R E S E A R C H

Annual Reports 1923 - 24.

Nursery & Plantation Experiments (Eng.& Wales).

" " " (Scotland).

Permanent Sample Plots.

(1) Growth of Scots and Corsican Pine Seedlings.

(11) Germination of Seed.

Comparative growth of Norway and Sitka Spruce Seedlings in ordinary and peaty soils.

Peat Investigations (chemical and physical effect on growth of trees).

Fungus Deseases in Nurseries and Plantations.

Insect Pests in Nurseries and Plantations.

Investigation of the Larch Hybrid.

NURSERY & PLANTATION EXPERIMENTS (England & Wales).

Report on Experimental Work (England & Wales)

November 1924.

The Report consists of :-

Part 1. Introduction.

2. Nursery experiments -

(a) Germination and seedling experiments.

(b) Transplanting experiments.

3. Planting experiments.

PART 1.

The experimental work in England and Wales was carried out until the 14th August 1924 by Mr Guillebaud. From that date Dr Steven was in charge. This Report has been prepared by Dr Steven in collaboration with Mr Guillebaud.

All the Nursery experiments were located in the Bagshot Nurseries. The germination and seedling experiments (Part 2 (a)) were carried out in Bushfield Nursery and the transplanting experiments (Part 2 (b)) in Rapley Nursery.

The experiments in Part 2 (a) have this year been seriously interfered with by pathological agencies. In the early summer the germinating seedlings particularly of European larch but also of Sitka spruce were attacked by damping off fungi and serious loss resulted. During the summer cockchafer larvae (Melolantha species) were numerous in the seedbeds. Surface caterpillars, larvae of the Noctuid moths, Agrostis and Mamestra species were present also. These pests were very destructive. Cockchafer larvae also did damage in one of the Transplanting experiments at Rapley Nursery.

Soil conditions.

Bushfield Nursery Experiments 1924.

The soil has a loam tending to a sandy loam on higher ground. It readily tends to cake if worked when not quite dry and after heavy rain. The soil is deep, 18 inches and over, and rests on sand.

Rapley Nursery. Transplanting Experiments.

The soil here is a light sandy loam. It is about 15" deep where a pan is sometimes met with, but which has been broken by trenching. The subsoil is variable, generally sand, but sometimes clayey.

Weather Conditions.

A Grade III meteorological status was established in Bushfield Nursery in 1923. The following is a summary for the period during which experiments were in progress.

Month.	Temperatures.				Rainfall	Mean Humidity %	No.of days 32° F. Class in screen.
	Mean Max.	Mean Min.	Highest	Lowest	ins.		
Nov.'23	43°F	31°	57°	14°	1.70	84	17
Dec. "	44	33	50	19	2.42	87	13
Jan.'24	44	34	51	25	2.39	85	9
Feb. "	41	31	49	16	.36	84	14
March "	49	33	60	22	.93	83	21
April "	54	36	72	23	3.33	77	12
May "	63	44	75	32	3.22	71	2
June "	67	48	76	35	3.99	74	0
July "	70	49	85	37	3.78	70	0
Aug. "	65	49	75	41	2.69	81	0
Sep. "	63	49	71	35	3.48	81	0

Compared with normal, both temperature and rainfall were deficient in November. The weather in December and January was more or less average. February and March were chiefly notable for very low rainfalls while the temperature was below normal in March. April had an excess of rain and also low temperature. In each of the succeeding months there was an excess of rain of greater or less degree while the temperatures were below normal in all months except May. The weather may be summed up as a cold dry spring and a cold, wet summer.

PART 2.

NURSERY EXPERIMENTS.

(a) Germination and seedling experiments.

Experiment No.1 on Season of sowing.

This experiment was carried out with three species - Douglas fir, Sitka spruce and European larch. The following is a summary of the laboratory germination data for the seed :-

Species	Ident. No.	Method	Germination % at -				Fresh Seed.	Purity.
			10 days	20 days	30 days	40 days		
Douglas fir	24/1	Jacobsen	18	49	65	68	3	96.9
		Hearson	22	57	59	59	2	
		Sand	18	59	74	78		
Sitka spruce	24/15	Jacobsen	10	51	56	-	-	90.6
		Hearson	22	47	49	-	1	
		Sand	19	56	60	-		
European larch	24/11	Jacobsen	23	35	-	-	1	81.3
		Hearson	33	40			4	
		Sand	39	44				

The sowings were made with perforated zinc plates designed by Dr Steven on an American principle. The object of this method was to secure even spacing of the seed and uniform depth of sowing. The area of the plate was 1 sq.ft. and the following numbers of seed per sq.ft. and depths were used :-

Douglas fir	300 seeds	1/8" depth
Sitka spruce	500 "	1/8" "
European larch	500 "	1/[illegible]" "

There were 10 series each consisting of 2 plates hence at each date of sowing 20 plates were sown for each species.

The following are the plant percentages obtained :-

Douglas fir.

Plant %	Dates of Sowing.					
	15/3/24	1/4/24	15/4/24	1/5/24	15/5/24	2/6/24.
Plant % at 25/7/24	17 ± 1.7	18 ± 1.6	8 ± .6	9 ± .5	9 ± .3	6 ± .4

The date of the plant percentage is that of the first count. Even at this date there was cockchafer damage and this increased, vitiating the subsequent count. The low plant percentages are not due mainly to this cause however, the explanation being unknown. The superior results obtained from the earlier sowings are significant statistically and confirm results in previous years.

Sitka spruce.

	Dates of Sowing.					
	17/3/24	2.4.24	16.4.24	2.5.24	15.5.24	3.6.24.
Plant % at 25/7/24.	17 ± 1.2	17 ± 1.5	19 ± .8	30 ± 1.0	16 ± 1.2	41 ± 1.4

The data for this species is complicated by damping off losses before the date of the first count while subsequent counts were vitiated by cockchafer and surface caterpillar losses.

It is probable that the variation in plant percentage is related to the tilth at and after the time of sowing. The soil at the time of the first two sowings was dry. The temperatures were however low and germination did not take place until the end of April. During the latter month there was heavy rain which tended to cake the soil. In the first May and June sowings although heavy rains continued the temperature was higher and enabled more rapid germination to take place. The poor result obtained in the Mid-May sowing is related to the tilth condition at the time of sowing.

The results indicate the sensitiveness of this species to tilth conditions of the soil. (This is further emphasised in a later Experiment No. 17). Preferably this species should not be sown on soils liable to cake. If this must be done the sowing should be made not only when the tilth is very good but at a time when the temperature is likely to be such as to ensure rapid germination.

European Larch.

Plant % at	Dates of Sowing.					
	25.3.24.	3. 4.24.	17.4.24.	3.5.24.	17.5.24.	4.6.2[illegible]
13. 5. 24.	31 ± .5	33 ± .8	26 ± .6	-	-	-
13. 6. 24.	-	-	-	30 ± .6	22 ± .7	-
25. 7. 24.	21 ± .7	20 ± .9	19 ± .7	24 ± .7	13 ± .7	17 ± .[illegible]
9. 9. 24.	14 ± .9	13 ± .8	11 ± .6	16 ± .9	8 ± .7	12 ± .[illegible]

The first count in this case was made while damping off was taking place, but includes the majority of the seedlings germinated. The plant percentages are very high and are obtained from sowings spread over a considerable period namely from 25.3.24 until 3.5.24. The tilth conditions do not appear to have influenced germination.

The subsequent counts are given to show the notable losses which took place from damping off fungi Meria laricis, cockchafer and surface caterpillars.

Experiment No.3 on the influence of shelter on germination losses and subsequent growth of coniferous seedlings.

This experiment was carried out with

(i) Douglas fir
(ii) European Larch
(iii) Sitka spruce.

The seed data for Experiment No.1. applies.

The following two methods were contrasted:-

1. Unsheltered.
2. Shelter consisting of 1" laths spaced ½" apart bound by webbin[g]

The laths were placed 12 - 15" above the soil. The application of the shelter was controlled by the maximum screen temperature. It was applied:-

(i) During germination when temperature rises for more than 2 days above 60°F.

(ii) When germination is well advanced when temperature rise[s] over 70°F.

This season the shelter was used between the following dates:-

May 16th to May 30th.
June 18th to July 2nd
July 8th to July 17th.

The unit of each method was 8 ft. and there were 8 repetitions in scattered plots. The method of sowing was broadcast, at the following densities :-

Douglas fir	1 lb to 120 sq.ft.
European larch	1 lb " 150 "
Sitka spruce	1 lb " 250 "

The sowings were made on the following dates :-

Douglas fir	26. 3. 24.
European larch	29. 4. 24.
Sitka spruce	28. 4. 24.

Unfortunately the European larch and Sitka spruce were attacked by damping off fungi and all three species suffered cockchafer and surface caterpillar damage, before the first count was made on 29th July. In view of the scale of the experiment and the number of repetitions and in the absence of evidence to the contrary it may be assumed that the damage was evenly distributed.

The following are the results at the 29.7.24, the shelters being used last on 17.7.24. The number of seedlings in the sheltered unit is taken as 100 and the unsheltered is expressed by the relative number. This is based on large and carefully analysed data :-

Douglas fir		European larch		Sitka spruce.	
Unsheltered	Sheltered	Unsheltered	Sheltered	Unsheltered	Sheltered.
100	107	100	158	100	144
Diff.+7	± 14	+58	± 18	+44	± 28.

+ denotes in favour of shelter.

In the case of Douglas fir the difference is clearly not significant statistically.

In European larch although the data is in favour of shelter, the variation in results within the experiment are such (as shown by the large probable error) that the result is only just significant in favour of shelter.

For Sitka spruce the same observations apply but in this case the result is not significant statistically.

The conclusion is that for this season with its relatively low temperature shelter was not of appreciable advantage.

Experiment No 17 on the effect of pregermination of seed upon the plant percentage.

The object of this experiment was to test on a field scale the results obtained by Mr Hiley on the benefit of pregermination.

The following species were used :-

(i) European larch
(ii) Sitka spruce

Two methods were contrasted namely -

1. Soaked for 7 days.
2. Incubated for 7 days at 20° C. in a Hearson Incubator.

The study was made at 3 different dates :-

April 11th, April 25th, May 9th.

The seed was sown by the broadcast method. The unit was 8 ft. and there were 10 repetitions in scattered plots. Shelter was applied on the principles laid down in the shelter experiment.

This experiment suffered from the pathological agencies enumerated before. The results are in consequence assessed on the first count made on the 15th July. Losses had however been experienced before that date. It is considered however that these were uniformly distributed.

The following Table gives the results. The pregermination method is taken as 100 and the soaked as the relative number. This is based on large and well analysed data.

Species.	Sown 11/4/24		Sown 25/4/24.		Sown 9.5.24.	
	Preg.	soaked.	Preg.	soaked.	Preg.	Soaked.
European larch	100	132	100	114	100	102
	Diff.	32 ± 9	14	± 12	2	± 4
Sitka spruce	100	181	100	233	100	114
	Diff.	81 ± 12	133	± 29	14	± 3

The results are contrary to what was expected. For the Larch the difference in the case of the first sowing is significant statistically in favour of soaking. The two other sowings gave no significant difference.

ForSitka spruce the soaking treatment gave significantly better results in all three sowings; it being least in the last sowing.

It is worthy of note that in both species germination was only about one half in the second sowing compared with the other two. This is definitely related to tilth at the time of sowing. The ground at the time of the second sowing was wet and caked subsequently becoming very mossy.

A smaller scale experiment on this subject was carried out for Douglas fir. Thirty drills for each of the following treatments were sown from 8th - 12th May 1924 :-

1.Dry seed.
2.Soaked for 7 days.
3.Seed incubated for 11 days at 22°C.

The following productions per lb of seed was obtained with amounts expressed relative to 100 for the pregermination figure.

1. Dry seed	15,500	seedlings per lb.	188
2. Soaked 7 days	16,000	" " "	191
3. Pregermination	8,320	" " "	100

Treatment "3" has obviously been harmful.

Experiment No 6 on Depth of Sowing.

Two species were studied namely Sitka spruce and European larch. The owings were carried out by the zinc plates and pegs of appropriate depths. he following depths were used :-

$\frac{1}{8}"$; $\frac{1}{4}"$; $\frac{3}{8}"$; $\frac{1}{2}"$.

