compared with 1,192.000 in 10 lbs of the uncleaned. seed, and would yield 128,600 1-year seedlings as compared with 66,160 from 10 lbs of the uncleaned seed. To a purchaser, therefore, such cleaned and separated seed would be worth nearly twice as much as the uncleaned seed.

Additional Data from Another Sample.

The experiment was sown in the same seed-bed as 4b, European Larch. Opportunity was therefore taken to secure further data. 540 extra large seed of the Indent. No. 25/13, used in Experiment 4b, were picked out and sown in 9 separated rows of 60 seed each. The germination obtained in the nursery was 39.08% as compared with the test figure of 38.00% and with a mean figure for the 7 day's and 1 day's water soakings of only 30.57% for nursery germination. This again shows the superiority of the larger seeds in the sample.

Reliability of Results.

The nursery results should be reliable owing to the method of laying-out the experiment, which eliminated the soil and atmospheric factors as far as possible. At the same time, the uniform results throughout the series strengthens the value of the mean figures obtained. The laboratory tests were not carried out as requested, owing to the seedtesting station being removed at the time. Only 2 tests were made for each size instead of 10 as desired.

This experiment is complete in itself, only for the particular sample of Larch seed tested and requires to be confirmed with other samples and species. So long as seeds are sold by weight, there must be an optimum size which will give the best return, since the number per unit of weight will decrease with the increase in size, while it would seem that a decrease in size reduces the number of viable seed.

The second part of the experiment relating to the correlation between size of seed and size of seedling will be reported in due course.

Losses.

The losses from various causes in the nursery were as follows:

Size.	Loss in % of seed sown.	Loss in % of seedlings appearing.
XA.	4.58	20.52.
XB.	2.83	22.82
XC.	1.33	37.20
25/13 seed.	6.48	16.44

These losses are considerable but could not be traced to any special cause. Many seedlings can germinate but are too weak to live. Others are killed by soil fungi and by surface caterpillars, while the dry summer may have contributed.

The figures appear to indicate that the seedlings from the larger seed suffer less severely.

Agreement of Results with those of other Investigators.

Work carried out on the continent by Bühler, Friedrich, Haack, and Biremmenger with various species gave similar results.

Busse and Centgraf, however, got negative results.

In America, R. H. Boerker got similar results with Douglas Fir and Pinus ponderosa to those recorded here.

Practical Value. The immediate value of this experiment is to show that seed of large average size is to be preferred to seed with a large proportion of small seeds, when purchases of Larch are being made, and suggest that firms who do not trouble to clean and separate the seed should be avoided.

(See Appendix II for Tables of data.)

MANURING AND SOILING CROP EXPERIMENTS.

Several assessments have been made in the course of the year, the results of which are given below.

Manuring Experiments.

The results of experiment No. 17a, carried out at Beaufort, were given in the 1924 report. Briefly, it appeared that Scots Pine had benefited slightly from an application of Hardwood humus in Beaufort Nursery; that Spruce had benefited by the application of Pine humus and of Peat, but that the application of Ammonium Sulphate was harmful. All these manures were applied to the seedbeds before sowing.

The experiment was repeated at Beauly with Corsican Pine and Sitka Spruce, while another experiment was carried out with varying amounts of Peat in Sitka Spruce seedbeds at Inverleith. These two experiments were assessed in the spring of 1925.

This year two further experiments on manuring with Peat, Humus, and Wood Ashes were begun this year, one in Inverleith and one at Beaufort. These are not yet completed.

Experiment 17a. On Effect of Humus and Nitrogenous Manures on Growth of Corsican Pine and Sitka Spruce Seedlings.

Object. To test the effect of applying per sq.yd. of seedbed

(1). 8 lbs of Scots Pine Humus,
(2). 14 lbs of Beech Humus with 3 oz. of Ammonium Sulphate,
(3). 14 lbs of Beech Humus alone,
(4). 8 lbs of Peat

upon the growth of Corsican Pine and Sitka Spruce seedlings.

Plan. There were 30 scattered plots, 5 for each treatment and 5 for control, each plot being 10½ sq.ft. in area. The extra 5 plots consisted of 1 Larch Humus, 1 Sodium Nitrate, 2 Beech Humus alone and 1 Beech Humus with Amm. Sulphate. In each plot 1.@5oz of Corsican Pine seed and .43 oz of Sitka Spruce seed were sown separately, 6 drills for each species, on 31/3/23.

A serious attack of a fungas, ______________, destroyed patches of seedlings in the Corsican Pine drills, so that this species had to be abandoned as an indicator. The 2-year seedlings of Sitka Spruce were lifted in the spring of 1925 and carefully graded into 4 sizes, the number of each size per drill being counted. In addition, the plants in each drill were weighed to the nearest ¼lb.

Results.

1. The lay-out of the plots did not permit of good assessment. The control plots, in particular, were not sufficiently scattered. Three of these were along one side and were sheltered and shaded by a fence, which had clearly promoted growth to a marked extent.

2. Comparison between Control and Scots Pine Humus plots was possible and it was clear that there was no significant difference in size of plant. As regards numbers, there were, if anything, more plants in the control beds.

3. The 6 plots alongside the fence were discarded in further assessment and also the 6 farthest from the fence, as they showed a marked fall-off in growth and numbers. This left, the following plots for comparison and they appeared to be sufficiently uniform in regard to locality and site to warrant more careful assessment:-

Beech alone 5 plots; Beech with Amm.Sulphate = 6 plots; Peat = 5 plots and 1 plot each of Scots Pine and Sodium Nitrate.

The average numbers in each size per drill were as follows:-

	0-2½"	2½"-3½"	0-3½"	3½"-5½"	over 5½"	over 3½"	Total.	Wt.per drill.
Beech	45	48	93	33	7	40	133	0.925 lbs.
"and Amm.S.	84	63	147	20	1	21	168	1.000 "
Peat.	42	43	85	34	9	43	128	0.900 "
Scots.Hu.	41	43	84	40	14	54	138	0.960 "
Sod.Nit.	22	28	50	29	7	36	86	0.630 "

4. Assuming that the Scots Pine Humus bed is equivalent to a control bed and using it as a basis for comparison, it seems that the application of Beech Humus or of Peat has no effect upon numbers or growth.

5. Application of Amm. Sulphate results in an increased outturn of smaller plants, but there is a marked fall-off in growth, there being only 21 per drill over 3½" compared with 40 for Beech Humus beds.

6. The Sodium Nitrate bed shows less plants, which are on the average larger than in the other beds.

7. It is not possible to say whether the decreased height growth in the Amm. Sulphate beds is due to the manure or to crowding. This suggests that the factor of crowding should be eliminated in experiments of this type.

Reliability of Results.

Except in the comparison between Beech Humus and Beech Humus with Amm. Sulphate beds, the reliability is not high owing to the faulty distribution of the control plots.

Agreement of Results with other Investigations.

No comparison can be made with similar experiments in other nurseries, but it is interesting to note that Amm. Sulphate was also harmful in its effects on Norway Spruce in this nursery in the previous year.

Practical Value. The use of Ammonium Sulphate as a manure in Beaufort nursery is decidedly harmful. There does not appear to be any lack of organic matter in that part of the nursery where the experiment was carried out, at least in the meantime.

Experiment 17b. On Manuring Sitka Spruce Seedbeds with Varying Amounts of Peat.

Object.

To test the effect of applying (1), 5 lbs, (2). 10 lbs (3). 20 lbs of Peat per 10½ sq.ft. of nursery seed-bed, upon the growth of Sitka Spruce sown therein.

Plan. There were 16 plots, 4 of each treatment and 4 control. There were 4 complete series, consisting of 1 plot of 10½ sq.ft. for each treatment. All the series were in one seedbed.

The Peat was worked into the first few inches of soil. Each plot was separated from the next by a wooden partition and there were 6 drills per plot, 9 gms of seed being sown per plot on 4/4/23.

Results Obtained.

The germination over all beds was very irregular. In the final count in 1925, only control beds and beds treated with 20 lbs of Peat were assessed, the 4 centre drills of each plot being graded and counted on lifting.

Control beds gave 86 plants on an average per drill, 9% over 4".
20 lb.Peat " " 51 " " " " " " , 9% " " .

The application of the Peat in the manner described was thus distinctly harmful to Sitka Spruce, resulting in a much poorer outturn of plants.

Reliability. This is not high owing to the interference of some uncontrolled factor, which operated along the seedbed with decreasing intensity from one end to the other, and also to the very irregular germination.

Experiment 17c. On Manuring with Wood Ashes, Peat and Humus.
(In 2 sections,-A. Inverleith and B. Beaufort.)

A. Inverleith.
Object. To test the effect on the germination and growth of Scots Pine and Sitka Spruce in the seedbed of applying per sq.yd-
(1). 3 to 3½ lbs of Ashwood ashes.
(2). 3½ to 4 lbs of Sprucewood ashes.
(3). 10 lbs of Peat.
(4). 10 lbs of sand mixed with humus from a burnt-over forest area.

Plan.
There are 30 plots, each 12 sq. ft., consisting of 6 control plots and 6 plots for each treatment. They are thoroughly scattered and separated where necessary by wooden partitions.

Application of the manures was made in March. The wood ashes were thoroughly raked into the top 2" of soil. The peat was mixed with the top layer of soil, passed through a ¼" riddle and evenly applied. The humus was in a very fine state of division and was applied as follows: The top inch or so of soil was cuffed back, the humus being applied in its place to a depth of 2" and the soil was then replaced above the humus layer.

Seed of Scots Pine and Sitka Spruce were sown in each plot by means of perforated zinc plates. 4 rows of 60 seed of Scots Pine and 4 rows of 120 seed of Sitka Spruce were sown per plot at a uniform depth of ¼". The sowings for each species were done in one day. In this way as far as possible, every outside factor was controlled. The experiment was protected from birds and mice by a net, and the soil was thoroughly dosed with Vaporite in March.

Several counts were made throughout the summer, but fewer than is desirable in a properly conducted experiment.

Results to Date.
The experiment will not be completed until next spring. Definite results have however been already obtained.

SCOTS PINE. The first count of seedlings on 15/5/25, 6 weeks after sowing, gave the following germination percentages:-

Control.	Hardwood Ash.	Conifer Ash.	Humus under Soil.	Peat.
44.72.	46.45.	40.41.	46.04.	54.38.

The rate of germination in the Peat beds was thus much faster than in any of the others, while the conifer ash beds were slower than the others. It is likely that these differences are due to alteration in the physical condition of the surface soil layers.

Damage by Soil-Fungi.

On 3/6/25 many deaths were noted in the woodash beds, the seedlings showing the typical effect of 'Damping-off'.

Dr. Wilson identified the cause of the damage as a species of Fusarium. Dead seedlings from the control and peat beds also developed the fungus when collected and kept under cover in the laboratory, indicating that the fungus was present originally in the nursery soil and was not introduced. Other beds of seedlings in the nursery also showed occurrence of 'Damping-off'.

A count was made on 10/6/25, the dead seedlings being removed and recorded separately. It was found that of the total number of seedlings which appeared above ground through the whole season, the following percentages were killed off before the 10th of June, the great majority of deaths being certainly due to Fusarium.

Control.	Hardwood Ash.	Conifer Ash.	Humus under Soil.	Peat.
5.47.	53.75.	31.85.	3.00	3.98

This shows very strikingly that the intensity of the attack is due to the application of the woodash, confirming results in America and elsewhere. Cf. Bull. 453 U.S.A. Dept. of Agriculture, where wood ashes are reported to have had disastrous results on Pine seedlings.

Some effort was next made, on Dr Wilson's suggestion, to ascertain why the woodash should have this effect. The soil acidity in 10 plots, 2 for each treatment was ascertained by Misses Smith and Noble of the Royal Botanic Garden Staff, with the following results:-

PH values for 2 centre plots for each treatment.

Control.	Hardwood Ash.	Conifer Ash.	Humus under Soil.	Peat
5.4	6.4	7.8	5.2	5.4
5.6	6.4	7.8	5.1	5.1

These values apply to the top inch of soil only and suggest that soil with a PH value of about 6.4 favours the fungus in some way so that the intensity of its attack is very high. A higher or a lower value makes for a less virulent attack. This agrees to some extent with conclusions by Melin on Fomes annosus, in which he found a P_H value of 6.1 was most favourable to the fungus.

On the 15th June, at Dr Wilson's suggestion, 3 of the hardwood ash plots and 3 of the Conifer Ash plots were drenched with 2/3rds of a gallon of freshly made Cheshunt Compound, the remaining beds being left untreated.

Subsequent counts showed that the treatment was not entirely effective, the following deaths being noted after application:- 3 in the treated and 16 in the untreated hardwood beds and 21 in the treated and 15 in the untreated conifer ash beds.

After the end of June the attack had spent itself. The total losses after June expressed as percentages of the total numbers which germinated, were as follows:-

Control.	Hardwood Ash.	Conifer Ash.	Humus under Soil.	Peat.
2.69	2.01	3.39	3.17	3.98

Some of these later losses were due to an attack of Agrotis caterpillars. The survivals on 1/9/25 expressed as percentages of the seed sown were:-

71.11	29.09	47.84	73.89	71.03

The laboratory germination was given as 94.75%.

Total Germination.

The final count on 1/9/25 in addition to such losses as had been counted showed that the total germination percentages were:-

77.41	65.75	73.89	78.74	76.72

Except in the case of the woodash beds, the total germination was thus very uniform. There was a fall-off in the woodash beds, particularly in the case of hardwood ash. It is possible, however, that several seedlings were killed by soil-fungi before or just after coming above ground and thus escaped count.

SITKA SPRUCE. The first count was made on 2nd June, nearly 8 weeks after sowing and gave the following results:-

Control.	Hardwood Ash.	Conifer Ash.	Humus under Soil.	Peat.
10.73	16.63	8.54	10.86	9.45

This shows considerable increase in the rate of germination in the Ash beds over untreated beds, but the Peat beds do not show any increase. The conifer Ash beds are again slower.

A second count was made on 31/7/25, with the following results:-

19.23	23.54	16.18	18.23	15.66

The Hardwood Ash beds still maintained the lead but the peat beds had fallen behind.

There was a marked recrudescence of germination during August, which is shown by the following total germination percentages as revealed by the final September count together with all losses observed:-

26.28	25.80	19.62	24.44	20.42

Except in the case of the Conifer Ash and Peat beds, in which there was a distinct fall-off, the germination was thus fairly uniform. The test figure given for germination was 53%.

Damage by Soil-Fungi.

Similar damage occurred as in the case of the Scots Pine. A count was made before the application of the Cheshunt Compound on the 15th June and gave the following losses before that date, due to Fusarium, expressed as percentages of the total number of seedlings which germinated:-

Control.	Hardwood Ash.	Conifer Ash.	Humus under Soil.	Peat.
0.93	26.11	13.63	1.70	2.89

The attack has been less severe than in the case of Scots Pine, but the intensity is again greatest in the hardwood beds. Later counts after treatment gave further losses, not all, however, due to Fusarium. These amounted to the following percentages of the total seed which germinated:-

3.96	6.46	9.20	3.84	3.57

The survivals in September expressed as percentages of the seed sown, were:-

25.00	17.40	15.14	23.09	19.10

Surface Caking.

A very important point was observed in connection with the effect of the application of these manures on the physical condition of the soil.

Encrustation of the soil around the plants was very marked in the control beds and especially so in the Conifer Ash beds. It was less marked in the Hardwood Ash and Humus beds and was almost entirely absent in the Peat beds. Further the soil surface in the Peat beds was not caked in any way. These remarks apply particularly to the Sitka Spruce, many of which were crusted nearly completely over by August. The differences were not so marked by the end of September, when some of the Peat beds had begun to show encrustations round the plants.

Mr Adams of the R. Botanic Garden Staff kindly undertook to photograph a Peat bed and a Control bed to show these differences. The photographs accompany this report.

B. Beaufort School Nursery.

Object. To test the effect on the growth of Scots Pine and Norway Spruce in the seedbed of applying per 20 sq.ft. of bed-

(1). 2 lbs of Larchwood Ashes.
(2). 2 lbs of Birchwood Ashes.
(3). 24 lbs of Peat.
(4). 24 lbs of Peat applied as in the case of the humus at Inverleith but covered with a layer of 1 inch of subsoil from the nursery.
This subsoil was unweathered glacial sand and gravel.

The seed were sown by weight so that no accurate counts of losses and germination were made. Assessment of growth will be made later on.

Damage by Soil Fungi.

Losses were observed, in the Pine especially, in this experiment also, occurring in patches in certain beds. On 27/5/25, many losses from 'Damping-off' were seen in 3 Hardwood Ash beds, 1 conifer Ash bed and 1 peat bed. Mr Fraser identified the fungus definitely as Rhizoctonia and dealt with the attack at once by spraying the attacked beds, before the soil acidity could be tested.

Subsequent estimation of the Hydrogen-ion concentration in the top-soil layer gave the following P_H values,-for 10 beds:-

Control.	Conifer Ash.	Hardwood Ash.	Peat under Subsoil.	Peat.
4.9	4.8	7.2(Sprayed)	7.2	4.8
4.9	4.8	7.6(Unsprayed)	7.2	4.8

The difference in P_H value between soil and subsoil in this nursery is very marked.

The attack here confirms the effect obtained at Inverleith with hardwood ash, that application of this manure encourages attack by soil fungi.

Experiment 17c. A control plot showing encrustation of soil on Sitka Spruce seedlings. Aug. 1925. Also delayed germination.

Experiment 17c. A plot to which 10 lbs of riddled Peat were applied, showing seedlings of Sitka Spruce, practically free from soil.

Conclusions. Final conclusions as to effect upon the growth of the seedlings are not yet possible. In the meantime:-

1. Application of woodashes to seedbeds is decidedly harmful, especially in the case of Scots Pine. It greatly increases the intensity of attack by soil-fungi.

2. Correlation between intensity of Soil-fungi attack and soil acidity is indicated.

3. Application of 10 lbs of finely riddled Peat per sq.yd. to the surface of nursery seedbeds on soil such as exists in Inverleith nursery markedly reduces surface caking and soil encrustation around seedlings.

4. Application of Peat in this way to Scots Pine seedbeds, increases the rate of germination appreciably, but applied to Sitka Spruce beds, appreciably reduces the total germination.

Transplant Manuring and Treatment experiment in S.Laggan Nursery.

A joint experiment was carried out with Mr Scott in S. Laggan nursery, where there are a large number of small 2-year 1 transplants of Norway Spruce.

Several treatments were applied in order to see if the growth of these plants could not be hastened so as to make them of a size for planting out in the coming season.

There was a series of separate small beds in the nursery, very convenient for the purpose. The centre of each bed was treated and the two ends left as control. The following treatments were applied:-

1. Shelter with 18" boarding against wind blowing up or down the valley.

2. Shading of bed by fixing broom branches at intervals among the plants.

3. Drainage. Narrow boarded trenches were dug alongside the bed, to increase drainage and aeration.

4. The following manures were applied:-

a. Spruce -wood litter between the lines.
b. Birch Sawdust " " "
c. Wood-ashes at ½ lb to the square yard.
d. Coal-ashes ditto
e. Basic Slag at ¼ lb to the sq. yd.
f. Sodium Nitrate at ½ oz " " "
g. Kainit at 1 " " " "
h. Superphosphate at 2 " " " "

A visit in July showed that Kainit and Woodashes had had a marked effect on the colour of the Spruce, turning it a dark green, and indicating a deficiency of Potash.

Accordingly a second application of Woodashes, Kainit and also Sodium Nitrate was made early in August.

Careful assessments will be made later, but preliminary measurements do not show any effect whatever on growth. The effect, may, however, be delayed until next season.

Soiling Crop Experiments No. 20 a and 20c.

Plan. Soiling crop experiment 20a, carried out by Mr James Fraser at Beaufort School was brought to a conclusion this year by the assessment of the effects of the soiling crop upon the growth of Norway Spruce 2-year seedlings, lined out for 2 years in the cropped areas. The assessment was very carefully made by measurement of the height of the plants in 1924 and the length of the 1924 leading shoot. There was no true control, only 3 areas which had been cropped with Potatoes, Mustard and Lupins.

These three areas were again divided into 3 sections each, one of which was not manured, another treated with Basic Slag, Kainit, and Sodium Nitrate and the third with Superphosphate. There were thus 9 different plots of Norway Spruce transplants to be dealt with.

Results.

1. As previously reported, the above dressing of artificial manures, resulted in an increase in the yield of Mustard of 300-400%, and in the case of Lupins, an increase of 30%, in Beaufort nursery.

2. The presence of the artificial manures or what remains of them in the soil does not alone affect the growth of Norway Spruce plants lined out after the soiling crop (See 1924 Annual Shoot growth), at least beneficially.

3. The Lupin soiling crop does increase the growth of Norway Spruce quite markedly and Mustard also has the same effect to a lesser extent, compared with Potatoes as a Soiling crop.

The following figures bring out these points clearly:-

	Total Ht. 1924.	Ht. increase in 1924.	% of good plants over 9" high.
Average for 3 plots with Basic Slag, Kainit and Nitrate.	9.17"	3.87"	42.33
do do 3 plots with Superphosphate.	8.84"	3.69"	41.48
do. " 3 plots with no artificials.	9.18"	3.74"	43.59
do. " 3 plots with Potatoes.	8.59"	3.56"	36.20
do. " 3 " with Mustard.	9.08"	3.73"	45.33
do. " 3 " with Lupins.	9.53"	4.02"	45.93

4. The absence of a true control plot with no soiling crop and no manure, makes it impossible to state whether the Mustard and Lupins have been beneficial and to what extent or whether the potatoes have been harmful.

REGISTERED EXPERIMENT N.S.20.a.

Complete Data after Lifting of Norway Spruce 2 yr. 2 yr. Transplants.

Plot No.	Fertilisers applied per acre to nearest 10 lbs.	Soiling Crop.	Date Sown	Date ploughed in	Total wt. of Crop p. acre	Further Treatment	Total wt. p. acre of 2nd Crop.	Data regarding Norway Spruce Transplants (1925): Mean ht. in 1924	1924 Annual Shoot	Ht. at end of 1923	Ht. Inct. % in 1924	Average Nos. per 10 ft. Planting Board: Total No.	No. fit for field	No. over 9" high	% over 9" in those fit for field
1.	Basic Slag 220 lbs Kainit 230 " Nitrate 130 "	Potatoes	2/5/22	-	-	-	-	8.85"	3.67"	5.18"	70.86	55.5	48.7	19.5	35
2.	Same as in 1	Mustard (26 lbs)	"	26/6/22	109 cwts.	Lupins sown 27/6/22	89.5 cwts 6/9/22	9.32"	3.92"	5.40	72.59	55.0	48.7	26.5	48
3.	Same as in 1	Blue Lupins 171 lbs.	"	17/7/22	122 "	Mustard sown 7/8/22	86 cwt. 17/10/22	9.35	4.02	5.33	75.43	54.5	47.9	24.0	44
4.	Superphosphate 220 " Kainit 230 " Nitrate 130 "	Potatoes	2/5/22	-	-	-	-	8.27	3.39	4.88	69.47	53.0	45.0	17.5	33
5.	Same as in 4	Mustard	"	26/6/22	120"	Lupins sown 27/6/22	83.5 cwts 6/9/22	8.69	3.63	5.06	71.73	53.0	48.0	22.5	42
6.	Same as in 4	Blue Lupins 171 lbs.	"	17/7/22	122 "	Mustard sown 7/8/22	88 cwts 17/10/22	9.58	4.04	5.54	72.93	55.3	49.0	27.0	49
7.	Nil.	Potatoes	"	-	-	-	-	8.64	3.59	5.05	71.09	55.6	47.4	22.4	40
8.	Nil.	Mustard 26 lbs.	"	26/6/22	33cwt.	Lupins sown 27/6/22	80 cwts 6/9/22	9.24	3.63	5.61	64.71	55.3	48.4	25.0	45
9.	Nil.	Blue Lupins 171 lbs.	"	17/7/22	91 "	Mustard sown 17/10/22	41 cwt 17/10/22	9.65	4.01	5.64	71.09	54.0	47.0	24.6	46

Experiment 20c. Winter Oats as a Soiling Crop.

Mr Fraser made a further soiling crop trial last winter, this time with Winter Oats. The experiment was not intensively carried out.

An area was sown in Beaufort nursery with Winter Oats on 18th and 20th November, 1924.

A mixture of artificial manures was sown on 1st May 1925, consisting of 2 cwt of Kainit, 1 cwt of Superphosphate and ½ cwt of Amm. Sulphate per acre.

The crop was a heavy one but there were several bare patches, which were successfully filled in by sowing lupins.

The crop was cut on 29th June 1925 and the weights of successive strips ascertained. The best yield amounted to 190.5 cwt per acre and the worst to 114.2 cwt per acre. The crop was dug in.

A belt of ground was left untreated alongside the cropped area and Mr Fraser proposes to assess the effect of the soiling crop by lining out Scots Pine seedlings in both areas.

SEEDLING EXPERIMENTS.

Assessments were made of Experiments No. 12a, on Density of Sowing Douglas Fir, of 15c, on Season of Sowing Douglas Fir, Sitka Spruce and European Larch and experiment 12b was carried a step farther. This experiment deals with the Density of Sowing of Corsican Pine by Drill, Broadcast and Band methods. Seedlings grown under the various densities had been lined out for 1 year and there behaviour when lined out is now reported upon.

Experiment 12a, Density of Broadcast and Drill Sowing of Douglas Fir.

This experiment was laid down in Inverleith nursery in March 1923 and the 2 year seedlings were lifted and analysed last spring.

The seed used were of Ident. No 22/19, Purity 93% and the Germinative capacity 57% + 10 fresh. It was unsoaked and sown on 26/3/3 and 29/3/23. The amounts sown per head of 12' x 4' were:-

Broadcast.		Drill.	
Bed 1.	4oz per 48 sq. ft.	Bed 5.	2 oz per 48 sq. ft.
" 2.	8 " " " " "	" 6.	4 " " " " "
" 3.	16 " " " " "	" 7.	8 " " " " "
" 4.	24 " " " " "	" 8.	16 " " " " "

The experiment was disturbed by a severe attack of Rhizoctonia identified by Dr Wilson. Potatoes had been stored here before the nursery was established and several grew up with the seedlings.

In the assessment, every third drill was lifted, counted and graded and in the broadcast beds, 9 bands, 6" wide were lifted and graded in the same way. Plants over 8" were placed in Grade 1 and good plants under 8" in Grade 2. Very short, deformed and diseased plants were culled.

The fall-off in growth from west to east was very marked and beds 2, 4, 6, and 8 were much damaged and irregular. Evidently an uncontrolled factor had made its appearance. The remaining beds should however, be comparable. The results were as follows:-

Broadcast Beds.			Drill Beds.		
Bed No.	No. of seedlings fit for lining per 100 sq. ft.	No. of seedlings fit for lining per lb. of seed.	Bed No.	No. of seedlings fit for lining out. per 100 sq.ft.	No. of seedlings fit for lining out. per lb.
1.	6050 (69%)	11616.	5.	5073 (75½%)	19,480
2.	9250 (52%)	8880	6.	5415 (54%)	10,400
3.	12,000(48%)	5760	7.	9576 (58%)	9,634
4.	7925 (37½%)	2536	8.	5643 (37½%)	2,708

The percentages in brackets refer to the percentage of good plants in the total number of plants.

Conclusions.

1. The results seem to indicate that the drill method gives a larger proportion of good plants than the broadcast method.

2. The drill method gives the greatest out-turn of good plants per pound of seen sown.

3. The broadcast method gives the greatest out-turn of good plants per unit of area.

Samples lined out.

4000 plants of Grade 2 were selected, 1000 from each of beds 1, 3, 5 and 8 and were lined out in Inverleith nursery.

Bed 3 was chosen in preferance to Bed 4 as it was obviously more typical of a densely grown broadcast bed.

The object of this is to find out any difference in behaviour between densely-grown and openly-grown seedlings when lined out.

Extension of Experiment 13b. To test the Behaviour of Densely-grown and Openly-grown Corsican Pine seedlings, when lined out.

The experiment was reported upon last year. Ten boards of 79 plants each of thickest and thinnest densities of Broadcast, of Drill and Band sowings were lined out in Seaton nursery in the spring of 1924.

The centre 5 boards of each lot were lifted, graded and counted with the following results:-

Percentage of Good Plants Fit for the Field in the total lined out in the nursery.

Broadcast.		Drill.		Band.	
Thickest.	Thinnest.	Thickest.	Thinnest.	Thickest.	Thinnest.
45½%	59½%	50%	55½%	60½%	67%

Conclusions.

1. In all three cases, thinly-grown seedlings give an appreciably higher out-turn of good plants, especially in the case of the broadcast beds, than densely-grown seedlings.

2. Corsican seedlings sown by the band method seem to give the best results in the lines.

3. This rather suggests that the losses in the transplant lines might be appreciably reduced by increasing the acreage under seedbeds and sowing more thinly.

Experiment 15c. On Season of Sowing.

This experiment was reported upon by Dr Steven in 1923, the results being based upon counts of 1-year seedlings.

In the spring of 1925, the 2-year seedlings were lifted and carefully graded into 2 sizes of good plants for each species and culls.

The data obtained are given in Appendix III.

Conclusions.

1. From 1923 sowings in Inverleith nursery, the highest returns of seedlings were from February and end of May sowings for Douglas Fir ex Durris, January, early March and end of May sowings for Douglas Fir ex canada, first week of March and April sowings for Sitka Spruce and first fortnight in April sowings for European Larch.

2. The highest yield of plants fit for the field were from February and March sowings for Douglas Fir, January and early April sowings for Sitka Spruce and the first fortnight of April for Larch.

3. The largest number of large plants (Grade 1) were got from January sowings of Douglas Fir and Sitka Spruce and from the first week of April sowings of Larch.

4. Generally speaking this confirms the 1923 conclusions, that early sowings give the best results for Douglas Fir and Sitka Spruce, late sowings for Larch.

Experiment 30. On Effect of tilting Seedbeds to various Aspects.

This experiment was laid down in Beaufort School nursery but has not so far been assessed. The species sown were Sitka and Norway Spruce. Germination was delayed for one day on the N.aspect.

TRANSPLANT EXPERIMENTS.

The main experiments No. 24 and 24a are in connection with the Spacing and Grading of transplants of six species.

Experiment 24 was reported upon last year fully, results being based upon counts in the lines. Three species were lifted in the spring of this year and final results obtained for these.

This spring experiment 24a was laid down at Seaton in precisely the same way with the same six species, but the sections on Speed of Transplanting and Exposure of Roots were omitted.

Experiment 24. Assessment of Results with Scots and Corsican Pines and with European Larch.

These three species were lifted as 2-year-1 plants in the spring of this year and graded under the supervision of Mr. J.A.Lamb in the same way as usually carried out at Seaton. Only plants fit for the field were counted.

An inspection of the plants showed very little difference all over, except between grade 1 and grade 2 of Scots Pine. 500 of each grade of that species were sent to be planted out in the field at Culbin (P.S.No.1011) (See page 17).

The percentages fit for the field of the total lines out were as follows, and differences over 4 times the P.Error of the mean percentage of all 15 treatments were considered to be significant.

Spacing.		Speed of Transplanting.		Grading.		Exposure of Roots.	
SCOTS PINE.							
1".	61.75.	Careful Working.	66.68	1.	59.08	Roots dried.	50.53
$1\frac{1}{2}$".	59.55.	Fast "	65.43	1 & 2	45.20	Av.precaution	72.25
2".	59.03.	Average "	65.65	2.	41.60	Special care	
3".	69.62.	Handlaying.	69.65	2. Bedded	33.48	against drying	73.65
CORSICAN PINE.							
1".	45.83.	Care.	50.78	1.	49.98	Roots dried	25.98
$1\frac{1}{2}$".	49.35.	Fast.	68.40	1 & 2	38.58	Av.precaution	45.05
2".	41.68.	Average.	52.95	2.	44.58	Special p.	40.80
3".	42.25.	Handlaying.	57.03	B.2.	32.88		
EUROPEAN LARCH.							
1".	58.53.	Care.	58.15	1.	74.90	Roots dried	56.85
$1\frac{1}{2}$".	59.80.	Fast.	55.73	1 & 2	68.33	Av.precaution	56.23
2".	59.68.	Average.	64.60	2.	58.28	Special p.	58.03
3".	56.00.	Handlaying.	76.00	B.2.	51.90		

The average percentages over all 15 treatments were:-
Scots Pine:- 59.54 = 2.07 P.E.
Corsican Pine:- 45.94 = 1.51 P.E.
European Larch:- 60.87 = 1.22 P.E.

Conclusions.

1. Over a variety of conditions, Scots Pine and Larch show almost the same average production of good transplants from 2-year seedlings, namely 60% of the number lined out.

2. The average production of Corsican over a wide variety of conditions is only 45% of the number lined out.

3. The probable errors indicate that Larch is least susceptible to the various factors causing loss in the transplant lines, and that Scots Pine, is most so. Larch will therefore stand rougher treatment.

4. Spacing. Losses in each species for all spacings tried are remarkably uniform. Only in the case of Scots Pine at 3" is there a noticeable fall in losses.

5. Speed of Transplanting. Losses in all three species are appreciably less in the handlaying section over the average for the board method. Rapid working markedly lessens the losses in the case of Corsican Pine and increases them in the case of Larch.

6. Grading. Mixed grade 1 and 2 plants in the case of the Pines give higher losses, in the case of Larch, lower losses, than in the graded sections. Bedded Grade 2 plants of Scots Pine and Corsican Pine give very high losses. Grade 1 Larch show very small losses. Grade 2 Scots Pine were much below the average in out-turn.

7. Exposure of roots. In the case of Scots Pine both average and special precautions resulted in considerably lower losses than the normal loss, but special precautions were not superior to average precautions. Drying of the roots did not result in appreciably higher losses.

Drying of the roots of Corsican Pine had a very marked effect in increasing losses.

Drying of the roots of Larch apparently had no effect whatever.

Summary, for Scots and Corsican Pines and Larch.

Losses can be reduced in the transplant lines in the case of Scots Pine by grading before lining out and by average precautions against drying of the roots.

In the case of Corsican Pine, heavy grading, rapid working and especially precautions against drying of the roots reduces losses very considerably.

In the case of Larch, care in transplanting reduces losses. Grading is not so important and exposure of the roots is relatively unimportant.

In all species wider spacing does not increase nor decrease losses appreciably.

The reduction of losses in all three species when handlaying is substituted for planting board seems to indicate that there is much room for improvement in the latter method.

The other three species will be assessed in due course.