There were 20 scattered plots each with 186 seeds for each depth.

Unfortunately there were serious losses from damping off and cock-hafer before the date of the first count on 1st August. The following re the plant percentages obtained at that date :-

Species.	Plant % and Probable Error of Mean for depths of.			
	$\frac{1}{8}"$	$\frac{1}{4}"$	$\frac{3}{8}"$	$\frac{1}{2}"$
European larch	14% $\pm$ .9	12% $\pm$ 1.0	8% $\pm$ .8	11% $\pm$ 1.1
Sitka spruce	9 $\pm$ .5	4 $\pm$ .4	.5 $\pm$ .1	nil

Definite conclusions cannot be drawn but the data indicates the advantages of the shallower depths.

Experiment on the effect of different kinds of soil for covering seed on subsequent weed growth.

A small preliminary experiment on this subject was carried out. Two coniferous species were sown namely Sitka spruce and European larch and covered with soil as follows :-

1. Ordinary nursery bed soil.
2. A soil with a larger percentage of humus.
3. Soil No 2. treated with 1% solution of copper sulphate. 1 gall. of liquid was applied to about $2\frac{1}{2}$ cubic feet of soil, before use.

The germination of the coniferous seed showed that the treatment had had o adverse influence on germination.

The following Table gives the time taken of 1 man to weed each plot of 1 sq.ft :-

Species and Treatment.		1st Weeding	2nd Weeding.
Sitka spruce	Bed soil	12 min.	15 min.
"	Humus	43 "	14 "
"	Humus & $CuSO_4$	8 "	8 "
European larch	Bed soil	29 "	22 "
"	Humus	45 "	13 "
"	Humus & $CuSO_4$	4 "	6 "

The weedy nature of the humus soil is demonstrated and the data shows the marked influence of the copper sulphate treatment.

Experiment on Mechanical sowing by No 3 Planet Junior Seeder.

Douglas fir and European larch were sown by this seeder with fittings to sow a 3" band as described in previous Scottish Reports. The Douglas fir was sown on 12th May and Larch on 19th May. The Douglas fir seed was pregerminated and mixed with sand for sowing. The larch seed was soaked for 7 days and redleaded.

The machine worked satisfactorily except that the covering was incomplete in some cases.

Germination and growth compare favourably with other stock in the nursery. A plant percentage of 13.5% was obtained for Douglas fir and 13% for European larch.

(13) Transplanting Experiments.

The Transplanting Experiments were directed mainly to the problem of transplanting Corsican pine but experiments dealing with other species were carried out also. As noted previously all the experiments in this category were carried out at Rapley Nursery, Bagshot.

Experiment No 13 on Season of Lining out Corsican Pine.

At each season noted below 10 rows of 160 plants were lined out in 5 scattered plots. The method of transplanting used was the "straight back Trench", at a spacing of 12" between the rows and 3" between the plants. Two types of plant were used :-

(i) 1 yr seedlings.

Raised on the light sandy loam of Rapley Nursery in moderately dense broadcast beds. The plants were small but fairly well rooted. The plants were not specially graded but the roots were lightly pruned.

(ii) 2 yr seedlings.

Raised on a clay loam soil at Bushfield in moderately dense broadcast beds. The plants were average size for their age and fairly well rooted. The plants were not graded but the roots were pruned lightly.

The following Table gives the results :-

Type of Plant	Dates of Lining out.	Loss Percentage & Probable error of mean at	
		17. 4. 24.	22. 9. 24.
1 yr seedlings	14.11.23	Not counted	*13% ± .9
	12.12.23	"	16 ± 1.2
	14. 1.24	"	13 ± 1.2
	12. 2. 24	"	12 ± .9
	11. 3. 24	"	14 ± 1.0
	22. 4. 24	"	52 ± 4.3
2 yr seedlings	14.11.23	29% ± 2.8	49 ± 2.3
	17.12.23	16 ± .7	31 ± 2.0
	14. 1.24	10 ± .8	14 ± .8
	12. 2.24	7 ± .6	18 ± 1.3
	11. 3. 24	10 ± .7	47 ± 3.2
	22. 4. 24	-	45 ± 2.1

* 4% of seedlings lined out at this date were badly thrown by frost.

The results are striking and the following are observations on them.

1. There is a marked difference in the order of the losses in the 1-yr old and 2-yr seedlings. This may be due to the difference in age or to the difference in soil on which the seedlings were raised.

2. In the 1-yr seedlings the losses were low over a prolonged period namely from mid-November to mid-March. Heavy loss occurred from the April lining out.

3. In the 2-yr seedlings the safe period was short namely in January and February. Before and after the losses were high.

4. The two counts showed there were two types of losses namely losses soon after lining out and again later in the season. These could be identified on the ground even in autumn, some plants had died before the buds had burst and apparently without root growth taking place; others had burst their buds and made some growth before death.

5. As far as is known the deaths are not due to pathological causes.

6. The low losses in winter lining out confirms the results obtained and reported on in the previous season.

Experiment No 14 on the effect of Rough Lifting Corsican Pine seedlings.

The object of this Experiment was to determine if one cause of loss in the lining out this species was root damage resulting from lack of care in lifting the seedlings from the seed bed.

At the three seasons noted below 10 rows each of 150 plants were lined out in 5 scattered plots, the seedlings being lifted as follows:

(i) Every care taken in loosening the soil and preventing root damage.

(ii) Soil only loosened sufficiently to prevent the stems breaking while being pulled up.

The observations on method and plants noted for experiment No 13 apply here also.

The following Table gives the results :-

Type of Plant.	Dates of Lining out.	Loss percentage (22.9.24). Probable error of mean when	
		Carefully Lifted.	Roughly Lifted.
1 yr seedlings	19.12.23	13% ± 1.1	13% ± 1.1
	16. 1.24	11 ± 1.7	13 ± 1.1
	13. 3.24	11 ± 1.4	12 ± .7
2 yr seedlings	19.12.23	34 ± 1.1	24 ± 1.8
	16. 1.24	20 ± 1.4	23 ± 1.6
	13.3. 24	84 ± 1.7	61 ± 2.3

The results show that the rough lifting has not had an adverse effect. The differences for the seasons confirm the results obtained in experiment No 13. As far as is known the deaths were not due to pathological causes.

Experiment No 18 on spacing in Transplant Lines.

The undernoted species were studied for two spacing distances namely 1½" x 12" and 3" x 12".

There were 5 scattered plots each of 1 row, 51 feet long.

The straight back trench method was used.

The experiment was carried out on the 5th and 6th March 1924.

The following are notes on the plants used.

Scots pine.

The plants were 2-yr seedlings raised on a clay loam in Bushfield Nursery, in dense broadcast beds. The plants had a stem length of about 4". Culls were excluded.

Corsican pine.

These were 2-yr seedlings raised on same type of soil and conditions at Bushfield as above. The stem length was 2-3". Culls were excluded.

Norway spruce.

2-yr seedlings raised on a sandy loam in Bushfield in dense broadcast bed. Stem length 3-4", culls excluded from experiment.

Douglas fir.

2-yr seedlings raised on a sandy loam in Bushfield in moderately dense broadcast bed. Stem length 4-5". Culls were excluded.

The following Table gives the results as at 23rd September 1924.-

Species.	Loss percentage and Probable Error of Mean for	
	1½" spacing	3" spacing.
Scots pine	39 ± 3.5	32 ± 1.5
Corsican pine	49 ± 3.7	45 ± 1.6
Norway spruce	30 ± 6	20 ± 1.3
Douglas fir	15 ± 5.2	10 ± .6

It should be noted that the efficiency of the gang which carried out this experiment could not be placed high and was probably under average for a production nursery.

The differences in loss between the two spacings are not significant statistically. The average time taken to line out 1 row with a spacing of 1½" was 14 minutes and for a row with 3" spacing 11 minutes twice the number of plants being of course lined out in the former compared with the latter.

Experiment No 19 on the influence of Grading of Seedlings upon losses in the lines.

The following was the grading system used :-

Grade 1. Seedlings one half the maximum shoot length and over with exceptions noted in Grade 3.

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

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

This worked out for the different species as follows :-

Grade	Scots pine	Corsican pine	Norway spruce	Douglas fir
I	over 4"	over 2½"	over 3½"	over 4½"
II	4" & under	2½" & under	3½" & under	4½" & under
III	as defined	as defined	as defined	as defined

Otherwise the notes on plants in Experiment No 18 apply.

The following grades of plants were studied -

(i) Grade I.
(ii) Grades I & II, i.e. Grade III only excluded.
(iii) Grade II

All the above lined out at 7 to a foot in lines.

(iv) Grade II bedded, i.e. 6" between lines and about 1" apar
(v) Grade III.

lined out at 7 to foot.

The straight back trench method was used and the lining out was done from 10th - 12th March 1924 on the same scale as Experiment No.18.

The following are the results at 23rd September 1924.

Species.	Loss percentage and Probable error of mean for				
	Grade I	Grade I & II	Grade II	Grade II bedded.	Grade III.
Scots pine	20% ± 1.8	36% ± 2.9	37% ±1.1	30% ± 1.9	71% ± 2.3
Corsican pine	33 ± 1.0	34 ± 2.4	38 ±2.7	40 ± 2.8	58 ± 2.2
Norway spruce	20 ± 2.4	29 ± 2.0	33 ±1.4	22 ± 3.7	27 ± 1.5
Douglas fir	6 ± 1.2	13 ± 1.5	12 ±1.1	21 ± 2.3	35 ± 2.3

Unfortunately there was a certain amount of cockchafer damage in thi experiment. There is no reason to believe, however, that this was not evenly distributed.

The results are of interest.

1. In Scots pine the loss in Grade I and the high loss in Grade III are significant statistically. The latter is of special importance indi cating that drawn seedlings of this species have a low survival probabili

2. In Corsican pine the losses are low having regard to the date line out. Only the loss for Grade III is significant.

3. The losses for Norway spruce are uniform and not markedly signifi- cant, the death rate even amongst culls not being notable.

4. The losses in Douglas fir are low, the culls here did badly also.

An experiment was designed and carried out to determine the influenc of the rate at which the work of lining out was done. The efficiency of the gang however made it impossible to get a variation and the results show no difference in losses.

Part 3. Planting Experiments.

Experiment No.501 on Season of Planting Corsican pine.

The object of this experiment is to determine what effect the season of planting has on the success of the plants.

The scale of the experiment was a series of plots each of 5 rows of 100 plants for each month from November to May. This series was repeate five times, in scattered plots.

The experiment was carried out at two places namely -

(i) Elvedon, Suffolk.
(ii) Allerston, Yorkshire.

(i) Elvedon.

The following is a summary of temperatures (taken in open and not in screen) and rainfall from March - September 1924.-

Month.	Temperatures in degrees Fah.				Rainfall. inches.
	Mean Max.	Mean Min.	Highest	Lowest.	
March	48.5	38.5	60	27	.64
April	53	47	70	36	2.35
May	65.5	56	76	44	3.30
June	70	65	82	50	1.79
July	73	64	88	57	2.26
August	65	59.5	78	50	2.90
September	64	58	73	53	2.91

As the thermometers were not in a screen the temperatures cannot be compared with "normals". The rainfall was markedly deficient in March, less so in June while there was an excess in all other months.

The soil is a fine sand resting on chalk and carries a bracken-grass herbage.

2-yr 1-yr Corsican pine ex Downham was used. Unfortunately the plants putin in April and May came to Elvedon in March and were heeled in from that month, hence the results for the last two months of the series may not be reliable.

The following Table gives the dates of planting and the percentage of plants surviving at the beginning of October :-

Percentage of surviving plants & Probable Errors for plants planted at.						
29.11.23	19.12.23	15. 1.24	6. 2.24	18. 3.24	3. 4.24	1. 5.24
64% ± 1.1	65% ± 1.5	86% ± .9	64% ± 1.4	38% ± 1.5	48% ± 1.9	54% ± 1.7

Two points stand out first the low loss in January namely 14% and secondly the high losses from March onwards. As noted above the April and May losses may be due to the plants being heeled in but the losses in March are real.

(ii) Allerston.

Maximum and minimum temperatures in the open were taken but these in themselves do not define the normality or otherwise of the season. The season was probably as elsewhere, a dry cold spring and a cold wet summer.

There were two zones of soil running through the plots namely -

(i) A moderately deep sandy loam carrying a bracken-grass herbage.

(ii) A stony gravelly shallow sandy loam carrying a grass herbage.

1-yr 1-yr stock of Corsican pine was used. The January, March and May plants were heeled in for a month in the nursery, i.e. plants for 2 monthly plantings were lifted each time. This mistake is not reflected in the results at least up to March which are as follows :-

Percentage of Plants surviving and probable errors for plants planted at					
19.12.23	16. 1.24	15. 2. 24	14. 3. 24	16. 4.24	2. 5. 24.
76% ± 1.5	74% ± 1.8	76% ± 1.7	78% ± 1.7	77% ± 2.7	57% ± 2.6

It is seen that there is no difference in the losses from December to April, the larger losses in May are significant statistically. This may however be due to the adverse effect of heeling in at that season.

It is interesting to note that, comparing Elvedon with Allerston, the 1-yr 1-yr stock of the latter are more tolerant of season of planting than the 2-yr 1-yr stock of the former. This is in the same time, as the differences noted in the transplanting experiments.

The conclusion obtained in this year's season of planting Corsican pine experiment confirm that obtained last year. During two consecutive seasons winter planting of this species has been found to be safer than spring planting.

The following experiments were carried out by the Divisional staffs on plans prepared by the Experiments Officer. He desires to express his thanks for the co-operation of the Divisional staffs in the establishment of planting experiments.

1. Spacing of Conifers.

(i) Brackley Forest - Division No.1

Species: Sitka spruce spaced 5 ft, 6 ft, 7 ft, & 8 ft.
Corsican pine spaced 4 ft, 5 ft, 6 ft, & 7 ft.

(ii) Rothbury, School Division.

Species: European larch a combination of spacing and age and type of plant. spacing: 5', 6', 7' & 8'.
Types: 1 yr 1 yr, 2 yr 1 yr & 2 yr 2 yr.

(iii) Haldon, Divisions 3 & 4.

Species: Corsican pine, spaced 3, 4 and 5 ft.

(iv) Llantrisant, Divisions 3 & 4.

Species: Corsican pine, spaced 3,4 & 5 ft.

(v) Margam, Divisions 3 & 4.

Species: European larch , spaced 5,6,7 & 8 ft.

(vi) Halwill, Divisions 3 & 4.

Species: Norway spruce 3,4,5 & 6 ft.
Sitka spruce 5,6,7 & 8 ft.

2. Age and Type of Plant.

(vii) Halwill, Divisions 3 & 4.

Species: Norway spruce.
Types: 2 yr, 2 yr 1 yr, 2 yr 2 yr and 2 yr 3 yr.

3. Experimental Plantations.

(viii) Halwill, Divisions 3 & 4.

Methods of planting on boggy ground.

Species: Norway & Sitka spruces.
Methods of planting on boggy ground.

(a) on unscreefed ground.
(b) on screefed ground
(c) on mounds.

(ix) Allerston, Division No.1.

A plantation has been laid out on a moderately exposed heather moor with a pan near the surface. This has been partially broken by ploughing.

The following species have been planted in belts of 4 rows repeated 4 times :-

(i) Scots pine
(ii) Corsican pine
(iii) Norway spruce
(iv) Sitka spruce
(v) European larch
(vi) Japanese larch
(vii) Douglas fir
(viii) Pinus ponderosa.

13. 11. 24.

NURSERY & PLANTATION EXPERIMENTS (Scotland).

Report on Experimental Work (Scotland) November 1924.

The Report is constituted as follows :-

SECTION 1.

Introduction.

The experimental work in Scotland was carried out until 14th August 1924 by Dr Steven and thereafter by Mr Anderson. This Report is a joint one by these officers.

The experiments included in Section 2 were carried out at the Royal Botanic Garden Nursery, Edinburgh and at Beaufort Forest School Nursery, Beauly.

The experiments in Section 3 were carried out at Seaton Nursery, Aberdeen.

Soil conditions in above Nurseries.

Royal Botanic Garden Nursery.

This is a deep sandy loam resting on sand. There is a considerable amount of fine particles on the surface soil which under wet conditions tend to form a very thin surface cake. Previous to 1923 this area was under allotments which received varying treatment as regards crop and manures. This for the present renders the growth results variable in places. The 1924 seed beds are located on ground which carried Larch transplants last year.

Seaton Nursery Aberdeen.

This is a similar soil to the above. The previous cropping does not show the same rapid variation, but the surface is undulating.

Beaufort Forest School Nursery.

A shallow coarse sandy loam resting on fine gravelly sandy loam passing into a coarse gravel.

Weather conditions in the above nurseries.

The following is a summary of the meteorological data for the Royal Botanic Garden Nursery, Edinburgh for the growing season, 1924.

Month	Mean Max. Temp.		Mean Min. Temp.		Highest Temp.		Lowest Temp.		Rainfall.		No. of Days Frost.	
	1924.	Normal.	1924.	Normal	1924.	Normal	1924.	Normal.	1924.	Normal.	1924.	Normal.
March	38.9°F	47.7°F.	30.8°F.	34.9°F	45°F.	59°F.	21.5°F.	26°F.	1.390"	1.76"	23	-
April	47.6	52.6	38	38.1	63.0	64	28.0	29	1.177	1.32	11	-
May	52.8	57.3	43.1	42.8	63.5	70	34.0	34	3.549	1.84	3	-
June	62.8	62.9	48.8	48.4	72.0	76	38.0	41	1.920	1.76	1	-
July	67.7	65.8	53.0	51.4	75.5	76	47.0	44	2.913	2.60	0	-
August	64.9	65.4	50.7	51.2	72.0	75	42.5	43	2.189	3.00	0	-
September	60.5	61.8	48.0	47.6	67.0	71	36.0	37	2.321	1.80	6	-
October	53.3	54.6	43.5	42.1	62.5	65	33.0	31	3.092	2.44	3	-

The data presented enables an accurate comparison between this season's weather and normal to be made. The season has been notable for low maximum temperature, deficient rainfall in March and April and excess thereafter.

The following Table gives a summary for Beaufort Forest School, Beauly. The thermometers are not in a Stevenson screen.

Month 1924.	Mean Max. Temp.	Mean Min. Temp.	Highest Temp.	Lowest Temp.	Rain-fall.
April	54.1°F	35.4°F.	66	22	1.875"
May	59.8	38.4	71	28	5.220
June	63.9	45.2	74	29	2.545
July	69.9	48.8	80	40	3.660
August	64.8	48.5	72	39	4.590
Sept.	61.7	43.0	74	28	5.930

The weather here compared with normal has been notable for an excess of rainfall from May onwards.

For Seaton Nursery only rainfall records are available:-

Jan.1924	2.53"	April	1.17	July	4.33
Feb.	1.19	May	4.60	August	1.78
March	1.05	June	1.60	September	4.44

Rainfall was in excess of normal in January, May, July and September.otherwise deficient. From the point of view of the Transplanting Experiments located in this nursery the wind in the spring was important. Cold, high N.E. and N.W. winds were frequent in March and April.

SECTION 2.

Germination and Seedling Experiments.

Experiment No.15c on Season of Sowing.

This experiment was carried out with three species, Douglas fir, Sitka spruce and European larch at the Royal Botanic Garden Nursery Edinburgh. The following is a summary of the seed data :-

Species	Purity %	Wt. per 1000 seeds in grammes	Germination Percentage - Hearson Incubator at 5 days	10 days	15 days	20 days	25 days	30 days	35 days	40 days
Test at March 1924.										
Douglas fir 24/1	97	8.355	-	11	21	27	39	45	51	59+20
Sitka spruce 24/15	92	2.460	-	39	51	53	53	54+6*		
European larch 24/11	80	5.290	9	41	45	45+5*				
Test June-July 1924.										
Douglas fir	-	-	1	24	34	37	40	45	49	50+26
Sitka spruce	-	-	13	14	32	41	42	43+12*		
European larch	-	-	14	41	42	42+3*				

* Fresh ungerminated seed at conclusion of test.

The sowings were made by specially designed perforated zinc-plates each of an area of 1 square foot. The following numbers of seed were sown per 1 sq.ft. and at the following depths :-

Douglas fir 300 seeds per sq.ft. ¼" depth.
Sitka spruce 500 " " " " ⅛" "
European larch 500 " " " " ¼" "

The unit was 1 plate and there were 12 repetitions in scattored plots. The dates of sowings were from Mid-March to June 1924.

The seed was soaked for 7 days in tap water and redleaded.

Larvae of Serica phylloperthа appeared in a few of the plots in July. The seedlings, whose roots were cut were lifted and the larvae were destroyed. This localised the attack and the experiment was in no way vitiated.

The following Tables give a summary of the results :-

Species.	Dates of Sowing.	Plant percentage and its Probable Error at		
		23.6.24.	15.7.24.	26. 8. 24.
Douglas fir.	11.3.24	33%	47% ± .7	48% ± .8
	3.4.24	8	50 ± .7	52 ± 1.0
	16.4.24	5	54 ± .8	56 ± .9
	11.5.24	2	44 ± .5	49 ± .8
	29.5.24	4	39 ± .6	48 ± .9
		3.6.24.	22.7.24.	29. 8. 24.
Sitka spruce	18.3.24	13%	18% ± .6	18% ± .8
	4.4.24	20	26 ± .7	30 ± .7
	23.4.24	8	31 ± .5	38 ± .7
	13.5.24	-	34 ± .7	36 ± .8
	1.6.24	-	52 ± .7	54 ± .6
		3.6.24.	22.7.24.	29. 8.24
European larch.	1.4.24	17%	14% ± .7	14% ± .7
	17.4.24.	25	22 ± .7	23 ± .6
	19.5.24.	1	16 ± .3	20 ± .5
	2.6.24.	-	39 ± .5	39 ± .5

The results are striking and the following are observations on them :-

1. The plant percentages are high, for the first time they approximate to the laboratory germination percentages. It was thought previously that even under favourable conditions only about one half the laboratory germination can be expected in the nursery for the above species but this year's work shows that much higher plant percentages can be obtained.

2. The results obtained together with the meterological data and continuous observations of the soil conditions show, that surface caking even of a thin layer i.e. 1/10" caused by imperfect tilth at the time of sowing and subsequent heavy rains has a serious inhibiting influence on germination. The different species vary in their sensitiveness to this. In general this season the caking decreased with lateness of sowing.

3. The plant percents of Douglas fir at the end of the season show uniformity. This species is less sensitive to caking than the other two. Reference to the count made in June shows that the plant percent from the March sowing is much higher than the later sowings. If conditions unfavourable to germination had supervened at that date, as in some pre-

vious seasons, this sowing would have been the best. As this is always a probability and as the species is not sensitive to caking early spring sowings of this species will always be safer than late ones.

4. The results for Sitka spruce show an increasing plant percentage with lateness of sowing. On the ground this increase could be related with decrease in caking. Between 19th March and 31st May there were 46 rain days out of a possible of 73. The amount of rain ranged up to .75 inch for 24 hours. The effect of this rain was to form a surface cake on the soil, which increased with the time which elapsed between sowing & complete germination. In June there was also much rain but this was associated with higher temperatures and there was little caking. There appears to be no doubt that this is the factor which operated and caused the high plant percentage for June compared with earlier sowings.

This experiment demonstrates that Sitka spruce is particularly sensitive to the condition of the surface layer of soil. If possible this species should not be sown on soils liable to caking. If this must be done, the sowing should only be made when the tilth is very good and late in the spring. When caking is not a factor previous results have indicated that early sowing is advantageous.

An investigation into cultural and other methods to prevent caking is desirable.

5. European larch shows similar results to Sitka spruce and the above observations apply.

<u>Experiment No 4a on Treatment of seed.</u>

This experiment carried out for Douglas fir in the previous season was repeated this year with Douglas fir, Sitka spruce and European larch, at the Royal Botanic Garden Nursery. The seed data given for experiment 15c apply here also.