Experiment 24a. This is a repetition of No. 24, and is due for assessment in the case of the same three species next year. It is not proposed to make a preliminary count before the plants are lifted. This experiment is being hand-weeded as it was clear that many losses last year were due to careless hoeing between the lines.

Experiment 19a. On Weed-control.

A preliminary experiment was carried out at Seaton and at Beaufort nurseries to ascertain whether strips of various materials laid between the transplant lines would be effective in keeping down weeds, without disturbing the growth of the plants.

Four materials were tested and, for the purpose of experiment, were fixed on lath frames, 8" wide and 5' long. The materials were, (1). Stoniflex Roofing Felt. (2). Hessian. (3). Cotton Duck and (4). Bituminous Paper.

Results to date.

At Seaton all 4 materials successfully prevented weed-growth and kept the soil in good open condition below up to September. No harmful effects whatever were noticeable on the Scots Pine between which the material was laid. Stoniflex, laid flat on the soil, gave the best results. This material is the most lasting.

At Beaufort the same remarks apply. In this case Norway Spruce were treated. The soil was in excellent condition. The Bituminous paper is waterproof and non-rigid, tending to sag, and would probably not last over 2 seasons.

COSTS.

The cost of Stoniflex required for 1 acre works out at about £120, without taking cost of carriage, cutting the strips and placing on the ground into account. The cost of weeding at present works out at £50 per acre per annum, more or less. Assuming a life of 4 years for the material, it is probable that a saving would ultimately be effected. Considerable reduction in cost might be effected if the material were supplied in suitable widths and ordered in bulk.

Further more extensive trials are necessary before any recommendation can be made, and cheaper materials might be tested.

Experiment No.29. On Mixing of species in the Transplant lines.

This has been carried out with (a) Beech and Norway Spruce at Beaufort; (b) Douglas Fir and Sitka Spruce at Beaufort and (c) Scots Pine and European Larch at Seaton (d) Douglas Fir and Norway Spruce at Seaton. No results are available so far.

Experiment 31. On Shelter of Transplants at Seaton.

As exposure from several directions appears to be an important adverse factor at Seaton, a simple experiment was made with shelters of boarding 18" high to see whether any improvement would take place in Scots Pine and Sitka Spruce after lining out.

The experiment will not be completed until next year but already in the case of the Sitka Spruce at least, there appears to be some improvement. This will be difficult to assess however.

Two short lengths of boarding were erected at right angles to one another in the centre of a bed of Scots Pine transplants in order to discover, if possible, from which side exposure was most harmful. There already appears to be a marked improvement in the angle protected and shaded from the S.E. over other angles and especially over the angle exposed to the S.E.

Repetition with Norway Spruce, which suffers very badly at Seaton, might give more marked results.

Experiment 32. On Continuous Cropping of Nursery Seedbeds.

This was begun with Scots Pine and Sitka Spruce in Seaton Nursery and with Scots Pine in Beaufort Nursery, the object being to see whether continuous cropping with one species would impoverish the soil.

Experiment 21a. On Wrenching and Undercutting of Corsican Pine.

In the 1923 report this experiment on Corsican Pine was described. There were 5 lots of 1-year seedlings treated as follows:- (1) Control. (2) Wrenched once. (3) Undercut once. (4) Wrenched twice and (5) Undercut twice. The plants were left another year in the beds and samples were lined out in the spring of 1924.

This year the transplants were lifted for the field and graded, with the following results:-

Lot.	%fit for the field of Total lined out.	Remarks.
1.	52.15	Roots poor with little fibre.
2.	57.00	" as above.
3.	58.55	" rather better than above.
4.	49.00	" good with more fibre than 1,2 and 3.
5.	53.81	Plants stronger and improved all round.

The improvement of the other methods over the control is not at all marked.

The experiment is continued in P.S.No. 1010 (1925) at Culbin, where 500 each of lots 1, 4 and 5 were planted out. This should determine finally whether better plants are obtained by wrenching and undercutting (See p.~~17~~ 21).

EXOTIC SPECIES AND RACES OF VARIOUS SPECIES.

Considerable numbers of tree seeds of various species, mainly from Japan and N.America were sown in Inverleith nursery during the year with satisfactory results except that one lot of Pinus ponderosa which took a long time to germinate, was eaten by birds and mice.

Seed of various races of Pinus sylvestris and of P. contorta were sown.

B. PLANTING EXPERIMENTS.

New Experiments 1925.

P.S. No.1007. Planting on Basin Peat.

A series of small, intensive experiments were successfully laid down on an area of difficult basin peat, known as the Lon Mor, at Inchnacardoch.

These are not due for assessment this year but so far the failures have been remarkably few and growth has been good.

The species used were Norway and Sitka Spruces, and the three main features of the experiments are (1) the method of lay-out. (2) the method of drainage and (3) the method of planting on shallow turfs.

A count of the failures during the year was made and showed 4 dead transplants out of 1630 and 27 dead seedlings out of 630, mostly due to an error in planting which allowed of opening of the notches in dry weather.

DAMAGE.

Some damage has been done by Black Game to the trees and 200 Scots Pine, which were planted round the experiments, more to fill gaps than anything else, have, in every case, had their top buds removed by Black Game.

The wooden shelters used in one experiment were made from freshly cut Scots Pine and they attracted Hylobius abietis, the nearest felled conifer area being several miles away. Some damage was done to Norway Spruce, but in no case severe. A number of weevils were trapped.

P.S. No.1008. To test the Effect of Shelter and Basic Slag on very Backward Sitka Spruce on difficult ground.

This experiment was successfully laid down at Inchnacardoch.

The shelters again formed an attraction for Hylobius abietis which did some damage to the already feeble plants.

P.S. No.1009. Experiment with Pot-grown Transplants.

298 Norway Spruce and 258 Sitka Spruce 2-year seedlings were planted out in pots in a small area of good soil in the midst of a difficult planting area at Inchnacardoch, the intention being to use the 2-yr-2 transplants for planting the worst spots later on.

Unfortunately, there was considerable delay in potting the seedlings, which was not done until 16/5/25, when growth had already begun. A number of plants died.

P.S. No.1010. Planting out of Wrenched and Undercut Corsican Pine from Seaton nursery.

500 2-yr-1 Corsican Pine transplants neither wrenched nor undercut, 500 which had been twice wrenched in the seedbeds and 500 which had been twice undercut, were planted out at Culbin, to ascertain what difference there might be in the three lots.

A careful assessment has yet to be made; but to the eye, the difference is not obvious.

A preliminary assessment made in September of this year has shown so far that there is no difference whatever in the behaviour and growth of the three lots. The losses in the first year are exactly the same in all three, amounting to 25%.

It was observed that the shoot growth of the Corsican Pine was very small, being too small to measure except in a few cases.

P.S. No.1011. Planting out of two grades of Scots Pine Transplants.

500 of grade 1 and 500 of grade 2 Scots Pine from N.S. No.24 in Seaton nursery, were planted out at Culbin in order to see what difference there would be, if any.

So far no difference is evident but a careful estimate has not yet been made.

A preliminary assessment made in September 1925 has shown that the differences between the two grades are small. The death rate amounted to 5.3% in Grade 1 and 6% in Grade 2. This experiment is alongside P.S. No.1010 and the greater death rate in the Corsican Pine, which has received the same treatment from the nursery stage, is noteworthy. Further, the average shoot growth since planting out has been 1.65" in the case of Grade 1 plants and 1.20" in the case of Grade 2 plants. This growth of 1 to 2 inches in the first year is of considerable importance on blown sand as it very often enables the Scots Pine to escape complete burial.

P.S. No.1012. Experiments in Beating-up.

(a). In Scots Pine at Monamuir, Fife.

All failures in P.S. Nos.1001 and 1002 with Scots Pine were carefully marked on the ground with wooden stakes about 18" high. Owing to the level ground and the very even planting in these plots, it was possible to construct charts on squared paper to show accurately the positions of all failures which had occurred in the year 1924-25. This was carefully done by Mr. J.A.B. Macdonald.

It is proposed to observe later on how the plants which were used in beating up and which are marked with the stakes, behave in comparison with the first planting.

The total area under observation here is 8 acres and the 4 spacing plots should give some interesting information, provided observations are maintained over several years.

(b). In Scots Pine at Culbin.

Approximately 1 acre of Scots Pine planted with 2-yr-1 plants in February, 1923, was beaten up with 3-yr-2 Scots Pine in March 1925. The positions of the newly planted trees have been marked with stakes as above.

(c). In Norway Spruce at Inchnacardoch.

An area of 1.6 acres of Norway Spruce planted with 2-yr-2 plants in the spring of 1922 was beaten up in April 1925 with 2-yr-2 Norway Spruce. The positions were marked with stakes as above. Some of the stakes were from freshly-cut Scots Pine and they attracted weevils which did some damage.

Assessments of these three experiments will not be made this year.

P.S. No.1013. On Grazing up to the Time of Planting.

Arrangements have been made at Glen Righ for a simple experiment to ascertain the differences in (a) cost of planting and (b) development of plants in areas (i) grazed up to time of planting, (ii) ungrazed for 1 year and (iii) for 2 years before planting.

A strip of 3 acres in extent has been selected, 1/3rd of which was fenced in February 1925. The second acre will be fenced next spring and the last acre in the spring of 1927, when the whole strip will be planted and a record of costs of planting and of subsequent losses and growth will be made. Vegetation records will also be kept.

Assessments of Experiments laid down prior to 1925.

Much careful assessment has been made this summer in the Northern Division by Mr J.A.B. Macdonald of Experimental Plantations and Planting Experiments, which have been laid down in past years.

Method of Assessment.

A method of assessment has been devised which, although somewhat subjective has the merit of being workable and of giving comparable results. All plants are classified into 4 classes. Class 1 contains plants with a good leader and healthy colour, Class 2, plants with a leader but unhealthy colour or with a healthy colour but no leader, class 3, plants with no leader and generally weak and unhealthy, and class 4, all deaths. The percentages of these classes are then worked out and a comparable figure or index figure worked out as follows. 1 per cent in class 1 counts 1, in class 2, ½ and in class 3, ¼ point. The sum of the points for these classes gives the index figure, which lies between 0 and 100, according to the success of the plantation.

P.S. No.1001. Experiment on Spacing of Scots Pine at Edensmuir.

Four plots of the following spacings were planted with 2-yr-1 Scots Pine ex Tulliallan Nursery of seed origin 19/7. The semi-circular spade was used and planting carried out in March 1924.

Failures between March 1924 and March 1925 were carefully noted with the following results :-

Plot No.	Planting Distance.	No.Planted	No.of Failures	% Losses.
1.	38' 6"	3528	200	5.6
2.	4' 6"	2156	50	2.3
3.	5' 6"	1440	64	4.4
4.	6' 6"	1020	47	4.6
		8144.	361	4.4

It was observed that losses occurred in groups where Holcus lanatus was abundant, which agrees with observations made elsewhere as to the difficulty of planting in this grass.

Clearly the percentage losses remain the same, irrespective of the planting distance.

P.S. No.1002. On Age and Type of Scots Pine at Edensmuir.

Four plots of the following types of Scots Pine plants were planted at a distance of 4' 6". In every case the screef method with semi-circular spade was used. Planting was done in March 1924 and failures counted in March 1925 gave the following figures:.

Plot No.	Age of Plants.	No.Planted.	No.of Deaths.	% Losses.
1.	Line (2-yr. About(2-yr-1 (2-yr-2	735) 735) 2205 735)	114) 25) 176 37)	15.5) 3.4) 8.0 5.0)
2.	2-yr seedlings.	2156	479	22.2
3.	2-yr-1 plants.	2156	22	1.0
4.	2-yr-2 "	2156	111	5.1

The origin of the plants was as follows:-

2-yr seedlings ex Tulliallan, No.22/80.
2-yr-1 plants " " No.19/7.
2-yr-2 " ex Beaufort ?

The 2-yr-2 plants were admittedly poor and this is reflected even more in their appearance than in the losses.

The loss of seedlings is very heavy indicating that the method of planting these is probably at fault, and, further, they were very small and in many cases were almost buried in the screeved patches.

The success of the 2-yr-1 plants in this instance is very marked.

As in the case of P.S.1001, the losses tended to occur in groups, especially where Holcus was abundant.

P.S. No.1006. Season of Planting Norway Spruce. (South Laggan)

This experiment was planted between June 1920 and May 1921 and consists of 12 monthly plots of 0.25 acre, one for each month between these dates. The plants used were Norway Spruce, 2-yr-1, ex Craibstone.

The site variation is very high and is a factor which has been quite uncontrolled in this experiment, so that results are not very reliable. * (See below)

Damage has been done by Black Game, Deer and the dense herbage in places, in spite of which the index figures obtained from the assessment made in Sept. 1925, are high, as follows:-

Date.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apl.	May	Av.
Index Fig.	65	83½	81½	57	71	72½	72	73	88½	76	75	46½	72
% Losses.	24	9½	6½	22½	14½	19	17½	18	7½	15½	20	46½	

Remarks. 1. In most cases the highest deviations from the mean index figure can be explained as due to variation in soil and site.

2. The low figure for Sept. is due to three-quarters of the plot consisting of wet ground, covered with Carices. The high figures for Feb. and July is accounted for by the large extent of Bracken ground in these plots, the former being particularly uniform as regards site. The March plot, also high, is covered with mixed Bracken and Aira caespitosa. The high August figures and the low May and June figures cannot be attributed solely to site variation, but the herbage is very long in the last two plots and short in the August plot.

3. The high figures generally indicate that this is a particularly good Spruce site, even when planting is carried out all the year round.

4. It is clear that this is not a very effective method of arriving at the desired information, owing to the rapid site-variation.

P.S. No.1006a. Season of Planting Sitka Spruce. (Inchnacardoch)

This area was planted between March 1923 and Feb. 1924 with 2-yr-1 Sitka Spruce ex. Inchnacardoch Nursery. There are 12 monthly plots. The same remarks as to site variation apply as in the above experiment.

The rock appears to be gneissose, but most of the area consists of a boulder moraine. The vegetation varies from Calluna - Erica cinerea to thin Bracken with grasses and herbs. The whole area has an irregular surface of moulds alternating with hollows.

The results of an assessment made in July 1925 are as follows:-

Date	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Av.
Index Fig.	56½	70	58	61½	50½	65½	57	44½	50½	47½	49½	53	55½
% Losses.	6½	8	8½	3	14	1½	1	0	0	0	½	0	

* The rock is schistose and outcrops in places, the rest of the area being over schistose moraine.

Remarks. 1. Soil conditions in plots from Oct. to March differ markedly from those in the other plots. In the former the ground consists mainly of bare moraine slops with Calluna-Erica cinerea, while the latter has Bracken and Grasses predominant. Clearly in this case also, the site variation is the factor which has most affected growth.

2. In spite of the proper conditions, the death-rate is lowest in the Oct. to Feb. plots, possibly owing to some extent to the shorter herbage not smothering the plants.

3. No definite conclusion can be drawn as to the effect of planting season upon growth, except that on patches of good ground with Bracken and grasses it is fairly safe to plant at any period of a wet year in this area. Had the order of the plots been reversed, very marked differences might have been seen between summer and winter plantings.

4. The experiment again shows how ineffective this method is for giving the desired information, owing to rapid site variation.

Experiment 1006b. Season of Planting Corsican Pine. (Culbin).

This experiment was planted between Sept. 1922 and Aug. 1923 with 2-year seedlings of Corsican Pine ex Wiseman's nursery, making a total of 12 monthly plots. The Sept. plot had high losses in the first year and was beaten up in Sept. 1923.

A count of the failures was made in January 1925 for each plot and the percentage losses were as follows:-

Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.
16.6	7.6	5.8	7.6	3.8	4.9	1.3	8.4	10.9	20.4	73.8	40.9

The site conditions are fairly uniform here and the results show rather clearly that on a type of ground such as dry fixed sand, where moisture and temperature conditions must be extremely variable throughout the year, that it is unwise to plant Corsican Pine between the months of May and October.

NEW SERIES. A new monthly series of Corsican Pine plots was laid down this year. An improved method of working was used in which 10 plots were staked out and 1 row of 50 plants planted in each plot every month. This obviously reduces the effect of site variation and greatly increases the reliability of results.

C. EXPERIMENTAL PLANTATIONS.

No.1. High Elevation Planting of Norway and Sitka Spruces. (S.Laggan)

The elevation of this site is 1800 ft on a N. aspect.

The species planted are 3-yr-1 Sitka Spruce ex Ireland and S. Laggan nursery and 2-yr2yr Norway Spruce ex Dunrobin and S.Laggan, each species occupying about 0.25 acre, and the whole well fenced against deer. The planting was done in May 1922.

SOIL. This is a good loam from weathered schists which are very rotten and friable. The vegetation is herb-rich and has developed very strongly within the fence. Mosses are abundant and grasses, mainly Aira flexuosa, Agrostis, A. caespitosa and Molinia, while there is a great variety of herbs, which all indicates good Spruce conditions.

The planting method was combined screef and notch. As the slope is steep, no drainage was required.

Conditions in 1925. A careful assessment in July 1925 gave the following percentages of the total planted:-

	Class 1.	Class 2.	Class 3.	Class 4.(Dead)	Index Figure.
Sitka Sp.	23	51	19	7	53½
Norway Sp.	58	25	7	10	72½

The Norway Spruce are excellent in colour and health, although the rate of growth is slow. The Sitka Spruce are also good and will doubtless improve in the next few years. The dense herbage has probably accounted for most of the deaths.

This experiment is valuable as it shows that there are good planting areas at high elevations in some localities which are more easy to deal with than some of the peaty morainic ground on the lower slopes and valley bottoms. A considerable extent of high ground could certainly be brought into the planting area at S. Laggan.

The effect of exposure later on has, however, to be considered.

No. II. Planting of Pines in mixture with Spruces. (Inchnacardoch)

This experiment is located at an elevation of 1050-1100 ft on a S. aspect. The area is exposed. There are 6 plots as follows, planted in April 1922:-

(1). 2-year seedlings of Norway Spruce notched into screeves, 1' sq.

(2). A similar plot, but the soil was stirred to a depth of 18".

(3). 2-yr seedlings of Scots Pine notched in the same way, with a 2-yr seedling of Norway Spruce planted 2' to lee of each Pine.

(4). 2-yr-2 Sitka Spruce, as in (1).

(5). Sitka Spruce, 2-yr-2, as in (2).

(6). Scots Pine and Sitka Spruce, as in (3).

SOIL. Scirpus-Calluna peat covers nearly the whole area and overlies a compact moraine, which is probably of gneissose origin. There are belts of Molinia in Plots 3, 5 and 6.

Condition in July 1925.

Plot.	Class 1.	Class 2.	Class 3.	Class 4,(Dead).	Index Figure.
1.	1%	29½	8½	61	18
2.	2½	61	4	32½	34
3.N.Spruce.	4	54	11½	30½	34
Scots P.	23½	37	9½	30	44½
4.	1	36	55	8	32½
5.	2½	31½	51	15	31
6.S. Spruce.	1½	32	49½	17	30
Scots P.	17½	46	6½	30	42

Remarks. 1. The results are poor, partly due to damage by deer, but mainly to the poor site and lack of intensive drainage.

2. The Scots Pine have shown the greatest power of recovery and are now better than the spruces. The losses in the Pine are to a great extent due to Black Game damage. Transplants might have done better.

3. The loosening of the soil has not had any marked good effects. It has, in fact, resulted in a washing away of soil and exposure of the roots.

4. The death-rate is lowest for Sitka Spruce, but, although this species is tenacious of life, even in bad conditions, it does not recover so rapidly as either Scots Pine or Norway Spruce.

5. This experiment also shows that satisfactory results are hardly possible on difficult moraine areas of this type, without special preparation beforehand.

No. V. Planting of various species at Culbin on Fixed sand.

This was laid down in April 1922, 8 plots of the following species being planted:- Pinus contorta, Corsican Pine, Douglas Fir, P. ponderosa, Scots Pine, P. pinaster, Japanese Larch and European Larch.

This experiment has not been assessed carefully but it is clear to the eye that the best results are with P. contorta and Scots Pine. The Corsican Pine were apparently a poor lot and have done badly, while Douglas Fir and the Larches have not done well.

No. VII. Different Species and Methods of Planting on Peat. (Inchnacardoch)

This plantation is at an elevation of 950 ft on an east aspect. There were 6 plots laid down in April 1923, as follows:-

(1). 2-yr-1 Sitka Spruce screefed and notched with double T notch.
(2). As in (1) but the plants were planted in inverted turfs, replaced in the holes from which they were dug. 2-yr-1 Mountain Pine were planted between the Sitka by the double T notch method without preparation.
(3). 2-yr-2 Norway Spruce planted as in (1).
(4). Norway Spruce with Mountain Pine as in (2).
(5). 2-yr-1 Japanese Larch as in (1).
(6). Japanese Larch and Mountain Pine as in (2).

SOIL. The soil is a shallow peat over compact gneissose and schistose moraine. The vegetation is largely Scirpus-Molinia-Calluna with Myrica and Narthecium in places. In plots (3) and (4) is an area of drier ground with Calluna-Erica cinerea and some grasses and herbs. Some Bracken also occurs in these plots.

Condition in 1925.

A careful assessment was made in August, 1925, with the following results:-

		Class 1.	Class 2.	Class 3.	Deaths.	Index Figure.
Plot (1).	Sitka.	1	43	45½	10½	34
" (2).	"	5½	55	25½	14	39½)
	Mt.Pine.	17½	57½	4	21	47)
" (3).	Nor. Sp.	8	67	11	14	44½
" (4).	Mt.Pine.	22½	45½	7½	24½	47)
	Nor. Sp.	5	53½	8½	33	34)
" (5).	Jap.Larch.	4	42	21½	32½	30½
" (6).	" "	10	45½	19½	25	37½)
	Mt. Pine.	6	57½	5	31½	36)

Remarks:-

1. The results are poor in all cases.

2. In the case of Norway Spruce, the special turf method has not given any better results than notching, while there is only a slight improvement with the Sitka Spruce and the Jap. Larch.

3. The superiority of Mountain Pine so far is clear from the index figures, although the death rate is high as in the case of Scots Pine in Experimental Plantation II.

4. The Japanese Larch were damaged by Black Game, but they otherwise showed good results on this poor type of ground.

5. The additional cost of £4-£5 per acre in planting by the special method over the cost of the notching method has not been in this case justified.

No. VIII. Methods of Planting on Peat at Inchnacardoch.

This plantation is at an elevation of 800 ft. on an E. aspect. The site is a peat flat over gneissose moraine in a saddle between an isolated hill and the main hill-slope. The peat is deep and main drains were dug in 1922, secondaries in the spring of 1923.

The following four plots were planted in April 1923:-

(1). 2-yr-1 Sitka Spruce by double T notch without screef.
(2). 2-yr-1 Mountain Pine by the same method.
(3). 2-yr-1 Sitka Spruce by the circular spade on upturned turfs 24" x 18" x 9", cut in the spring of 1923.
(4). A mixture of Sitka Spruce and Mountain Pine planted as in (1).

The vegetation is fairly uniform, consisting of Scirpus-Calluna-Cotton-Grass, E. tetralix, etc., with a bottom-layer of Sphagnum, Hylocomium, Lichens, etc. Plots (3) and (4) appear to be drier and the Molinia is more abundant than in the other two.

A careful assessment was made in August 1925 with the following results :-

Plot.	Class 1.	Class 2.	Class 3.	Class 4.(Dead)	Index Figure.
1. Sitka.	9½	57	29½	4	45½
2. Mt.Pine.	7	46	8½	38½	32
3. Sitka	2	53½	37½	7	38
4. "	2	42	47½	8½	35
Mt.Pine.	26	41	5½	27½	48

Remarks:-

1. In the assessment it was noted that 70% of Class 1 plants were growing close to drains.

2. The heavier losses in the Mountain Pine are again evident and also the greater tenacity of the Sitka Spruce, which has not, however, shown the same power of recovery so far.

3. Apparently the Belgian method has not been more successful than the notching method but accurate comparison cannot be made as the site factors have not been controlled.

4. The superiority, for instance, of the Mountain Pine in plot 4 over that in Plot 2 is marked and is probably due to drier conditions and greater shelter from the longer herbage in the former plot.

No. X. On Methods of Planting on Peat at Inchnacardoch.

This experiment lies alongside No. VIII and was laid down in April 1924 to test methods of planting Sitka Spruce, carried out in such a way as to keep the nursery roots near the surface.

The methods adopted were as follows:-

1. Vertical notching into the screefed surface as control.

2. Planting in a shallow basin-shaped hollow about 4" deep and 9" in diameter, the roots being directed upwards from the centre of the hollow towards its rim.

3. Planting on upturned, partially-weathered turfs, placed in a surface drain, 18" wide and 6" deep, cut to run down the slope. The turf is split in two and one half inverted on either side of the plant whose roots lie on the bottom of the drain.

4. A similar method to 3 but the plant is not placed in a surface drain but in the hollow from which the turfs have been dug.

The experiment was carried out in 15 parallel series, each series containing 140 plants, 35 for each treatment.

Condition in Sept. 1925.

A careful assessment was carried out, 2 seasons after planting with the following results:-

Plot.	Class 1.	Class 2.	Class 3.	Class 4.	Index Figures.
1. Control.	1	58	15½	25½	34
2. Shallow Pits.	1½	67	15	16½	39
3. Turf in drain.	1½	84½	13	1	47
4. Turf in hole.	1	78	13½	7½	43½

Remarks:-

1. The best root-development and least failures occur with methods 3 and 4, and these methods with upturned turfs show a higher index figure than the other methods.

2. The drainage afforded by the surface drain appears to have a beneficial effect and to give better results than when the turfs are merely returned to the holes from which they were dug.

3. Even the shallow pit method appears to be definitely superior to simple notching.

4. The extremely high deathrate in the Sitka after only 2 seasons in method (1) on what is rather better soil than in the other experiments, is striking and inexplicable.

No. XI. Various Species, Pitted and Notched, on compact Hill-slope GlenRigh.

The elevation is 300 on a west aspect and the site is fully exposed. The peat is shallow over a moraine of Quartzite and Clay Slate debris. The slope is moderately steep and only a few drains were dug in the area.

Plan.

An improved method of laying out the experiment has been adopted. There are 10 series of 8 rows each with 40 plants to a row. The rows are composed of the following species in order:-

1. 2-yr-2 Sitka notched. 3. Nor. Sp. notch. 5 Jap Larch. Notched.
2. " " pitted. 4. " " pitted. 6. " " Pitted.
7. Scots Pine. notched.
8. " " pitted.

The vertical notching spade was used. The pits were prepared by removing 10 sq. ins. of peat and stirring up the mineral soil below and mixing it with the lower peat layers,; the plants were put into the mineral soil, the peats halved, inverted and placed one half on either side of the plant.

The vegetation is of two main types (a), Scirpus-Calluna-Molinia-Narthecium with a sole of Sphagnum and Hypnum, and (b) Carices-Molinia-Nardus and Juncus articulatus.

Conditions in 1925. A careful assessment was made in August, 1925, with the following results:-

Species.	Method.	Class 1.	Class 2.	Class 3.	Class 4.	Index Figure.
Sitka	N.	1	74½	16½	8	42½
"	P.	0	82	12½	5½	44
Norway Sp.	N.	1½	71	6½	21½	38½
" "	P.	½	80	5	14½	41½
Jap. Larch.	N.	2½	71	14	13	41½
" "	P.	5½	67	10	18	41½
Scots Pine.	N.	40½	58	½	1	69½
" "	P.	34½	63½	1	1	66½

Remarks.

1. In comparing the species, Scots Pine are very much superior so far to any of the others, for which the index figures are all very much alike.

2. So far, the pitted plants in all four species have not shown any decided superiority over the notched plants, except perhaps in the case of Norway Spruce, where the proportion of failures is greater. There is also a slight improvement in the case of Sitka spruce. If anything the notched Pine are better than the pitted.

3. The reliability of these results is higher owing to the improved method of experiment. Even more reliable results would be got if the plants were more closely spaced as that reduces the area necessary for experiment and so reduces the site variation, making it possible to carry out complete experiments in uniform patches of soil and vegetation. At the same time, the work of assessment is simplified.

GENERAL NOTE ON RESULTS OF PLANTING EXPERIMENTS.

The results so far indicate that the establishment of pure Norway or Sitka Spruce on good loam or brown-soil, indicated by the presence of pasture grasses and a herb-rich flora, even at high elevations, is relatively straight-forward.

Morainic deposits covered with a variety of vegetational types which depend upon the absence of peat or variation in its depth, present a more difficult problem.

So far, Scots Pine and Mountain Pine, although they suffer higher losses, make the best recovery, especially where Black Game are absent. On shallow peat overmoraine, Jap. Larch does fairly well. These three species do quite well even when simply notched in on slopes with natural drainage, at least in their first year.

On such slopes, however, and especially on deep peat in the hollows between morainic mounds, the successful establishment of both Norway Spruce and Sitka Spruce is difficult, although the latter species is the most tenacious of life of the species tried.

On the whole, special methods of planting have not given improved results over screefing and notching combined, except in Experimental Plantation No. X, where an improvement was obtained in Sitka Spruce by running shallow drains up and down the slope and planting into upturned turfs placed therein.

That drainage is necessary on these peat soils, is evident, and the policy now in experimental work is to assume that intensive drainage is required and that planting must be carried out on upturned turfs, especially on true basin peat. This year's work carried out on these principles, shows promising results and it is proposed to try a similar method on peat slopes and mounds.

The success of Scots Pine and Mountain Pine even on difficult sites suggests that these species should be used as nurses, planted several years before Spruce or other species is introduced. It is proposed to test other species of Pine in addition.

The operation of establishing plantations by planting or sowing is the most important of all Forestry operations, for at least two reasons, namely - (1) that once the plantation is established it is seldom possible to rectify mistakes without a fresh establishment until the next rotation, (2) that all nursery operations must lead up to this stage of the work.

It is obviously therefore, the pivot upon which all Forestry operations hinge, and for this reason becomes of first importance in experimental work, more especially as there is clearly much room for improvement in existing practice and for varying that practice to meet the wide variation in locality conditions which occurs in this country.

Experiments on choice of species, age and type of plant and on methods of planting on difficult ground should therefore be looked upon as of first importance.

In Scotland, there are three main types of land which demand attention experimentally and one subsidiary type. The main types are (a) Peat areas (b) Hard Pan Areas and (3) Areas at high Elevation. The subsidiary type is on Blown Sand at Culbin, which has been dealt with fairly intensively.

There is now a centre for Peat experiment at Fort Augustus and arrangements for future experiment on an intensive scale on Hard Pan have been made at Teindland.

It is proposed to enclose an area of high ground at Fort Augustus for future experiments at high elevations. The area is very moderate in regard to soil quality and is fully exposed.

It is hoped by thus concentrating the field work in this way that better supervision will be secured and more reliable results obtained.

Mark Anderson

9th November 1925.

APPENDIX I.

SEEDLING COUNTS PER SERIES IN EXPERIMENT 4b.

KA SPRUCE.

ries No.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
ter-7 days.	162	174	206	185(727)	157	158	140	154(609)	144	136(280)
" 1 "	181	193	151	176(701)	115	133	124	137(509)	113	115(228)
dine.	159	156	181	160(655)	106	152	133	134(525)	108	115(223)
ter @ 50°C.	188	197	201	187(773)	167	141	135	155(598)	125	87(212)
				2856				2241		943

Same expressed in terms of water for 1 day at room temperature.

ter-7 days.	89.5	90.1	136.4	105.2	136.6	118.8	112.9	112.4	127.5	118.2
" 1 "	100	100	100	100	100	100	100	100	100	100
dine.	87.3	80.8	119.9	90.9	92.2	114.2	107.3	97.8	95.6	100.0
ter @ 50°C.	103.9	102.1	133.1	106.3	145.2	106.0	108.8	113.2	110.6	75.7

Means for these values:-
(1) 114.75. (2) 100.0 (3) 98.6 (4) 110.49.

PEAN LARCH.

ries No.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
ter-7days.	103	120	144	130(505)	131	128	149	131(359)	171	146(317)
" 1 "	171	175	187	189(722)	156	145	168	188(657)	141	156(297)
dine.	196	191	193	124(730)	169	150	182	188(689)	146	189(285)
ter @ 50°C	141	158	187	124(610)	141	162	160	151(634)	179	194(373)
				2567				2339		1272

Same expressed in terms of water for 1 day at room temperature, which eliminates the site variation.

ter-7 days.	60.2	68.6	77.0	73.0	96.8	88.3	88.7	69.7	121.3	93.6
" 1 "	100	100	100	100	100	100	100	100	100	100
dine.	114.7	109.1	103.2	79.4	108.3	103.5	108.3	100	103.5	89.1
ter @ 50°C	82.5	90.3	100	65.6	90.4	111.7	107.2	80.3	127.0	124.4

Means for these values:-
(1). 73.7 (2). 100.0 (3). 101.9 (4). 97.9.

APPENDIX II.

DATA FROM EXPERIMENT N.S.No.33.

Table A.

SIZING OF SEED.

	No. of Seeds.	Weight.	Wt. per 1000.	Av.Wt.per seed
Size A. Lab.Test.	550	2.64 gm.	6	.0048 gms.
" " Nursery.	1550	7.50 "	-	.0048 "
Total.	2100	10.14 "	4.83 gms	.0048 "
" B. Lab.Test.	1820	6.92 "	-	.0038 "
" " Nursery	6000	22.33 "	-	.0037 "
Total.	7820	29.25 "	3.74 "	.0037 "
" C. Lab.Test.	2000	5.47 "	-	.0027 "
" " Nursery.	15199	41.70 "	- "	.0027 "
Total.	17199	47.17 "	2.74 "	.0027 "
Total Sample X.	27119	103.30 "	3.19 "	.0032 "
Less impurities -		86.56 "		

Table B.

TOTAL NURSERY GERMINATION per Series.

Series.	Sample XA.		Sample XB.		Sample XC.	
	Seedlings.	Losses.	Seedlings.	Losses.	Seedlings.	Losses.
I.	29	4	18	4	2	0
II.	25	6	17	1	4	1
III.	31	4	12	2	8	3
IV.	27	2	11	4	2	0
V.	25	11	16	1	3	0
VI.	30	4	19	6	4	1
VII.	28	8	13	2	6	5
VIII.	21	1	14	2	7	2
IX.	21	2	15	5	3	1
X.	31	13	14	7	4	3
Means.	26.8	5.5	14.9	3.4	4.3	1.6

APPENDIX III.

FINAL DATA FROM EXPERIMENT 15c on SEASON OF SOWING.