The following were the methods of treatment studied :-

1. Dry untreated seed.

2. Seed put into water at 50°C. and allowed to remain for 24 hours, no additional heat being applied.

3. Seed put into tap water for 6 hours and then into a saturated solution of iodine for 18 hours.

4. Seed put into tap water for 6 hours and then into a 1% copper sulphate solution for 18 hours.

5. Seed soaked 2 days in water at 10°C then moist incubated for 5 days at 20°C.

In each case the seed was redleaded before sowing.

The seed was sown by the zinc plate method as for season of sowing and at the same density and depth. The unit was 1 plate which was repeated 10 times in scattered plots.

The dates of sowing were as follows :-

Douglas fir	7th - 14th April 1924.
Sitka spruce	7th - 16th " "
European larch	19th - 26th May "

Species.	Method of Treatment.	Plant % and Probable Error at			
		3. 6.24	23.6.24	24.7.24	28. 8.24
Douglas fir	1. Control	0%	9%	58%	61% ± .9
	2. Water	0	14	56	58 ± .8
	3. Iodine Sol.	0.5	13	65	67 ± .9
	4. Copper sulphate sol.	0.2	6	66	67 ± .8
	5. Moist Incubation.	4	7	58	58 ± 1.0
		3. 6.24	-	25.7.24	1. 9.24
Sitka spruce	1. Control	6%	-	26%	30% ± .8
	2. Water	10	-	32	35 ± .5
	3. Iodine Sol.	7	-	30	34 ± .8
	4. Copper sulphate sol.	4	-	28	34 ± .7
	5. Moist Incubation.	22	-	28	33 ± .5
		14. 6.24	-	25.7.24	1. 9.24
European larch	1. Control.	6%	-	22%	26% ± .6
	2. Water	15	-	29	31 ± .5
	3. Iodine Sol.	32	-	37	38 ± .6
	4. Copper sulphate Sol.	13	-	30	32 ± .6
	5. Moist Incubation.	18	-	16	16 ± .4

The following are observations on these results :-

1. The Douglas fir was sown at a time which proved the optimum for the season and the nursery. The plant percents are however even higher than these obtained in the Experiment 15c on season of sowing. The results are practically identical to those obtained last season. The iodine and copper sulphate give small but statistically significant increases in outturn compared with the control. The very high plant percentage should be noted, it being equivalent to 33,000 1-yr seedlings to 1 lb of seed,

2. The Sitka spruce was sown at a season which resulted in inhibition of germination by caking (see observations in Experiment 15c on season of sowing). It will be noted that all treatments give a small but statistically signifi cant increase in plant percentage over the control. There is no difference in the final count of the different treat ments. No treatment has given the maximum plant percenta obtained in the last sowing of Experiment 15c hence it may be concluded that treatment is not of as great importance as other factors. The relatively high percentage obtaine in Moist Incubation at 31st June should be noted. This was not maintained but would have been of importance if sub sequent conditions had not been favourable to germination.

3. The results for European larch are more striking than f the other two species. The moist incubation treatment was unsatisfactory as the sowing was held up owing to unfavour able weather and the pregermination had proceeded too far. Treatments 2 and 4 gave statistically significant improve- ments over the control. The best result was however give by the Iodine treatment. In the case of this species thi treatment had a marked stimulating effect causing earlier germination and a higher plant percentage. It is true th in Experiment 15c in season of sowing the seed soaked for 7 days and sown about the same time gave a similar plant percent to that of the iodine treatment. Even if we assum that the iodine treatment is no better than 7 days soaking as regards outturn it has an advantage in being only a 1 da treatment.

4. Taking the detailed evidence over two years we conclude that treatment of seed before sowing has an influence on rate and amount of germination. That influence, however, is not sufficient to override adverse factors such as un- favourable weather and soil conditions. The data indicate that the iodine treatment is at least as good as any. It is simple and short and has given improvements in outturn.

Experiment No 26 on the Influence of Depth of Sowing.

This Experiment was carried out at the Royal Botanic Garden with Douglas fir, Sitka spruce and European larch. Th seed data given for Experiment No. 15c applies here.

The following depths of sowing were studied :-

Douglas fir	$\frac{1}{4}$", $\frac{1}{2}$", $\frac{3}{4}$", 1".
Sitka spruce	$\frac{1}{8}$". $\frac{1}{4}$", $\frac{1}{3}$", $\frac{3}{8}$".
European larch	-do-

The sowings were made by the zinc plate method with pegs of appropriate depths so that the depths were correct for each depth and individual seed. There were ten repetitions of the one which was 2 rows of 50 seeds.

The sowings were made at the following dates :-

Douglas fir	25. 4. 24.
Sitka spruce	23. 5. 24.
European larch	28. 5. 24.

It will be noted that these dates approached to what proved to be the optima for this season.

The seed was soaked for 7 days and red leaded.

The following Table summarises the results :-

Species.	Depth of Sowing.	Plant Percentage and its probable Error of Mean at.		
		23.6.24	15.7.24	26.8.24
Douglas fir	$\frac{1}{4}$"	0%	50%	54% $\pm$ 1.2
	$\frac{1}{2}$"	0	45	48 $\pm$ 1.1
	$\frac{3}{4}$"	0	35	42 $\pm$ 1.5
	1"	0	16	22 $\pm$ .8
Sitka spruce	$\frac{1}{8}$"	23%	32%	35% $\pm$ 2.0
	$\frac{1}{4}$"	21	35	38 $\pm$ 1.1
	$\frac{1}{2}$"	11	28	31 $\pm$ 1.2
	$\frac{3}{4}$"	2	15	17 $\pm$ .5
		23.6.24	22.7.24	26.8.24
European larch	$\frac{1}{8}$"	35%	39%	39% $\pm$ 1.4
	$\frac{1}{4}$"	30	35	36 $\pm$ 1.1
	$\frac{1}{2}$"	18	21	22 $\pm$ 1.1
	$\frac{3}{4}$"	0	1	1 $\pm$ .2

The following are observations on these results.

1. For Douglas fir the plant % for the $\frac{1}{4}$" depth is highest and statistically significant. It should be noted that up to $\frac{3}{4}$" good plant percentages were obtained, hence on a sandy loam, too deep sowing is not likely to be an important cause of low outturn for this species.

2. For Sitka spruce the differences between $\frac{1}{8}$" and $\frac{1}{4}$" depths are not statistically significant hence the optimum depth for this species with the soil and weather conditions studied may be taken as $\frac{1}{8}$" - $\frac{1}{4}$". A depth of $\frac{1}{2}$" is the critical depth for this species, beyond which the plant % falls sharply.

3. For European larch the observations for Sitka spruce apply but $\frac{1}{4}$" is the critical depth hence special care should be taken against sowing this species too deeply.

Experiment No.12 on the influence of Method and Density of Sowing on Quantity and Quality of plant.

(1) Corsican pine.

An experiment on this subject and species was begun in May 1922 at Seaton Nursery, Aberdeen and the 2 yr seedlings were lifted and analysed this spring. Three methods were studied :-

(i) Broadcast.
(ii) Drill, 1½" drills spaced 4½" apart across the bed.
(iii) Band, 4" wide spaced 4" apart across the bed.

The following were the amounts of seed sown per bed 12 ft x 4 ft:-

Broadcast.		Drill.		Band.	
Bed 1	4 ozs.	Bed 5	2 ozs.	Bed 9.	2 ozs.
2	6 "	6	4 "	10	4 "
3	8 "	7	6 "	11	6 "
4	12 "	8	8 "	12	8 "

The seed was ex Corsica, Identification No.22/11, Puri[ty] 100% Germination capacity 85%. It was soaked 6 days, redleaded and sown 6-8th May 1922. Germination was good and even and the seedlings were unprotected agai[nst] frost lift, which did no damage.

The following Table gives the productions obtain[ed]

Broadcast.			Drill.			Band.		
Bed No.	No.of Seed-lings per bed.	Produc-tion per lb.	Bed No.	No.of Seed-lings per bed.	Produc-tion per lb.	Bed No.	No.of Seedlings per bed.	Produ[c]tion [per] lb.
1	4080	16,320	5	2144	17,152	9	1962	15,7[..]
2	5958	15,888	6	3573	14,292	10	3723	14,8[..]
3	7903	15,808	7	4774	12,728	11	5383	14,35[.]
4	10477	13,968	8	6687	13,374	12	6747	13,49[.]

It will be noted that there is a progressive de-crease in production per lb with increasing density. Th[ere] is no marked difference in production in the 3 methods which was not to be expected in the absence of frost li[ft] damage.

The plants were divided into two grades :-

Grade 1. Good plants suitable for lining out.
2. Drawn, suppressed, forked, diseased and badly rooted plants.

Lophodermium pinastri was present on seedlings in all methods and densities.

The following Table gives the percentage of Grade plants in each Method and density :-

Broadcast.		Drill.		Band.	
Bed & Density No.	Percentage Grade I Plants & P.E.	Bed & Density No.	Percentage Grade I Plants & P.E.	Bed & Density No.	Percentage & Grade I Plants & P.E.
1	56% ± 3	5	30 ± 2	9	35 ± 2
2	45 ± 2	6	33 ± 1	10	53 ± 2
3	38 ± 1	7	24 ± 2	11	52 ± 1
4	22 ± 2	8	39 ± 2	12	39 ± 2

The following are observations on the data 1.

1. It is seen that Corsican pine did not respond favourably to the Drill method of sowing.

2. It is clear that this species is adversely affected by heavy densities. The best result was obtained in the highest band sowing which was a sowing of 1 lb to 384 sq.ft. and a seedling density of 41 seedlings per square foot. The next best was the lightest broadcast which was 1 lb to 192 sq.ft. and 85 seedlings per square foot. Taking the net area on which the seedlings were growing these densities were the same. It is probable that even thinner crops would have given better results but these may be taken as maximum densities.

3. The influence of density of sowing on subsequent losses and growth on the lines is being studied. Samples from each method and extremes of density were lined out.

(ii) Douglas fir.

This species is being studied at the Royal Botanic Garden Nursery and the 2-yr seedlings are due to be lifted next spring.

(iii) European larch.

An experiment on this species was begun this spring at the Royal Botanic Garden Nursery and gives promise of good results.

Registered Experiment No.17a on the influence of Humus manures on coniferous seedlings on "new" ground.

In view of the generally unsatisfactory growth on coniferous stock on ground which has not previously carried coniferous crops, an experiment on this subject was begun at Beaufort Forest School, Beauly in May 1922. Under Mr James Fraser's supervision the ground previously carried agricultural crops, for soil description see "Introduction".

The following 5 treatments were given :-

1. Control, no manure

2. Ammonium sulphate at rate of 1½ oz.per sq.yd.

3. Scots pine humus & forest soil at rate of 10 lb per sq.yd

4. Mixed hardwood humus at rate of 10 lbs per sq.yd.

5. Peat dust from heather moor peat at rate of 10 lbs per sq.yd

These manures were applied in May before sowing and worked into the soil. There were 5 scattered plots, each of 6 drills, for each species and treatment. The following species were used to assess the manurial effect:-

(i) Scots pine sown at a density of 320 sq.ft.to 1 lb. (drill method).
(ii) Norway spruce " " " 335 " "

Germination and growth was very good and full crops were obtained. There were no disturbing factors.

The seedlings were lifted in spring 1924. The plants in each drill were weighed and graded as follows :-

Grade I - over 3 ins. shoot length
Grade II - 3" and under.
Grade III - Culls

The following Table summarises the results :-

Species.	Treatment.	Wt. in lbs per thousand plants.	Percentage of Grade I plants
Scots pine	1. Control.	11.7	67%
	2. Ammonium sulphate	10.9	63%
	3. Pine humus	10.6	75%
	4. Hardwood humus	12.5	80%
	5. Peat	12.0	72%
Spruce	1. Control	3.6	24%
	2. Ammonium sulphate	3.1	23%
	3. Pine humus	4.3	28%
	4. Hardwood humus	3.9	23%
	5. Peat	5.0	30%

In the case of Scots pine the treatments have not had pronounced influence. Hardwood humus has however given a small but statistically significant improvement. The growth in general was good and yields of over 25,000 2-yr seedlings per lb were obtained.