Date of Sowing.	% fit to line out.	% of Grade 1 in Total.	Production per lb. Total.	Production per lb. Fit Plants.
DOUGLAS FIR. ex Durris.				
23/ 1/23.	-	-	-	-
20/ 2/23.	62.4	25.6	14,180	8845.
2/ 3/23.	63.9	24.4	13,840	8845.
20/ 3/23.	52.4	18.5	11,640	6130.
3/ 4/23.	51.5	23.5	11,230	5784.
13/ 4/23.	61.3	17.7	12,590	7711.
4/ 5/23.	37.8	11.8	10,210	3856.
23/ 5/23.	54.8	14.5	14,290	7823.
5/ 6/23.	36.5	10.5	5,896	2155.
DOUGLAS FIR. ex Canada.				
23/ 1/23.	55.5	29.2	19,620	10,880.
20/ 2/23.	-	-	-	-
2/ 3/23.	55.8	23.7	19,720	11,000.
20/ 3/23.	53.9	23.6	18,710	10,090.
3/ 4/23.	55.7	21.7	16,900	9,412.
13/ 4/23.	58.9	23.6	17,120	10,090.
4/ 5/23.	34.7	7.1	13,720	4,762.
23/ 5/23.	43.8	12.9	18,140	7,938.
5/ 6/23.	34.8	7.3	17,920	6,237.
SITKA SPRUCE.				
23/ 1/23.	-	-	-	-
20/ 2/23.	83.8	27.4	22,380	18,750
2/ 3/23.	69.1	21.4	24,500	16,930
20/ 3/23.	78.3	20.0	22,690	16,630
3/ 4/23.	73.8	18.6	24,190	17,840
13/ 4/23.	62.3	9.3	20,860	13,000
4/ 5/23.	28.6	0.0	10,590	3,024
23/ 5/23.	48.3	3.4	18,140	8,770
5/ 6/23.	13.6	0.0	13,300	1,814
EUROPEAN LARCH.				
23/ 1/23.	-	-	-	-
20/ 2/23.	-	-	-	-
2/ 3/23.	63.4	37.0	4,762	3,062.
20/ 3/23.	60.9	60.7	5,217	3,176.
3/ 4/23.	69.0	51.0	8,052	5,556.
13/ 4/23.	65.8	32.7	8,958	5,896.
4/ 5/23.	62.5	30.0	3,628	2,268.
23/ 5/23.	71.8	30.4	7,257	5,217.
5/ 6/23.	36.7	9.1	3,402	1,247.

HEATHER - BURNING

The results of enquiries into this matter, made by me, have shown on the whole an absence of any definite policy with regard to heather-burning. In some cases no burning is carried out if it can be avoided, and if burning is done it is carried out in Spring. There are other cases where burning has been done indiscriminately regardless of season, the only object being to remove the heather covering somehow.

I have been able to obtain, however, some really useful information from a report of extensive experiments carried out in Sweden from 1888 onwards. This report by Wibeck was published in February 1911 and it clearly shows that the operation of heather-burning is a very delicate one, requiring considerable judgment and skill.

The following remarks are based upon the experiences and observations of a number of Swedish foresters who have a special knowledge of heather-burning:-

"The effect of heather-burning is to a very great extent dependent upon the strength with which the fire attacks the substratum, and thus on the season when it is carried out. Most heather-burning, intentional and otherwise, takes place between March and August, the intentional usually in spring or early summer. The early spring burnings do not reach the actual soil as a rule, as it is still frozen or at least, cold and damp.

After such a burning the root-system of the ling is unharmed and the plants send out new adventitious shoots the same year, which come from the deep-seated, so-called dormant buds, which are easily seen and with which ling is specially well equipped.

The ling may grow in this way up to 1 dm (4 ins) in a year, and after 6 (even in 3) years the heather covering may have the same appearance as before burning.

Such a burning benefits in most cases a subsequent Pine sowing. The plants are for a time freed from the competition for food and water which the untouched ling crop causes and have got into the bargain a useful manuring. No encroachment on the food capital of the soil has been made, since the mould has not been burned, which can be avoided by correct choice of season. Burning has in this case temporarily presented the trees with certain advantages, and this particularly applies to poor soil. Sowing should be made the same year as the burning or the value of the ash is lost. Another, but certainly less, benefit is obtained if a delay of some years is made after burning, since the ling roots die and decay and so open up the soil.

Burning means ease and cheapness in working as small patches and strips can be made without fear of smothering. Burnt areas also receive more attention from grazing animals, which come for the grass and herbs which spring up in a few years' time.

There are cases when not even a burning of the light nature here described, is advisable, namely, on loose sandy soils, which would be subjected to erosion, if their protective covering were removed and also on very shallow soils which need all the shelter and vetetation they can get. It also seems doubtful whether it is, broadly /

broadly speaking, advisable to burn on ling ground which has no bottom-vegetation or where that - in contrast to the Hylocomium-ling heaths, which form the large majority - mainly consists of lichens and fire-mosses. That the value of burning is also less and in some cases becomes harmful, on damp ground will be explained later.

All the charges against heather-burning centre around one point, which is wrongly often said to be a necessary effect of the burning, namely the burning of the soil, or rather of the top layers of the soil.

Soils with varying mould content, porosity and warming-capacity, etc., probably react differently to burning, but there are no reliable data.

Actual soil-burning and in particular repeated soil-burning, leads however, as a rule to soil deterioration, such as many experts describe and should therefore be carefully avoided. Soil-burning is only too easy if the work is done at unsuitable seasons, e.g., too late in spring or early summer, when the frost has gone and the soil is dry. In the driest season, fires are very harmful.

The first sign that burning has been carried too far is given by the ling itself, which no longer produces root-shoots. After a year or so it certainly comes in as seedlings, which are uneven and there often is - not counting the ephemeral grass and herb vegetation - another vegetation for many years scattered in patches throughout, especially Erica tetralix.

As Graebner, Raunkiaer, etc., have shown, Erica tetralix endures greater moisture than ling; its natural place on the ground is thus a lower zone than the latter, especially on spots with periodically greater variations in moisture. Erica tetralix and some other species, Leucobryum, Molinia, etc., usual in burnt Ling areas, have decided connection with the increased moisture which, at least for a time, characterises these areas. Anyone, who has trod a ling-heath after rain, knows to what a great extent ling, under such circumstances is wet. This shows that the ling-covering catches a great part of the rain-water, which thus does not reach the soil, but is evaporated directly from the ling. Then further, the ling transpires water which it takes from the soil. Thus these are two good reasons for the increase of soil water on bare ground. In long droughts, the ling may shelter the soil from drying out, especially if there is a bottom-layer of vegetation. Ling regulates the water conditions in the soil. These effects are of less importance on burnt areas which lie over deep, even beds of moraine or boulder gravels, where the drainage as a rule is excellent, but are of more consequence on the rugged and often thinly soil-covered rocky soils which characterise large areas of ling-heaths in our wettest regions. On burnt areas on such ground, the water circulation is very irregular with marked local changes. Water runs away from some parts quickly and completely, in other parts it collects in hollows in the rocky ground and often forms very definite pools. A bare burnt area of this class after some years shows very marked drying out or patches washed bare by rain and surface water and also several small swamps, whose origin and spread are clearly promoted by the vanishing heather-covering. In addition, the fine layers of charcoal, which cover the soil are markedly hygroscopic/

hygrosscopic and so form a favourable substratum for the growth of swamp vegetation. The water-regulation which the forest exercises on a rugged landscape, devolves upon the smaller heather covering on rocky heaths on our west coast. The maintenance of the heather is here undoubtedly of much greater importance than an any other kind of ling soil. On such ground, if burning is to be done, great discrimination and care has to be exercised. On the small uniform patches over the deeper gravel deposits, it may be done with advantage to an immediately succeeding crop.

A strict geographic index of ling soils which can be burned with advantage or not, is difficult to establish, but on the whole, the former include those areas where ling-heath occurs on relatively uniform and deep gravel deposits, on barrens; the latter, those tracts, where the growth is on looser sand or shallow rock soils, as is generally the case in the coast region etc. Within both such area types, exceptions may occur.

The result of the research carried out showed that the burning of heather - if not invariably, at least under certain conditions - may be an improvement so that some words as to the best time and method of burning may be in place. The technique which exists, is based on the experience of J. Andersson, for 20 years at Hottja, where every year 60-70 hectares were burned.

An ideal burning is one which, without attacking the soil in any way, completely reduces the heather to ashes. The success of this depends on the time of burning, which should be chosen with regard to the fact that the manuring of the ash on the unwashed soil surface is to help the plants. The burning should thus take place earlier in the same year in which the sowing is made. Burning on hard frozen soil as Gyberg says, certainly gives good guarantee that the soil will not be burned, but, as pointed out by the Danish Heather-burning Committee, the soil is not available for checking or limiting the fire. The best time for Swedish conditions seems to be the earliest spring, when the frost has just left the soil, but the latter is still cold and damp, while the ling is dry after some days of wind or sunshine. The heather is actually easier to burn then than later on, before the sap rises. The best time may vary in different areas, and in different years, but should be completed in March or the first half of April.

The area to be burnt should be limited so that as far as possible use is made of the fixed or natural more or less non-inflammable limits, such as roads or tracks, stone walls, ditches, swamps, etc. These limits should be strengthened and completed where needed, by cutting back the ling to sufficient width. With the heather-scythe (a short, strong model) one man in a day should cut back about 300-400 metres of such lines. If a sedge swamp is used as a boundary, the rushes and sedges must be dragged over with a switch or a rope to sufficient width, so as to dip them into the water, for in many cases they conduct fire faster than heather.

To burn fire-lines first as is at times proposed, is as Andersson says quite impracticable, as it would be quite as difficult as burning the whole area itself. Nor would it be any advantage to burn at night. The disadvantage, which is overcome by/

by this method, namely the difficulty of seeing sparks and cinders by daylight, is more than outweighed by the greater mobility and power of finding his way about of the worker. It is also more difficult to get labour and more expensive for night work.

One foreman cannot be expected to manage more than 15 to 20 men, but 12 - 15 are under normal conditions quite enough to control the fire on a burning area up to 100 hectares in size. The men should be equipped with the necessary tools; branches, mattocks and even buckets, spades and axes.

The operation should be carried out in fairly calm weather and the fire always laid on the leeward side of the area close in to a boundary or fire-line. The fire extends more quickly to the sides than straight into the wind, so that after a bit the burnt surface is half-moon shaped, reaching right over the area. All fires which tend to cross the boundary lines are put out by the squad which is spread nearly the whole length of the area on the lee-side. When the fire has spread the whole width of the area the whole length of the wind-ward side can then be lit. The two fires soon meet. Men should also be posted on the windward side but it is less important than the lee side. If the wind changes the men must be grouped accordingly.

If heather-burning is carried out in this way with the necessary guard maintained for some time after, it is, as the Danish Committee says, quite a safe operation as far as surrounding land is concerned.

The evil effects of a too severe heather-burning upon the soil conditions can readily be seen in several of the areas belonging to the Commission. Instead of a bottom-layer of Hylocomium and other mosses under the heather, areas occur with a dense layer of lichens and with Erica Tetralix and Sphagnum amongst the heather. The first stage is a complete burning of the top soil surface such as can be seen on the Balloch Hill near Huntly. This is followed later by the second stage where a thick felted lichen-moss sole forms over the soil surface and prevents the rain water from percolating into the soil layers. This water flows off down the slope and floods the flats and hollows below, with the result that a dense peat vegetation develops there, consisting of Polytrichum, Sphagnum, Rushes &c. Typical areas of this kind occur at Teindland and Monaughty. On Culbin the burnt areas are still lichen-covered and it is quite noticeable that growth is poorer and failures are more numerous on such ground. The effect of the extensive burnings at Inchnacardoch has not by any means been entirely a good one. The removal of the heather covering and the sole of mosses in this case undoubtedly accounts for the swampy nature of the ground, and for the development of Erica, Sphagnum, Molinia and Scirpus, where formerly Calluna predominated. The ground in this case, in view of the heavy rainfall, seems to belong to that type which should not be burnt, or, at least, not severely burnt.

In all these areas small patches occur where burning has not been complete or has not occurred, and where the moss-covering is intact, and usually growth of the plants is better than on the burnt area. This is very marked at Culbin and to a lesser extent at Inchnacardoch.

It is clear that it takes many years - even over 20 - for such over-burnt soils to recover, and that surface drainage with special preparation is almost essential before successful plantations can be established, and the soil conditions brought back to normal.

DIRECT SOWINGS.

In accordance with the terms of my instructions, I visited the following areas in Scotland where direct Sowings have been carried out -

S.W.Division.	Forest.	Species.
	Dalbeattie	Corsican Pine
	Screel Hill	" "
	Tentsmuir	" "
N.E.Division.	Culbin	Maritime Pine, Corsican Pine, Douglas Fir.
	Teindland	Scots Pine, Corsican Pine, Sitka Spruce
	Monaughty	Norway Spruce,
	Glenmore	Scots Pine, Corsican Pine.
N.Division.	Port Clair	Norway Spruce.
	Beaufort	Scots Pine, Corsican Pine.
	Port Clair	Douglas Fir
	Glen Righ	N.Spruce.

In each case, time was too short to make anything but a very cursory examination of the area.

A considerable amount of damage is done to sowings by ground game. This is clearly demonstrated in Mr Fraser's sowings at Beaufort, where he took the precaution of fencing part of the area sown against rabbits. Within the fence there is a good crop of seedlings of both Corsican and Scots Pine. Outside the fence hardly one plant can be found. At Culbin the sowings of Douglas Fir have been badly bitten by hares. I paid two visits to this area and noticed on my second visit that the good plants previously observed had been bitten back.

Apart from these results the following areas were noted as very successful namely, Norway Spruce at Monaughty (2 areas) and at Port Clair, Scots Pine and Corsican within the fence at Beaufort, Corsican Pine at Culbin, Maritime Pine at Culbin. The growth and colour on other areas varied considerably especially on a third area of Norway Spruce at Monaughty and generally on the Teindland Sowings. In every case, with the possible exception of Culbin, disturbance of the soil was a feature of the methods used. It is therefore clear that no general statement can be made against the value of disturbing the soil. In fact, as in the case with most other Forestry problems, the factors which come into play in the operation of Direct Sowing are several and are so confusing that only very careful and detailed research can solve the problem in its general aspects.

The area of Norway Spruce sown at Monaughty on mounds of soil dug from surface drains is so variable that it affords a clue to at least one, if not, two of the factors of importance, for this species at least. These are, humus content in the soil and overhead or side shade. The mounds of earth vary very much in texture some being pure mineral soil, but others have a large peat or humus content. It is certain that the latter mounds show the better results especially when the other factor of overhead shade is present. Very poor results occur on exposed mounds with pure mineral content.

content.

It seems evident that direct sowing will do best on conditions which most nearly approach these found in nature, namely, in semi-shade in a mineral soil containing a considerable amount of humus.

It is certain that where both humus content and shade are absent results are generally poor, and where present results are generally good.

Disturbance of the soil.

The preparation of the patches for direct sowing is not a simple matter. On some soils, where the heavy humus litter is burnt off, the resultant salts appear to sink into the soil layers and provide a good seed-bed, at least for Pines. In such cases, soil disturbance is probably unnecessary as the mixing of salts with the mineral soil has already taken place. On dry soils of a sandy texture, stirring of the soil may even be harmful.

On good brown-soils or loams, even when the surface vegetation is removed, enough humus occurs in the soil to satisfy the young plants.

On poor sandy soils or leached "podsols" however, matters are different. Here the humus occurs in a layer above the mineral soil and if the seed is sown on the surface without screefing, it is probable that more satisfactory results will be obtained. If, however, the humus layer is screefed and thrown aside and the mineral soil stirred up to receive the seed, the lack of humus in that soil is reflected in the poor growth of the seedlings. On the other hand, if the humus layer were broken up and mixed with the mineral soil, good growth might result.

The problem is, therefore, a little complicated and on the last type of soil mentioned requires to be dealt with step by step. I propose to carry out intensive experiments at Teindland on the preparation of the soil surface for direct sowing.

EDINBURGH, October 1925.

REPORT ON NORWAY SPRUCE SAMPLE PLOTS.- WHETHER MIXED OR NOT.

The temporary plots and sub-plots and the permanent sample plots of Norway Spruce were examined in order to ascertain whether these had been grown pure or in mixture.

The material was dealt with in two lots, one containing all plots at elevations of 800' or more and the other consisting of all plots at elevations below 800 feet.

A. Norway Spruce at high Elevations.

Plot No.	Locality.	Elev.	Q. Class.	Soil Type.	Mixed.	Nature of Mixing.
11.	Birnam.	800.	III.	Grits and Schists.	Yes.	With Larch.
49b.	Drummond Hill.	950.	II.	Mica Schist.	Yes.	By groups with other species.
57.	Ballindalloch.	800.	III.	Till on Moine Sct.	No evidence.	
147.	Durris.	800.	-	Peat over Gneiss.	Yes.	Various conifers.
211.	Portmore.	1100.	III.	Till on Silurian.	Yes.	With Scots Pine
221.	Roxburgh.	900.	III.	ditto.	Yes.	Scots Pine.
244.	Drumlanrig.	850.	II.	ditto.	Yes.	do.
284.	Drummuir.	900.	III.	Till on Mica Scht.	Yes.	Scots. etc.
317.	Cluny.	900.	IV.	Till on Granite.	Yes.	Scots & Larch.
327.	Clova.	1000.	IV.	Till on O.R.Sandst.	No.	--
328.	Clova.	1100.	V.	Clay Slate.	No.	--
329.	Clova.	1150.	V.	ditto.	No.	--
330.	Glenkindie.	1300.	V.	Till on Gneiss.	Yes.	Scots Pine.
331.	Kildrummy.	1000.	IV.	Sand on O.R.Sandst.	No.	--
338.	Rhinstock.	1400.	IV.	Black Schist.	Yes.	Larch.
354.	Mar.	1500.	IV.	Quartzite.	No.	(A narrow strip)
362.	Abergeldie.	1300.	IV.	Till on Granite.	Yes.	Scots Pine.
368.	Invercauld.	1250.	IV.	Till on Schists.	Yes.	Larch.
397.	Invermark.	1050.	IV.	Till on Quartzite.	No.	(A narrow strip)
398.	Invermark.	850.	IV.	River Alluvium.	Yes.	Under Birch.
401.	Glenogil.	1100.	IV.	Clay Slates.	Yes.	In Larch.
403.	Glenogil.	850.	II.	River Alluvium.	No.	(Small strip.)
405.	Cortachy.	850.	III.	Sand on Schistose	No.	--
S.P.3.	Portmore.	1050.	IV.	Till on (Grits. Silurian.	Yes.	Scots Pine.
" 24.	Arntilly.	950.	IV.	Granite.	No evidence.	
" 25.	Deskryshiel.	1050.	IV.	Till on Schists.	Yes.	Scots Pine.
P.P. 38 & 39.	Douglas.	1150.	IV.	Till on Andesite.	Yes.	Scots Pine.
61.	Strathtay.	1150.	V.	Till on Schists.	No.	

Summary of Above.

Mixed. Stem.	Mixed. Group or Strip.	No. Evidence.	Not Mixed. Large Block.	Not Mixed. Narrow Belt.
15.	2.	2.	6.	3.

TOTAL = 28.

B. Summary of Remaining Plots below 800 feet.

Mixed.	No. Evidence.	Not Mixed.
40.	16.	12.

TOTAL PLOTS.

Mixed.	No. Evidence.	Not Mixed.
57. (59½%)	18. (19%)	21. (21½%).

A large proportion of the Spruce woods in which measurements were made were thus grown in mixture with other species.

GENERAL NOTE ON EXPERIMENTAL WORK.

The past 5 years of experimental work may not have been very fruitful in results which are of real and immediate practical value but, apart from that aspect, they furnish a considerable amount of valuable information regarding the actual practice of experiment.

(a) In the first place it is quite clear that the field of operations is far too wide to be adequately covered by the very small staff employed. It is not the practice in other branches of science to have workers engaged on several lines of work unassisted, nor should it be the case here. At present the planning of experiments, their supervision and the carrying out of the work, the assessment of results and recording and reporting of results are all carried out by one individual. This would be quite possible if one line of experiment only was being dealt with. A glance through any Annual Experimental Report shows how far this is from being the case. It is beyond the capacity of one man to do justice to the amount of work expected. Further, it is quite possible for any individual outside the Experimental Branch, working on one line of research only, to obtain earlier and more conclusive results than members of the Experimental Branch.

(b) The work is also made more difficult by the fact that it is so scattered over the country and by one fact that we have to rely upon people, inexperienced in experimental work, to carry out many of the essential operations of experiment. Nearly all of the field experiments in Scotland lie North of the Grampians, which entails very considerable loss of time in travelling to and from the Headquarters in Edinburgh.

An essential part of experimental work is very careful observation and recording of every operation carried out and repeated examination to see that no unexpected factor appears.

(c) In the actual carrying out of experiments, too much stress has been laid upon the method of assessing results, especially upon the necessity for applying elaborate statistical methods, which demand a great deal of careful measurement and calculation.

Too little attention has been paid to the method of laying out experiments so as to eliminate, as far as possible, all uncontrolled factors. This is the first essential of all experimental work and if sufficient attention is paid to it, the results are at once both more reliable and more easily assessed.

The one great lesson from most of the work so far carried out, is the need for correct replication and lay-out, so that the effects of site factors, which have a very marked influence on results, can be eliminated. This applies especially to field experiments.

(d) Too much attention has been paid to the collection of quantitative data from experiments carried out on a small scale.

Much more accurate and reliable quantitative data will be available in due course and in as short a time, from the actual operations of the Commission on a large scale.

One line of experiment which would give more important results would be to direct efforts towards developing general practice by improvement in mechanical appliances and methods of using these.

Such improvements are usually of wide application and do not refer only to one particular locality.

The following suggestions which are based on the above points, are therefore put forward -

1. Restricting of the number of experiments and the range of experimental work, or conversely, increasing the staff and subdividing the work.

2. The winding up of as many old experiments as possible, especially such as do not appear to furnish anything of real practical value.

3. Concentrating experimental work as far as possible so as to secure better supervision. This is being done in regard to the field experiments.

4. Paying more attention to the lay-out of both field and nursery experiments, so that all the site factors are controlled and results made more reliable. This is also being done.

5. Paying more attention to the use of tools and mechanical appliances and methods of using these.

MARK L. ANDERSON.

EDINBURGH Nov. 1925.

B.44.

APPENDIX IV.

METEOROLOGICAL DATA FOR March to October, 1925. ROYAL BOTANIC GARDEN. EDINBURGH.

Month	Mean Max. Temp.		Mean Min. Temp.		Highest Temp.		Lowest Temp.		Rainfall.		No.of Days of Frost.	
	1925.	Normal.	1925.	Normal.	1925.	Normal.	1925.	Normal.	1925.	Normal.	1925.	Normal.
March.	-	47.7°F.	36.1°F.	34.9°F.	-	59° F.	27.0°F.	26° F.	1.080"	1.76"	15	-
April.	-	52.6	37.5	38.1	-	64	31	29	3.427	1.32	11	-
May.	60.3°F.	57.3	45.1	42.8	67° F.	70	35	34	3.550	1.84	3	-
June.	68.3	62.9	49.3	48.4	84	76	44.5	41	0.340	1.76	1	-
July.	69.7	65.8	53.4	51.4	82	76	46	44	1.740	2.60	0	-
August.	68.2	65.4	52.4	51.2	76	75	44	43	3.370	3.00	0	-
September.	61.9	61.8	45.3	47.6	76	71	37.5	37	3.710	1.80	6	-
October.	57.8	54.8	44.9	42.1	71	65	28	31	1.625	2.44	7	-

Meteorological Data. Beaufort School. 1925.

	Rainfall.	Days Frost.
Mar.	2.51"	7.
Apr.	2.69"	10.
May	3.53"	2.
Jun.	0.52"	0.
Jul.	2.33	0.
Aug.	1.13	0.
Sep.	2.71	4.
Oct.	1.33	7.

General Notes:-

The season has been the reverse of 1924. This year there have been High Maximum and High Minimum Temperatures throughout the growing season, with exceptional heat on several occasions. The rainfall was excessive in April and May and deficient in June and July. The August rainfall was normal.

The last frost at Beaufort was on May 14th but a slight frost was experienced in Inverleith nursery on the 24th of June. The first autumn frost in both cases was on the 4th of September. The hardest frosts were on the 22nd March at Beaufort, when 10° of frost obtained; and on the 21st and 27th March at Inverleith, when 11° were registered. In autumn, on the 16th Oct, 10° of frost were again registered at Beaufort and on the same day, 15° of frost were registered at Inverleith.

REPORT ON PERMANENT SAMPLE PLOT WORK.

1924 - 1925.

INDEX.

Report on Permanent Sample Plot Work

for the Year 1924-25.

The year was spent in working as follows :- 2 months in measuring plots in England and 5 in Scotland while 3 months were spent in England in repainting in plots which are due for remeasurement in the coming winter.

7 new plots have been laid down, all in Scotland. 5 plots have been remeasured in England and 3 in Scotland while 11 plots in England have been prepared for remeasurement and thinning in the winter. A wind blow in 1 plot in Scotland has been cleaned up.

The new plots are of the following species :-

European larch	2
Scots pine	4
Abies nobilis	1

The remeasured plots are of the following species :-

England		Scotland	
European larch	3	European larch	1
Japanese larch	2	Sitka spruce	2

Present Position.

At the end of September 1924 there had been established in Great Britain a total of 149 sample plots, 84 in England and 65 in Scotland. During the year under review one plot in England has been abandoned making the total for that country now 83 while the new plots laid down in Scotland bring the total there up to 72. The number of plots in Great Britain at the end of September 1925 is thus 155

The various species are represented as follows:-

Species.	Measured. Once.	Twice.	Thrice.	Others.	Total.
Oak	3	-	-	-	3
Oak & Beech	-	-	3	-	3
Ash	1	-	-	-	1
Scots pine	24	-	-	-	24
Corsican pine	11	-	-	-	11
Weymouth Pine	1	-	-	-	1
Scots pine & Norway Spruce)	1	-	-	-	1
Norway spruce	13	3	-	-	16
Sitka spruce	4	2	1	-	7
European larch	15	6	9	4	34
Japanese larch	15	3	-	-	18

Species.	Measured. Once.	Twice.	Thrice.	Other.	Total.
Douglas Fir	25	2	3	-	30
Abies grandis	1	1	-	-	2
" nobilis	1	-	-	-	1
Thuja plicata	2	-	-	-	2
Tsuga heterophylla	1	-	-	-	1
Totals	118	17	16	4	155

The accompanying map shews the distribution of the plots over the country.

According to counties, they are distributed thus -

England & Wales.		Scotland.	
Cheshire	2	Aberdeen	9
Devon	3	Argyll	7
Durham	1	Dumfries	6
Gloucester	13	Inverness	6
Hampshire	10	Kincardine	8
Monmouth	6	Kirkcudbright	5
Montgomery	6	Lanark	3
Northants	1	Moray	4
Northumberland	14	Peebles	5
Shropshire	4	Perth	12
Somerset	13	Renfrew	3
Surrey	5	Ross	4
Wiltshire	5		
Total	83		72

From this it will be seen that all parts of Scotland have been fairly represented. The east and north of England (with the exception of Northumberland) have not been touched and Wales is imperfectly represented.

Work carried out in Plots in England.

The following plots were remeasured and rethinned -

Nos. 15, 16 (afterwards abandoned) and 17 - Cressage, Shropshire.

Nos. 21 and 22 - Monk Hopton, Shropshire.

The following plots were repainted and made ready for remeasurement and thinning in 1926.

Nos. 23, 24 and 25 - Welshpool, Montgomery.
Nos. 26, 27 and 28 - Lake Vyrnwy, Montgomery.
Nos. 35, 36, 37, 38 & 39- Bagshot, Surrey.

In addition, a new plot in a plantation of mixed Japanese larch and Douglas Fir, was demarcated and the trees numbered at Lake Vyrnwy. This plot will be measured and thinned in 1926.

Remeasurements.

Plots 15, 16 and 17. European Larch. Cressage.

These plots were laid down in 1915 as a set of comparative plots, plot 15 receiving a light thinning, plot 16, a moderately heavy thinning and plot 17, a heavy thinning.

Unfortunately, for strict comparison, they are spoiled to a certain extent by the presence of two Quality Classes and plot 15 which is of Quality Class III (60') can only broadly be compared with plots 16 and 17 of Quality Class II (70').

The plots were measured and thinned on establishment and again in 1920 and in 1925.

In 1925, it was decided to abandon plot 16 but the plot was measured and given a light C. grade thinning.

The plots are growing on what was once agricultural land but was given up as too heavy for profitable working and planted up with larch. The soil is a stiff clay loam passing into clay at places. It is deep and free from stones.

Plot 15.

The first measurement was made in 1915 and gave the following results. The age in that year was 31.

No. of stems to the acre was 858, the average height - 43 feet; average girth 16 inches; Form Factor .356. The under bark volume was 1830 cub.ft. 130 trees per acre were taken out in a thinning and these had a volume of 50 cub.ft. The total volume in 1915 was thus 1880 cub. feet.

In 1920 - age 36, the number of trees per acre was 724, with an average height of 49 feet and girth of 18 inches. The underbark volume was 2355 cub. feet and the Form Factor ·375. 134 trees per acre were taken out with a volume of 129 cub.feet. The total volume in 1920 was 2484 cub.feet and the mean annual increment for the period 1915-20 came to 131 cub.feet or 7·16%.

In 1925 - age 41, the number of trees per acre was reduced to 638. The mean height was 54½ feet and the mean girth 19½ inches. The underbark volume was 2642 cubic feet and the Form Factor .369. 86 stems per acre with a volume of 156 cubic feet were removed. The total volume was 2798 cubic feet, giving a mean annual increment for 1920-25 of 89 cubic feet or 3.78%.

Plot 16.

Result of measurements.

1915.

Age 31. Number of trees per acre 720. Mean height 48 feet: Mean girth 17½ inches. The underbark volume was 1920 cubic feet and the Form Factor .351. 120 trees per acre were removed and these had a volume of 80 cubic feet. The total volume was thus 2000 cubic feet.

1920.

Age 36 years.

Number of stems per acre, 570. Mean height, 51 feet; mean girth, 19½ inches. The underbark volume was 2275 cubic feet and the Form Factor .369. 145 trees per acre removed in thinning yielded a volume of 250 cubic feet. The total volume was 2525 cubic feet and the mean annual increment for the period 1915-20 was 121 cubic feet, or 6.30%.

1925.

Age 41 years.

Number of trees per acre, 490. Mean height, 54½ feet; mean girth, 21 inches. The underbark volume was 2373 cubic feet and the Form Factor .359. 80 trees per acre, with a volume of 220 cubic feet, were removed in thinning. The total volume was thus 2593 cubic feet, giving a mean annual increment for 1920-25 of 64 cubic feet, or 2.81%.

Plot 17.

Results of measurements.

1915.

Age 31 years.

Number of trees per acre, 698. Mean height 48 feet; mean girth 18 inches. The volume (underbark) was 2254 cubic feet and the Form Factor was .378. 188 trees per acre with a volume of 190 cubic feet were removed. The total volume was 2444 cubic feet.

1920.

Age 36 years.

Number of trees per acre, 542; mean height 54 feet; mean girth 20½ inches. The underbark volume was 2634 cubic feet and the Form Factor .394. 154 trees per acre with a volume of 360 cubic feet were taken out in thinning. This brings the total volume up to 2994 cubic feet. The mean annual increment for the period 1915-20 was 148 cubic feet or 6.57%.

1925.

Age 41 years.

Number of trees per acre, 474. Mean height, 56½ feet; mean girth, 21½ inches. The underbark volume was 2625 cubic feet and the Form Factor .375. 66 trees per acre with a volume of 275 cubic feet were removed. The total volume is thus 2900 cubic feet giving a mean annual increment for 1920-25 of 53 cubic feet or 2.01%.

Remarks.

All three plots show a falling off in the mean annual increment during the second period. This is not noticeable in Plot 17. For the period 1915-20, the increment of each plot compared satisfactorily with that of the corresponding Quality Classes in the Yield Tables. During the period 1920-25, the mean annual increment of Plot 15 (Q.Cl.III) fell to 3.78%. The Yield Tables for this Quality Class give a mean annual increment of 5.93% between the ages of 35 and 40.

Plots 16 and 17 (Q.Cl.II) show a mean annual increment of 2.81% amd 2.01% respectively, for the period 1920-25, while the Yield Tables show a mean annual increment of 5% for larch of this Quality Class between the ages of 35 and 40.

The mean Form Class of plot 15 is .725; that of plot 17 is not so good, being .690.

Plot 17 showed a poor response to the thinning of 1920 and in 1925, the heavy thinning prescribed for it had to be modified. Having regard to the soil conditions, it is improbable that the crop will improve during the next five-year period and heart-rot which is setting in, may cause a further deterioration.

Plots 21 and 22. Japanese and European larch.

Monk Hopton, Shropshire.

These plots were established in 1920 in a plantation which was formed with a mixture of Japanese and European larches, the European being the more numerous. The Japanese have gone ahead and are dominating the other species.

Plot 21.

This plot was subjected to a heavy thinning on establishment and was thinned again on a C. grade in 1925.

Result of Measurements.

1920.

Age 16 years.

Number of trees per acre, 499. Average height 34 feet; average girth 17½ inches. Volume per acre (under bark) was 1022 cubic feet, and the Form Factor, .348. In the thinning, 1231 trees per acre were removed, with a volume of 92 cubic feet. The total volume was 1114 cubic feet.

1925.

Age 21 years.

Number of trees per acre, 338. Average height, 43½ feet; average girth 23 inches. The volume (under bark) was 1565 cubic feet and the Form Factor, .362.

In the thinning, 161 stems to the acre were removed, with a volume of 337 cubic feet.

The mean annual increment over the five-year period has been 176 cubic feet, or 17.22%

Plot 22.

This plot was thinned on a B. grade scale in 1920 and in 1925.

Result of Measurements.

1920.

Age 16 years.

Number of stems per acre, 1219. Average height, 32 feet; average girth, 13 inches. The volume (under bark) per acre was 1035 cubic feet and the Form Factor, .292. 759 trees per acre were removed in the thinning.

1925.

Age 21 years.

Number of stems per acre, 859. Average height, 38½ feet; average girth 16½ inches. Underbark volume per acre, 1824 cubic feet and the Form Factor, .365.

In the thinning, 360 trees per acre were removed, with a volume of 62 cubic feet. The total volume was thus 1886 cubic feet and the mean annual increment over the period, 170 cubic feet or 16.42%.

Remarks.

After the next thinning plot 21 should be almost pure Japanese larch. The proportion of European larch in plot 22 will be reduced only gradually. At present about 40% of the crop is European larch.

Work carried out in Plots in Scotland.

The following new plots were laid down -

Nos. 66 and 67	European larch	Tom aw Uird, Strathspey
Nos. 67, 69, 70 and 71.	Scots Pine	Curr Wood, Strathspey.
No. 72.	Abies nobilis	Durris, Kincardineshire

The following plots were remeasured and thinned.

Nos. 8 and 9	Drumlanrig, Dumfriesshire.
No. 13.	Durris, Kincardineshire.

The following plot was cleaned up after a wind blow.

No. 12.	Durris, Kincardineshire.

New Plots.

Plots 66 and 67. European larch. Strathspey.

These two plots which were laid down by Dr. Anderson in Tom aw Uird Plantation, Strathspey, are of considerable interest, in that they are the first plots to be established in natural or self-sown larch. The plots were subjected to different treatment, one being lightly thinned and the other heavily.

The results of the measurement were.

Plot 66. C. grade. Thinning.

Age 31 years.

Number of trees per acre, 806. Average height, 40 feet; average girth, 13½ inches. The underbark volume was 982 cubic feet and the Form Factor, .300.

In the thinning, 1115 trees per acre were removed, with a volume of 124 cubic feet.

The total volume was 1106 cubic feet and the mean annual increment has been 36 cubic feet.

The Quality Class is III (60').

Plot 67. B. grade Thinning.

Age 31 years.

Number of trees per acre, 1117. Average height 36½; average girth 12 inches. The volume (underbark) was 875 cubic feet and the Form Factor, .275. In the thinning, 963 trees to the acre were removed with a volume of 20 cubic feet.

The total volume was thus 895 cubic feet and mean annual increment has been 29 cubic feet. The Quality Class is III.

Remarks.

These plots should make a very fair comparison.

The stocking is variable but less so than would be expected in a natural wood.

The type of tree is excellent, the stems being straight and symmetrical, and almost free from canker.

Heart-rot, unfortunately, is very serious. In plot 66, 60% of the thinnings were affected; in plot 67, 54%.

Plots 68, 69, 70 and 71. Scots Pine. Strathspey.

A series of four plots was laid down in the natural Scots Pine in Curr Wood, Strathspey.

At the time of the establishment of the plots, the wood was practically untouched and very dense.

Each plot received a different grade of thinning. In plot 68, a crown thinning was applied; in plot 69, a light low thinning; in plot 70, a moderately heavy low thinning and in plot 71, a heavy low thinning.

Plots 68, 69 and 70 are sufficiently alike to give a good comparison. Plot 71 is rather different in several respects and is not accurately comparable with the others.

Plot 68. D. grade Thinning.

Age 44 years.

Result of measurement.

Number of trees per acre, 1413. Average height, 38½ feet Average girth, 16 inches. The underbark volume was 2449 cubic feet and the Form Factor .323.

In the thinning, 370 trees to the acre were removed with a volume of 414 cubic feet. The total volume was thus 2863 cubic feet and the mean annual increment has been 65 cubic feet.

The Quality Class is III.

Remarks.

The stocking of this plot is very high.

Squirrel damage has been severe in this plot and the thinning was directed chiefly against dominants which had suffered in this way, 29% of which were removed.

It will be of interest to follow the development of a slow growing crop such as this, subjected at regular intervals to a crown thinning. It is possible that the gradual removal of misshapen dominants may have a beneficial effect on the crop as a whole.

Plot 69. "B" grade Thinning.

Result of measurement.

Age 44 years.

Number of trees per acre, 1306. Average height, 38½ feet; average girth 16½ inches. The underbark volume was 2415 cubic feet and the Form Factor, .326.

In the thinning, 409 trees per acre were removed, with a volume of 157 cubic feet. The total volume was thus 2572 cubic feet and the mean annual increment, 58 cubic feet.

The Quality Class is III.

Remarks.

The stocking is high in this plot also. Squirrel damage is found to a less tent than in plot 68 and misshapen dominants are not so numerous.

PLOT 70. "C_1" Grade Thinning.

Result of measurement.

Age, 44 years.

Number of stems per acre, 1110. Average height, 39½ feet; average girth, 16½ inches. The underbark volume per acre was 2356 cubic feet and the Form Factor,.329.

In the thinning, 645 stems to the acre were removed with a volume of 420 cubic feet.

The total volume was thus 2776 cubic feet and the mean annual increment, 63 cubic feet.

The Quality Class is III.

REMARKS.

The stocking is rather more irregular in this plot.

A certain amount of squirrel damage has been done, but the number of good trees in this plot is greater than in the others.

A moderately heavy thinning was made with the object of encouraging the good trees.

PLOT 71. "C_2" Grade Thinning.

Result of measurement.

Age, 45 years.

Number of trees per acre, 915. Average height, 43 feet; average girth, 18½ inches. The underbark volume was 2670 cubic feet and the Form Factor, .351.

In the thinning, 628 trees per acre were removed, with a volume of 671 cubic feet.

The total volume was thus 3341 cubic feet, and the mean annual increment, 74 cubic feet.

The Quality Class is II.

REMARKS.

This plot is a higher Quality Class, and carried originally a much heavier volume than the others.

The stocking is fairly regular but there has been considerable squirrel damage.

Though a heavy thinning was carried out, the full C_2 grade was not applied at once owing to risk of wind damage, but will be applied later.

PLOT 72. Abies nobilis. Durris, Kincardineshire.

A small plot of Abies nobilis laid down at Durris is of interest as it is the first plot of this species to be established.

No thinning was made as the plantation had recently been thinned.

The result of the measurement was:

Age, 22 years.

Number of stems per acre, 2145. Average height, 32½ feet; average girth 14 inches. The underbark volume was 3052 cubic feet and the Form Factor, .408.

The mean annual increment has been 139 cubic feet.

REMEASUREMENTS.

PLOT 8. European Larch. Drumlanrig,Dumfries-shire.

This is a single plot, established in 1920 and re-measured for the first time this year.

Result of measurements.

1920.

Age, 26 years.

Number of trees per acre, 805. Average height, 36 feet; average girth, 15½ inches. Underbark volume, 1335 cubic feet, and Form Factor, .355.

In the thinning, 60 trees per acre were removed with a volume of 30 cubic feet. The total volume was thus 1365 cubic feet.

1925.

Age, 31 years.

Number of stems per acre, 645. Average height, 44 feet; average girth, 18 inches. Volume (underbark) per acre, 1863 cubic feet and Form Factor, .371.

In the thinning, 155 trees per acre were removed with a volume of 175 cubic feet.

The total volume was thus 2038 cubic feet and the periodic mean annual increment has been 141 cubic feet or 10.56%.

REMARKS.

This plot was heavily thinned just before establishment and in 1925 a light "C" grade thinning was carried out.

The crop which was rather poor and badly cankered appears to have improved during the past five years, probably as a result of thinning, and the increment has been very satisfactory.

The stocking is rather irregular.

PLOT No. 9. Sitka Spruce. Drumlanrig, Dumfries-shire.

This plot, established in 1920, was remeasured for the first time this year.

Result of the measurement:

1920. Age, 21 years.

Number of trees per acre, 570. Average height, 41 feet; average girth, 25½ inches. Underbark volume, 3110 cubic feet; Form Factor, .374.

10 trees per acre were removed with a volume of 10 cubic feet.

The total volume was thus 3120 cubic feet.

1925. Age, 26 years.

Number of trees per acre, 515. Average height, 58 feet; average girth, 30 inches. Underbark volume, 5895 cubic feet; Form Factor, .403.

In the thinning, 53 trees were removed per acre, with a volume of 91 cubic feet.

The total volume was thus 5986 cub. feet and the periodic mean annual increment, 575 cubic feet or 18.49%.

Remarks.

This plot was planted in 1900, the plants being put in at 9' x 9'. In consequence they have had ample room and the crowns are large and symmetrical. No thinning was necessary in 1920 and only a very light one was carried out this year.

No sample trees could be cut and a set of nine standing sample trees was measured by the New Form Quotient method. The data so obtained were checked by measurements from two blown trees.

It will be possible to measure the same trees, or most of them, on future occasions, and valuable information as to changes in form will be obtained in this way.

PLOT 13. Sitka Spruce. Durris, Kincardine-shire.

This plot in older Sitka Spruce was established in 1920.

Results of Measurement.

1920.

Age, 38 years.

Number of trees per acre, 430. Average height, 62 feet; average girth, 32½ inches. Underbark volume, 6083 cubic feet; Form Factor, .394.

55 trees per acre with a volume of 270 cubic feet were removed in thinning, making the total volume 6353 cubic feet.

1925.

Age, 43 years.

Number of trees per acre, 372. Average height, 69½ feet; average girth, 35½ inches. Underbark volume, 7468 cubic feet; Form Factor, .420.

49 trees per acre were removed, with a volume of 475 cubic feet, while in 1923, 5 trees with a volume of 95 cubic feet were taken out, making the total volume thus 7943 cubic feet.

The periodic mean annual increment was 391 cubic feet or 6.43%.

Remarks.

Two standing sample trees had to be measured here, but the others were obtained from the surround and from wind blows.

Two large trees were blown in the plot and the risk of further damage is considerable.

A light thinning was made in 1925 but the canopy is still dense.

The crowns are large, but the foliage is rather light.

OTHER WORK IN SCOTLAND.

When the party was at Drumlanrig, opportunity was taken to girth plot 7, Norway Spruce, which has been sold and is likely to be cut in the near future.

Plot 12 - Douglas Fir, at Durris, has suffered from a succession of wind blows and is now reduced to 90 trees.

All the blown trees on the ground were cut off root and trimmed up. This operation took 3 days.

GENERAL.

Inspection of Plots.

England.

The following plots were inspected during the year.

Nos.	32, 33 and 34..	European Larch ...	Haldon, Exeter.
"	40,46 and 47...	Corsican Pine ...	Dunster,Somerset.
"	18,42,44 & 45 .	Douglas Fir ...	do. do.
"	41	Sitka Spruce ...	do. do.
"	43	Scots Pine ...	do. do.
"	48	Tsuga Larch ...	E.Quantoxhead,do.
"	49,50,51,52 &53	Douglas Fir ...	Stonehead, Wilts.
"	54,55 and 56...	Japanese Larch ...	do. do.

Some damage had been caused by wind in plots 52 and 53 at Stonehead.

The Japanese Larch in plot 54 and the European Larch in plot 32, both thinned to a D grade had been damaged by bending over many of the smaller stems. In plot 54, 127 trees were affected in this way. Damage of this kind was most severe round the gaps left by the removal of large trees in the crown thinning.

Plot No. 43 (Scots Pine) and Plot 48 (Tsuga), both at Dunster, have been partly cut out in error by the estate staff. Plot 43 will have to be abandoned, but plot 48 can be repaired.

SCOTLAND.

After the severe gales of the past winter, inspection was made of the following plots:-

Nos. 1,2,3 & 4	.. ..	Haystoun, Peebles.
" 15,16 & 17	.. ..	Glendye, Kincardine.
" 18,19,20,21 & 22	..	Fyvie, Aberdeenshire.
" 23	.. .. ..	Glentress, Peebles.
" 32	.. .. ..	Kildrummy, Aberdeenshire.
" 41,42,43,44,45,46 & 47		Murthly, Perthshire.
" 48,49,50 & 51..	..	Grandtully, Perthshire.
" 52,53,54,55,56 and 57,		Dunach, Argyll.
" 61	.. .. ..	Pitcastle, Perthshire.
" 63	.. .. ..	Inverliever, Argyll.

Douglas Fir was the only species which had suffered in the gales. The plot at Inverliever has been wrecked and there is considerable damage at Dunach and less serious damage at Murthly.

NEW PLOT AREAS.

A visit was paid to the north of England with a view to the selection of sites for new sample plots in an area which has not so far been represented.

Woods on the following estates were visited: Thirlmere, Rydal, Brackenbrugh in Cumberland; Pull Woods, Lancashire; Bolton Abbey, Washburn Valley, Jervaulx, Helmsley and Cloughton, Yorkshire.

Possible sites for some twenty plots were seen and it is hoped that a start may be made during the coming year.

SUPPLY OF TIMBER FOR TESTING.

Arrangements have been made to supply timber from the Sample Plots to the Imperial Forestry Institute, Oxford, for testing.

The first consignment was sent off from Durris.

CLASSIFICATION OF STEMS.

Though the present classification works admirable in practice, it is suggest that two small alterations might be made.

One is the establishment of a new class 2d, corresponding to the existing 1d, to represent the whips in the second storey At present, such whips have to be classified as 2c and in a 'B' grade thinning this class cannot be touched. A new class would allow the smaller whips to be removed without straining the classification.

The second is the abandonment of class 6, viz., diseased trees. In practice, this class is scarcely ever employed and it is difficult at any time to decide when a tree is sufficiently diseased to be marked off from its fellows.

It is suggested that diseased trees should be classified as if they were healthy and a note made at the same time of any disease which may be present. This is done with larch canker.

Maps showing the location of the plots and the work done are attached.

Final summaries of all plots measured during the year are attached in full.

(Sgd.) J. MACDONALD.

31st October, 1925.

(50,045). Wt.177—63. 250. 4/20. Gp.132. A.&E.W.
(55,903). „ 1887—131. 500. 11/20. „ „

1 9 2 5.

Sample Plot Form No. 7.

Record of periodical measurements per acre.

Sample Plot No. **New Plots.**

Year of measurement.	Age of crop.	Main Crop.								Intermediate yield from Thinnings.					Total Crop.		Increment of Main Crop.			
		Number of trees per acre after thinning.	Height.		Form Factor.	Girth at 4′ 3″.	Basal area per acre after thinning.	Volume per acre (under bark).	Bark %	Number of trees.	Average height.	Girth at 4′ 3″.	Basal area per acre.	Volume per acre (under bark).	Basal area.	Volume (under bark).	Periodic.		Periodic mean annual.	
			Average of largest trees.	Average of crop.													Basal area.	Volume.	Basal area.	Volume.
	Years.		Ft.	Ft.		Inches.	Sq. ft.	Cub. ft.			Feet.	Inches.	Sq. ft.	Cub. ft.	Sq. ft.	Cub. ft.	Sq. ft.	Cub. ft.	Sq. ft.	Cub. ft.
tland.																				
b. 66	31	806	46½	40	.300	13½	81.9	982	19	1115	25	7½	35.0	124	116.9	1106				
' 67	31	1117	45	36½	.275	12	87.1	875	19	963	23	6½	21.6	20	108.7	895				
' 68	44	1413	44½	38½	.323	16	196.6	2449	20	370	34	13½	37.4	414	234.0	2863				
' 69	44	1306	44	38½	.326	16½	192.6	2415	20	409	30½	10½	24.4	157	217.0	2572				
' 70	44	1110	44	39½	.329	17	181.3	2356	20	645	32	11½	48.2	420	229.5	2776				
' 71	45	915	46	43	.351	18½	176.7	2670	18	628	35½	13	60.6	671	237.3	3341				
' 72	22	2145	40	32½	.408	14	230.0	3046	9	12	31	13½	1.2	16	231.2	3062.				

(50,045). Wt.177—63. 250. 4/20. Gp.132. A.&E.W.
(55,903). ,, 1887—131. 500. 11/20. ,, ,,

1 9 2 5.

Sample Plot Form No. 7.

Record of periodical measurements per acre.

Sample Plot No. Remeasurements (England).

Year of measurement.	Age of crop.	Main Crop.								Intermediate yield from Thinnings.					Total Crop.		Increment of Main Crop.			
		Number of trees per acre after thinning.	Height.		Form Factor.	Girth at 4′ 3″.	Basal area per acre after thinning.	Volume per acre (under bark).	Bark %	Number of trees.	Average height.	Girth at 4′ 3″.	Basal area per acre.	Volume per acre (under bark).	Basal area.	Volume (under bark).	Periodic.		Periodic mean annual.	
			Average of largest trees.	Average of crop.													Basal area.	Volume.	Basal area.	Volume.
	Years.		Ft.	Ft.		Inches.	Sq. ft.	Cub. ft.			Feet.	Inches.	Sq. ft.	Cub. ft.	Sq. ft.	Cub. ft.	Sq. ft.	Cub. ft.	Sq. ft.	Cub. ft.
1925,																				
No.15																				
1915	31	858	44	45	.356	16	119	1830	25	130	40	10	7	50	126	1880				
1920	36	724	50	49	.375	18	128	2355	19	134	44	13	12	129	140	2484	21	654	4.2	131
1925	41	638	56	54½	.369	19½	131	2642	20	86	48	14½	10	156	141	2798	13.4	443	2.7	89
No.16.																				
1915	31	720	47½	45	.351	17½	121	1920	19	120	42	11½	9	80	130	2000				
1920	36	570	53½	51	.369	19½	121	2275	18	145	45½	15½	19	250	140	2525	19	605	3.8	121
1925	41	490	55½	54½	.359	21	121	2373	21	80	50	17	12.9	220	134.2	2593	13.2	318	2.6	64
No.17.																				
1915	31	698	50	48	.378	18	124	2254	17	188	45	12½	17	190	141	2444				
1920	36	542	56	54	.394	20½	124	2634	18	154	49	16	22	360	146	2994	22	740	4.5	148
1925	41	474	57½	56½	.375	21½	124	2625	20	66	53½	19½	14	275	138	2900	13.6	266	2.7	53

(50,045). Wt.177—63. 250. 4/20. Gp.132. A.&E.W.
(55,903). „ 1887—131. 500. 11/20. „ „

1925.

Sample Plot Form No. 7.

Record of periodical measurements per acre.

Sample Plot No. **Remeasurements (England).**

Year of measurement.	Age of crop.	Main Crop.								Intermediate yield from Thinnings.					Total Crop.		Increment of Main Crop.			
		Number of trees per acre after thinning.	Height.		Form Factor.	Girth at 4′ 3″.	Basal area per acre after thinning.	Volume per acre (under bark).	Bark %	Number of trees.	Average height.	Girth at 4′ 3″.	Basal area per acre.	Volume per acre (under bark).	Basal area.	Volume (under bark).	Periodic.		Periodic mean annual.	
			Average of largest trees.	Average of crop.													Basal area.	Volume.	Basal area.	Volume.
	Years.		Ft.	Ft.		Inches.	Sq. ft.	Cub. ft.			Feet.	Inches.	Sq. ft.	Cub. ft.	Sq. ft.	Cub. ft.	Sq. ft.	Cub. ft.	Sq. ft.	Cub. ft.
[illegible]	16	499	36½	34	.348	17½	86.4	1022	16	1231	18	7½	39.4	92	125.8	1114				
[illegible]	21	338	45½	43½	.362	23	99.3	1565	15	161	39½	16½	23.7	337	123.0	1902	36.6	880	7.3	176
[illegible]	16	1219	35½	32	.292	13	110.7	1035	17	759	-	5½	13.2	-	123.9	1035				
[illegible]	21	859	42	38½	.365	16½	129.8	1824	15	360	31½	9	16.0	62	145.8	1886	35.1	851	7.0	170

(50,045). Wt.177—63. 250. 4/20. **Gp.132.** A.&E.W.
(55,903). ,, 1887—131. 500. 11/20. ,, ,,

1925.

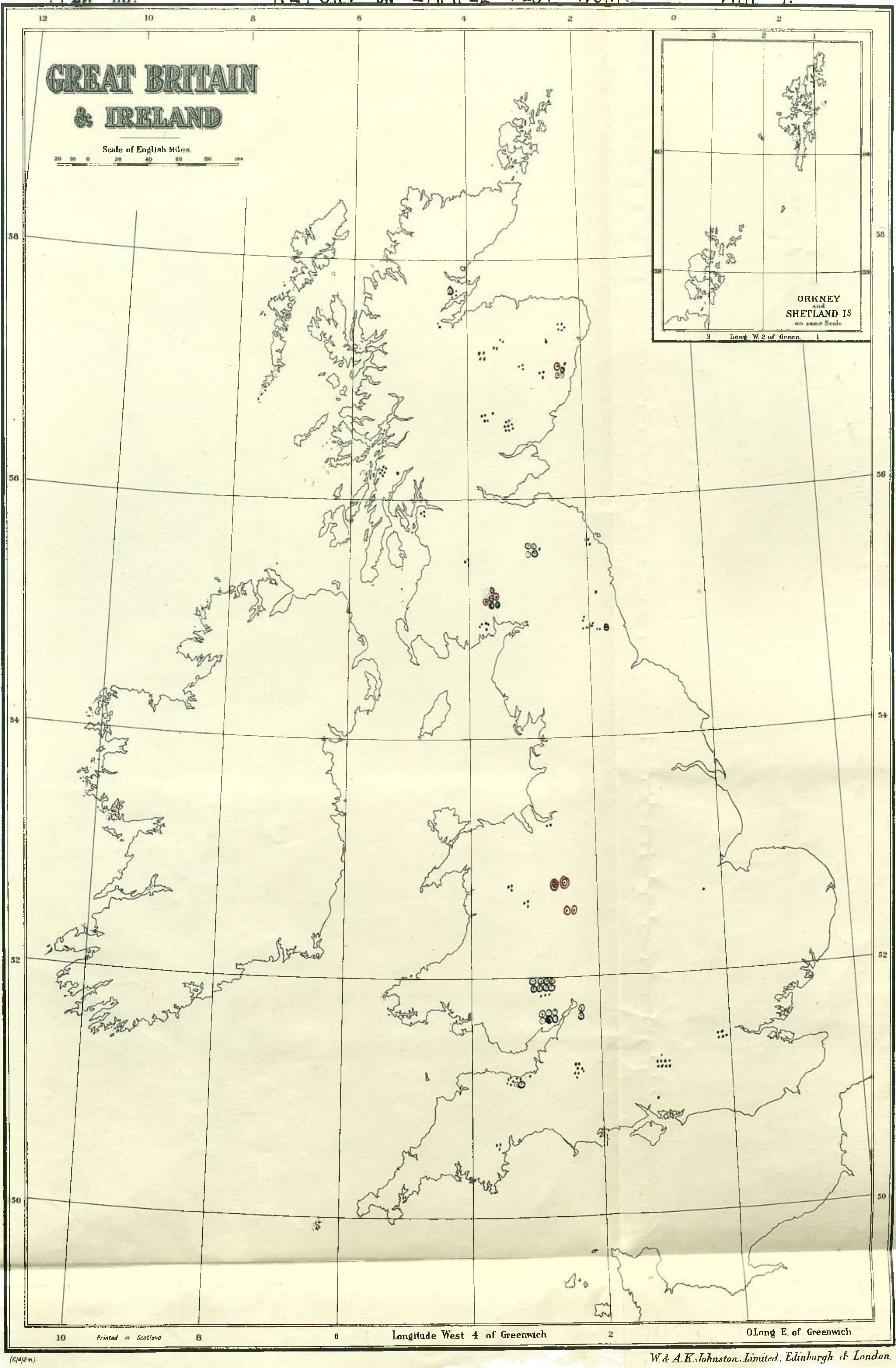
Sample Plot Form No. 7.

Record of periodical measurements per acre.

Sample Plot No. **Remeasurements (Scotland).**

Year of measurement.	Age of crop.	Main Crop.								Intermediate yield from Thinnings.					Total Crop.		Increment of Main Crop.			
		Number of trees per acre after thinning.	Height.		Form Factor.	Girth at 4′ 3″.	Basal area per acre after thinning.	Volume per acre (under bark).	Bark %	Number of trees.	Average height.	Girth at 4′ 3″.	Basal area per acre.	Volume per acre (under bark).	Basal area.	Volume (under bark).	Periodic.		Periodic mean annual.	
			Average of largest trees.	Average of crop.													Basal area.	Volume.	Basal area.	Volume.
	Years.		Ft.	Ft.		Inches.	Sq. ft.	Cub. ft.			Feet.	Inches.	Sq. ft.	Cub. ft.	Sq. ft.	Cub. ft.	Sq. ft.	Cub. ft.	Sq. ft.	Cub. ft.
[illegible].8																				
1920	26	805	-	36	.355	15½	104	1335	21	60	31	11	4	30	108	1365				
1925	31	645	47	44	.371	18	114.2	1863	20	155	37½	13	14.7	175	128.9	2038	24.9	703	5	140.6
[illegible]																				
1920	21	570	-	41	.374	25½	203	3110	12	10	39	18½	1	10	204	3120				
1925	26	515	61	58	.403	30	251.9	5895	11	53	40½	15	6.5	91	258.4	5986	55.4	2876	11.1	575
[illegible]13																				
1920	38	430	-	62	.394	32½	249	6083	8	55	46	21	14	270	263	6353				
1923	-	-	-	-	-	-	-	-	-	5	-	-	3.5	95						
1925	43	372	74½	69½	.420	35½	256	7468	8	49	58½	26½	19.0	475	275	7943	29.5	1955	5.9	391

1924-25. REPORT ON SAMPLE PLOT WORK. MAP 1.



(C/4/2m.)

PLOTS ESTABLISHED IN 1924-25 •

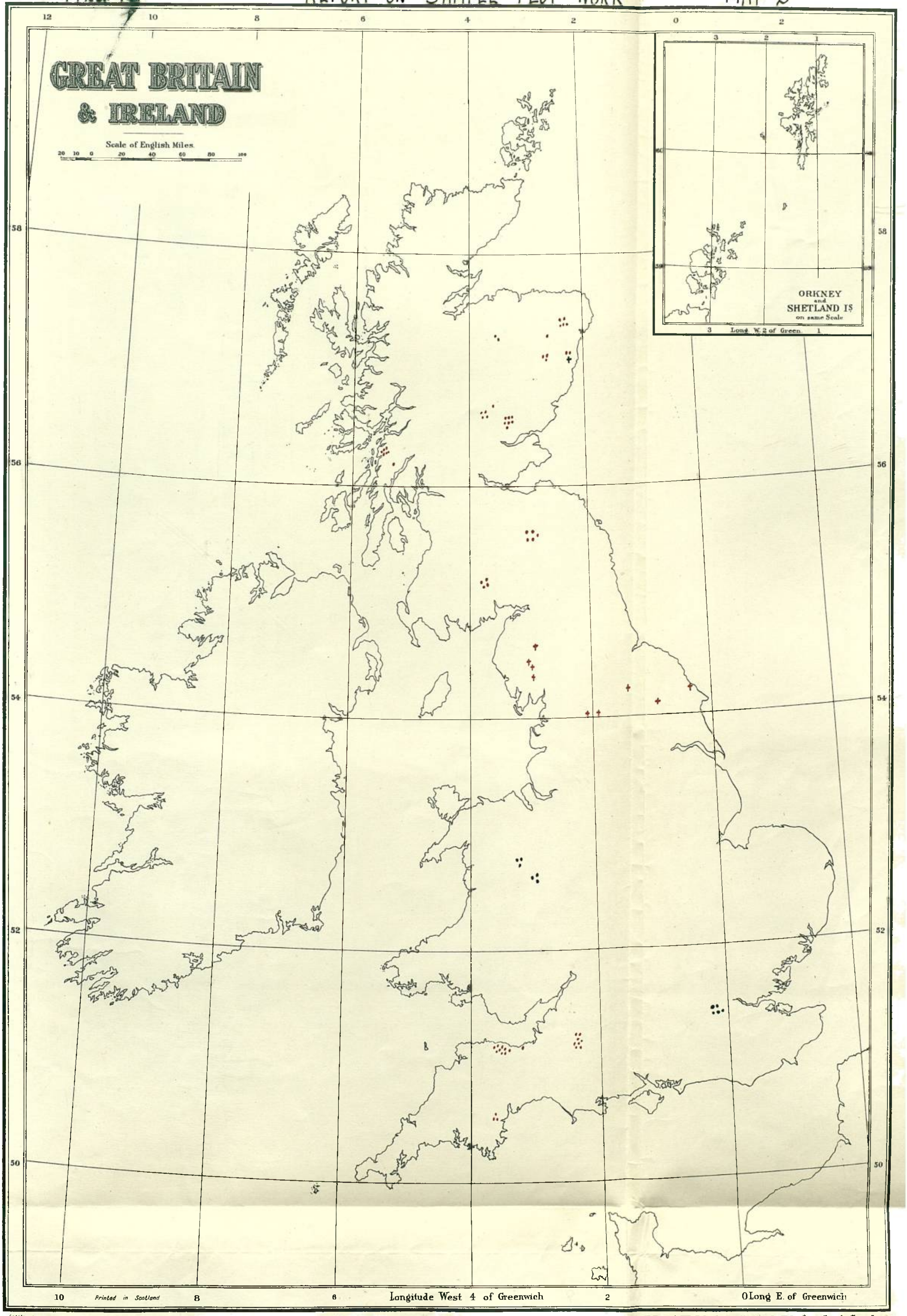
" " PRIOR TO 1924-25 •

" REMEASURED " " 1924-25 ʘ

" " " " "
AND AGAIN IN 1924-25 ◎

PLOTS REMEASURED IN 1924-25 ʘ

1924-25 REPORT ON SAMPLE PLOT WORK MAP 2



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REPORT ON RESEARCH, 1925.

E. V. LAING.

I N D E X.

REPORT ON RESEARCH 1925.

M.V.LAING.

Investigations have been in progress during 1925 on the following subjects :-

1. Water content of seedlings and transplants of Norway Spruce, Sitka Spruce and European Larch.

2. Nature of and seasonal variations in the food stores of Norway Spruce, Sitka Spruce and European Larch.

3. Peat planting.
(a) Age and size of Plants.
(b) Species.
(c) Spruce colour. (d) Drying out of roots. (e) Calcium oxalate.

4. Miscellaneous. - Mineral requirements of the Spruce

1. Water Content.

The water contents of 2 yr. seedlings and 2yr. 2nd. year transplants of Norway Spruce, Sitka Spruce and European Larch have and are being determined. The plants have been obtained from Seaton Nursery. The determinations are intended to extend over a period of one year and as they were commenced in the middle of March the results are not complete for the report, but the data so far obtained are given and as far as possible analysed.

The object of the investigation was to find whether the species mentioned presented marked seasonal differences in water content; when the greatest water contents occur; with what factor or factors the water content could be correlated and the effect of shading on water content, the ultimate aim being to find the best time for transplanting from the point of view of the amount of water in the tissues of the plant. It was thought that a period of high water content would be a suitable transplanting time. 2nd.year seedlings and 2/2nd. transplants were chosen for analysis, since these plants would normally be transplanted at the end of the year under review and hence give data as regard the time of lifting.

The water contents have been found separately of shoot, root and plant, the percentage being expressed in terms of dry weight. In addition the distribution in root and shoot of the total water in the plant has been calculated, whilst incidental findings such as the shoot and root ratio in both the wet and the dry state have been noted. The plants were lifted at as short intervals as possible. Frequently the length of time between lifting was extended owing to the wet condition of the shoots - the plants were always lifted when the shoots were dry to obviate error due to adherent water or having to remove adherent water under artificial methods. The plants were lifted about three o'clock.

The determination of the water content presented one considerable difficulty namely that of finding the water content of the roots owing to the adherent soil particles. No matter how thoroughly the roots are shaken when they are lifted, a considerable amount of soil remains attached to the roots. In the Spruces in particular the soil, even after the shaking of the roots, weighs many times the weight of the roots themselves. In Larch the amount is far less, the larch being a very clean lifting plant.

Washing off the soil and then removing surface water on the roots by means of drying or blotting paper is unsatisfactory. It is difficult to find when all surface water is removed and whether water in the process of drying is not actually lost by the roots. A more satisfactory method it to take into consideration the water content of the soil and the weight of the soil on the roots. The roots are separated from the shoots immediately on lifting and weighed with the soil attached. The soil is then carefully washed from the roots and soil and roots are dried separately and weighed. From the water content of the soil - samples of soil are taken from the neighbourhood of the roots at the time of lifting - the weight of the wet soil on the roots can be got.

For instance if the soil washed from the roots when dry weighs 20 gms. and the water content of the soil is 25% then the amount of the wet soil about the roots would equal 25gms.

On lifting the seedlings the roots were separated from the shoot and placed separately in weighed air-tight glass tubes. The transplants on the other hand were lifted in bundles roots separated from shoots and placed separately in bags and weighed immediately. The results from the transplants are therefore less accurate than for the seedlings where the greatest accuracy possible was aimed at.

Drying was carried out in an oven at a temperature of 100° Centigrades

Shading was effected by placing wooden boxes over the plants for 48 hours before lifting.

The data derived from the investigation are given in the following tables. Interpretation of the result however, is helped by the attached graphs.

1. Norway Spruce

The water content of the plants, although all through there are fluctuations, shows in both seedling and transplant no decided upward trend until the first fortnight in May following what is really a decided upward trend in temperature condition. Previous to this the roots show variations in their water content, and there is a very marked correlation in these variations with rainfall and soil water content. When the rainfall is high the root water content is high and vice versa. The water content of the root in both seedlings and transplants, but more particularly in the seedlings rises to a maximum about the 29th. April after which date there is a falling off. This maximum corresponds to a rise in the soil water content and a period of rain. In the shoot the correlation appears to exist with temperature - the general curve for temperature and that for shoot being similar - a similarity

2nd. Year Norway Spruce.

Date	Shoot	Root	Plant	S/R Wet	S/R Dry	% H_2O Distribution S	R	% Water content of soil
[illegible].3.25	133	241	176	2.2	3.2			36
[illegible].3.25	137	283	187	2.4	3.8	48	52	34
[illegible].3.25	149	255	172	2.48	3.5	67	33	30.6
[illegible].4.25	135	347	206	1.1	2.0	44	56	30
[illegible].4.25	143	188.5	162.3	1.58	1.8	59	41	26.2
[illegible].5.25	118	378.4	191.3	1.17	2.56	44	56	22.5 Fr.
[illegible].5.25	105.8	312.4	160.	1.4	2.8	48.8	51.2	29.2
[illegible].5.25	163	248.5	187	1.8	2.4	62	38	25.08
[illegible].5.25	175 224	233 275	193 239	2	2.35	63 66	37 34	25 - 24.2 X
[illegible].5.25	274.4 256.4	295.1 302.5	280 267	2.7	3.	71 73.7	29 26.3	23.9 - 29.5 X
[illegible].6.25	241 320.4	199.1 407.5	234.4 337.8	4.5	4.5	86 76	14 24	24.4 - 24.8 X
[illegible].6.25	236.1 257.5	264 227.9	243.1 249.7	3.17	3.15	73 78	27 21	18.2 - 21.4 X
[illegible].7.25	203.1							
[illegible].7.25	223.4	255.5	229.9	3.5	3.9	77	23	18.9 -
[illegible].9.25	192.3	228.1	202.7	2.6	2.9	71	29	23.1 X
[illegible].9.25	184.1 216.3	190.3 343.6	186.04 251.2	2.02	2.42	68 62.4	32 37.6	27.8 - 23.6 X
[illegible].10.25	192.2 189.2	217.4 233.4	199.7 200.9	2.28	2.56	67.5 69.5	32.5 30.5	26.1 - 23.5 X

(-) Unshaded

(X) Shaded

(Fr.) Frosted

2/2nd. Norway Spruce.