For spruce the results are more striking. Both pine humus and peat have given increases in weight and size which are significant. In yield also these treatments gave significant increases while ammonium sulphate reduced the yield by a significant number.

The conclusion is that on this soil pine humus and peat have had beneficial effects on Norway spruce in increase of size, weight and yield. Ammonium sulphate have had an adverse influence. Other experiments on this subject are in progress.

Registered Experiment No.23 on the influence of Half-shade on the size of Sitka spruce seedlings.

The object of this experiment is to determine whether continuous summer shade increases the size of Sitka spruce seedlings. It is a repetition of an experiment carried out last year. Last year the shade was applied continuously from the time of sowing and tended to delay germination. This year the shade was applied in mid-June after germination had been proceeding for three weeks. Even thus, however, the shading this year had a much more adverse effect than last year. + The unshaded drills gave a mean number of seedlings of 224 ± 4.0 equal to a plant percent of 33 while the shaded beds gave 136 ± 2.8 equal to 20%.

The experiment begun last year is due for analysis next spring. It is clear however from the beds that the unshaded seedlings are larger than the seedlings shaded continuously during the two seasons.

Experiment No.27 on races of Douglas fir.

This spring seed of Douglas fir from 4 different localities in Canada and 1 in U.S.A. was received and sown in the Royal Botanic Garden Nursery. The following is a brief summary of the locality data for the seed.

(i) Identification No 24/22. Craigellachie, B.C. elevation 1,400 ft. The rainfall was 30-32 inches and mean annual temperature 44.5° F. The soil is sandy with some gravel but fairly moist. The associated species are Pinus monticola, Larix occidentalis, Thuya plicata, Tsuga heterophylla, Betula alba papynfera, Picea Engelmanni, Taxus brevifolia, Populus tremuloides and P.tricocarpa Acer Douglassii.

(ii) Identification No.24/23. Shuswap Lake, B.C. Similar to (i) but the rainfall is lower namely 24-25".

(iii) Identification No 24/24. Louis Creek, B.C. Elevation 2,600 ft. Rainfall less than 20 ins. Mean annual temperature about 42°F. The soil is a rather dry glacial gravel. Douglas fir is the principal species but P.contorta, Murrayana comes in after fire.

(iv) Identification No.24/25. Salmon River, B.C. Elevation 2,200 ft. Rainfal 17" and mean annual temperature 43°F. The soil is gravelly of glacial origin and derived from basalt.

(v) Identification No.24/88. U.S.A. No information regarding locality but presumably true coast type.

The following table gives seed and germination data :-

Ident. No.	Laboratory Germn. capacity. Sand for 40 days	Mean No. of seedlings per drill of 3 grammes of seed at 4.6.24.	23.7.24.	18.9.24.	Production per lb at 18/9/24.
22/24	70%	22	55	58	8,580
24/23	56	22	118	127	18,800
24/24	47	26	101	107	15,830
24/25	57	12	89	103	15,240
24/28	Not tested	Nil	153	155	22,940

The seed was sown in mid-March 1924. There are two point of interest in the above data first the relatively low outturn in " 24/22 and secondly that the seed from U.S.A. took longer to germinate but finally gave the highest yield.

There are differences in the 1-yr seedlings which are as follows :-

Identification No.24/28. This is a typical coast type seedling; shoot length 3", pale green needle and stem; termin bud hidden by curling leaves; buds pale yellow.

Identification No.24/22. Shoot length 2½"; dark green needles and greyish purple stem; buds reddish brown, terminal bud not hidden by leaves.

Identification No.24/23. Shoot length 3"; Mid-green needles and reddish or green stem; buds bright red to crimson; some terminal buds hidden but majority not hidden.

Identification No.24/24. Shoot length 3"; mid-green needl and most stems red but some green. Buds yellowish red and som terminal buds hid by curling needles.

Identification No.24/25. Shoot length 2"; dark-green needles and purplish stems; buds dark reddish brown, terminal ones very obvious, not in any way hidden by needles.

Experiment No.28 on miscellaneous races of trees.

Seed of the following species and origins were received through Dr Borthwick from Dr Enderlin, Chur, Switzerland.

Species.	Ident. No.	Altitude gathered in feet.	Wt. per 1000 seeds gm.	Germination % in 5 days	10 days	15 days	20 days	Fresh seed
Picea excelsa	24/42	5250	6.39	56%	71%	72%	72%	9%
" "	24/43	2300	8.72	13	44	46	47	49
Larix europaea	24/44	4425	5.53	2	22	26	27	8
Pinus austriaca	24/45	-	19.45	32	88	90	91	4
Pinus uncinata	24/46	5900	-	-	-	-	-	-

The seed was sown in the Royal Botanic Garden Nursery at the beginning of June 1924. Germination has been very good. The points of interest so far refer to the spruce. It is seen in the above table that in the incubator the high elevation seed germinated much more rapidly than the lower elevation seed. This was so in the Nursery also and the high elevation seed has given the larger outturn. The high elevation seedlings at the end of the first season are distinctly smaller and darker green in colour than the lower elevation stock.

Three different lots of larch seed were sown in Edinburgh in 1923 namely:-

European larch 23/4 reputed Pusterthal, Italy. Laboratory germination capacity 29%.

European larch 23/8. Liebenthal, Silesia. Laboratory germination capacity 46%.

European larch 23/18. Embrun Forest, France. Altitude 5,000'. Germination capacity 71%.

As 2-yr seedlings these show differences in growth and ripening. The French seed has given much the more vigorous plants and the shoots ripen earliest. The Silesian Larch comes next and the Pusterthal last. It is intended to utilise this stock as a nucleus of a race study of larch on Drummond Hill, Perthshire.

Experiment No.20 on Soiling Crops.

The following species of soiling crops were sown this year at Beaufort School Nursery, Beauly :-

(i) Buck wheat (Polygonum fagopyrum).
(ii) Marrow kale.
(iii) Broad beans.
(iv) Rape.
(v) Tares.
(vi) Cole rape.
(vii) Rye.
(viii) Lupines.
(ix) Mustard.
(x) Swedes.

Each species was manured as follows :-

(1) Control no manure.
(2) Lime 4 cwts. per acre.
(3) Rainit 4 cwts " "
(4) Acid super phosphate 2 cwts. per acre.
(5) Ammonium sulphate 2 cwts " "
(6) Superphosphate;ammonium sulphate and Potash in amounts stated above.

The crops were sown during the first week of June. All species germinated well but, with the exception of Buckwheat, all were smothered by weeds hence they failed in their most important role.

A plot of buckwheat sown at the beginning of July gave in one month a crop of 315 cwts per acre of which 186 cwts were shoots. This species gives great promise. This experiment was carried out by Mr James Fraser.

Section 3. Transplanting Experiments.

Special attention was given this year to the problem of losses in the lines. The experiments were carried out at Seaton Nursery, Aberdeen, one of the largest transplanting nurseries. The experiments consist of the usual season of lining out study and a large scale detailed study of what was considered to be sources of loss. There are also special Corsican pine studies of the influence of density of seedbed on subsequent loss in the lines and the influence of wrenching and undercutting in the seed bed on subsequent losses. These latter will be analysed next spring.

Experiment No.16 on Season of Lining out.

At each of the seasons noted below 400 plants of each species were lined out in 5 rows at a spacing distance of 10" x 1½". The following Table gives the results at 30th October 1924.

Species.	Date of Lining out & Loss per cent.									
	8.10.23	22.10.23	1.11.23	1.1.24	15.3.24	1.4.24	15.4.24	1.5.24	15.5.24	1.6.2[4]
Scots pine	29%	27%	37%	52%	34%	31%	35%	30%	-	-
Corsican "	35	26	31	61	66	56	59	51	85%	88%
Norway spruce	23	18	20	31	15	16	12	12	-	-
Douglas fir	36	27	23	27	35	17	17	17	-	-
Sitka spruce	39	20	29	24	8	12	19	13	-	-
European larch	14	19	26	61	56	32	55	-	-	-

The variation in losses in the case of some of the species do not follow the same tendencies as noted in last year's report. Last year Scots pine showed a marked preference for spring lining out, this year the losses are more uniform throughout. Last year Corsican pine had the lowest losses in the spring, this year it is the autumn. The explanation may be in the unfavourable spring experienced in this nursery this year in respect of deficient rainfall and high winds. Norway spruce, Douglas fir and Sitka spruce follow previous results in showing a preference for spring lining. The variations in European larch are due in part to variations in quality of stock experienced this year.

If growth and quality of plant are taken in conjunction with losses the following are the conclusions:

Scots pine:	Mid March to 1st April
Corsican pine:	November
Norway spruce:	No variation. This species does not do well in this nursery.
Sitka spruce:	Mid March to 1st April
Douglas fir:	Mid March to 1st May
European larch:	November.

This follows closely the results obtained in previous years in this nursery.

Experiment No.24 on Methods of Transplanting.

In this experiment the relation between the following factors and losses and growth are being investigated :-

(a) Spacing of Plants.
(b) Speed of Transplanting.
(c) Grading of seedlings.
(d) Exposure of roots during lining out.

Each subject was investigated for 2 yr seedlings of the following 6 species :-

(i) Scots pine.
(ii) Corsican pine.
(iii) Norway spruce.
(iv) Sitka spruce.
(v) European larch.
(vi) Douglas fir.

The experiment was carried out at Seaton Nursery by two experienced gangs consisting of 2 men who did the spade work and lining and 3-4 boys or girls who filled the boards and carried them to the men. The work was done under the personal direction of the Experiments Officer.

The experiment was carried out from the 24th March to 29th March 1924 under good weather conditions. During the next 3 weeks there were frosts and high winds which threw a number of the plants which were replaced.

(a) Spacing of Plants.

The spacings were -

1. 1"
2. 1½"
3. 2"
4. 3"

In each case the distance between the lines was 9". Each spacing was done by "Ben Reid" Boards, in a plot of 5 rows of one board. The plot was repeated 4 times in scattered plots. The work was timed for a unit of 30 boards i.e. 5 boards for 6 species. The following are the average times for 30 boards:-

1" spacing.	1½" spacing.	2" spacing.	3" spacing.
45 min.	40 mins.	39 mins.	40 mins.

It is seen therefore that the labour cost of lining out per unit number of plants is directly proportionate to the spacing, i.e. the cost of lining out 1,000 plants at 3" apart is double that of the same number at 1½".

It is considered that the influence of the spacing on losses and growth can only be safely assessed when the transplants are lifted and graded.

The following Table gives the actual losses to date :-

Spacing.	Percentage of losses for the following species.					
	Scots pine	Corsican pine.	Norway spruce	Sitka spruce	European larch.	Douglas fir.
1"	7%	18%	24%	12%	16%	5%
1½"	9	18	15	3	18	4
2"	11	21	12	7	19	2
3"	10	23	13	3	15	3

The maximum probable error of the means is less than 1 hence to be significant the differences must exceed 3. It is seen therefore, that there is no marked significance in these differences except the higher losses in the 1" spacing of Sitka spruce and Norway spruce.

The final analysis at the time of lifting is expected to reveal differences in the response to different spacings the various species. At present the Douglas fir in the 2" and 3" spacings show better colour and growth than in the 1" and 1½". On the other hand the closer spacings in the case of Scots pine and Corsican pine give the best appearance.

(b) Speed of Transplanting.

The object of this study was to determine whether "rush" work was the cause of death and poorer plants in the lines. Four variants were used -

1. Transplanting with the greatest possible speed.
2. " " average contract speed.
3. " " greatest care.
4. Hand laying by experienced workers.

The spacing used was 1½" x 9". Transplanting boards were used in 1-3.

The following Table gives the speeds for 30 boards (2,400 plants) in 1-3:-

Fast.	Average.	Careful.
30 mins.	42 mins.	49 mins.

It was found that the difference lay partly in the care of digging and laying the plants and partly in the rate and care of filling the boards. The gang was 2 men and 4 girls.

In this section also the assessment can only be made at the time of lifting. The following are the actual losses to date :-

Speed.	Percentage Losses for the following species.					
	Scots pine	Corsican pine	Norway spruce	Sitka spruce	European larch	Douglas fir.
1. Fast	14%	31%	16%	5%	25%	13%
2. Average	11	24	11	8	16	11
3. Careful	11	18	16	9	21	11
4. Handlaying	6	31	16	13	18	10

The standard of significance is as before, it does not exceed 3. In the case of Corsican pine the more careful work is reflected in the losses and in Scots pine handlaying has a significantly low loss. In growth all sections appear uniform. It remains to be determined whether root form has been influenced.

(c) Grading.

Each species was graded on the following principles :-

Grade 1. Seedlings one half the maximum shoot length and over with the exception noted in Grade 3.

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

Grade 3. Badly suppressed, drawn, weakly, badly-rooted, forked, damaged and diseased seedlings.

The following groups were lined out :-

1. Grade 1 plants only.
2. Grades 1 & 2, i.e. Grade 3 eliminated.
3. Grade 2 plants lined out.
4. Grade 2 " bedded.

The spacing in "1-3" was 1½" x 9"; in "4" 1" x 6".

The following Table shows how this grading worked out for the species and seedlings used :-

Grade	Scots pine.	Corsican pine.	Norway spruce	Sitka spruce	European larch	Douglas fir.
I	Over 2"	over 1½"	over 3"	over 4"	over 3"	over 6"
II	2"& under.	1½" & under.	3" & under.	4" and under.	3" and under.	6" and under.
I & II	all sizes.	all sizes.	all sizes.	all sizes.	all sizes.	all sizes.

The following are the actual losses to date :-

Grade	Percentage losses for the following losses.					
	Scots pine	Corsican pine.	Norway spruce.	Sitka spruce.	European larch.	Douglas fir.
I	18%	25%	11%	3%	15%	4%
I & II	27	30	14	5	17	6
II	27	27	17	9	27	5
II bedded.	27	43	28	16	34	18

The standard of significance is as before. It is seen that the Grade I losses are lowest, while with the exception of Scots pine, bedding has not given good results. Here also the assessment will be made at the time of lifting.

Section (D) on Drying of roots while transplanting.

The roots were treated as follows :-

1. Greatest possible care taken to prevent drying of roots. After plants were filled into boards the boards were put down into a trench with water.

2. Average care.

3. Roots exposed to wind until they were obviously dry, this took 1-3 hours depending on the species.

The spacing was 9" x 1½".

The following Table gives the results,-

Treatment.	Percentage Losses for the following species.					
	Scots pine	Corsican pine.	Norway spruce.	Sitka spruce.	European larch.	Douglas fir.
1. Great care.	14%	26%	18%	18%	41%	18%
2. Average care.	18	25	20	21	46	18
3. Dried roots.	31	46	45	20	44	38

The differences between "1" and "2" are not significant. With the exception of Sitka spruce and European larch the drying of the roots gave significantly higher losses. It is clear that here is an important source of loss. The present type of shelter used in which to fill the boards calls for improvement. If the sun and wind come from different directions it is inefficient.

Section 4. Planting Experiments.

The following planting experiments were carried out and recorded during the past season.

Experiment No.1001 on spacing of Conifers.

Situation: Edensmuir Forest, Fifeshire.
Species: Scots pine.
Spacings: 3'6"; 4'6"; 5'6"; 6'6".

Experiment No.1002 on Age and Type of Plant.

(i) Situation: Edensmuir Forest.
Species: Scots pine.
Ages & Types: 2-yr; 2-yr 1-yr; 2-yr 2-yr. Carried out in 1 acre plots and in alternate and repeated rows.

(ii) Situation: Kirkhill, Aberdeenshire.
Species: Sitka spruce.
Ages & Types: 2-yr; 2-yr 1-yr; bedded; 2-yr 1-yr lined; 2-yr 2-yr; 1-yr 2-yr. Carried out in alternate and repeated rows.

Experiment No.1006 Season of Planting of Norway spruce.

Situation:	South Laggan Forest, Inverness-shire.
Species:	Norway spruce.
Method:	One quarter acre plot in each month of year, October 1923 to September 1924.

Experiment No.1006 (a) on Season of Planting Sitka spruce.

Situation:	Inchnacardoch Forest, Inverness-shire.
Species:	Sitka spruce.
Method:	One quarter acre plot each month in year from April 1923 to March 1924.

Experiment No.1006 (b) on Season of Planting Corsican pine.

Situation:	Culbin Forest, Morayshire.
Species:	Corsican pine.
Method:	One quarter acre plot each month from September 1923 to August 1924. There has now been a complete set of monthly plantings for this species at Culbin for three consecutive years.

The results of these seasonal plantings will be assessed in due course. The results of previous sets were set forth in last years report.

Section 5. Experimental Plantations.

These refer to the continued study of peat conditions.

Experimental Plantation No.X.

The investigation carried out by the Experiments Officer on "Root form on Peat" in 1923 at Inverliever showed that the spruce root system on peat sites is very superficial and that the nursery roots die when put deep into the peat. This experiment was designed to determine if and how spruce could be planted to ensure the development of the nursery root system pending the formation of the "collar" adventitious system and thus reduce the degree and period of check on peat sites.

The site was the peat investigation centre at Inchnacardoch. It is a basin type of bog of variable depth of peat from 1 ft. to over 3 ft. The type of peat and herbage vary. The prinicpal plants are Scirpus caespitosus, Molinia caerulea, Caluna vulgaris, Myrical gale and Sphagnum and Hyprum species, with varying dominance. The main drains were cut in 1921 and the drainage completed in 1923. There has been a noticeable improvement in vegetation since 1921 particularly in the increase of Molinia caerulea. There are now a few clumps of Agrostis alba in the best places.

There are still areas of typical fibrous Heather-Scirpus peat however.

The following methods of planting were carried out in rows under direct supervision:-

Row 1. Vertical Notching as control.

Row 2. A shallow saucer-shaped pit $7\frac{1}{2}$" wide and maximum depth of 4" made by special designed "S" spades.

" 3. A continuous strip of turf 18" wide and 3" deep was cut, running down the slope. The plants were put into this shallow strip and 2 pieces of this turf 18" x 9" placed inverted on the roots. The roots are thus near the surface. The continuous strip was designed to intensify local drainage.

" 4. As 3 but patches 18" x 18" x 3" and not continuou

The set of 4 rows each of 35 plants was repeated in 15 series scattered over the varying and recorded site.

2-yr 1-yr Sitka spruce were used. The roots of this type o plant were considered to be of the best size and type for the methods.

The experiment was studied in August and it was found that first objective was attained. In methods 2 to 4 there had been marked development of the nursery roots which was reflected in t needle length, colour and length of this years shoot. It will i some years before an assessment can be made but this is the most promising advance made in the peat planting experiments so far. A development of this study should be of value in the planting o spruces generally.

Experimental Plantation No. XI.

This plantation is designed to study the establishment of the following species planted by two methods at Glen Righ, Inver ness-shire on an exposed peat site :-

Row 1. Sitka spruce 2-yr 2-yr notched.
2. " " " " pitted.
3. Norway spruce 2-yr 2-yr notched.
4. " " " " pitted.
5. Japanese Larch 2-yr 1-yr 1-yr notched.
6. " " " " " pitted.
7. Scots pine 2-yr 1-yr notched.
8. " " " " pitted.

The set of 8 rows each of 40 plants was repeated 10 times.

A study of Peat Reclamation in Belgium was made by Dr Steven in conjunction with Mr E.V.Laing and Mr O.K.Fraser in September. This forms special Reports.

12.11.24.

PERMANENT SAMPLE PLOTS.

REPORT ON PERMANENT SAMPLE PLOTS FOR THE YEAR 1923-1924.

M. L. Anderson.

The year was divided up as follows:- 5 months on measuring plots in England and 4 in Scotland. 1 month in England was spent on testing a method of measuring standing trees. 1 month in Scotland was spent on office work and 1 month on leave.

During the year, in addition to one Temporary Plot measured in Scotland, and 4 plots thinned and put in order in England, but not carefully measured, 6 new plots were established, 2 in England and 4 in Scotland, while 15 plots were remeasured, 14 in England and 1 in Scotland.

The new plots were distributed over the species as follows:-

England. 1 Corsican Pine.
1 Ash.

Scotland. 1 Abies grandis.
1 Douglas Fir.
2 Scots Pine.

The remeasured plots were distributed as follows :-

England. 3 Mixed Oak and Beech Coppice.
7 European Larch.
3 Douglas Fir.
1 Sitka Spruce.

Scotland. 1 Abies grandis.

Present Position Summarised.

Up to the end of September, 1924, a total of 149 sample plots has been established in Great Britain, of which 84 are in England and 65 in Scotland, while 17 plots have been remeasured once, 12 in Scotland and 5 in England. In addition, 13 plots in England have been remeasured twice. These latter plots are all dealt with in this report.

There are, besides, 4 Larch plots in England which have been once remeasured and were due for a second remeasurement this year. These are to be kept under observation but not carefully measured. Owing to disease and failure of the underplantings, the main object of these plots cannot now be fulfilled.

The position with regard to species is now as follows :-

Species.	Measured. Once.	Twice.	Thrice.	Others.	Total.
Scots Pine	20	-	-	-	20
Norway Spruce.	13	3	-	-	16
Mixed Scots & Norway Spruce.	1	-	-	-	1
European Larch.	14	8	7	4	33
Douglas Fir.	25	2	3	-	30
Thuya plicata.	2	-	-	-	2
Tsuga heterophylla	1	-	-	-	1

Abies grandis.	1	1	-	-	2
Corsican Pine.	11	-	-	-	11
Sitka spruce.	5	2	-	-	7
Japanese Larch.	17	1	-	-	18
Weymouth Pine.	1	-	-	-	1
Oak.	3	-	-	-	3
Oak & Beech mixed.	-	-	3	-	3
Ash.	1	-	-	-	1
Totals -	115	17	13	4	149

General.

The work consisted almost exclusively of remeasurements.

14 plots were remeasured, 4 others, though not carefully re-measured, were thinned and put in order, while two fresh plots were established, namely, one Corsican Pine and one Ash.

A considerable amount of time was spent, in the remeasurements, in converting and correlating the data previously obtained from old plots and bringing the figures into line with present methods.

New Plots.

Corsican Pine - Forest of Bere.

A single plot was established in the Forest of Bere, South Hants in 1914 by Mr A.P.Long. As the figures for that measureme[nt] are not available, this plot is equivalent to a new one. The rat[e] of growth is exceptionally fast, above Quality Class I (70'),give[n] in the Yield Tables. The age is 37 years, the number per acre, 485; average height, 65'; average Girth, 28½"; and u.b. volume, 5691 cu.ft. 101 thinnings per acre were taken out, with a volume o[f] 465 cu.ft. The total volume was thus 6156 cu.ft., making the M.A.I. 166 cu.ft. or 131 Q.G. The locality did not appear to be at all exceptional for the district. The stocking, however, is rather too high.

Ash. - Boughton Estate, Northants.

An interesting hardwood plot was laid out on the Boughton Estate of the Duke of Buccleugh in Northants. The crop is pure Ash with Beech underplanting. The Ash has been planted 24 years, the Beech having been introduced about 8-9 years ago. The planting distance for the ash was 4½' x 4½', and, as the wood has only been cleaned of dead trees, the stocking was too dense. The crowns are small and the stems are lanky. A heavy thinning was made. The data obtained were as follows:- Age, 24 years; number after thinning, 979; Av.Ht. 35½'; Av.Girth, 10"; u.b.vol., 372 cu ft. Form Factor, ·193. The number of thinnings was 642, with a volume of 92 cu.ft. The total volume was thus 464 cu.ft. The Quality class corresponds closely, judging by the height, to Wimmenauer's Quality Class I, in Germany.

Remeasurements.

Beech and Oak Coppice Plots - Tintern, Monmouthshire.

These 3 plots constitute a special experiment of considerable local importance. They were laid out in a wood of Oak and

Beech coppice with Oak standards in 1914, with a view to ascertaining the best method of conversion to high forest.

In Plot E.4, the standards were left untouched, in Plot E.5 the standards were left in, but were pruned of some of the lower branches, while in Plot E.6, the standards were cut out. A moderate thinning was made in 1914. No further thinning has been made until 1924. No volume measurements were carried out before 1924, so that the Basal Area data alone are available for the interpretation of the results to date.