Date	Shoot	Root	Plant	Shoot / Root Wet	Shoot / Root Dry	% Distribution of H_2O in shoot & root S.	R.
0.3.25	117		166				
1.3.25	110	237	175	1.5	2.5	54	46
1.3.25	115	263	159	1.4	2.4	51	49
1.4.25	100	200	121	1.4	2.2	52	48
11.4.25	118	266	171	1.1	1.8	45	55
14.4.25	108 119	166 186	117 146	1.4	1.7	61 49	39 - 51 X
1.5.25	120 123	300 300	174 187	1.2	2.0	48 41	52 - 59 X
8.5.25	125	180	146	1.3	1.6	53	47 -
14.5.25	157 125	266 250	190 166	1.6	2.15	57 50	43 - 50 X
1.5.25	225 208	300 300	250 231	1.95	2.5	60 62	40 - 38 X
8.6.25	240 169	250 200	243 192	2.65	2.8	70.6 74	29.4 - 26 X
1.6.25	247 277.7	250 240	248 264	2.37	2.2	70 68	30 - 32 X
0.6.25	206 344	250 350	236 345	3.8	4	70 80	30 - 20 X
4.7.25	167	200	174	3	3.4	73.6	26.4 -
0.9.25	157 153	200 200	168.4 171	2.4	2.8	69 55	31 - 45 X
1.10.25	137 141	211 216	155.5 165.4	2.05	2.7	67 61	33 - 39 X
10.10.25	123	211	145.7	2.07	2.9	62	38 -

(-) Unshaded

(X) Shaded

2nd. Year Sitka Spruce.

ate	Shoot	Root	Plant	$\frac{S}{R}$ Wet	$\frac{S}{R}$ Dry	H_2O % Distribution S	R	% Water content of soil.	
1,3,25	193.7	325	240	1.2	2			36	
1,3,25	162	286	203	1	1.8			34	
1,3,25	174	314	220	1.3	2	58	48	27.5	
1,4,25	171	382	264	1.2	2.9	48	52	34.6	
1,4,25	152	270.1	187	1.4	2.34	57	43	29.07	
1,5,25	133.6	480.3	232.2	1	2.6	41	59	29.2	Fr.
1,5,25	135.9	392.5	208	1.2	2.5	46	54	31.6	
1,5,25	137	359	204	1.2	2.3	47	53	24.2	
3,5,25	244.4 245.2	171 325	224.6 274	1.46	2.2	79 58	21 42	23.7 26.1	- x
0,5,25	184 242.5	343.4 473.6	225.6 291.3	2	3.25	60 65	40 35	24.9 23.2	- x
1,6,25	265	324	274.9	4.3	5	80	20	22.6	-
0,6,25	250.6 241.3	232.9 296.9	246.1 250.9	3.55	5	76 79	24 21	15.5 18.2	- x
4,7,25	248.2	314.4	258.1	4.7	5.6	81.7	18.3	16.3	-
1,7,25	250.9	244.6	250.4	5.2	5.7	85.4	14.6	19.7	-
1,9,25	186.07	279.7	210.9	2.1	2.7	64.9	35.1	26.7	-
0,9,25	192.4 232.3	221.3 271.3	200.2 240.4	2.9	3.27	70 76.7	30 23.3	26.7 21.7	- x
1,11,25	204.8 217.5	253.7 274.3	217.1 228.7	2.6	3.15	70.5 71.6	29.5 28.4	29.3 27.1	- x

(-) Unshaded
(x) Shaded
(Fr.) Frosted.

3rd. Year Sitka Spruce.

[illegible]	Shoot	Root	Plant	Shoot/Root Wet	Shoot/Root Dry	Distribution of H_2O in shoot & root S.	R.
3.25	140		163	2	3.75		
3.25	131	275	164	2	3.75	60%	40%
3.25	126	250	162	1.7	2.63	57	43
4.25	140	216	161	1.8	2.5	62%	38%
4.25	133	243	172	1.6	2.6	60%	40%
4.25	133	133	133	3	3	75%	25% -
	139	184.5	142.5			75%	25% x
5.25	140	368	223	1.4		43%	57% -
	140	362	200		2.7	51%	49% x
6.25	168	200	180			56%	44% -
	162.5	200	175	1.75	2	62%	38% x
6.25	250	250	250	2	2	67%	33% x
7.25	180	216	189	3.2	3.2	75%	25% x
9.25	208	233	213.3	3.7	4	78%	22% x
10.25	169.7	175	171.2	2.7	2.75	72%	28% x
10.25	183	200	188.4	2.1	2.25	67%	33% x

- Unshaded

x Shaded

2/2nd. Sitka Spruce.

Date	Shoot	Root	Plant	S/R Wet	S/R Dry	% Distribution of H_2O S	R
17.3.25							
20.3.25	107		167				
24.3.25	122	269	182	.8	1.4	39	61
27.3.25	108	275	175	.8	1.5	37	63
3.4.25	100	200	142	.9	1.4	41	59
21.4.25	115	275	186	.9	1.6	33	67
24.4.25	127 119	166 166	141 136	1.4	1.7	58 56	42 - 44 x
1.5.25	132 137	170 225	150 166	1.37	1.77	52 55	48 - 45 x
8.5.25	157 159	300 240	202 171	1.25	1.72	50.5 49.4	49.5 - 50.6 x
16.5.25	177 208	250 243	194 216	3	3.325	69 70	31 - 30 x
23.5.25	237 274	211 315	228 294	1.65	1.6	67 55	33 - 45 x
30.5.25	264 232	337 278	283 244	2.25	2.6	68 68	32 - 32 x
13.6.25	233 303.7	233 325	252 312	3.3	3.37	77 75	23 - 25 x
30.6.25	191 233	200 250	193 237	3.1	3.4	78 75	22 - 25 x
14.7.25	195	233	210	3.4	3.8	74	26 -
10.9.25	200 220	192 187.5	197 208.7	2.8	2.8	74 69	26 - 31 x
3.10.25	173 181	187.5 219	173 189.7	2.6	2.9	69 75	31 - 25 x
19.10.25	129.7	200	149	2.02	2.64	63	37 -

(-) Unshaded
(x) Shaded

End. European Larch.

Date	Shoot	Root	Plant	S/R Wet	S/R Dry	% Water Dist. S	% Water Dist. R	% Soil Water Content.	
17.3.25	156.7	220.1	177	2.6	2.1	60	40		
24.3.25	151	340.9	205	1.4	2.6	53	47		
3.4.25	204	377	255	1.6	2.7	58	42		
14.4.25	274.4	361.3	300.6	1.9	2.45	64	36		
1.5.25	283.4	433.5	323.1	2.01	2.6	64.7	35.3	30.2	
8.5.25	264.3	446	297.5	2.76	4	71	29	30	
16.5.25	243	417	279.7	2.5	3.8	69	31	26.4	
25.5.25	275.9	377.2	295.7	3.9	5	78	22	22.5	
30.5.25	250.8	315.7	303.9					25.3	
13.6.25	300.1	394	319.5	3	3.8	74	26	26.8	
30.6.25	273.3	310.9	279.5	4.6	5	81.7	18.3	18.4	
10.9.25	220	216	219.2	3.3	3.3	77	23		
6.10.25	200	133.5	177.7	2.96	2.82	75	25		-
	191	216	196.4			76	24		x
19.10.25	164.3	163.6	164.1	2.55	2.34	71.6	28.2		

(-) Unshaded
(x) Shaded

2/2nd. European Larch.

Date	Shoot	Root	Plant	S/R Wet	S/R Dry	% Distribution of H_2O. S	R
17.3.25			194				
20.3.25	158		220				
24.3.25	192	287	228	1.9	2.5	44	56
27.3.25	182	300	223	1.3	1.9	51	49
3.4.25	225	300	250	1.6	2.0	60	40
11.4.25	243	300	258	2.2	2.5	67	33
24.4.25	186	166	180	2.45	2.45	72	28 -
	262	300	272			69	31 x
1.5.25	254	200	237	2.6	2.2	73	27 -
	247	240	244			61	39 x
8.5.25	275	450	310	2.6	3.6	71	29 -
	273	400	308			68	32 x
16.5.25	208	208	209	3.0	2.75	75	25 -
	258	187	237			76	24 x
23.5.25	265	237	260	3.7	3.4	88	12 -
	280	325	280			74	26 x
30.5.25	245	250	246	3.3	3.35	76	24 -
	274	318	284			76	24 x
13.6.25	231	266.6	237	3.65	4.75	79	21 -
	235	266.6	243			76	24 x
20.6.25	214	200	211	3.7	3.5	79	21 -
14.7.25	211	200	208	3.1	3	76	24 -

(-) Unshaded
(x) Shaded

which continues until the end of May, when a decided depreciation in the amount of rain and increasing temperature appears to cause a fall in the water content. This fall is more gradual in the transplant than in the seedling.

In the seedling it is interesting to note that when the root water content is high the shoot content is low and vice versa.

As regards the actual distribution of the water between root and shoot, in the spring the root holds the greater % age. As the season advances the shoot takes the ascendancy, and holds it until October (?) when the root content begins to rise.

2. Sitka Spruce

The fluctuations in this instance are also marked. The plant water and root water content in the seedling follows the soil content and rainfall rather closely. It is to be noted that the very high plant and root content in March-April is probably owing to the fact that the cover was still in the seedbeds. The shoot is irregular to begin with in the seedling but in both seedling and transplant the shoot curves follow the temperature curve. The very low water content in the seedling from the 2nd. - 12th. May is the result of a night of a very severe frost. The variations in the seedling root are wide, but in the plant as a whole the variations are the smallest found in any plant examined. In the seedling the maximum root water content occurs at the end of March and beginning of April (owing to shading probably); in the plant on the 13th.June; in the shoot on 13th.June. In the transplant, root, shoot and plant show a maximum about the 29th.May. After these dates there is a falling off but in the seedling the fall off is very easy.

Again, as in Norway spruce, in the earlier part of the season the root contains the higher percentage of the total water in the plant; in the summer and autumn it is the shoot, giving way gradually to the root once more.

3. European Larch.

When the determination of water contents for this species was commenced in March, the percentage moisture was found to be increasing rapidly particularly in the root. This increase continued in the seedling until the end of May for the root and plant and until the middle of June for shoot. Thereafter the water %age decreased. In the seedling Larch the fluctuations in root and plant until June are dependent on rainfall; in the shoot they appear to be more related to temperature, although in March and beginning of April the shoot content is rising independent of temperature. In the transplant the correlation seems to be in all cases with rainfall, the increase in March again being indepedent of temperature.

As compared with the spruces the period during which the roots of the Larch retain the higher percentage of the total water of the plant would appear to be a short one. In April the shoot share is rising rapidly and it is only beginning to fall in October.

Water Content and Period of Transplanting.

That variations occur in the water content of trees and that these variations are more or less seasonal has been known for long to foresters and expressed by the phrase "the sap is up" or "the sap is rising" or "the sap is down", the former representing the period of activity, the latter a period of so-called inactivity. Professor Craib has shown that there is really no period of inactivity. The present investigation bears out the general idea that there are seasonal differences in water content to this extent namely that there is an extended period of low water content and an extended period of high water content but it also brings out

(1) that within the main variation there are smaller fluctuations

(2) that the time of the increase in the water content is well in advance of any evident foliar activity e.g. in Larch.

(3) that the time of the increase in the water content varies in different trees.

(4) that the roots, shoot and plant as a whole behave differently from each other - that roots for instance react to soil water content and rainfall, whilst shoots except in the case of the Larch to begin with conform more to temperature.

The fluctuations within the main variations are well marked in the Spruces. In March and April before the buds even begin to swell the curves for shoot, root and plant show rises and falls. In this period of so-called inactivity the roots in particular show decided differences in their water content and this is reflected in the total water content of the plant. In Larch the smaller fluctuations in the plant are less marked so far as data at present available shows, but those which do occur fit in well with rainfall as also does the root fluctuations which are more decisive.

It is generally believed that transplanting should be carried during the so-called period of inactivity since that is the period of safety. In the other period the plant roots are likely to dry out owing to the high temperature or the young shoot suffer irretrievably from loss of water. In the safety period it will be safer to transplant when the water content is high since then the plant can afford to lose water. Periods of high water content occur, and the variations particularly in the roots are very great. There is really no period of inactivity but moisture variations occur within the plant at all seasons. Advantage of these can be taken in transplanting. The time to plant would probably be before the young shoots appear at a time when plant and root water contents are high. These periods would occur following rain.

The water content of the roots and also the plant as a whole is influenced by the water content of the soil - the higher the water content of the soil the higher the content of the root and vice versa. An artificial supply of water to the beds previous to lifting would give an increased root and plant content which might be expected to survive drying out influences more satisfactorily.

In the Larch the general rise in water content is much earlier than in Spruce. It might be expected that Larch could be transplanted much earlier. Dr.Steven found that the best results with Larch were obtained with January transplanting.

It was thought that the water content of plants in the nursery might be increased by watering and by shading.

The correlation between the water content of the soil and the content of the root and plant is generally so close that drenching before lifting would artificially increase the water content.

Shading gave results which are ambiguous and difficult of interpretation. It might be assumed that by shading the plant transpiration would be reduced and the water content would be raised. This was found to be undoubtedly the case with the seedlings with one or two exceptions as regards plant root and shoot water content, although it is doubtful whether in some instances the differences are significant. Taking total amount of water in the plant, shading leads to an increase in the shoot and corresponding decrease in the root.

In the transplants though in most instances shading causes an increased water content in shoot, root and plant frequently the reverse takes place. Further as regards the distribution of total water shading tends if anything to increase the proportion in the root.

The water content is further influenced by age of plant and type of plant and notably also by frost.

Water Content and Age of Plant.

Seedlings have a higher shoot water content than transplants. The percentage is in inverse proportion to the age in the seedling; proportional to the age in the transplant. For instance by taking measurement during March and April, the following table is obtained.

2nd.Yr.	Sitka	Spruce	varied	from	152-174
3rd.Yr.	"	"	"	"	128-140
2/2 Yr.	"	"	"	"	107-127
2/3 Yr.	"	"	"	"	120-128

2nd.Yr.	Norway	Spruce	varied	from	133-149
2/2 Yr.	"	"	"	"	100-118
2/3 Yr.	"	"	"	"	102-122

Further the older the seedling or transplant the less are the variations. For instance 2/2nd Sitka Spruce and 2/3rd Sitka Spruce from the 20/3/25 - 21/4/25 gave the following values:-

2/3rd. Sitka Spruce - 128, 125, 126, 128, 120.
2/2nd. " " - 107, 122, 108, 100, 115.

Total plant water content also gave greater uniformity in the older plant whether transplant or seedling. The older the seedling or the older the transplant the more stable it is; the less is it dependent on external variations.

Effect of Frost on Water Content.

Following a night at the end of April giving 6 degrees of frost both Norway and Sitka seedlings showed a marked fall in water content of shoot, the root not being evidently affected. Norway Spruce fell to a figure (108) much below Sitka Spruce (133) but recovered more speedily, new shoots developing strongly. The transplants showed no such marked fall as the result of the frost in the shoot, but at this time there was a decided fall in the root content (see Tables for 24/4/25). The seedling larch did not seem to be affected in the shoot or root.

Water Content of Spruces in Peat.

The water content of Spruces in peat was determined only for the shoots. The difficulty of root moisture determination is intensified in peat owing to the surface film of water which is very pronounced on the root system, and to the adherent peat which is difficult to remove.

Throughout the season estimations were made with Norway and Sitka Spruce plants which were lined out in peat as 2yr.seedlings in April. The results were as follows:-

	Norway Spruce	Sitka Spruce
22/5/25	114	158
5/6/25	198	167
12/6/25	168	203
11/7/25	135	153
26/7/25	119	130
8/10/25	114	180

In both Norway and Sitka Spruce the water content drops in July to a low value. In October Norway Spruce has long reached its winter values; Sitka Spruce is probably still above its winter value and may be expected to drop further. The water content of Norway Spruce fell very markedly after transplanting and maintained this low moisture condition for a month or more. Sitka Spruce on the other hand a month after transplanting gave a good moisture content quite comparable to that found in better soil.

In the beginning of the season estimations were made on the shoots of plants put out on peat last year. Sitka Spruce smaller shoots have a value equal to 110%; Norway Spruce 106%. The nursery figures for shoots at the same time were slightly higher, namely 129% and 115% respectively. There is a tendency for Spruce in peat to have a shoot water content slightly lower than the normal. This tendency is further shown from Inverliver figures where shoots from trees out of the check stage gave for Sitka Spruce 102% and Norway Spruce 106%.

<u>Rates of Shoot to Root.</u>

Variations in the ratio of shoot to root in the dry condition are found in all species. These variations may be due to (a) using up reserved food stores (b) increased growth of either shoot or root at different times.

<u>A. Norway Spruce.</u>

In both seedling and transplant, until the end of April the ratio of shoot to root fell. This might indicate a period of root growth. Thereafter the shoot weight increases in proportion to root until a maximum is reached in June and July when a fall then ensues, the root increasing in weight. When the ratio of shoot to root increases the increase may be due partly to food being stored in the roots, root growth, or a combination of these.

B. Sitka Spruce.

In the Sitka Spruce in contrast to the Norway there is a slight rise in the ratio of shoot to root until the 23rd May and then a more rapid increase until the 14th July after which time the ratio falls. The Sitka Spruce therefore behaves differently from the Norway Spruce.

C. European Larch.

From March onwards the ratio of shoot to root rises. The rise is slow to begin with say until 8th May, after which date there is a sudden increase. In the seedling the highest point is possibly attained during the end of May and throughout June. In the transplant the highest point in the ratio is reached on the 13/6/25.

It is hoped to be able to take up this subject in more detail next season.

Food Stores.

The main series of tests for the nature and variation in the food reserves have been made with 2yr. 2nd.year Norway Spruce, Sitka Spruce and European Larch. The food reserves so far tested for have been starch and fats (osmic acid test). Tests for other materials such as sugars were made but the micro-chemical technique was felt to be unsatisfactory. Since the usual test for sugar for instance depends on a reducing action, a wrong interpretation may be made owing to the presence of reducing enzymes. The variation in distribution and amount of Calcium oxalate has been examined and found to be interesting.

Spruce plants have also been examined from peat ground at Inverliver and Parkhill, Aberdeenshire.

For brevity the main results for the 2yr. 2nd.year Nursery plants are summarised at monthly intervals in the following Tables. The monthly summary represents the general finding for the period resulting from two or three tests carried out during the month. Data are not given fully for the young root as it is hoped to do this in more detail for the mycorhiza investigation.

A. 17.

[illegible]

[illegible]

	LEAF		STEM		OLD ROOT		YOUNG ROOT.	
	Starch	**Fat**	**Starch**	**Fat**	**Starch**	**Fat**	**Starch**	**Fat**
MARCH	Epiderm; Mesophyll.	Intense in Mesophyll.	Strong in Cortex	Strong in Cortex	Strong in Pericycle; Primary elements & Med. rays.	Strong in Pericycle; Primary elements & Med. rays.	Pericycle	Pericycle
APRIL	Epiderm & round resin canals of leaf.	Intense in Mesophyll.	Pith; Med. rays and Cortex.	Bast; Cortex.	Strong round resin canals; Med. rays and Pericycle.	Strong in Pericycle.	Pericycle	Pericycle
MAY.	Epiderm	do.	Primary element, scarce in Cortex.	Bast; Cortex.	Pericycle strong; Med. rays.	Strong in Pericycle; Med. rays.	Pericycle	Pericycle
JUNE.	Nil.	Mesophyll & Cell walls of Epiderm.	Med. rays. Traces in Cortex.	Cortex strong.	Pericycle strong. Med. rays.	Strong in Pericycle; wood, and med. rays.	Scarce in Pericycle.	Opposite point where new root emerges.
JULY.	Mesophyll & Endoderm packed.	Strong in Mesophyll	Traces in Cortex; Med. rays.	Cortex strong.	Pericycle; Med. rays; Pith intense.	Pericycle; Med. rays & primary elements.	Nil	Endoderm
SEPT.	Strong in Mesophyll; round resin canals and Endoderm.	do.	Cortex diffuse; intense in Pith	Primary elements; outside cells of Cortex.	Pericycle and cells of Resin canals.	Outside of Pericycle and round resin canals.		

TABLE II [illegible]

	LEAF		STEM		OLD ROOT		YOUNG ROOT	
	Starch	Fats	Starch	Fats	Starch	Fats	Starch	Fats
MARCH	Epiderm & Mesophyll	Mesophyll	Cortex & Pith	Strong in Cortex	Very strong Pericycle; Med. rays & primary elements.	Strong in Pericycle; round resin canals.	-	-
APRIL	Epiderm & Mesophyll	Mesophyll	Cortex, Med. rays, & primary elements.	Cortex, Med. rays & primary elements.	Pericycle	Pericycle	-	-
MAY	Nil.	Strong in Mesophyll	Reduced in Cortex; Pith Med. rays & primary elements.	Med. rays outside of Cortex & primary elements.	Pericycle, Med. rays, but reduced in amount.	Outside of Pericycle; Med. rays slight.	-	-
JUNE	Nil.	Mesophyll	Pith, Med. rays, traces in Cortex.	Strong in Cortex; Pith; outer layer of Bast.	Pericycle; Resin canals	Strong in Pericycle & Primary Wood.	Being deposited in Pericycle.	As in Starch
JULY	Mesophyll packed.	Mesophyll strong.	Certain cells of Cortex; Med. rays & Pith	Cortex	Pericycle origin of Med. rays.	Origin of Med. rays. Pericycle.	Nil.	Endoderm.
SEPT.	Intense in Mesophyll	Strong in Mesophyll	Cortex diffuse; Med. rays & Pith.	Outside of Cortex.	Pericycle; Resin canals.	Outside of Pericycle & round canals.		

Table III

EUROPEAN LARCH

	LEAF		STEM		OLD ROOT		YOUNG ROOT	
	Starch	Fats	Starch	Fats	Starch	Fats	Starch	Fats
MARCH	-	-	Nil	Cortex	Pericycle strong.	Outer Pericycle.	Pericycle	Outer Pericycle
APRIL			-	Strong in Cortex.	do	Outer cells of Pericycle strong	do	Bast.
MAY	-	-	Primary elements; Origin of leaf traces.	Fairly strong in Cortex, Pith.	Fairly strong in Pericycle grains small.	Pericycle	-	-
JUNE	-	Present in Mesophyll.	Cortex packed.	About One-half the cells of Cortex.	Pericycle packed and round resin canals	Pericycle packed.		
JULY								
SEPT.	-	Intense	Primary elements; Med. rays; diffuse in Cortex.	Cortex; cells of bast and Pith.	Primary tissue and Pericycle.			

Analysis.

1. Starch and fats are the main food reserves. Fats are less fluctuating than starch.

2. It is interesting to find the presence of starch in the epiderm of the leaf in both the spruces. The starch is not found in the Sitka Spruce after April nor in the Norway after May. In May and June no reaction for starch could be got in the Mesophyll nor in Norway in October. At other times the Chlorophyll contained grains which gave the starch reaction immediately. Fats are found in the mesophyll of the spruces at all times. At no time has starch been found in the Larch leaf although fats are generally intense.

3. In the stem, in the spruces, the starch content falls from May onwards. In the Larch stem starch is absent in March and April and less intense in Sept. and October than in the preceding months. In Norway Spruce only during the September period do the fats increase; in the Sitka Spruce there is a decrease in Sept. and October. In Larch it is the June period which shows the decrease.

4. In the older roots of both Spruces the starch and fat content is always high. During the April period in the Larch the starch has completely disappeared reappearing in May as very small grains. The fats increase in the Larch from March onwards.

5. In the younger roots in Sitka Spruce starch is depleted during March-May reappearing again in June. In the July period no trace of starch could be got in the pericycle but it reappeared in September Fats in this Spruce behaved in a similar manner. In Norway Spruce starch began to disappear in June, was absent altogether in July reappearing again in October. In both species the connection of the endoderm in July is interesting.

6. The Larch has a behaviour totally different to the Spruces. In April the plant shows a depletion of reserve food i.e. before the buds burst. Such a time of food depletion would be an unsuitable time for transplanting. The reserve is highest on the other hand in the spruces in March, April with the exception of the young roots of Sitka Spruce. These species from the point of view of food reserve would be best transplanted when the reserve is highest.

<u>Spruces from Peat or Humus</u>.

In no instance so far have Sitka or Norway Spruce from peat ground been found to be deficient in starch or fats. Fats indeed appear to be somewhat more intense than in the nursery plants. Checked plants at Inverliver for instance, show a large fat content even in the bast. In normal plants only a few cells of the bast contain starch. In peat spruces every part with parenchymatous cells such as pith, primary elements, pericycle contain starch invariably in large quantities: in effect plants from peaty ground are pre-eminently starch plants as compared with say nursery plants. Spruces from peaty ground frequently show frost rings and the parenchymatous cells of these rings react strongly to the starch test.

Fats have been noted in the endoderm and cortex of roots devoid of mycorrhizal fungi but absent or much reduced in amount in mycorrhiza. Invariably so far it has been found that taking "searcher" roots and mycorrhiza from one and the same plant in the searcher the endoderm and cortex are packed with fatty material in mycorrhiza only the outside layer of cells next fungal mat show fats and it is confined to a layer bounding the wall of the cell.

Norway and Sitka Spruce plants which were raised from seed and grown in various culture solutions to test the effect of the absence of different food elements were tested for fats and oils.

At the time the tests were carried out the plants were in their second year. The more important findings were as follows:-

1. Absence of Potash. In both species the absence of potash led to a decided deficiency in fats. Fats were absent or slight in leaf, stem and hypocotyl. In the root system however the fats were more intense than in the control. The starch content showed little difference to that in the control.

2. Absence of Magnesia led in both species to a greater fat content. In the leaf fats were found in every part, particularly in the epiderm region. Between epiderm and hypoderm there was a broad band of fatty material. In both species the bast gave a reaction for fats. Starch was more abundant in the leaf in Norway Spruce than in the control. The starch content in Sitka did not differ.

3. Absence of Iron. In both species the plants grown in the absence of iron were starch plants; every parenchymatous cell being filled with starch grains. The root system was peculiar, the tips of the rootlets being thick and swollen. Fats also were intense. A notable feature in the root was the thick layer of fat on the inner wall of the endoderm. It is to be noted that the Spruce grew in the absence of iron as seedlings at any-rate. Norway maintains better growth than Sitka, but in both the growth is very much less than in the normal.

4. Absence of Lime. In Norway Spruce the absence of Lime increased the Fat content of leaf,stem,hypocotyl and older root. On the other hand the absence of lime seems to lead to a deficiency in Starch - no trace being found in any tissue.

5. The absence of other elements such as phosphate did not appreciably bring about any difference in starch and fat content from those in the control.

Main discussion on the food reserve research on the peat is not called for owing to the unfinished nature of the work. Two points however appear to be of value (1) The high fat content of the root particularly in the endoderm of roots which are not mycorhiza. (2) The high starch content of spruces on peat combined frequently with poor growth. The former is important as confirming Priestly's work to some extent and it is important in that the high fat content of the endoderm may interfere with the movement of food bearing solution and water inwards. It is to be noted also that the layer of fat was present in the endoderm of plants grown in culture minus iron. Further the abundance of starch in the tissues of the spruces in peat and the abundance of starch in plants grown in culture minus iron is suggestive in view of an original finding in my peat research that in many peats the soil solution could be found to give no reaction for iron. If iron is found it is not in an available form and the problem would resolve itself into making this iron available probably by altering the P.H. value of the soil.

It is intended to follow up the question of the food stores with special reference to roots in more detail.

Peat Research.

(a) Age and Size of Plants.

This experiment has been carried out at Parkhill, Aberdeenshire with Norway and Sitka Spruce to obtain some idea as to the most suitable age and size of plant for use on peat ground. The material used was seed, 3 weeks old seedlings reared in the nursery, 2 yr. seedlings, 2yr.2yr.transplants and 2yr.3yr.transplants.

The seed was sown on the natural surface, screefed surface, prepared patches and on turfs. On the natural surface only about 4% germination was obtained. On the screefed patches germination was much better - Norway Spruce 15%, Sitka Spruce 23%. The plant % in October here was very striking.

In the prepared patches germination was nil in Norway Spruce. Sitka Spruce was better - the best result in this experiment being where calcium phosphate and the next best where Potassium phosphate had been applied previous to sowing. In the prepared patches the plants are larger than in the screefed patches and the root system is more branched and deeply penetrating. The turf sowing was a complete failure, probably owing to the drying out of the seed in the exceptionally dry weather. Only a very few seedlings were obtained and these were very small.

Examination was made to discover if possible the fate of the seed which had failed to germinate. The seed was found to be lying where it had been placed and the kernel in most instances was fresh.

Rather similar results were obtained with seeding at Inverliver. On an average about 4% germination in Sitka Spruce was obtained and the seedlings so obtained even on the very worst type of peat on turfs were healthy and strong with a stem growth of about one-third inch and a good well-branched root system. Norway Spruce failed to germinate almost completely and the seed was again found to be lying where placed with the kernel rather fresh.

The causes of the failure in germination of the Spruces on peat require to be investigated as they might give us information of value in other directions. Last year better germination was obtained with Norway Spruce than with Sitka Spruce. This year the reverse has happened.

More satisfactory results were obtained with transplanting 3 weeks old seedlings from Seaton Nursery to the peat at Park-hill. Practically no check was experienced and both the Norway and Sitka plants have well-developed shoots and well-filled buds whilst the root system is strong and healthy. From this experience it seems that there is some factor in the peat adversely affecting seed and the seedlings which may arise from that seed but which a vigorous seedling manages to overcome. This is again a line of research which should be followed and it is intended that it should be included next season under a general examination into the Periodicity of root development in the Spruces.

The 2yr. seedlings were lined out and are very satisfactory. The Norway Spruce in colour and wealth of needles are at the present time vastly superior to the 2yr.1yr. Norway Spruce in the nursery. The Sitka Spruce are quite the equal of the nursery plants.

In the older plants the casualties so far are as follows:-

	2yr.2yr.	2yr.3yr.
Norway Spruce	2%	5%
Sitka Spruce	5%	6%

(b) Species of Tree

A small experiment was laid down at Parkhill to test the success or failure of different species which were available in the nursery at the time of planting.

	Casualties.	Remarks
Scots Pine 2yr.1yr.	1%	Good growth
Fraser River Douglas	0	Vigorous healthy plants.
Omorika Spruce	20%	Falling off badly
Norway Spruce	2%	
Sitka Spruce	5%	
Mountain Pine	Only few survivors.	Small plants which have been overcome by the vegetation.
Abies nobilis	4%	Poor growth but healthy.
Douglas Fir	32%	Poor growth.
Sequoia sempervirens	9	Healthy and vigorous
Abies grandis	32%	Losing needles.
Cupressus macrocarpa	2%	Healthy generally but poor growth.
Chamaecyparis lawsoniana	0	Healthy.
Thuja plicata	0	"
Thuja occidentalis	0	"
Tsuga albertiana	heavy	Due to small nature of the plants.

The plots were formed on cotton-grass undrained peat - one of the worst types which we have in the East of Scotland.

During the winter it is hoped to be able to examine these species in more detail as regards root differences, food stores &c.

(e) Spruce Colour.

The Norway Spruce (Picea excelsa) frequently on certain soils particularly peat develops a yellowish green colour. It has previously been recorded that trees with this light colour may be found in which the lower branches which are protected by other growth for instance heather are of a deeper and more healthy colour. This points to the cause being exposure. In the previously mentioned transplant lines of Norway Spruce placed out as 2yr. seedlings at Parkhill protecting tests were made by putting screens along part of the lines so as to give the plants shelter and at the same time side-shade; over part of the lines so as to give overhead shade; and also by completely enclosing plants in groups of three to give complete side shade and shelter. No difference in colour was obtained in the first two cases, but in the third the depth of green in the needles is marked. Norway Spruce must be completely sheltered and shaded from the side in every direction to produce a deep green colour under the condition found in the experiment. A similar depth of colour however was obtained by treating the plants in groups with Potassium nitrate, Calcium nitrate and Sodium nitrate. No other salt was found to be effective. This points to lack of nitrates. This also held for Sitka Spruce.

In the nursery in manuring experiments Potassium carbonate was found to produce a decided deepening of the colour.

The improvement in colour can therefore in Norway Spruce be accomplished by shading and by the addition of some suitable food material. If the plants are nourished they can stand exposure.

At Inverliver a marked improvement in colour on checked plants in heather has been effected by placing bags under the plants and thereby keeping down the heather. The plants are developing numerous roots at the collar and in the heather.

(d) Drying of Spruce Roots previous to Planting.

Tree roots undergo considerable drying from the time of lifting in the nursery until they are finally placed in their new home. The degree of drying out will depend on the care exercised in the various operations, but frequently it has been noted that drying out appears to be unnecessarily excessive. To test the effect of drying out, bundles of Sitka and Norway Spruce were left exposed to the atmosphere for a short period whilst the control bundles were immediately heeled in. The planting was done on Eriophorum peat at Parkhill. The losses among the exposed plants have been high particularly in Norway Spruce. Sitka showed 18% losses as compared with 5% in the control and Norway 51% as compared with 2% in the control.

(e) Calcium oxalate.

Very seldom is it possible to find either Sitka or Norway Spruce without traces of Monohydrated Calcium oxalate in the tissues of the bast. Such crystals have been found to be exceedingly abundant however in both Sitka and Norway Spruces on certain classes of peat - notably for instance where the dominant plant is Calluna, Scirpus or where the type is Calluna-Scirpus or Scirpus-Calluna. The cells of the bast are seen to be filled with crystals and frequently within the cell they occur in two series. In Molinia Calluna or even Calluna-Molinia on the other hand or where conditions are better the quantity of Calcium oxalate is much less.

In the worst types of peat the calcium oxalate crystals are not confined to the stem, but are found in checked plants in the root - quite an abnormal condition so far as has been observed. A longitudinal section of a root from which younger roots are developing, shows the tissue of the younger root inside the older root surrounded with calcium oxalate containing cells whilst the cells of the young root itself are filled with crystals (see Fig.) Other roots alongside such roots show destruction and disintegration of the cells and frequently gummoses or intense resin production.

In the stem there is no indication that there is any connection between the oxalate production and fungi since no trace of mycelium could be demonstrated. Fungus mycelium, however, is frequently met with in the root.

Oxalic acid production in such soils would appear to be intense and is the result of poor aeration. Oxalic acid by itself is capable of killing tissues and requires to be neutralised by calcium. Is it possible that in the sites mentioned the plants are suffering from a scarcity of lime owing to all available lime being required to neutralise the toxicity of oxalic acid? Metabolic processes would be interfered with; free oxalic acid will kill the tissues. In areas like those mentioned where the plants show abundant calcium oxalate the application of lime or some manure which will liberate lime bound up in the soil, say Potassium, might be beneficial.

4. Miscellaneous.

The water culture experiment to test the effect of the absence of different mineral elements on the growth of Norway and Sitka Spruce was continued into the second year until July when the experiment had necessarily to be closed. It has not been found possible as yet to find relative development by weight but the height growths are given in the following tables.

	Norway Spruce	Rmks.	Sitka Spruce	Rmks.
1. Control	5.3		5.3	Ambiguous result.
2. Sol. Non-Aerated	4.5		7.45	
3. " plus MnO	5.7		9.6	
4. " minus Potassium	2.5		8.1	
5. " " Nitrate	2.3		dead	
6. " " Iron	2.7	Chlorotic plants	1.6	Browning.
7. " " Phosphate	1.9		2.2	
8. " " Lime	2.7	Very bushy growth	7.9	
9. " " Magnesium	2.7		3.8	
10. " " Concentration	4.9		6.25	
11. " x 2 Concentration	3.7		3.45	
12. " x 3 Concentration	2.5		dead.	

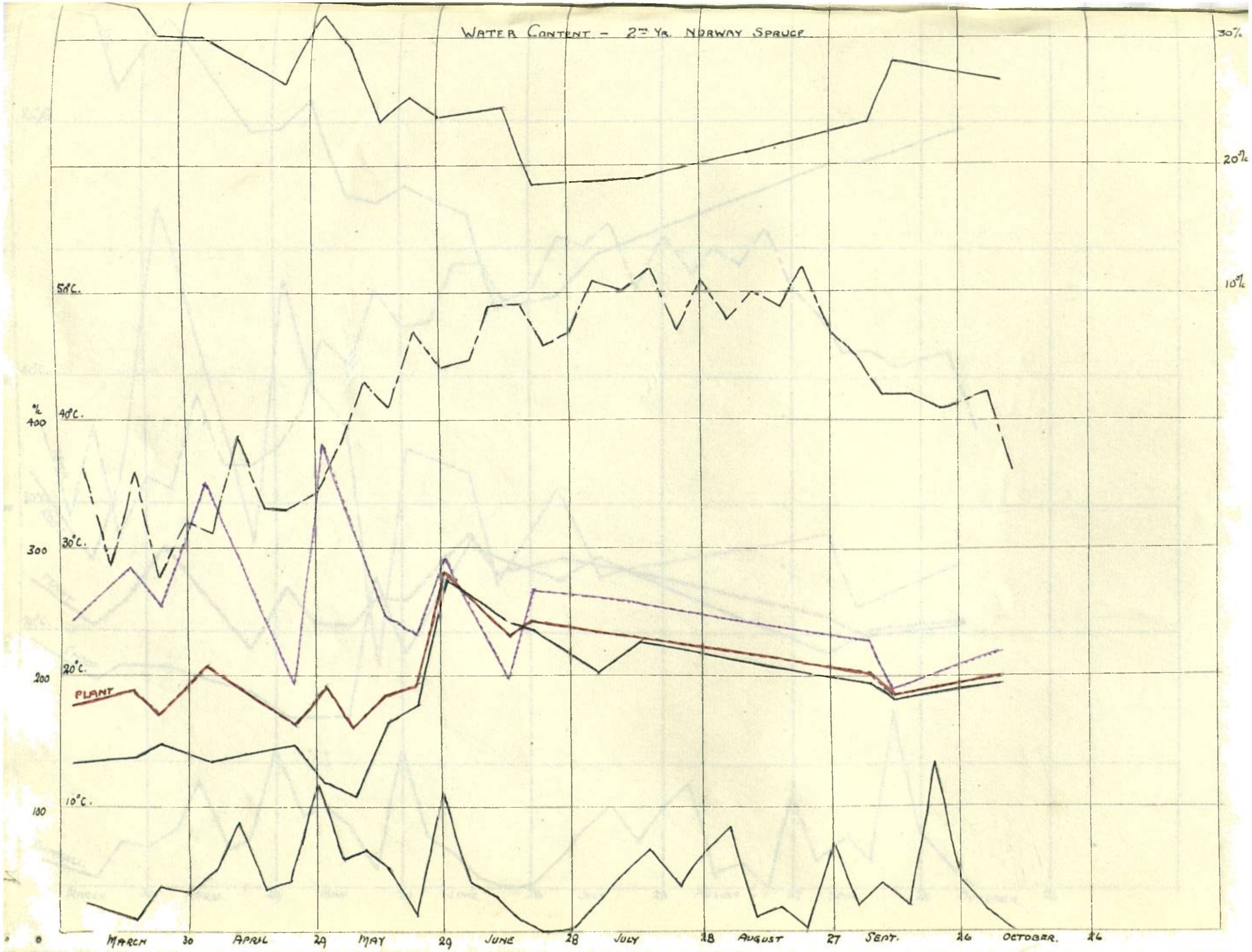
Conclusions.

I. In the second year of growth Sitka suffers most from the absence of nitrate, iron, phosphate and magnesia; Norway from phosphate to the greatest extent, the others being about of equal value. The nitrate in the Norway jar was probably affected by soot which gained entrance twice to the jar due to a fault in the cover.

2. Manganese dioxide has again a slight stimulation effect, lack of aeration in Norway a retarding effect.

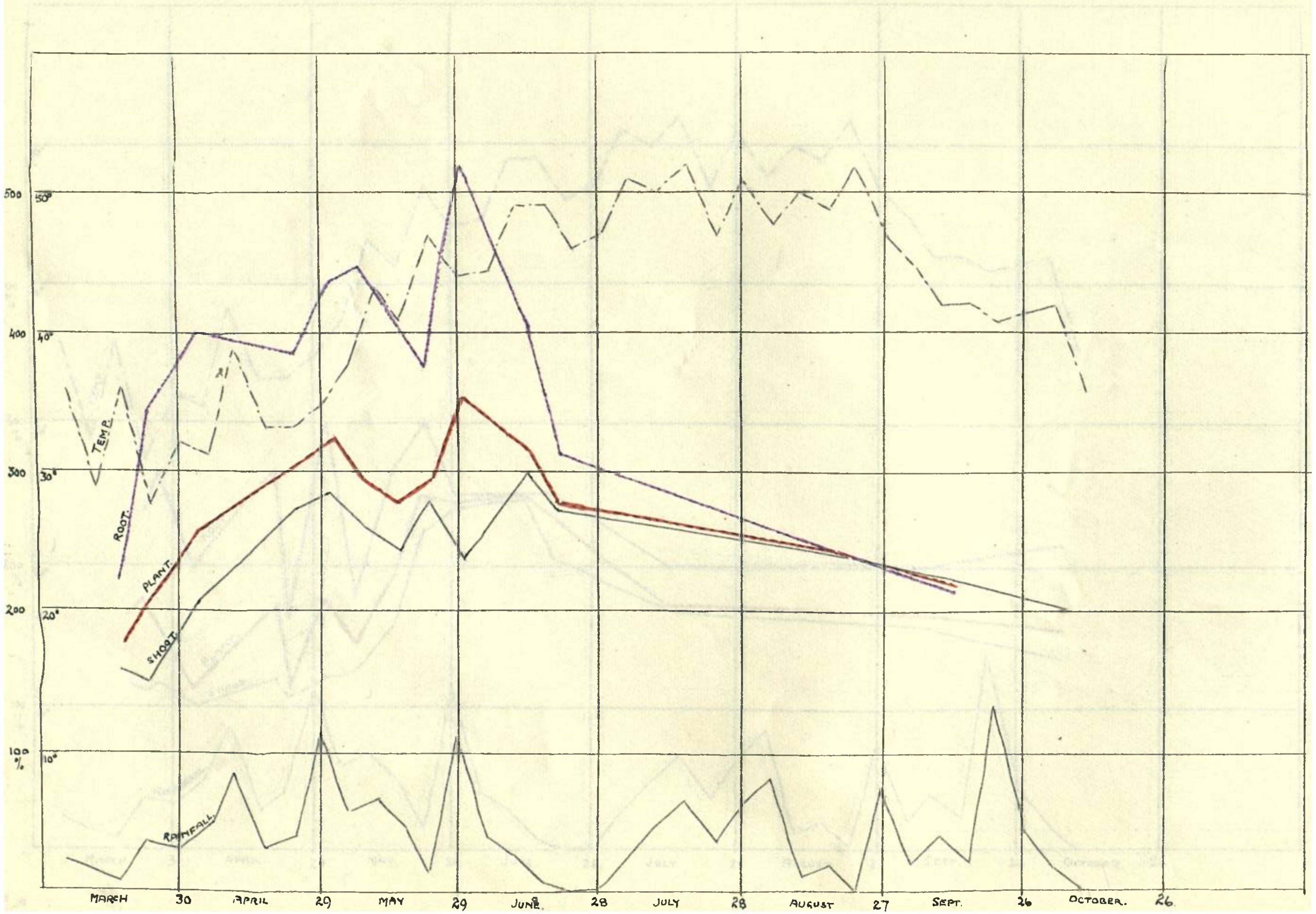
3. The colour of the Norway Spruce in the jar minus magnesia continued to remain lighter.

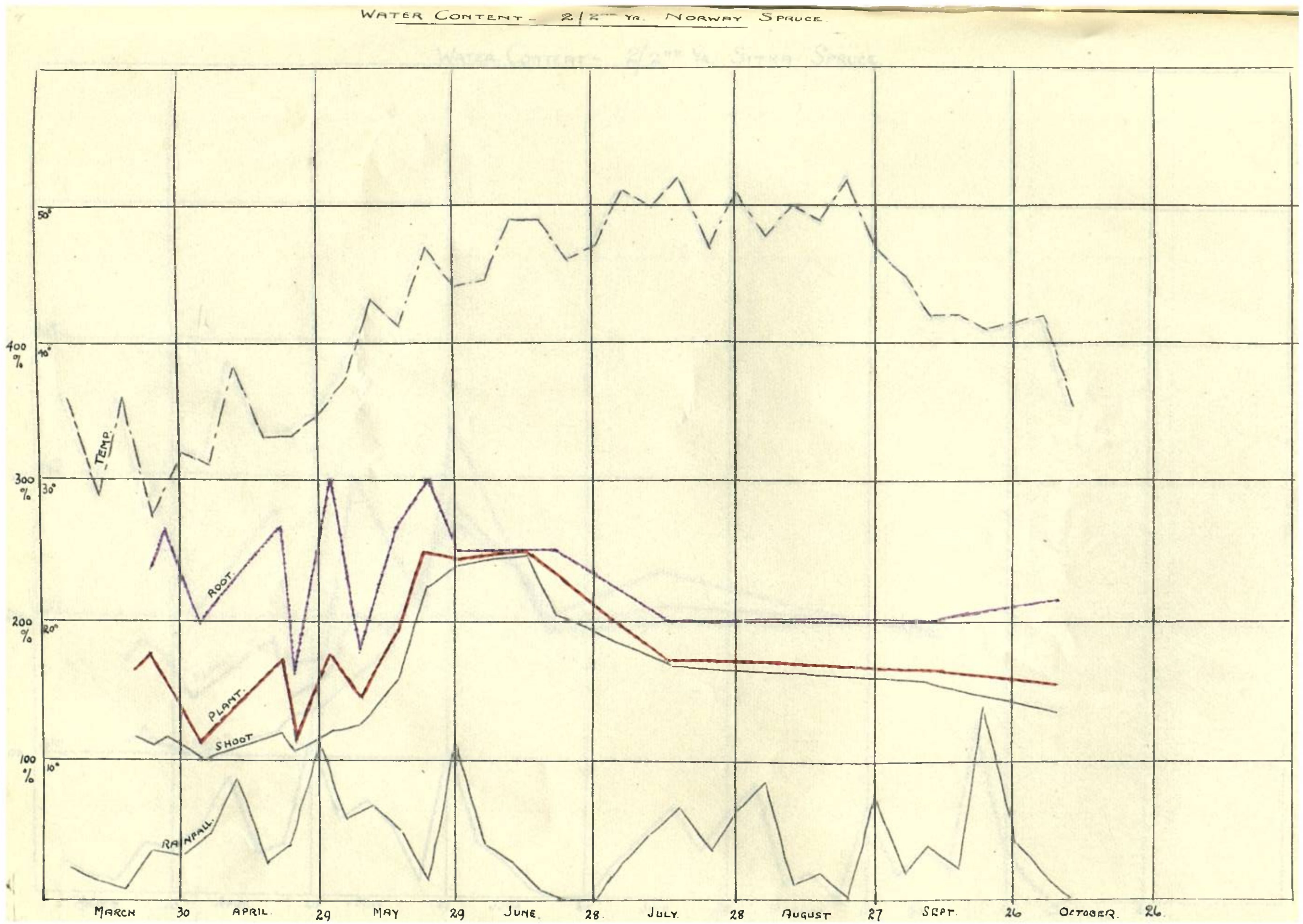
4. Too high a concentration affects growth adversely leading in both species to death in the second year.


WATER CONTENT - 2nd YR. NORWAY SPRUCE
30%
20%
10%
50°C.
40°C.
30°C.
20°C.
10°C.
%
400
300
200
100
0
PLANT
MARCH
30
APRIL
29
MAY
29
JUNE
28
JULY
28
AUGUST
27
SEPT.
26
OCTOBER.
26

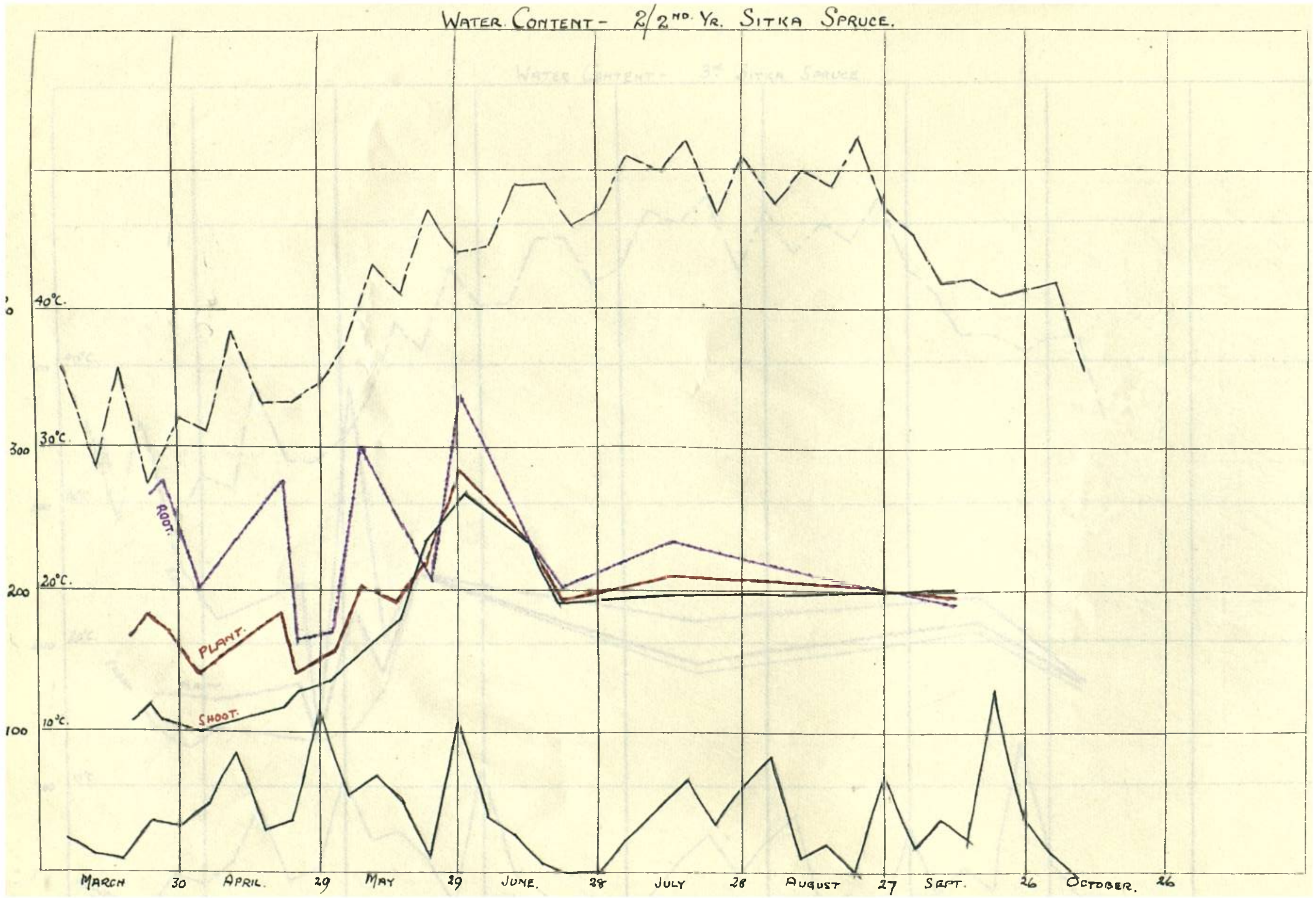

35%.
SOIL.
25%.
500
400
40°C.
TEMP.
300
30°C.
ROOT.
PLANT
20°C.
200
%
SHOOT.
10°C.
100%
RAINFALL.
MARCH
30
APRIL.
29
MAY
19
JUNE
18
JULY
28
AUGUST
27.
SEPT.
26
OCTOBER.
26.

Water Content – 2nd Yr. European Larch.

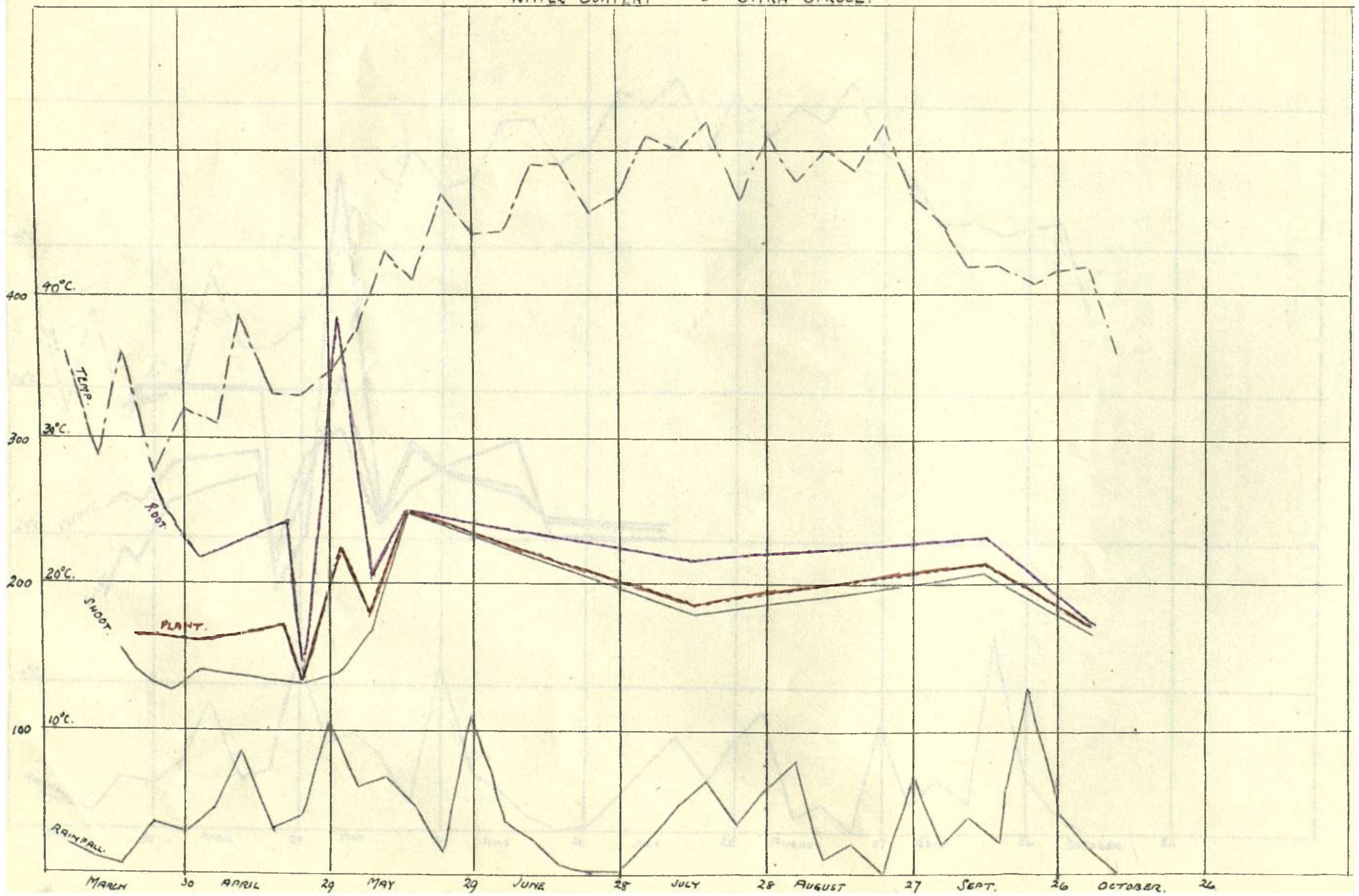




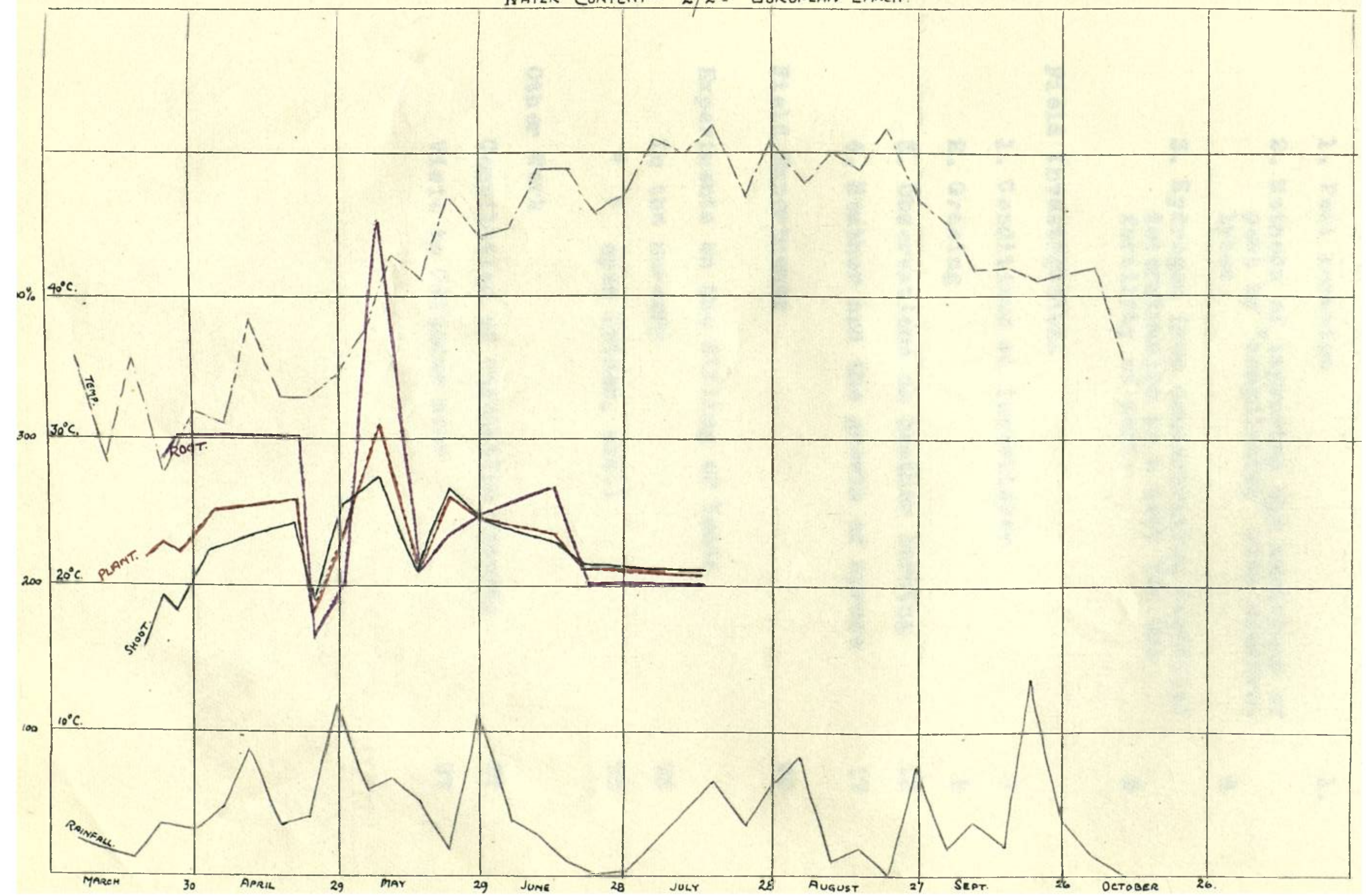
Water Content - 2/2nd Yr. Norway Spruce.
400 %
300 %
200 %
100 %
50°
40°
30°
20°
10°
Temp.
Root
Plant
Shoot
Rainfall
March
30
April
29
May
29
June
28
July
28
August
27
Sept.
26
October
26


Water Content - 2/2nd Yr. Sitka Spruce.
40°C.
30°C.
300
20°C.
200
10°C.
100
Root.
Plant.
Shoot.
March
30
April.
29
May
29
June.
28
July
28
August
27
Sept.
26
October.
26

Water Content - 3rd Sitka Spruce.



WATER CONTENT - 2/2nd EUROPEAN LARCH.



REPORT ON RESEARCH, 1925.

G. K. FRASER.

I N D E X.

REPORT ON RESEARCH -- 1925.

Geo. K. Fraser.

LABORATORY INVESTIGATIONS.

1. PEAT AERATION.

The difficulties underlying the determination of the Air-requirements of peat are two-fold. (a) Difficulties of sampling and of keeping samples in the condition in which they are in the field; (b) Difficulties of technique in making determinations and the absence of a suitable method of determination which may be directly applied to peat. (a) As regards sampling:- colour changes in the lighter peats indicate that exposure to air is immediately followed by a change in the constitution of the substance of the peat itself, so that samples must be handled without exposure to air; the withdrawal of oxygen from the atmosphere with which they are inclosed occurs more rapidly with the lower portions of peats of the better qualities (e.g. Molinia-Rush peat) than with peats of the more obviously anaerobic types, so that when kept in sample vessels "good" peats may rapidly attain a degree of "non-aeration" which they do not possess in situ. Therefore samples ought to be immersed in the test solution (or the test must be made) in the field. This is impracticable owing to the amount of material requiring to be carried about; although as with Hydrogen Ion determinations colorimetric tests may be made, yet so far as the indicators in use go it has been found that the results obtained are even more unsatisfactory than the colour tests for Hydrogen Ion which are almost useless on peats in the field, while in addition a supply of air-free water is necessary.

The method adopted for sampling areas near the laboratory, when the samples can be tested in a comparatively short time is as follows:- The peat is cut to the required depth with a 1 ins. auger and the central part of this sample is driven through a sample tube open at both ends, the portion of the sample held in the tube is sealed in by rubber stoppers and the whole enclosed in a package of the same peat. The central portion of the sample is preserved for some time at least in the "in situ" condition and it alone is used for testing lack of aeration. For longer distances the only method giving reasonable results is to take large blocks of peat as samples and for testing use only the central core of the block which is tested before drying out occurs to any appreciable degree.

Methods of performing the preliminaries of the test in the field (such as are done with sea water) necessitate the immediate thorough mixing of peat and reagent which is obviously impracticable, while the reagents used are unsuitable for physico-chemical reasons for the determination of the reducing power of peat.

(b) As regards method of determination, the Electrometric "Reduction Potential" Method was expected to give valuable results since peat itself conforms with the experimental conditions under which tests were made by the originators of its application to the soil. When the method advocated by these workers was carefully followed the results obtained were very irregular, such that no dependence could be placed on the method. For example the same block of peat frequently gave tests showing in parts an oxidation potential in others a reduction potential, that is opposed results, in less than a square inch of surface of an apparently homogeneous peat: such variation may occur but results which are wanted are the oxidation or reduction potential of the peat as a whole, which cannot be satisfactorily obtained by this method. In.acerating the peat in air-free water gave somewhat more concordant results, but it is felt that the details of the method have not been brought to a satisfactory basis.

The method previously adopted of treating with a Ferric Sulphate solution in Sulphuric Acid has been found to give quite satisfactory and concordant results and the range of values obtained for the different types of peats is such that peats may be separated into distinct series with reference to their power of reduction or inversely their lack of air.

The results of the determinations indicate that (a) for any type of peat the reducing power, calculated to the weight of organic substance contained in the peat, is fairly constant under consistent conditions of weather or when the peat is in its normal condition. (b) The reducing power of peat is a fair index of the necessity for aeration, or of the effects produced by drainage; and of the rate at which decomposition of the peat goes on. (c) Indications are appearing that in some of the drier peats rain following drought is accompanied by an increase in the necessity for oxygen, followed by a still greater lowering after a time; indicating that in dry peat decomposition is held up for want of moisture and that wetting causes rapid development of reducible substances.
(d) Increase in reducing power is not regular from the surface downward in all peats although for most deep peats it reaches a more or less stable maximum a short distance below the surface. It is certain however that some Rush-Molinia and other peats (characterised on the whole by a bad smell) have a horizon of more intense reduction just where surface peat merges into sub-peat. No other wide exception has been noted except that Iron-flush peats (usually small in extent) have a very high reducing power below the surface; this is likely due to the presence of large amounts of Ferrous compounds.

Typical figures for these determinations are given in Appendix I.

II. <u>INVESTIGATION INTO METHODS OF IMPROVING THE AERATION OF PEAT BY "COAGULATING" WITH ELECTROLYTES.</u>

Experiments attempted along these lines have not been successful in producing results other than confirmatory of last year's work. The main difficulty lies in obtaining penetration of the peat by the substance used. The natural rate of penetration is exceedingly slow in an unbroken peat, so that the application of electrolytes for this purpose must be accompanied by a thorough breaking up of the peat mass. In the laboratory the preliminary beneficial effects of treatment and freezing quickly wear away if the peat is allowed to settle in a wet condition and in actual practice in the field it is likely that the same result would follow; the condensed peat would subside and itself remain badly aerated without thorough drainage. This subsidence is rendered irregular by the mixing of the peat with soil - nodules of peat are formed round the soil grains, and aeration is accomplished in this way; this would be a partial explanation of the dictum that the addition of manure without soil is not of much value in the improvement of peat. Naturally the same result is produced by dominant Molinia by the deposition of that plant of moderately large amounts of Iron and Lime in its leaves while its network of stiff roots act as centres of contraction of the peat.

Practical conclusions arrived at from the investigation are that the natural processes of Peat improvement, through the development of flushes and the consequent manuring and aeration of the peat are very slow processes requiring a long period to produce a small result; and that any means of peat improvement by manuring must include thorough mixing of peat, manure, and very likely of soil in addition; the work must therefore of necessity be confined as much as possible to the localities in which the plants are put and not be carried out in a general way over the area planted. The results obtained are, as far as they may be of use, being applied to the field work at Parkhill.

III. HYDROGEN ION CONCENTRATION (ACIDITY) DETERMINATIONS AS A TEST FOR THE FERTILITY OF PEAT.

So much attention has been given lately to the Hydrogen Ion method of testing the acidity of soils that the methods were applied and used extensively during the investigation of peat types. Samples were tested in the field, as rapidly as possible in the laboratory, and after storage for some time. Both colorimetric and electrometric methods were used in the laboratory.

With regard to field work the conclusion was early arrived at and has been confirmed that colorimetric field methods of determining øH value are not of sufficient accuracy nor are they suitable for the determination of the acidity of peat. They are quite satisfactory for drainage water but even for soils only fair reliance can be placed on the results obtained, while for peats good determinations are usually impossible owing to inability to produce sufficiently clear suspensions from the necessary amounts of water; e.g. many peats retain under ordinary conditions as much as 8 times (occasionally twice that amount) the quantity of water equal to their dry weight. Up to 5 times the dry weight may be added to a soil before affecting the ø H value, after this the value may be affected. In order to get a clear suspension from some of these wet peats over 20 times the dry weight of water has to be used and the result is accordingly not accurate. Determinations of clear water (from drains, streams, etc.) can be readily carried out in the field.

The same remarks apply to colorimetric work in the laboratory, but clear solutions may be obtained by filtering, and colorimetric tests were made in the laboratory in this way.

More accurate work can be done in the laboratory with suspensions where clear water is not required by means of the

the Hydrogen electrode, or Electrometric method. Details of the work are the same as for soil, but a longer time is required not only for the individual determinations but, through the necessity for frequent change of the electrode caused by "poisoning", a series of determinations becomes a very long process.

If the peat is air-dried in a clean atmosphere before being tested clear solutions may be obtained, and here, as may be seen from the figures in Appendix II a, concordant results were on the whole obtained from the two methods, otherwise colorimetric determinations must be considered only as approximations.

Conclusions arrived at are as follows:- Hydrogen Ion determinations indicate that this method of determining acidity is not of value as an index to the fertility of peat, at any rate within the range of peats studied, since while the figures obtained are on the whole low (showing high acidity) the variations occurring in each type are greater than the mean differences between the types themselves. For example p H values obtained from what are certainly good types of Molinia peat cover a range which includes the range of values obtained for Deep Scirpus peat - Molinia 3.0 to 5.6; Scirpus 3.0 to 3.9 or 4.3.

On the whole the higher p H values do fall among the better types of peat if tests are confined to the surface layers.

The values obtained at different seasons for the same peats and similar types of peat indicate that acidities in peat vary slightly from season to season but field estimations made this summer seem to indicate that greater variations occur temporarily through change in weather conditions during the growing season.

Considering the figures obtained as a whole it must be stated that variations in the results obtained and the small variation occurring from peat to peat make the method, whether colorimetric or electrometric of no value in the study of peats within our range.