The data are somewhat complicated by the presence of the standards and the mixture of the species, but I propose to deal with the Oak and Beech for the three plots together for each time of measurement. Remarks on the standards will at first be kept separate.

In 1914. The number of Oak shoots in Plot 4 was 285 with a mean girth of 17" and a B.A. of 46.6 sq.ft. The number of Beech shoots was 369 with a mean girth of 10½" and a B.A. of 22.9 sq.ft. The total number of shoots was thus 654 with a B. Area of 69.5 sq.ft.

In Plot 5, there were 258 Oak shoots with a mean girth of 16½" and a B.A. of 39.1 sq.ft.; there were 393 Beech shoots with a mean girth of 10" and a B.A. of 20.8 sq.ft., the total number of shoots being 651, with a total B.A. of 59.9 sq.ft.

In Plot 6, there were 295 Oakshoots with a mean girth of 16½" and a B.A. of 43.1 sq.ft.; there were 459 Beech with a mean girth of 12" and a B.A. of 36.6 sq.ft., the total number of shoots thus being 754 with a total B.A. of 79.7 sq.ft.

It thus appears that the number of shoots and total B.A. of Plot E.6 was a good deal higher than in either Plot E.4 or E.5, and that, while 4 and 5 had the same number of shoots, the B.A. in 5 was 10 sq.ft. less. Further the mixture of Oak and Beech was approximately the same in Plots 4 and 5, but in plot 6 the proportion of Beech was slightly higher. Further the average size of the Oak was highest in 4, and that of the Beech, in Plot 6.

In 1919, after 4 years' growth. As no thinnings were made, to all intents and purposes the numbers of shoots remain the same as in 1914. In Plot E.4, the average girth of the Oak was now 19½" and the B.A. was 60.5 sq.ft. The mean girth of the Beech was 12½" and the B.A. 32.4 sq.ft. The total B.A. was 92.9 sq.ft. The M.A.I. of the Oak had thus been 7.45% and of the Beech, 10.4%. For the two together the figure is 8.42%.

In Plot E.5, the average girth of the Oak was 19" and its B.A. was 54.1 sq.ft. The figures for the Beech were 12" and 32.2 sq.ft. respectively. The total B.A. was thus, 86.3 sq.ft. The M.A.I. of the Oak has thus been 9.6% and of the Beech, 13.7%, while that of the whole crop was 11.0%.

In Plot E.6, the average girth of the Oak was 18½" and its B.A. was 51.8 sq.ft. The average Girth of the Beech was 15" and the B.A. was 55.6 sq.ft. The total B.A. was thus 107.4 sq.ft. The M.A.I. of the Oak was thus, 5.05%; of the Beech, 12.98%; and of the two together, 8.73%.

Remarks:- For the Oak, the increment % is much higher in the plot with the pruned standards than in either the plot without standards or the plot with standards unpruned. For Beech, the increment % is again highest in the plot with pruned standards, but only slightly more so than in the plot without standards. The response of the Oak in the latter plot has been practically nil while that of the Beech has been marked. Up to 1919, therefore, the general effect of the experiment seems to have been most felt in the plot where the standards were pruned.

In 1924, after a further growth of 5 years. - As no thinning had been carried out, the number of shoots was again approximately the same, although certain slight differences were made. In Plot E.4, the Av.girth of the Oak was now 20½" and the B.A. was 67.3 sq.ft. The mean girth of the Beech was 13½" and its B.A. was 36.9 sq.ft. The total B.A. was 104.2 sq.ft. The M.A.I. of the Oak has been 2.24%; of the Beech, 2.78% and of both together 2.44%.

In Plot E.5, the average girth of the Oak was 20" and its B.A. was 60.8 sq.ft. The figures for Beech were 13½" and 38.4 sq.ft. respectively. The total B.A. was 99.2 sq.ft. The M.A.I. of the Oak has been 2.48%; of the Beech, 3.88%; and of the two together, 2.60%.

In Plot E.6, the Av.girth of the Oak was 19½" and its B.A. was 60.7 sq.ft. The girth of the Beech was 16½" and its B.A. was 66.5 sq.ft. The total B.A. was thus, 127.2 sq.ft. The M.A.I. of the Oak has been 3.14%; of the Beech, 3.68%, and of both together, 3.88%.

Remarks:- For this period, the Oak increment has been much higher in the plot where the standards were cut out than in the one where they were untouched, and a good deal higher than in the plot with the pruned standards. Similarly the Beech increment has also been higher in the same plot, but only slightly higher than in the plot with pruned standards. The removal of the standards does not seem to have affected the Oak until several years after removal, while the effect on the Beech appears to have been immediate. The B.A. of plot E.5, has gradually overhauled that of Plot E.4. If the Oak increment % between 1914-19 is significant for plot E.5, it would seem to indicate that the Oak prefers a gradual improvement in the light conditions, rather than a sudden one. That species seems to have been somewhat checked at first in Plot E.6, but has recovered rapidly between 1919 and 1924.

The effect of the experiment is now most marked in that plot from which the standards were removed.

The Standards.

In Plot E.4, there are twelve standards per acre, whose mean girth has risen from 52½" in 1914 to 56" in 1919 and to 57½" in 1924. The corresponding B.Areas were 18.8, 21.5 and 22.9.

In Plot E.5, the 9 standards per acre, which were pruned, had a mean girth of 52½" in 1914, of 54" in 1919 and of 55½" in 1924. The corresponding B.Areas were 13.4, 14.4 and 15.2.

In Plot E.4, the increment % between 1914 and 1919 was 1.44, and between 1919 and 1924 it was .65. In Plot E.5, the corresponding percentages were .75 and .56. Apparently, then, the effect of the pruning was an immediate and marked fall off in the rate of growth, followed by a recovery after 4 or 5 years.

Position after the 1924 Treatment :

In 1924 all the plots were thinned. The oak was subjected to a Cl grade and the Beech to a D grade, i.e., to a crown thinning. In other words, the Oak is favoured. This is necessary owing to the faster growth of the beech. In Plot 6 where the Beech had been allowed to get somewhat out of hand, owing to the steep slope, it was severely dealt with. Here it was growing out at an angle over the Oaks farther down the slope.

In Plot E.4, the main crop, which is now 46 years old, consists of 182 Oak and 342 Beech. The Av. Girth of the Oak is 23" and of the Beech 13". The u.b. vol. of Oak is 1117 cu.ft. and of the Beech, 491 cu.ft. In addition, there are 469 cu.ft. in the standards. The total volume of the plot is thus 2077 cu.ft. and of the coppice alone, 1608 cu.ft. In the thinning, 232 cu.ft. of Oak was cut out and 95 of Beech, making 325 cu.ft. in all. Net Value £6.7.7½d.

In Plot E.5, the main crop now consists of 173 Oak and 352 Beech. The Av.girth of the Oak is 22½" and of the Beech, 12". The u.b.vol. of the Oak is 967 cu.ft. and that of the Beech 457 cu.ft. In addition there is 296 cu.ft. in the standards. The total volume is thus 1720 cu.ft. and of the coppice alone, 1424 cu.ft. In the thinning, 207 cu.ft. of Oak were cut out and 152 cu.ft. of Beech, making 359 cu.ft. in all. Net Value £7.7.0d.

In Plot E.6, the main crop now consists of 205 Oak and 356 Beech. The Av.girth of the Oak is 21" and of the Beech 14½". The u.b.vol. of the Oak is 984 cu.ft. and of the Beech, 725 cu.ft., making a total volume of 1709 cu.ft. In the thinning, 169 cu.ft. of Oak were cut out and 549 cu.ft. of Beech, in all, 718 cu.ft. Net Value £12.13.9d.

Remarks: In Plots E.4 and 5, the Beech now appears to be the same in number, size and volume, but the Oak in Plot E.4 is superior in all these respects to the Oak in E.5. In Plot E.6, the Oak volume is intermediate between that of the other plots, while the number of trees is a good deal greater and the Av. size less than in either of these plots. Although the number of Beech is nearly the same, the size and volume of this species is much greater in plot 6 than in the others. If the main object be the growth of a good Oak crop, then, even ignoring its standards, Plot E.4 is superior to the other plots. The type of Oak shoot in this plot is better than in the others, apart from the higher volume and size. It will be interesting to see the effects of the heavy thinning in the Beech in Plot E.6. The total production to date has of course been much higher in Plot E.6 than in the others.

It is of interest to note that the volume of the main crop in Larch Plot E.1 at 46 years was 3255 cu.ft., almost exactly double that of the coppice of Plot E.6 in the same time. Plot E.6 has not, however, been burdened with establishment costs and the probability is that it will maintain its rate of production better than the Larch, which is of Quality Class I. (See Appendix for a financial statement for each of these plots, based on the available data.)

European Larch :

Eleven plots of European Larch were dealt with, 3 at Tintern and eight at Dymock, Glos., all on crown property.

Tintern. Three single Larch plots here were due for re-measurement. These were established in Dec.1913, when a measurement was made. In 1916, a thinning was carried out but no measurement of the main crops. They were remeasured and thinned in 1919 and again this year. From the data available, it was found to be possible to obtain reasonably correct figures for the 1916 main crops in these plots. In this way, four measurements became available and 3 increment periods could be dealt with.

Plot E.1. This plot is now 53 years old and is of Quality Class I. The number of trees per acre in the main crop has decreased from 300 in 1913 to 165 in 1924. 225 stems have been removed in the thinnings with a total volume of 2450 cu.ft. which is very high. The main crop in 1913 was 3420 cu.ft. and after thinning in 1924 is 3180 cu.ft. The total known production, of which 2450 cu.ft. have been realised has been 5630 cu.ft. The thinnings have been moderately heavy. From the Yield tables, the total production of Qual. Class I in 50 years should be 7560 cu.ft. In this case there were probably thinnings made before establishment of which there is no record. The M.A.I. shows a steady decrease from 180 cu.ft. between 1913 and 1916 to 162 between 1916 and 1919 to 80 between 1919 and 1924. The increment % gives a better index. For the three periods the M.A.I. % are 5.31, 4.98 and 2.23 respectively.

Plot E.2. This plot is now 61 years old and is of Quality Class II. The number of trees per acre in the main crop has dropped from 310 in 1913 to 190 in 1924. 245 stems have been removed in the thinnings with a total volume of 1885 cu.ft. The main crop in 1914 was 3535 cu.ft. and after thinning in 1924 is now 3020 cu.ft. The total production, of which 1855 cu.ft. have been realised, has been 4905 cu.ft. The thinnings have been moderately heavy. The total production according to the yield tables for Qual. Class II of Larch in 60 years should be 7470 cu. ft. The plot is thus very much behind, but some thinnings may not have been recorded. The M.A.I. shows a very marked fall off from 120 cu.ft. between 1914-1916 to 70 between 1916-19 to 30 cu. ft. between 1919 and 1924. The corresponding percentages are 3.39, 2.71 and 0.85. The increment is now so low that from an economic point of view, the plot should be cut. It has been suggested that the fall may be due to climatic variation during the periods. The wood, however, looks so unhealthy and the crowns are so small, that future recovery is unlikely.

Plot E.3. This plot is now 45 years old and on the border line between Qual. Classes II and III. The number of trees per acre in the main crop has decreased from 590 in 1913 to 310 in 1924. 280 stems have been removed in thinnings with a volume of 1020 cu.ft. The main crop in 1913 had a volume of 2175 cu.ft. and in 1924, of 2440 cu.ft. The total known production, of which 1020 cu.ft. have been realised, is 3460 cu.ft. The thinnings have been moderately heavy. The total production of Qual. Class III according to the Yield Tables in 45 years should be 3970 cu.ft., so that the production of this wood is also low.

This plot also shows a slight fall off in increment, but not so marked as in Plots E.1 and E.2. From 1914 to 1916 the M.A.I. was 182 cu.ft., from 1916 to 1919, 145 cu.ft. and from 1919 to 1924, 90 cu.ft. The corresponding percentages are respectively, 8.37; 6.47; 3.56. At the same time the main crop is showing a steady increase and there appears to be little tendency for height growth to deteriorate. The crowns are also larger and healthier than in the other plots, although the situation is more exposed, and more subject to drought.