More satisfactory results as regards acidity are obtained by the use of the "Lime requirement" or the simpler Calcium acetate method designed to determine the amount of base (i.e. lime) required to satisfy the soil acidity, or the lack of Lime in the soil. Using this method peats fall in a general way into an order of relative fertility, due weight being given to other factors. This method cannot, of course, be applied in the field.

pH value figures and notes are given in Appendix II.

IV. <u>DURING EASTER, SAMPLES OF AN INTENSIVE KIND WERE COLLECTED FROM THE AREAS CHOSEN FOR THE CONTINUOUS CROPPING EXPERIMENTS LAID OUT BY DR. ANDERSON AT BEAUFORT AND AT SEATON, and THE NECESSARY PRELIMINARY ANALYSES WERE CARRIED OUT. THESE ARE NOT REPORTED UNTIL THE COMPLETE ANALYSIS HAS BEEN MADE.</u>

FIELD INVESTIGATIONS.

1. Investigations into conditions at Inverliever have been pursued in continuation of former work, the phase particularly studied this season being the effects of grazing, while former work at Inverliever has been linked up with observations carried out at Borgie, Achnashellach, Slattadale, Fort Augustus and Inchrie. Since the analytical work in connection with these localities is only in the initial stages, only general deductions from field observations are made.

The vegetational types observed at Inverliever are on the whole repeated with minor points of difference at all the localities visited, especially if there is included in Inverliever not so much the earlier area enclosed but that more recently removed from the effects of grazing.

At the same time the variations which do occur on similar sites in these places are probably indicative of differences in soil and in climate, e.g. the distribution of Molinia as a principal element in the flora at Borgie is much less frequent than at Inverliever, a fact which may be due to the drier summer climate and the rounder topography and consequently stronger exposure; at Borgie, Slattadale and Inchrie occur fairly large stretches of shallow peat bearing a scant cover of poor Scirpus supplemented by Lichenous and bare black peat; here the cause is to be attributed to bare rock exposures, surface fan and barren rocks producing infertile soil if any, that is a complex of extreme moisture conditions and poverty of mineral food; this scarcely occurs at Inverliever where climate is uniformly wet and the soil-forming rock is distinctly rich in mineral foods. The effects of bad mineral soil conditions are emphasised at Inchrie where the worst peat types occur on almost pure Quartz while the more complex rocks and soils support much better vegetational types. It ought to be noted, however, that at Inchrie geological variations are somewhat coincident with variations of aspect and that this latter factor may be operative in the result produced. At Slattadale on the whole as at Inverliever, topographical variations seem to determine the incidence of floristic types within the peat area.

The peat types found correspond like the vegetation with those found at Inverliever, minor variations in macroscopic appearance being noted. The exceptionally dry summer may influence any observations and deductions made, while it may be worth while to note that any observations made at Easter when the weather was bad and the whole area waterlogged are apt to require modification in the summer when conditions are much better; so that it seems necessary on such areas to pay at least two visits before any adequate opinion can be formed of soil conditions as well as of vegetation.

In these areas vegetational types (with few exceptions) resemble much more closely those found in the recently grazed areas at Inverliever than in the forest in that plants readily suppressed by fire or grazing are much less frequent, or less healthy, e.g. Calluna; while, except in the low lying flush areas, one plant (either Scirpus, or much less frequently Eriophorum vaginatum) tends to predominate.

A considerable number of observations depend on analyses for verification and these are not yet made.

II GRAZING.

Previous ideas with regard to grazing have been somewhat modified. The question is complicated by the custom of burning over grazed lands which appears to have been general.

The general conclusion arrived at is that the effects of grazing vary in different vegetational types, in one type good results may follow, in another distinctly harmful results. For example, it has been noted by various authorities that in certain English heaths the removal of sheep is followed by the rapid change from Grassy-heath to Calluna heath; if the reverse be true, it may be stated that grazing produces the beneficial effect of change from heather to grass. Cases observed may be reduced to common terms, that grazing favours the development of such plants on an area as are best able to adapt themselves to its effects. On dry soils or such fresh soils as support a mesophytic vegetation this will result in the development of graminaceous plants whose growth form is adapted to withstand browsing; here the result is favourable to Forestation.

In wet localities and on such soils as are waterlogged and stagnant the plants favoured are not necessarily of graminaceous types although they are usually of similar habit; in such areas there is usually the special element in the flora, Sphagnum, to be taken into consideration. The usual plants having a habit adapted to recover from grazing and growing in conditions above specified are Sedges (usually confined to special localities), the Cotton Grasses, Scirpus, Narthecium with a few other less important species. On grazed land, these species are favoured at the expense of the other species which might compete against them, the most important of which are sub-shrubs like heather, bilberry, etc., which are much more protective of the soil than the favoured plants. These latter afford no protection to the soil for a great part of the year beyond their own immediate stems or tufts of stems, and this is especially the case when grazed.

The result of grazing is therefore that the surface is laid bare and the undergrowth consisting of Sphagnum is enabled to extend to a much greater degree than it would under ungrazed conditions, and the final condition of the area is that of a wet Sphagnum peat, with the herbage level on the surface for the greater part of the year and forming a highly absorptive layer on the surface of the soil. Such grasses as there are on the area succumb to grazing and the growth of Sphagnum, with occasional stems and even small tufts of Nardus, Fescues, Hair grass and Molinia, holding out for a longer time as exceptions. The results of grazing on this type of land are not confined to the area already occupied by sphagnum, the peat conditions extend themselves in all directions, moving upwards and the peat thus formed will eventually occupy all stable soils in the neighbourhood of the original Sphagnum area. Even where sphagnum is not present, in most grazed areas there occurs a compacting of the surface vegetation and soil, so that there tends to be developed a badly aerated soil and in wet conditions acidity and finally peat.

Examples of these processes can be observed frequently in the grazed areas at Inverliever where the presence of a water-collecting hollow on the otherwise even slope of a hill causes, under grazed conditions, an extension of peat conditions the margin of which is progressing over the grassland on all sides. The presence of Bracken with its shade, and its immunity from sheep apparently acts as a check to the invasion. On steep sheltered slopes with good soil the grass vegetation persists in spite of grazing. On flush flats grasses mixed with species of rushes (etc.) persist, apparently in part owing to the comparatively slight grazing which these suffer and to the greater variety of and therefore greater shade cast by the vegetation, as well as to the better soil conditions (Drier stream banks may be compared where the sheep can find better conditions, grazing is heavier and peat much more frequently develops).

Another example of this kind of "grazing succession" is seen on shallow soils somewhat liable to occasional (i.e. subject to alternate soaking) soaking/and drying. The typical species found on such is Deschampsia caespitosa. When this type occurs in grazing land the grass is thoroughly eaten down by sheep and the shade which it otherwise casts is lost; alongside of it occur species like Nardus (chiefly as individuals) and Juncus squarrosus, and among these Sphagnum develops; in time the peat formed eliminates almost if not completely the Hair grass and a very poor Scirpus + Juncus squarrosus and Carex glavea peat is formed in place of the humose though shallow Deschampsia soil - an unplantable type replaces a type which grows very good Spruce in high-rainfall areas.

In areas of high rainfall, especially on the more exposed sour soil types there can be little doubt that continued grazing is harmful; probably especially so when regular and severe burning of sub-shrubs is carried on in connection with it.

When sheep are removed after the formation of such types as have been indicated a simple reversion does not occur.

Study of the older enclosed area and comparison of this with the sheep land are conclusive demonstration of the contrary, and of the processes which are going on.

Among the species partly eliminated by the grazing of the older area only the sub-shrubs continue to hold a precarious existence as weakly dwarfs amongst the Scirpus and Cotton-grass (e.g.g. Heather, Bogmyrtle, Bilberry, etc.). These, along with the deep peat species become more luxuriant at least on the more sheltered localities when grazing is stopped and with their increased growth form a half shade under which the development of Sphagnum may become extremely rapid as compared with the slow growth in height which occurs on the almost static conditions under sheep. At Inverliever the rate of development of Sphagnum has kept pace with the growth of the other species and in some places seems to be eliminating everything but heather after which in turn it is invaded by Scirpus. At least it may be said that the whole of the Inverliever planting area in so far as it is covered by the poorer types of peat (i.e. leaving out of consideration Flushes, Rush, Molinia, and Iris Bogs) and peaty grasslands is in a state of rapid vegetational transition, the result of which will, as far as present indications point, be an almost continuous cover of more or less deep peat; the rate of development of this deep peat is apparently the more rapid, the more shelter is given to the soil by the general topography and by neighbouring plants and plantations. Where trees have joined canopy this development has of course been checked.

On the deep flat peats of the "Hoch-moor" type the main effect of the removal of grazing has been the development of sub-type vegetational units; e.g. the Ridge and Furrow complex of alternate Heather and Scirpus or Sphagnum becomes more obvious, and so on but the sum total effect is much less than is the case in shallower peats and grassy heaths adjacent to these.

With regard to the other areas visited it would appear that similar results have followed on grazing. The removal of grazing might not necessarily be followed by the same "Rapidly growing Sphagnum" phase, although it is almost certain to result in a similar type in most instances (Fort Augustus and Borgie may revert to heather without Sphagnum as conditions are apparently drier in the growing season). At the present time the peat is shallow, before plants have had opportunity to join canopy they may be over a foot in depth.

OBSERVATIONS ON HEATHER BURNING.

Observations were made during the year whenever opportunity occurred; note was taken of the opinions of reliable foresters on the question, especially in connection with specific areas which had been dealt with in the near past.

Conflict of opinion seems to arise from (a) differences in the extent to which burning is allowed to proceed, (b) differences in the effects of burning on different types of vegetation of which heather forms one or the main constituent.

In the East the burning of old heather is generally considered advisable before planting with Scots Pine or Larch. The vegetational types treated are likely on the whole to be Heaths and Grassy-heaths. On these the effects of burning have been observed to be advantageous, at least temporarily, since after burning there is an increase of the more Nitratophilous elements in the vegetation - indicating better soil conditions. In the former type (i.e. almost pure heather - Calluna and Erica cinerea). This does not always follow, cases were found where on a shallow panny soil the ground remained bare except for temporary development of poor mosses and lichen and only slow growing heather was coming up in the third year. In ground of the heath types the improvement is only temporary on the whole; by the fourth year reversion has occurred.

Severe burning is advised on very hard dry turf but the results of this have not been observed.

It may be noted that an opinion frequently expressed is that natural regeneration is not only more dense but of better growth when it "comes up along with young heather", after burning lightly.

In the west opinions varied more markedly and conclusions could not be formed from a general consideration of the ideas expressed.

General conclusions from observations:- On heath types in the east burning of the ground vegetation has a temporarily beneficial effect. On exposed sites this effect may be counteracted as far as plantation is concerned by the removal of shelter.

On peat of the deeper and wetter types in the east superficial burning is not advantageous and is at least temporarily harmful, being followed by an increased growth of species like Eriophorum vaginatum and E. angustifolium, along with an increased surface waterlogging due in part to the reduction of evaporation following the death of plants like heather, and in part to the caking of the unprotected peat surface when flooded with water. The species mentioned as surviving the burning do so in virtue of their deep and well protected under-surface stems. Severe burning of such peats in the east has not been observed (but combined with ploughing this is used as a means of reclamation in Buchan); periodic burning of moors improves the lower ground in their neighbourhood by manuring the latter, deep peat may be changed to grassland by this process.

Heather-burning in "bad" areas seems to have been carried out somewhat drastically in the west where possible before planting. The results vary obviously with the co-dominant and principal subordinate species mixed with the heather.

Examples:

Where heather occurs with tufted Molinia burning is followed by a marked development of Molinia and possibly by an increased tendency to the formation of tufts. This effect is apparently fairly permanent. An example of this was seen on the island at Loch Maree.

Where heather and Eriophorum vaginatum form the main constituents of the vegetation, burning is followed by complete dominance of the Cotton-grass, more thorough and permanent than observed in the east.

Similarly with Heather and Scirpus. For example the heather-covered knolls typical of more exposed, ungrazed sites at Inverliever, the chief subordinate species in which is Scirpus, are scarcely to be seen in similar positions at Borgie, Fort Augustus, Inchrie, etc., although one would expect the type to be more abundant, at least in the first two localities; and this appears to be due to two causes; (a) Grazing, which keeps the heather close and renders it unnoticeable at a distance; (b) Burning of the heather within comparatively recent times. On these knolls the peat is similar from all localities although at Inverliever the development of Sphagnum has somewhat modified the surface; this would indicate that all the types were originally the same and that the growth of heather followed enclosure at Inverliever. I have been informed that at Borgie and Fort Augustus these knolls were severely burnt and that there heather was abundant and rank before burning (the sticks are still to be seen). That is to say, for some years after burning, a very poor Scirpus peat occupies a site in which heather used to be dominant.

The same applies to the deeper peats, where however Scirpus has a greater dominance even when no grazing or burning occur. Surface burning of Heather-Scirpus knolls is therefore harmful, but very severe burning on such areas might be worth experiment since by that means both Heather and Scirpus would be removed for a time.

Heather -Scirpus-Molinia: On this type Burning is followed by the temporary development of Scirpus and Molinia. On the whole the former seems to be most favoured, but where Molinia is abundant it seems that it tends to check the Scirpus for a time at least. Difficulty was found in estimating the former condition of such areas owing to the great variations which occur in the mixture, but it may be taken as fairly certain that unless Molinia is very abundant, it will not likely produce much good effect to burn.

Heather with grassland and bracken; slight burning of bracken-heath is followed by a stronger development of bracken and of "sweet" nitratophilous vegetation in general. Examples were seen at Borgie, and older examples at Fort Augustus.

General conclusion:- The result of burning of heather is beneficial only in certain conditions and when carried out to a certain degree. On better classes of heath burning should be slight and if so results in improved soil conditions. On the poorer types of Heather ground superficial burning tends to emphasise the unsatisfactory soil and vegetational conditions and here - although no observations have been made on the point - it is not unlikely that the removal of the infertile peat surface as well as the harmful vegetation better conditions for tree growth might be obtained.

In addition it is felt that all evidence goes to show that continued intermittant burning of peat and peaty areas is a strongly contributory factor in the wide spread development of Scirpus and Eriophorum vaginatum in the West; that heather has been frequently replaced by these two more noxious species. In the east where climatic conditions are not suited to the growth of these two species burning is followed by the temporary development of grass developing to heather or by the direct growth of heather except for specially wet or otherwise infertile areas.

HEATHER AND THE GROWTH OF SPRUCE.

Although it is the general opinion that Heather is inimical to the growth of Spruce, the actual causal factor concerned is somewhat doubtful. There are two likely explanations of the phenomenon

(a) Heather may grow most frequently, if not always, on sites unsuited to Spruce.

(b) Heather may be specifically harmful to Spruce either by its mode of growth or by some toxic by-product it excretes. (Its grass has been shown to be in the case of apple trees). There can be no doubt that spruce does not develop without a more or less prolonged period of check in ground where heather forms a considerable proportion of the vegetation; for example at Inverliever (and other places) the growth of spruce can be correlated with the absence of heather in heather-grassland; the last year's shoot growth changes as follows with the relative amount of heather (The figures % of heather are approximations obtained by the linear measurement of the relative amounts of heather and grass, while the growth figures are in inches the average growth of the shoot in about 20 plants from each grade. The last two figures show where grass is replaced by Scirpus in the same locality:-

Length of Shoot	(Norway Spruce	16,	14½,	12,	9,	5,	3,	1,	½
	(Sitka "	25,	24,	21½,	19,	15,	10	6,	3½
% of Heather	......	10,	30,	50,	70,	90,	100	70,	60.

These figures may be repeated with transition percentages of Molinia and Heather, so that it may be taken that heather is at least indicative of bad conditions for Spruce. The last two figures in the table point to the conclusion that the presence of heather may not be the factor involved but that conditions are developing which favour heather up to a point and then tend to favour Scirpus and that these conditions become almost uniformly more harmful to Spruce. And this is generally the case. Actual luxuriance of heather (apart from its frequency) cannot be correlated with either good or bad growth of spruce. For example on deep Scirpus peat the general rule is that the more healthy the heather is the more protracted is the life of the spruce plants; on the drier parts such as near drains and such like. Individual Sitka grow well on Cotton grass peat, apparently owing to the preliminary shelter afforded by heather.

Again on the better qualities of moorland in Eastern districts Spruce does not do well in contact with heather, but at the same time it makes only slightly better progress on vegetational types occupying similar habitats, e.g. on Deschampsia flexnosa heaths or even closely cropped grassland of any kind; so that from a purely physical point of view heather-land may be considered as a soil unsuited to spruce with no necessity for laying the blame to the account of the heather itself. Even if the heather were killed out there is no evidence to hand that Spruce would come away on a typical heather moor.

Physiologically heather and its associates are characterised by ability to withstand extreme moisture and aeration conditions of the surface soil - stagnant moisture or extreme drought or alterations of these.Spruce with its surface root system and heavy foliage is illadapted to drought and is equally illadapted to stagnant moisture, so that from general principles the two plants do not go together.

(b) Plants like heather which have the power of becoming dominant over large areas usually tend to produce conditions favourable to themselves, for a time at least. Thus heather tends to produce strong acidity of the soil, to increase infertility by leaching and to promote unstable air and moisture conditions by retaining moisture on the surface. In this way, it prevents the development of species like spruce. The general soil conditions are rendered unsuitable to the tree. This bad effect is ameliorated by the action of overshade in opening up the heather itself and favouring of more normal kinds of vegetation. So that if heather-land is treated by previous plantation of other suitable species then spruce has a better chance of obtaining the soil conditions necessary to it. It is probably as much by this process as by the sheltering of the foliage of the spruce that a nurse crop is beneficial on such ground. At any rate moderately good Spruce trees have been found in close canopy with heather debris below them and heather ground surrounding the woodland. Whether these trees were grown pure or in mixture with Scots pine and Larch cannot be ascertained; when seen at the age of about 35 they form a pure block.

With regard to the toxic effect of Heather on Spruce, there is no definite evidence that this effect is a specific effect of Heather; in fact the evidence as obtained in the field is to the contrary; the toxin if there is such is most probably produced by many moorland plants; Erica tetralix is apparently worse than Calluna, Erica cinerea, the Cotton-grasses, Scirpus and others are very likely as toxic.

The laboratory determination of a specific substance or set of substances present in heather soil and not in others is a problem too complicated to be attempted in conjunction with the other work in hand but a general survey of the question has been made. Plants of these types (c.f. Priestly) are characterised by the abundance of lipoid or fatty substances contained in their cell walls. Those substances which have been isolated in soils which are strongly humose, acid, and noxious to plant growth belong to the decomposition products of fatty and waxy bodies (for example dihy-droxy-stearic acid found in "sick" soils); so that if such toxins as are thought to occur in heather soils, are actually present it seems certain that they belong to the fatty acid group; that such are present in peat and heather soils is certain from the observed fact that these invariably give on being saponified a noticeable but exceedingly small percentage of "soap". If those are harmful (which is not certain) then the only practicable method of remedying their effects is the application of lime in sufficiently large quantities to satisfy the lime-requirement of the peat and render them innocuous; at the same time of course the heather might be destroyed. This aspect of the question is being dealt with as part of the peat manuring problem and in connection with the destruction of heather.

FIELD EXPERIMENTS.

A series of experiments has been laid out at the Corbie Loch, Parkhill, in continuation of the work begun last year on the problem of the effects of manures on Peat.

The last year experiments were as follows:-

The area, chosen as being of as even conditions as possible, was treated with manures broadcasted on in plots of $\frac{1}{10}$ th of an acre, in two series; one of a heavy dressing (similar to an agricultural dressing), the second series of half that amount, the manures being, (a) Quick lime; (b) Basic slag; (c) Super-phosphate; (d) Gypsum; (e) Kainit; (f) Ammonium Sulphate; (g) Calcium nitrate; h = (b + e + g); j = (c + e + f); k, Spent Lime from paperworks, Carbonate of lime.

The effect of the addition of manure in general was at first harmful to the vegetation at least with the heavier dressing; these harmful effects soon passed off on the whole and on examination this year, apart from a greater rankness in the vegetation not much change could be recorded apart from the fact that heather seemed to suffer most from contact with the manures (especially quicklime) and this year was distinctly less in amount. Sphagnum was obviously badly injured by all the manures where these actually lay in contact with it but with the smaller dressing the effect was quite uneven. In the second year the amount of Sphagnum was somewhat reduced, an effect produced in part by the ranker growth of the taller plants like Cotton-grass. This experiment could not be continued as intended in the form of a planting experiment this year, only observations being permitted to be made.

The results are quoted in tabular form below; only the full manure is considered as the half manure was less effective, andonly the effects on the vegetation indicated. The quantities of manure added were such as to give per acre (Full dressing)

CaO - 1 ton; $P_2 O_5$ - 2 cwt; $K_2 O$ - 2 cwt; N - ½ cwt.

Immediate effects.	At end of Season.	This year.
a. Distinctly harmful	Not much difference	Better growth.
b. Little	ditto.	ditto.
c. Harmful	ditto.	ditto.
d. Little	Ranker growth	Not much change.
e. Harmful	ditto.	Better growth.
f. Very harmful locally	Growth checked	Not much change
g. ditto.	Not much difference	Better growth
h. Very harmful	Better growth	ditto.
j. ditto.	ditto.	ditto.
K. Little effect	ditto.	ditto.

A set of experiments has been laid out on a larger scale on the Corbie Loch areaat Parkhill this year, using the same manures with the addition of smaller quantities of substances calculated to produce coagulation of the peat or direct oxidation, at least on the surface, while manuring has been combined with drainage and planting has been carried out simultaneously. The experiment, especially on the drainage side, has been considerably upset by the exceptionally dry conditions which prevailed during the summer, turf planting being badly affected by drought. No results can be recorded from this year's growth.

The scheme of the experiment is as follows:-

The main experimental plot is divided by ditches into 13 sub-plots of the same dimensions. Nos. 1, 5 and 9 are turned on the lines of the Belgian system. Each strip is divided into 4 sections, two of which are planted or treated for future planting and two left for comparison or future treatment. The whole area is to be dealt with so as to show the effects of different manures applied during planting, before planting and after planting, in each case with and without turves, while one area has been set aside for treatment without drainage at all. Strip No. 6 has been used in an experiment to test the possibilities of manures and weed-killers in the removal of vegetation from rides etc.

Experiments have been carried out at Inverliever and Parkhill with regard to the distribution of manures. Since by natural processes vegetational change takes place by the gradual percolation of manure - laden water over the surface of peat, it was thought that this method might be imitated artificially on slopes.

At Inverliever ditches were dug on a slope, near Cruachan, horizontally across the upper part of the slope and into these Lime and Basic slag were thrown; in a short time the ditches overflowed and channels were dug on the lower walls so that the manure-charged water was evenly distributed down the hillside.

Analyses were made of a series of samples from the peat immediately below the position of the ditches last year and this year and increase in the lime-content noted. The figures (Appendix) show that any increase in lime-content is confined to the first two yards of the area below the drains and in agreement with this any marked effects on the peat and vegetation are as yet confined to the margin of the ditch and mainly on the turf which has been laid bare inmaking these; it is noteworthy that since the ditches cut through the peat into the soil below, the lime content has increased to a greater degree at the soil surface than at the peat surface, indicating that greater percolation occurs between peat and soil than over and into the peat itself.

At Parkhill wet depressions were used as centres of natural distribution from which lime could be conveyed by percolation. After the preliminary death of the Sphagnum in these the manure became covered with a calcium "humate" film which seems to act as an impermeable membrane, since, later on, the undisturbed peat water overlying the manure had a high acidity which disappeared on stirring up the lime, while Sphagnum growth had become as vigorous as ever even in the water in which the lime lay.

These results are confirmatory of laboratory results and indicate that manures of the coagulating type especially must be well mixed with the peat otherwise they have only a very local effect due to their occlusion in mass in the peat.

EXPERIMENTS ON THE KILLING OF WEEDS

(a) In the Nursery; Moss.

The phenomenon of moss-covering in the nursery may be considered to be due to two causes (1) lack of surface tilth due to continued dampness and usually occurring on heavy soils, generally accompanied by lack of lime and of humus in the surface layer. A heavy soil with good tilth and free play of air does not as a rule develop moss. (2) More usually moss growth is to be connected with surface caking of the soil. This is produced by the leaching action of rain on the surface causing "puddling" which is rendered permanent by over-rapid drying; the soil will recover from this puddled condition if allowed to dry slowly so that capillary water movement replaces the material leached from the surface. On the puddled surface, moss tends to develop. On the assumption that prevention is better than cure, means should be taken to lessen the chances of caking. This may be accomplished by the addition of soluble bases (Lime) and retentive material (humus) to the soil surface, for example well limed compost should be used to cover seedbeds in nurseries liable to caking, that is those having a silty soil, while good shelter should be afforded against drying winds. (The addition of coarse sand is also useful but perhaps impracticable). Paths should be kept clean as constituting a source of infection.

Various weed killers in weak solution may be used to kill out moss from paths and these were used as a starting point for experiment. Pots of seedlings in the dormant winter condition were treated with weak solutions of Mercuric Chloride, Zinc Sulphate, Copper Sulphate and Iron Sulphate. It was found that so long as these did not remain long in contact with the aerial parts of the plants large quantities could be poured or sprayed on the pots without causing injury to the plants, quantities sufficient to soak the surface at least. Solutions of varying strength were then used on moss from a caked soil, and it was found that solutions of $\frac{1}{2000}$, $\frac{1}{500}$, $\frac{1}{300}$ of Mercuric Chloride, Copper Sulphate and Zinc Sulphate respectively were sufficient to kill the moss when it was in a moderately dry condition; the moss remained green for a few days but ultimately became discoloured. When moss of a similar type in the open was sprayed with these solutions it was killed. Stronger solutions than these were applied to seedlings in pots and in the winter condition without injury, but if the seedlings were beginning to bud or if the liquid remained in contact with the green parts for a time they were injured. At that strength the solutions could be left for over-night.

This work was not completed in time to be applied to the nursery, but is considered a satisfactory basis for nursery experiments.

KILLING OF WEEDS IN THE OPEN (RIDES, etc.).

For this purpose part of the area at Parkhill was used. Ordinary agricultural manures were used; strong applications were broadcasted.

Ammonium sulphate, with Calcium nitrate second, was found to be the most satisfactory of these, the amounts required to be used were found to be prohibitive, while the effects were only superficial, i.e., the roots were not affected.

Quantities required to destroy heather vegetation were equivalent to 2½ tons/acre.

All the usual types of "non-poisonous" and some of the less dangerous weed-killers were used.

The results narr w down to the choice of Copper Sulphate and some of the organic "non-poisonous" forms which are all coal or wood-tar derivatives, usually the latter salted with carbonate and Chloride of Soda.

Tests of these are as follows:-

A_0 Copper Sulphate 1.0 % Solu; A_1 - 2.5 %; A_2 - 5.0%.

B. McDougall's Non-poisonous Weed Killer 1 to 25.

C_0 Cresol (Commercial) 1 to 10; C_1 1 to 20.

D_0 Coal tar Creosote 1 to 10; D_1 1 to 20.

All were applied at the rate of 1 quart/sq. yard.

Results -

A_0 Only very partially successful; regrowth soon afterwards commenced.

A_1 Better than A_0 but not quite satisfactory.

A_2 Practically all the green vegetation was killed but regrowth started in two months.

B. More satisfactory than A_2 the deeper rooted species like

Cotton-grass escaped and growth began again. (Grass tested in this way remained withered all summer).

C_o & C. Both inferior to B, but similar.

D_o Irregular in its action (owing to difficulty in emulsifying %) but on the whole equal to B; must be kept agitated during application. D_1 similar to C_o.

All these were used when the ground was fairly dry.

(It may be noted that a new weed-killer was put on the market this season; it consists mainly of Salt and Sodium Chlorate, this latter substance is fairly expensive to purchase so that the weedkiller is probably a by-product. Inquiries regarding Sodium Chlorate as a waste product have been so far unsuccessful; but so far as rough tests indicate it seems to be more effective than other commercial types of weedkillers and more lasting).

Conclusions are that the killing of weeds along rides by chemical means is probably too expensive to be attempted as a general practice. Data are not to hand as to present costs but the following are the costs of material for cleaning as above noted.

A_2	...	£40 / ac.	Approximate figures.
B	...	£30 / ac.	
C_o	...	£43 / ac.	
D_o	...	£27 / ac.	

WORK CARRIED OUT IN ADDITION TO THE ABOVE AND AS PART OF THE INVESTIGATIONS RECORDED BUT NOT YET SUITABLE FOR INCLUSION IN THE REPORT WAS:

Compilation of vegetation records for comparative purposes in connection with different localities, effects of grazing, effects of drainage, treatment of soil in planting, and partial analyses of samples in connection with these.

A visit was paid at Mr. Scott's wish to the area at Culloden Moor. This area as a whole is not peat in the usual sense of the term. Actually the surface blanket consists of a thin layer of dry peat on a shallow layer of slightly decomposed boulder-clay overlying a boulder-clay formation which may be best described as a cement pan, the subsoil being packed together by physical agencies into a layer of at least some feet in depth and as impervious to moisture and plant roots as a pan. The flatness of the area gives bad drainage, the thinness of the loose soil causes rapid drying so that in one half of the year it is bone dry, in the other it is waterlogged. Extreme fluctuation in water conditions of this type is worse than continual drought or wetness so that thorough drainage would require to be assured. Planting operations to have any chance of success should include the opening up of pits before winter and Scots pine would apparently have more chance of success than any other species, although Spruce might come up as a secondary species under shelter from the main crop, in wetter hollows.

APPENDICES.

Reducing powers of Peats of various types (Sub-surface).

Type.	Reducing power % of dry Wt. Maximum.		Minimum.
1. Scirpus (Deep peat)	25.3		11.7
2. Water logged Sphagnum		27 ±	
3. Eriophorum vaginatum (Deep peat)	23.8		11.0
4. Shallower "Mixed vegetation"	16.3		9.1
5. Poorer Molinia types	10.5		2.3
6. Better tufted Molinia	4.6		2.2
7. Molinia Rush	4.3		1.7
8. Rush flush	4.2		1.7
9. "Dry" Knolls	9.7		5.4

A Series in three types (near each other).

	Scirpus	Molinia	Molinia Rush (Bad Smelling)
@ Surface)	6.2	2.7	2.7
@ 3 ins.)	20.4	4.1	8.6
@ 6 ins.)	21.3	7.7	5.3
@ 12 ins.)	21.3	13.3	12.9
@ 2 ft.)	22.0	20.7	21.4

Surface of "Dry" peats (East coast).

Before rain.	After rain.	Two days after.
6.6	5.3	7.3
6.2	5.9	6.3
4.9	4.6	5.7

Other examples were found to be irregular, e.g. in a similar peat.

5.7	5.9	5.7
5.8	5.8	6.3

Hydrogen Ion concentration Determinations.

p H value ± 4 Very strongly acid.

± 6 Acid.

7.2 Neutral.

Selection from different peat types comparing results obtained by different methods.

	Electrometric.		Colorimetric.	
No.	Wet.	After drying.	Wet.	After drying.
1	3.8	3.2	3.8	3.2
2.	3.95	3.8	3.7	3.8
3.	3.8	3.35	3.8	3.35
4.	4.0	3.7	4.0(+)	3.7 (-)
5.	3.7	3.7	3.7	3.7
6.	3.6	3.25	3.55	3.3
7.	3.8	3.4	3.85	3.4
8.	3.7	3.4	3.7	3.4
9.	3.7	3.3	3.65	3.3
10.	3.6	3.6	3.9	3.8
11.	5.3	5.0	5.3	5.0
12.	5.35	5.2	5.2 (-)	5.15
13.	5.6	5.4	5.8	5.4
14.	5.3	5.3	5.1	5.3
15.	5.2	5.0	5.2	5.1
16.	6.0	6.0	5.9	6.0
17.	4.95	5.0	4.9	4.9
18.	4.05	3.7	4.0	3.7
19.	4.2	3.6	3.9	3.6
20.	4.15	4.0	4.1	3.9
21.	4.3	4.1	4.4	4.0
22.	4.6	4.4	4.4	4.3
23.	4.0	4.0	3.8	4.0

Field p H values from adjacent areas on shallow peat.

Tr.
1. Surface peat.
2. Subsurface peat.
3. Soil below peat.

A. Molinia flush - good spruce.
B. Ridge Grassy heath - Spruce not very good.
C. Dry ridge with Heather and Scirpus - Spruce weak or dead.
D. Rush - Molinia hollow - Good Spruce.
E. Heather-Vaccinium - Spruce not very good.
F. Willow and Birch clump - Spruce very good.

	A.	B.	C.	D.	E.	F.
1.	5.2	4.5	5.0	5.0	3.8	3.8
2.	3.4	3.3	4.5	4.5	5.0	4.5
3.	3.2	3.3	4.2	4.4	6.2	6.2

Examples of variations occurring in peat and the moisture in contact with it.

		Water from		
Scirpus peat (Wet weather);		Sphagnum.	Ditch.	peat.
	3.8	3.6	6.7	4.5
Dry weather	3.8	3.6	4.0	4.0
Molinia peat (Wet weather):				
	4.4	4.0	7.0	6.0 ±
	4.2	4.4	6.4	6.4

(Water from the peat was obtained by making a cutting and collecting clear water from this).

p H Values.

Change due to Season.

Samples from the same localities at different seasons.

	Easter.	August	October.
Scirpus	3.2-3.6	3.0-3.2	3.2
Good Molinia	4.8	4.3-4.6	4.4
Eriophorum	3.6-3.8	3.4	3.6
Scirpus Calluna	3.3-3.5	3.3	3.4-3.6

It is noteworthy that drainage water from the peat area at Inverliever is for the most part approximately neutral. In dry weather it becomes more acid - slightly acid in streams to strongly acid in ditches. The drainage from non peaty areas is usually distinctly acid.

Calcium Acetate acidities of peat types (Round numbers).

Semi aquatic Sphagnum types	40 - 55
Deep Scirpus types	32 - 41
" Eriophorum "	30 - 41
Shallower types (Mixed flora) with a good many exceptions.	30 - 35
Molinia (poor growth)	28 - 38
" Good types	20 - 30
Molinia - Rush	(10)-20- 30

For example a series as for p H value test above (marked Tr); sub-surface peat.

	A.	B.	C.	D.	E.	F.
p H value	3.4	3.3	4.5	4.5	5.0	4.5
Acidity	22.3	37.6	41.1	18.7	29.3	22.6

The second set of figures are a much better record of relative fertility than the p H value figures.

Analyses of peats to indicate the distribution of manure from ditches at Inverliever.

Calcium content and Phosphate per cent of dry weight.

Before application of Manure (Basic Slag)

Lime = ·215 (CaO) Phosphate ·073 (P_2O_5)

(a) After application and at 1 foot from ditch
(b) " " " " 2 feet " "
(c) " " " " $2\frac{1}{2}$ " " "
(d) " " " " 3 " " "
(e) " " " " 4 " " "

α Surface peat to 4 inches.

β Peat just above soil.

	Lime.		Phosphate.	
	α	β	α	β
(a)	.76	.77	.096	.111
(b)	.63	.77	.088	.099
(c)	.59	.75	.089	.094
(d)	.28	.39	.070	.073
(e)	.22	.16	.070	.067

The lower figures in β (e) are due to a larger quantity of ash (mineral soil) in the peat.

REPORT ON ENTOMOLOGICAL WORK.

1924 - 1925.

INDEX

Report on Entomological Work during 1924-25.

The entomological work carried out this year has been modified by my transfer to Oxford. The experimental work laid down in the Working Plan has been slightly modified but, except that thinning experiments and spraying experiments against Chermes cooleyi have not been carried out for reasons given below, the trend of the work is unaltered.

Pine Weevil.

Two experiments were proposed here and both have been carried out but have been modified by local circumstances. They were designed to show -

1. Whether trapping during felling will prevent or reduce weevil infestation in the stumps.

2. Whether trapping prior to felling will prevent or reduce weevil infestation when felling has taken place.

Because felling in Hawkhill was governed by local circumstances it was not possible definitely to restrict the work to these two experiments and these have become merged into the more general question whether trapping before or during felling is more effective than trapping after felling. It is too soon at this date to state a definite conclusion but the observations made indicate that early trapping is an advantage.

The area was visited fortnightly in December, once in January and on February 4th the first fellings were made. At this season, no weevils were to be found, although careful search was made in the standing pine belts. In March and April the weevil was still in hibernation but Myelophilus was active in felled stems in the middle of April.

The first active weevils were found on May 14th under branches or tops lying on the ground as follows:-

Group No.1. 1 female Hylobius. Ovaries fully developed.

" No.2. No weevil and no signs of feeding on logs or branches.

" No.3 do. do.

" No.4 & 5 do. do.

Group No.6. 2 female weevils both mature. On another log a gnawed patch occurred and adjoining it a small excavation containing 1 egg.

" No.7 No weevil and no signs of feeding on logs or branches.

" No.8 1 male *Hylobius*. 2 gnawed patches.
" No.9 1 " " but no sign of feeding.
" No.10 No weevil, no feeding.

" No.11 3 female weevils, 2 males. Numerous gnawed patches but no egg holes.

" No.12 No weevil, no feeding.

From these records it may be assumed that at that date the weevil was just appearing after hibernating and trapping was therefore begun as soon as the logs were removed to the sawmill. From May 18th to May 28th few weevils were found and no exact record was kept until May 28th when the weevils collected were as follows :-

May 28th	137
June 2nd	145
" 5th	174
" 8th	83
" 11th	109
Total	648

These records are significant. They show to what extent *Hylobius* does occur in standing woods for there is no reason to suppose that these weevils represent a migration or an invasion. Unfortunately time did not permit of examination by dissection of all the weevils taken but as on May 14th the female weevils examined were heavy with eggs and therefore in a condition when they are very sluggish it may safely be assumed that these represent the normal *Hylobius* population in these Hawkhill belts. We have too the experimental work at Montreathmont Muir to support us in this assumption.

The Hawkhill belts were formed by severance cuttings in 1915-16. In 1919 I reported on the area. In 1920 the stumps resulting from the 1915-16 felling no longer harboured the weevil and the population now present must be living in the standing woods and be the offspring of weevils living in the woods.

The final results of the experimental work will not be available until next year but meanwhile the results obtained so far are of interest. I have thought that they can best be assessed and interpreted by comparison with results obtained in other areas. Figures of the numbers of weevils collected in trapping are available for the Culbin and Port Clair areas and if these figures are plotted against those from Hawkhill interesting results are obtained. How far the interpretation of these results is reliable, further results to be obtained next June will show.

In a felled area where trapping is delayed for some time after felling the numbers of weevils trapped rise rapidly from May to June and July and then fall until in September trapping ceases to be effective. This has been observed in Surrey (Bagshot) the New Forest, Rendlesham (Suffolk),Montreathmont Muir (Forfarshire),Port Clair (Inverness)and Culbin (Elgin.)

The accompanying graphs indicate the different conditions prevailing in Hawkhill and at Culbin and Port Clair. In those areas where trapping is being carried out one or more years after felling the curve rises steadily reaching its maximum in June and July then falls, until in September when no weevils are found it drops to zero. In Hawkhill the curve is much less regular and its maximum is reached in May with a second rise in June and July.

The interpretation I make of the two types of curve is as follows :-

In the felled area of a year or more the numbers of weevils caught rise steadily first as the weevils emerge from their winter quarters and then as they emerge from their pupal cells. These recently emerged weevils are the cause of the height of the curve in June and July as has been proved by dissection of weevils at Montreathmont Muir, Monaughty, Culbin and Rendlesham. After mid-summer no further weevils emerge and* their numbers in the traps fall.

At Hawkhill the curve shows a rise in May then a sudden fall, due I surmise to a hot spell of weather causing the weevils to seek shelter in the soil, then comes a rise and then a fall. This last fall I interpret as indicating that most of the weevils emerging from winter quarters were trapped. Then the weevils recently emerged from the pupal state appear and the curve rises in the end of June and then drops.

If my interpretation of the curve is correct it shows two important features, first that the number of weevils hibernating in a standing wood is limited and second that in Hawkhill the weevil population is declining because while in old felled areas the June July population exceeds the May population at Hawkhill it is less.

In the graph shown for Hawkhill the total numbers of weevils taken on the area have been used. If the numbers in individual belts are considered the rise and fall in numbers is equally marked. Nine belts were utilised in the experiment of which Nos.1 to 4 were the first felled. The figures for the individual belts are as follows :-

Date.		Belt Nos.								
		1.	2.	3.	4.	5.	6.	7.	8.	9.
June	15th	17	18	24	18	4	4	1	-	-
"	18th	8	11	17	7		2	-	-	-
"	22nd	6	9	11	6	2	1	2	-	-
"	25th	5	9	10	8	2	2	-	-	-
"	29th	16	20	40	17	8	10	9	-	-
July	3rd	-	18	22	24	-	-	-	-	-
"	6th	-	4	3	-	-	-	-	-	-
"	9th	6	3	8	-	-	-	-	-	-
"	13th	3	10	7	6					
"	16th	6	5	8	-	-	-	2	-	-
"	20th	2	8	5	7	-	-	-	-	-
"	23rd	-	4	3	7	-	-	-	-	-

In belts Nos.5,6,7,8 and 9, few weevils were taken and in Nos.5,6 and 7 the highest numbers were taken when the belts were felled. All my observations indicate that there was a gradual concentration of the weevils into the felled belts and this was to be expected.

From the numbers of weevils trapped it is evident that early trapping will prove economical but the best evidence is to be found in the number of weevil larvae found in the new stumps. A few stumps were examined in June but as detailed microscope examination of the various weevil and bark-beetle larvae found in the stumps was necessary to identify *Hylobius* from *Pissodes* and *Hylurgops* further assessment of their numbers has been deferred until winter by which time a marked difference in size of the larvae of *Hylobius* and the others will make counts easy.

Meanwhile it is anticipated that such weevil larvae as do occur in the stumps will be few in number and situated in the upper part of the stump where peeling will destroy them. The questions will be decided this winter.

Pine Shoot Beetle.

Examination of felled stems was made throughout the summer and the best times for barking them to destroy *Myelophilus* were determined.

Chermes cooleyi.

The work proposed on Chermes cooleyi was to assess its status as a pest of Douglas fir and to carry out experiments in spraying and thinning. These experiments have been deferred after consultation with the Experiments Officer because there was not then sufficient evidence to base experimental work on.

Spraying has been carried out by Mr Felton at Lining Wood but it is as yet too soon to see any result which ought however to be visible next spring.

Thinning at Lining Wood has been deferred because in the site proposed a marked decrease in Chermes infestation has already taken place height-growth has improved and until growth conditions are stabilised experimental work cannot safely be done. It is proposed to consider the whole question of thinning with the Experiments and Sample Plot Officer in January on the ground.

In Experiment No.4 relating to the occurrence and spread of *C.cooleyi* in mixed plantation of Douglas fir and Thuja definite results cannot be obtained until the plantation closes more and the whole question of the occurrence of C.cooleyi and its capacity for injury must be determined by extended observation from year to year.

Observations made this year have shown that two aspects of cooleyi infestation are important namely the type of tree attacked and the weather conditions. The first aspect is most evident at Lake Vyrnwy on which the following observations were made :-

1. That the Chermes occurs sporadically throughout the whole of the plantations.

2. That in places and on certain trees infestation is severe.

3. That there is no evidence yet that it is causing appreciable injury except on certain trees.

4. That there is no justification for extensive felling of groups of trees or of plantations in order to check the spread.

5. That ladybirds occur on heavily infested trees in great numbers.

The most important point is (2) that in places and on certain trees infestation is severe.

At least two types of Douglas fir occur in the plantations These were distinguished as follows :-

Type A. Fast growing, branches almost horizontal; cones long with long tongued bracts. Apices of buds pointed not markedly resinous. Colour pale green to bluish green. Needles long and horizontal.

Type B. Slower growing with branches more erect and internodes shorter. Cones shorter with short tongued bracts. Apices of buds bluntly rounded more resinous. Foliage dark green, needles shorter and denser tending to curl downwards. Between these two fairly well marked types intermediate forms occur but for the present purpose these may be passed over. The important point in recognising the two types is that Type A. even when it occurs side by side with Type B. is always only slightly affected and infested by the Chermes while Type B. if it is infested at all is heavily infested. In counts made at random the numbers of individual larvae on small twigs of Types A and B were as 1 to 10 to 1 to 40.

Another point worth noting is that the Type B. is slowing off in growth apart from Chermes infestation and Mr Carsley tells me that it is only within recent years that these types have been definitely distinct. In his view and in mine the two types become more distinct when they attain the ages of 15 to 20 years.

A comparison of type B. from Lake Vyrnwy with a Douglas fir shoot from Lining Wood, Forest of Dean shows that this type occurs in Lining Wood and the question arises whether in considering the <u>cooleyi</u> problem it is not of importance to consider the types of Douglas fir. If there is a type corresponding to this Lake Vyrnwy type B, which falls off in growth at 15 to 20 years and which is especially infested by the Chermes it is important to recognise it and to give it consideration when assessing the status of <u>C.cooleyi</u>.

At Lake Vyrnwy the two types of Douglas fir are mixed in the plantations or occur in groups as on the South side of the lake. Generally it appears that the type B trees are acting as the chief centres of infestation and it seems probable that the most useful action to be taken against the Chermes is gradually to remove these trees, from time to time as far as the density of the stands permit. The removal of groups of infested trees is not advisable as there is risk of wind damage. My opinion is that the best results in checking the spread of the Chermes will be got by removing the B type or other badly infested trees in the course of thinning operations. The wide, sporadic, distribution of the Chermes renders the complete removal of infested trees impracticable.

In inspecting the Vyrnwy plantations those to the east of the forester's house were visited first and all along that South side eastwards the Chermes was found. It was most obvious along the roads and rides but occurred also in the hearts of the plantations. It is present in both of Mr Mac Donald's sample plots and doubtless his records of these plots will show how far the recognition of A and B type trees is sound silviculturally.

West of the forester's house the Chermes occurs to the end of the lake and is prevalent throughout Plantations 16 and 17.

On the North side of the lake inspection was begun at Bridge Cover (Plantation 39) where infestation is most severe. Westwards the Chermes occurs here and there and extends into Sections 2 and 4 up the small valley on the right. In Section 2 the Chermes occurs chiefly in the valley and becomes less frequent and finally disappears on the higher ground. We climbed to the higher ground through a ride in Section 2 noting the decrease of the Chermes as we went, then returning along the top of Sections 2 and 4 we descended by the margin of Section 4 and in it the Chermes re-appeared about one third of the way down the slope and increased in intensity as we descended. On the larch adjoining this section traces of Large Larch Sawfly work was seen and one caterpillar was found.

From Sections 2 and 4 we worked round the lake to Plantations 16 and 17 and completed the circle of the Lake.

The ladybird beetles found feeding on C.cooleyi at Bridge Cover and on the S.side of the lake occurred in great numbers. Over forty individuals were beaten off one branch. The species is Adalia obliterata L. which is associated with pine woods. I have never before found ladybird beetles in such numbers on Douglas fir and I believe that the presence of this species at Lake Vyrnwy is a most hopeful sign that C.cooleyi may ultimately be kept in check by these beetles. They occur in several places at Vyrnwy and will probably increase in numbers in time. A number have been brought to Oxford for rearing purposes and when more is known of their life-history it may be possible to increase their range and numbers artificially.

Taking all my observations at Vyrnwy I think that it would be unwise to take too serious a view of the attacks of Chermes cooleyi. While some trees show marked ill effects due to the presence of the Chermes others show no ill effects and those which are heavily infested belong to a type which is, even when not attacked by the Chermes, slowing down in its rate of growth and developing a habit which precludes such trees from forming any important part of the final crop.

This observation is quite in keeping with the results of recent work on the Aphides in general namely that races of plants occur which are favoured by the aphides and that the elimination of such plant races or types is a sound line of control. Further there is reason to hope that the ladybird beetle <u>Adalia obliterata</u> may increase in numbers and ultimately reduce the status of <u>C.cooleyi</u> to that of the larch and pine Chermes where serious injuries result only in circumstances unusually adverse to the trees concerned.

The conditions at Vyrnwy suggest two lines for control first the elimination of poor type Douglas firs from our plantations and greater insistence on the proper selection of seed trees and second study and encouragement of <u>Adalia obliterata</u>. Until these matters have received more consideration it would be unwise to conclude that the <u>Chermes cooleyi</u> problem is as serious as that of Dreyfusia nusslini on the Silver fir.

At Lining wood the same conditions occur as at Vyrnwy except that the Type B. Douglas fir is much the more common.

At High Meadow the Type A. fir dominates and it is interesting to find that in High Meadow and in Bunjups Wood there is marked recovery this year from <u>cooleyi</u> attack. At Bunjups the recovery is slow represented only by a few inches, better height growth but in High Meadow in the Simon's Yat section the recovery of groups of trees which in 1921 looked almost beyond recovery is most marked.

Another aspect of the <u>Chermes cooleyi question</u> has been studied namely that of insects predaceous on <u>C.cooleyi</u>. The most significant result of that study was that compared with larch, pine and spruce plantations in the same locality, Douglas fir plantations are exceedingly poor in ladybird beetles and hover flies and further when ladybird beetles do occur they are confined to the genus <u>Adalia</u> the beetles found at Vyrnwy.

Now *Adalia* is of all the smaller ladybird beetles the most varied in its prey and there is a hope that it may continue to inhabit Douglas fir plantations in increasing numbers and serve as a check on *C.cooleyi*.

Mr Chrystal has investigated the effect of the feeding of *C.cooleyi* on the Douglas fir but it is too soon to look for final results. Meanwhile an important effect of the insects feeding is reduction of the starch content in the cells penetrated by the insects stylet.

Oak Tortrix.

Reports sent in by D.O's and my own observations in the New Forest, at Bagshot and Bagley Wood, showed a most marked decline in the prevalence of the Oak Tortrix. No parasites were reared this year and attempts to rear the predaceous beetle *Silpha 4.punctata* failed owing to the hot weather in the first half of June which killed the female beetles.

Owing to the relative scarcity of the Tortrix and the relative abundance of Geometrid caterpillars it was not possible to assess the relative immunely of *Quercus sessiliflora* from attack. Further the flushing of the two oaks varied in different parts of Bagley Wood in some parts *Q.pedunculata* being earlier than *Q.sessiliflora*.

Cockchafer.

Experiments Nos.6,9,10 and 11 were not carried out. No.10 could not be carried out for lack of sulpho-carbonate. Nos.6,10 and 11 were omitted because the flight of the chafers was so small and irregular and spread over such a long period. Furthermore, both at Bushfield and Rapley the majority of the chafer grubs and beetles were destroyed in spring by late digging.

Potassium sulpho-carbonate the chemical required for Experiment No.6 could not be obtained from any of the commercial and manufacturing chemists. Attempts were made to make it in the laboratory from sodium sulphide and carbon bisulphide. It was found however that unless the Sod.sulphate was freshly roasted that no action took place and further that such small quantities as might have been made would be insufficient for the experiment.

Instead of the sulpho-carbonate (No.6) experiment another was substituted using Carbon bisulphide. This insecticide was to be used in protecting nursery experiments from chafer damage and before such protection was undertaken some tests of the $C.S_2$ were desirable.

The experiments were carried out at Bagley Wood with a Vermorel Soil Injector and cockchafer larvae were used.

In the first experiment 16 grubs were used 8 serving as controls. The area treated was about 3 square feet and 20 gms of $C.S_2$ were used. The result on 27th May the day following injection was as follows.

	Dead	Alive(but flabby)
Treated section	5	3
Control	2	6(alive & active)

On 1st June 2 more of the treated grubs were dead and all the control grubs were alive. The effect of the $C.S._2$ was to paralyse the grubs and grubs killed by it did not become black and putrid. The two control grubs which dies rapidly blackened and putrified and it was evident they died from mechanical injury.

In the second experiment fine, sifted soil was used. The $C.S._2$ failed to penetrate it and of 8 grubs treated only 2 were flabby and both recovered.

In the third experiment the same soil was used but was hard packed. 8 grubs were treated and 8 used as controls. 2 injections of 8 gms were made at 6 inches apart. On June 1st all the controls were alive, 6 of the treated grubs were dead and 2 flabby. 1 was alive and active. On June 3rd the 2 flabby grubs were dead.

These experiments confirm the Swiss work with $C.S._2$ injection. Its efficiency is dependent to some extent on the nature of the soil. Its action is slow and irregular but as the protection work carried out in Dr Steven's nursery experiments shows $C.S._2$

is a valuable check on chafer in the nursery. A series of experiments with naphthaline were carried out at Bushfield nursery as set out below. The plots selected were those which last year were heavily attacked by chafer. Owing to delay in obtaining supplies of naphthaline the actual conduct of the experiments took place a fortnight later than the dates shown.

Experiments with Cock-chafer at Bushfield.

Experiment 1.

To test the value of corrosive sublimate against chafer.

The sublimate will be applied as a solution or suspension in water 6 gms. of sublimate to 2 gallons of water (1 part in 1600). This will be applied with an ordinary watering can as follows:-

Plot 25 S.1.C. Corrosive sublimate solution 2 gallons to be applied on the plot on June 22nd.

Plot 25 S.2.C. to be used as a control.

Plot 25 S.3.C. Corrosive sublimate solution 2 gallons to be applied to the plot on June 22nd and again on June 29th.

Plot 25 S.4.C. to be used as a control.

Experiment No.2.

To test the value of naphthaline against chafer.

The naphthaline will be applied between the drills and hoed in.

Plot 25 D.1.C. Naphthaline applied at 2 ozs. per square yard on June 22nd.

Plot D.2.C. Used as control.

Plot D.3.C. Naphthaline applied at 4 ozs. per square yard on June 22nd.

Plot D.4.C. Used as control.

Experiment No.3.

To test the value of naphthaline against cock-chafer.

Plot S.1.B. Naphthaline applied at 20 ozs. per square yard on the following dates. June 22nd. July 6th. July 20th Aug.4th.

Plot S.2.B. used as control.

Plot S.3.B. Naphthaline applied at 4 ozs. per square yard on the following dates. June 22nd. July 6th July 20th Aug. 4th.
Plot S.4.B. Used as control.

The results of these experiments were disappointing as no chafer larvae were found at their close although grubs were certainly present prior to the experiment as shown by fresh injury to the plants. Adult chafers were found in Plots D.3.C. and S.1.B. at a depth of eleven inches unharmed. A number of chafer grubs were destroyed by mice which burrowed for them in May and June.

Naphthaline dug in on 18th August was still present in all the treated plots on the 22nd September but although in the heavily treated plots the flakes were easily seen in the soil the cresylic odour was gone and only the purer naphthaline smell remained. Even in the lightly treated plots the odour was apparent when the soil was rubbed in the hand. No injury was done to the plants by the heavy doses of naphthaline.

These experiments raised the question of the movements of the chafer grubs in the soil. In Dr Stevens's experimental plots at Bushfield the movements of the chafer grubs present baffled all search for them. The same was true in parts of Bagley nursery when search was made in the spruce beds of grubs causing recent damage.

A search through the literature on cockchafer threw little light on the question and as observations were made and grubs collected it became apparent that the chafer problem is more complex than was supposed.

There are at least three chafers present in the nurseries considered namely the cockchafer Melolontha vulgaris, the summer-chafer or Solstice beetle, Rhizotrogus solstitialis and the small brown chafer Serica brunnea.

The occurrence of Serica brunnea was known last year. This year it has been received from the West Coast nurseries, from Elgin and from the Dean and New Forests. It occurred in

Bagley and was responsible there for much more injury to transplants than was *Melolontha*.

The occurrence of *Rhizotrogus* was not discovered until September 24th when contrary to my expectations large numbers of larvae resembling half-grown *Melolontha* grubs were turned up in the lupin breaks at Rapley. On careful examination of these I suspected that they were not Melolonthas and then by comparing them with half-grown Melolontha collected in 1923 I found that they were some other species agreeing most closely with Perris' description of *Rhizotrogus*. At Kew last summer I collected adult *Rhizotrogus* beetles in flight around the Prunus collection and through the courtesy of one of the student gardeners I obtained larvae from that locality. They were half the size of the larvae from Rapley but showed the same arrangement of spines and hairs on the anal segments and there is now no doubt whatever that the Rapley grubs are *Rhizotrogus* grubs.

Later on October 27th I obtained Rhizotrogus grubs and 1st year *Melolontha* grubs at Herbert nursery in the Dean Forest and it is clear that we have in the south of England three species of chafer to deal with and that until more information is available regarding *Rhizotrogus* and *Serica* experimental work is unlikely to prove satisfactory. Enquiries are therefore being made in the New Forest, Dean Forest and at Rapley for specimens of chafer grubs taken this winter when it will be possible to assess the relative importance of the three chafers. Meanwhile it is already evident that *Serica brunnea* is in Scotland far more injurious at present than *Melolontha*.

Megastigmus.

The Commissioners made enquiries regarding Douglas fir seed in September and two sample lots were submitted. They gave the following analysis:-

Glenkindie	Sound seed	36%
	Empty seed	57%
	Megastigmus	7%

10 cases containing 550 seeds were examined.

Beaufort.	Sound seed	8%
	Empty seed	72%
	Megastigmus	20%

14 cones containing 610 seeds were examined.

Furniture Beetles.

At the request of the Forest Products Board the yards of several firms belonging to the High Wycombe Furniture Manufacturers Association were visited and the losses caused by Lyctus and other wood-boring beetles investigated. An investigation along the lines suggested below is under consideration and will shortly be begun.

Several kinds of wood-boring beetle are causing concern to the various High Wycombe firms but of these only one is of vital importance at present. The beetles are:-

1. Ambrosia beetles in American oak and in mahogany. These have cut through the heart wood. The tunnels show no dust, and are blackened with fungus. They vary in diameter from pin-holes to holes ⅛ inch in diameter. They are cut when the wood is green and abandoned on the drying of the wood and are therefore of no importance. It is not possible to state what species are concerned nor is it important at present.

2. A longhorn beetle Callidium variabile F. in English and Polish oak. Larvae and adults of this beetle have been obtained. The larvae are bark-borers but enter the sapwood to the depth of about one inch for pupation. This species is of little importance but its identification has made it possible to relieve the anxiety of the manufacturers as to its capacity for injury in their yards.

3. Powder-post beetles Lyctus species, L.planicollis rarely, L.brunneus abundantly. These beetles occur in American oak and Ash, in English oak and lies commonly in Polish oak. They are the real cause of loss in this trade.

The Lyctus problem at High Wycombe.

Visits to six of the chief yards at High Wycombe have been made and the following summary of the conditions under which losses occur is based on observations made and information obtained in these yards. The yards were :-

Messrs Howland & Sons,

Messrs Parker & Sons,

Messrs A.P.Vine & Co.

Messrs Castle Bros.

Messrs Abbott & Castle,

Mr Wm. Barrett.

Past experience has shown that American Ash and Oak is a main source of introduction of Lyctus beetles into British timber yards and while to-day English oak is more affected by the beetles than American timber there is little doubt that the trouble began with American timber. Unless this is so it is difficult to account for the presence in some of the yards of Lyctus planicollis a species which is indigenous only in the United States.

To what extent Lyctus brunneus the other species, is now established and distributed in Britain and in particular in the country within 100 miles of High Wycombe it is not possible to say and the matter desires attention.

I have had several years experience of collecting timber insects in oak woods in the New Forest, Forest of Dean, Cambridgeshire, Richmond Park and elsewhere and have never yet taken or reared any species of Lyctus from timber in the field. The two species so far recorded from Britain are easily obtained in timber yards and amateur entomologists are unlikely to look for them in the field. A survey of the woods around High Wycombe for Lyctus would be useful as indicating how far the species L.brunneus and L.planicollis do occur in these woods now. The main supplies of English oak to the High Wycombe yards come from Norfolk, Oxfordshire, Sussex, Suffolk, and Hampshire east of the New Forest.

The Lyctus beetles do not attack green timber nor do the beetles bore into seasoned wood. The eggs are laid by the femal beetle in the wood vessels and the female exercises great discrimination in selecting a suitable vessel. Thus heart-wood is never selected for ovi-position and when heart-wood is attacked it is either invaded by larvae from the sapwood or by larvae from sapwood lying in contact with heart-wood.

Thus heart-wood boards lying on sapwood may be invaded by larvae from these.

Open pored woods or woods with large vessels are selected for oviposition by Lyctus and this explains why oak and ash are so largely attacked while beech and elm remain immune.

This feature of Lyctus has too an important bearing on the present heavy infestation of English oak. It would seem that within the last year or two a better type of American oak is imported and little sapwood is sent over. Home oak on the other hand has a high proportion of sapwood and while American manufacturers and High Wycombe manufacturers using American oak can reject the sapwood and so eliminate Lyctus those using English oak cannot do so because its use would no longer be economical.

The Lyctus problem has therefore changed within the last four years from one affecting American timber to one affecting home timber.

Lyctus attacked the timber after seasoning and presumably only after it is converted.

Timber in the board and "dimension" timber (timber roughly shaped prior to finishing into chair legs and arms) rarely shows evidence of the presence of Lyctus. That Lyctus is present in such timber I was able to show in Messrs Castle's yard where dimension timber stacked for drying was heavily infested.

The attacks and damage are first noticed by the furniture makers when timber taken into the drying yard is removed for sawing or assembling. Then small piles of dust are found on the boards or on the pieces of dimension timber and exit holes may occur from which the dust has been thrown.

The timber is now finished up, polished and assembled the more obviously attacked boards or pieces being rejected. The next process is staining and polishing and the furniture goes to the store yard until despatched to the retailer.

The difficulty at High Wycombe is that timber not apparently attacked by the Lyctus beetles is sent out to the retailer, shows signs of the grubs at work in from three to six months and is returned to the maker by the retailer. One firm in the last year spent £500 in replacing such rejected furniture.

To summarise the position it may be said :-

1. That Lyctus is the main and greatest cause of loss.

2. That this loss occurs between the drying and the "assembling" of the furniture.

3. That if timber can be treated to destroy the Lyctus before the furniture is made up a distinct gain will be obtained.

4. Once furniture is built and varnished it is almost, if not wholly immune until wear and tear and especially loosening of the joints allows the beetles access to the vessels of the wood.

Control Measures.

The losses through Lyctus at High Wycombe can be checked by the use of the dry kilns.

Snyder has carried out a series of experiments in such control with results as follows :-

Dry Heat.

Dry heat at 180 F.(70 C.) is fatal to Lyctus larvae and beetles in situ in timber if prolonged above half-an-hour. Such dry temperature discolours the timber and produces brittleness.

Moist Heat.

1. Temperature below 130 F.(60 C.) is not fatal to Lyctus when the temperature of infested ash and oak timber is raised to these temperatures in a kiln by the use of live steam if all parts of the wood have not previously been brought to kiln-drying temperature.

2. Temperatures of 130 F. and upward maintained for 1½ hours, or longer, are fatal to these insects if all parts of the wood infested by them have at the beginning of the exposure to these temperatures been brought to the minimum temperature of 130 F.

3. The standard kiln-drying schedule for ash and oak, to be used for aircraft stock, in a kiln operated by live steam will prove fatal

to the powder-post beetle and will check all damage that is being done to any infested material.

Snyder's experiments were donducted in the U.S.Navy Department's Bureau of Construction and Repair, and the Naval Aircraft Factory in Philadelphia. The kiln used was of the Tremann type.

The problem at High Wycombe is to ascertain what type of kiln will best suit the requirements of the various manufacturers. One firm (Parker & Sons) is prepared to consider the erection of a kiln the others wish to adapt their existing drying stoves but if one firm adopts the dry kiln process the others will follow. Meanwhile the following investigation is required.

1. To repeat Snyder's experiments.
2. To devise a smaller type kiln giving the same results.
3. To demonstrate to the High Wycombe Federation the economy of kiln drying of timber.

Bark-beetles.

The bulletin on bark-beetles has been completed and submitted to the Publications Officer for printing.

Grey Squirrel.

A short report on Grey Squirrel was submitted to Dr Borthwick and has been published in the Transactions of the Royal Scottish Arboricultural Society. Further notes are being collected.

Revision of Leaflets.

The leaflets on Chermes on Conifers and on Megastigmus have been revised. The Chermes cooleyi leaflet is in course of revision.

Advisory Work.

The advisory work is summarised below. The queries have been classified under the Orders to which the insects concerned belong.

Advisory Work.

HEMIPTERA.

Chermesidae.

Chermes cooleyi was submitted for identification and report from Surrey, North Wales, North Ireland, and Laurencekirk those last two constitute new records of the occurrence of C.cooleyi which was not known to occur in Ireland nor north of Dunkeld in Scotland.

Chermes abietis was reported as injurious to young spruce in Surrey but it was apparently confined to plants "hanging back" from other adverse conditions.

Pineus strobi was submitted from Wroxham, Norfolk on ornamental Pinus strobus. Spraying with carbolineum emulsion was recommended. This insect has been unusually prevalent this year in Bagley Wood on Weymouth pines of various ages.

Aphididae.

Aphis abietina was prevalent in nurseries at Orlon, Seaton and Chopwell but was kept in check by spraying with paraffin emulsion. No serious injury was reported.

Lachnus piceae occurred at Orlon and Seaton nurseries in the summer months and was checked by use of a nicotine spray.

LEPIDOPTERA.

Tortrix viridana was the subject of numerous queries. Experiments in spraying with Carbolineum and Lead Arsenate were proposed by Lord Winterton and Sir Philip Sassoon but they were advised that the season was too advanced for Carbolineum spraying and before Arsenate spraying was begun the decline in the prevalence of the Tortrix rendered experimental spraying unnecessary.
Evetria buoliana. Scots pine buds attacked by this species were submitted from Wroxham, Norfolk. Handpicking was recommended and adopted.

Tortrix forsteieana. This species normally a Vaccinium feeder was submitted from Margam where it had attacked Scots pine.

This was apparently due to an unusual increase in numbers of the caterpillars which attacked the pines after destroying the bilberry It is unlikely to cause serious injury to the pines and the attack will probably subside next season.

Steganoptycha pinicolana. This moth also known as Enarmonia diniana was submitted from the School Division and was the cause of complete defoliation of larch at Cockermouth. The species has occurred in the Border district of Scotland for some years where however it attacks only Scots pine. It is a very serious enemy of the larch in Switzerland and a very careful watch for it has been kept in this country. It occurred at Ghelli in N.Wales in 1919 and is probably widely distributed and should be carefully watched for as it becomes extensively harmful.

Hepialus species. Caterpillars of a Hepialid moth were submitted by Mr. J.M. Murray from Inverliever nursery. It was attacking seedlings and transplants which appeared as if suffering from chafer attacks. No chafer grubs were found and it was evident that the Hepialus was responsible for the damage. Several species of Hepialus, H.humulus, H.lupulinus and H.hectus were submitted as the cause of injury in larch plantations and at Stockley in the New Forest a number of larch, two years planted, have been killed by Hepialus the roots being gnawed severely.

Zeuzera aesculi and Cossus ligniperda were submitted by various correspondents as injurious to oak, ash and beech.

Hybernia defoliaria. This moth was sent in by numerous correspondents from oak. This year it has been a more important oak pest than T.viridana.

Agrotis species. Damage done by cutworms was reported by Messrs Steven, Anderson and others. The worst attack seems to have been in Ampthill nursery. In all cases poison bait was recommended, Fryer's most recent formulae being given.

Mamestra pisi a common bracken moth was sent in by Mr.J.M. Murray as feeding on Sitka Spruce.

COLEOPTERA.

Otiorrhynchus picipes was sent in from many localities. Considerable damage was caused by it at Port Talbot, Bournemouth and the Black Isle. Scots pine from Port Talbot was severely gnawed as if by Hylobius. Beating of the weevils from the plants and trenching of the area to prevent spread was recommended. In the Black Isle the needles and leading shoots of larch, Scots pine and Douglas fir were badly gnawed. The buds of larch and Douglas fir were eaten out and in Scots the bark was gnawed as if by Hylobius. Among the Black Isle weevils sent, two were parasitised probably by the Braconid was Perilitus. At Bournemouth the damage reported was gnawing of Scots pine as by Hylobius. Serica brunnea was submitted by Mr. Murray from the Western Nurseries and from Pitgaveny, Elgin. It is evidently more important than the Cockchafer in Scotland and fuller reference is made to it in the report on Chafers.

Pissodes notatus was submitted by Mr. Hollis from Margam where it was associated with Otiorhynchus damage.

HYMENOPTERA.

Nematus laricis was sent in as injurious to willow at Orsett Hall, Essex.

Croesus septentrionalis was submitted from willow at Beauly by Mr. Fraser.

MISCELLANEOUS.

The following insects of minor importance were submitted for identification.

Pulvinarea betulae, Neuroterus lenticularis, N. numismatis, Biorhiza aptera, Sitodrepa, Scymnus lateralis, Anthocoris spp. and panicea.

(Sgd.) J.W.M.
10/11/25.