General Remarks: It is admitted that thinning was too long delayed in plots E.1 and E.2, both of which, but especially the latter, have suffered in consequence. Plot E.3 was taken in hand earlier and apparently with better results. The Form factor is much higher in Plot E.3 than in the other plots, due to fuller form as shown by a Form Class of .740, while so far, the rootswelling is comparatively small. The mean Form-classes of E.1 and E.2 are .714 and .716 respectively, showing poorer form than in Plot E.3. The lower Form Factor of Plot E.2 is due to relatively greater rootswelling, which is, in turn, probably due to the shallower soil.

Dymock.

Out of the eight Larch with underplanting plots at Dymock, 4 were retained for careful measurement, while the other 4 were thinned and are to be kept under observation with the help of the local staff.

Of the four retained for careful measurement, 3 occur together in the same wood, while the fourth may now be considered as a single plot.

Plot E.11, which is the single plot, consists of a Larch crop now 32 years old, which was underplanted in 1915 with Douglas Fir. The intention is to thin the Larch out strongly until there are only about 80 stems per acre, while the Douglas are to form an under crop.

So far, the experiment has been a marked success. Severe cuts have been made into the Larch crop and the Douglas now form a uniform, healthy crop, fully-stocked.

At the commencement of the experiment, there were 765 Larch with a volume of 1386 cu.ft. 219 were than taken out with a volume of 200 cu.ft. The Douglas were then planted. In 1916 and 1917, 26 trees were removed with a volume of 32 cu.ft. In 1919, 4 years after establishment, 123 more trees were cut out with a volume of 208 cu.ft., leaving 397 stems with a volume of 1423 cu.ft. In 1924, 204 trees with a volume of 856 cu.ft. were removed, leaving 192 trees with a volume of 994 cu.ft. The Larch should be reduced to the desired number in 1929. The M.A.I.% between 1915 and 1919 was as high as 10.0. Between 1919 and 1924 it was still 6.67%, which is good. In the meantime, the Douglas Fir have reached a mean height of 5 to 6 feet and are growing vigorously. In a few years they will require to be thinned, while further returns may still be expected from the Larch. Eventually the Douglas will replace the Larch. If anything, it has been improved in general health and appearance by this method of growth.

From the practical point of view, with regard to the effect of falling large crowned trees under this system, the damage done to the Douglas was of the slightest, although no special precautions were taken. Care was, of course, exercised. About 6 trees were badly damaged. Later on the risk will be greater, when the Douglas are too high to see over.

Plots E.12, E.13 and E.14: These form a series, of which E.12 is underplanted with Sweet Chestnut; E.14, with Tsuga heterophylla while E.13 is a control without underplanting.

The series was established in 1915, when the age was 25 years, a thinning being made and the undercrop planted.

Unfortunately the ground is far from uniform, while the crop at the commencement was also irregular in stocking and growth, the Qual. Class varying from I to II. The data obtained is, therefore, not reliable as a basis for any conclusions regarding the effect of the undercrops. Some interesting general information is, however, available, especially with regard to form. Form Quotient measurements were made on all the sample trees felled, 7 or 8 being cut from within each plot. These provided accurate information as to the form of the crop. This information is of much value in interpreting the figures from the three plots.

In 1915, to begin with, the numbers per acre in E.12,13 and 14, respectively, were 1030, 1137 and 1268. The Av.girth were 15", 14½" and 13" respectively, while the u.b. volumes were 2119, 2014 and 1707 cu.ft. respectively. This clearly shows the variation over the experimental area. A thinning was made, which left 628, 661 and 602 stems per acre with av. girth of 17", 16½" and 15" and volumes of 1813, 1703 and 1251 cu.ft. respectively. This thinning was most severe in Plot E.14, and least so in E.13.

In 1916 and 1917, several trees were cut out or blown over. The numbers of these were 48 in E.12, 72 in E.13 and 20 in E.14. This had the effect of making the number of trees nearly the same in each plot.

In 1919, a second measurement was made. The numbers of trees before thinning were 575, 586 and 582 respectively. The av.girths were 19½", 19" and 17½" and the volumes were 2131, 2014 and 1742 cu.ft. resp. The height growth in plot E.13 had gained a little on E.12, but that of E.14 was still 2½ to 3 feet behind. A thinning was made, leaving 453, 470 and 485 stems per acre respectively of av.girths 20", 20" and 18" and volumes of 1859, 1878 and 1574 cu.ft. Generally speaking plots E.12 and E.13 were now alike in most respects. The form factors were .358, .358 and .378 respectively. The M.A.I.% had been 5.7%, 8.3%, and 10.4%, i.e. highest for the heaviest thinning.

In 1924, a third measurement was made. The numbers of trees before thinning were 453, 420 and 482 averaging in girth 21½", 21¼" and 19", and the volumes were 2255, 2380 and 2081 cu.ft. respectively. In height growth, Plot E.12, which is the most exposed, had fallen behind to be relatively less than E.14 and 2 feet less than E.13. A thinning was made, leaving 262, 273 and 268 stems per acre respectively, of average girths 22½", 22" and 20½" and volumes of 1449, 1552 and 1334 cu.ft. The similarity between plots E.12 and 13 was still great, but the discrepancies of E.14 had been reduced in some respects. The Form factors were now .358, .363 and .407, i.e., for plot E.12 it was stationary, for E.13, the increase was slight and for E.14, there was a marked increase.

The Form quotient measurements on the sample trees have respectively mean Form classes of .713, .713 and .745. There is thus a very marked superiority in form in E.14, which in the beginning had the highest density. It seems possible that the early effects of density upon form may last for a long time. The slightly decreased Form factor in E.12 is due to the greater rootswelling compared with the other plots. It is of interest to note, that the root swelling increases on the higher and most exposed ground. The M.A.I.% were 4.2, 5.3, and 6.4 respectively. The improvement in Plot E.14 is again outstanding.

Remarks: It is obvious from the figures given that any differences must be put down to variation in the locality and in the crop and not to the treatment. This plainly demonstrates the necessity for absolute uniformity in original crop and local conditions, in the case of comparative sample plots, which are intended to demonstrate the effect of treatments. The standard of uniformity of conditions for such plots must be considerably raised in future.

Douglas Fir:

Three single plots of Douglas fir were dealt with, two on the Tortworth Estate, Glos. and one on the Dunster Estate, Somerset.

Tortworth.

The two single plots on the Tortworth Estate are near each other on the south side of a deep combe.

Plot E.19 is now 55 years old and is of Quality Class I. It was first measured in 1912. As the plot area then staked out was altered in later measurements and likewise the method of measurement, the figures then found do not fit in absolutely with later figures. The data, however, converted to the same basis as now in use, were:- Number per acre, 215; mean height, 94 feet; av.girth, 47½"; u.b.vol.,8113 cu.ft. and Form factor, .321. No thinning was made.

In 1919, a fresh plot was established and thinned. Several recently blown trees provided useful data. The figures for this measurement were:- number per acre, 222; av.height, 106 feet; av. girth, 50½"; u.b.vol., 9590 cu.ft. and Form factor, .330. In addition 26 thinnings were cut out with a mean height of 84 feet and a volume of 389 cu.ft.

In 1924, the plot was remeasured and rethinned. The method of measurement was based on several standing sample trees and form quotients, with one felled sample tree as a check. This is a case where the usual number of felled sample trees is impossible. The figures obtained now were:- number per acre, 196; mean height, 112½ feet; mean Girth, 53"; u.b.vol. 10392 cu.ft. and F.factor, .344. In addition, 22 thinnings had a mean height of 94½ feet and a volume of 615 cu.ft. The M.A.I. for the period was 283 cu.ft. or 2.95% which is still satisfactory. The total recorded production for the plot is, thus, 11396 cu.ft. This is certainly one of the tallest plots ever measured; the highest tree is 131½ feet high while some were over 125 feet. The situation is undeniably favourable and there are few localities where it will be possible to carry such a heavy stocking of Douglas Fir to this age. As it is, where the soil is wet, severe windfall damage has occurred.

Plot E.20 has the same history as plot E.19, which is close at hand.

In 1912 the age was 29 years and the number per acre was given as 205, rather less than in E.19. The mean height was 66 feet, the Qual. Class being II. The mean Girth was 39½", the u.b.vol., 4049 cu.ft. and the Form factor, .351. No thinning was made.

In 1919, several blown trees were available for samples. The figures obtained for this measurement were:- number per acre, 177; mean height, 78½ feet; mean girth, 40½", u.b.vol. 4314 cu.ft. and the Form factor, .341. 14 thinnings taken out had a volume of 55 cu.ft.

In 1924, a second measurement and thinning were carried out. The number per acre was 163, with a mean height of 88 feet, a mean girth of 43" and a u.b. vol. of 5097 cu.ft. In addition, there were 14 thinnings with a volume of 141 cu.ft. The M.A.I. for the period was 185 cu.ft. or 4.3%, which is hig

The age of this plot is now 41 years, which approximates to that of plot E.19, at its first measurement, namely 43 years. A comparison of the data for the two plots at these ages is interesting:-

Plot No.	No.of Trees.	Ht.	F.F.	Girth.	B.A.	u.b. vol.	Bark %
E 19	215	94'	.321	47½"	268.8	8213	12
E 20	163	88'	.344	43	166.4	5098	15

At first sight the volume of E.20, compared with that of E.19 seems remarkably low, amounting to only 62% of the volume of the latter plot. The greater part of this difference is due to the smaller number of stems in plot E.20, amounting to only 76% of that in E.19. Moreover the percentage of bark is 3% greater. The difference is not in excess of what might be expected with the lower Quality Class and the poorer density. The plot is also a good deal more exposed than plot E.19.

Dunster.

Plot E.18 at Dunster is situated in a Douglas Fir wood of Qual. Class III. It has the same history as plots E.19 and 20.

In 1913, a measurement was made, which gave the following results. The age was then 33 years. The number of stems was 350; average height, 74 feet; average girth, 33"; u.b.vol. 559[illegible] cu.ft. and the over-bark F.F., .402. A slight thinning was made, removing 5 trees with a volume of 76 cu.ft. In 1915 and 1918, thinnings were made by the estate staff, which realised 892 cu.ft.

In 1919, a new plot was laid out. No satisfactory sample tree data were available, but by working back from the 1924 data the following figures were obtained. Age, 39 years; number per acre, 232; mean height, 81 feet; mean girth, 40"; u.b.vol., 6518 cu.ft. and Form factor, .392. In addition 16 thinnings were taken out with a volume of 228 cu.ft.

In 1924, eleven standing sample trees were measured as none could be felled. The figures for this year were:- Age, 44 years; number per acre, 223; mean height, 85½ feet; mean girth, 42½"; u.b.vol., 7467 cu.ft. and Form factor, .396. In addition

10 thinnings were taken out with a volume of 178 cu.ft. The M.A.I. between 1919 and 1924 was 225 cu.ft., corresponding to 3.45%, which is still satisfactory.

The total known production from this plot has been 6968 cu.ft., of which 1298 cu.ft. have been realised in 11 years, or 118 cu.ft. per annum, which at 6d per foot, is nearly £3 per annum. The thinnings have been moderate throughout. The volume is slightly higher than that given in the British Yield Tables for this Quality of Douglas Fir. The plot is now considerably exposed in the crowns and most of the tops are broken.

Sitka Spruce:

The single plot, E.41, established at Dunster in 1921, was remeasured and rethinned, as the thinning was overdue. No thinning was made in 1921, although the plot was measured.

In 1921, the figures were:- Age, 13 years; number of trees, 1654; Av.Ht., 32½ feet; mean Girth, 13", u.b.vol., 1649 and Form factor, .323.

A heavy low thinning was made this year with the following results:- Age 15 years; number per acre, 981; Av.Ht., 42 feet; mean girth 16"; u.b.vol., 2285 cu.ft. and Form factor, .380. In addition, 662 thinnings were removed with a volume of 563 cu.ft. The total volume was thus 2848 cu.ft. At 15 years Qual. Class I of Douglas Fir produces only 1833 cu.ft. This wood, which is in a very favourable situation, has given more than half as much again. In the 2½ years since the first measurement, the M.A.I. has been 480 cu.ft., or 29.11%. The total M.A.I. has been 190 cu.ft., which is high for 15 years.

General.

One temporary plot was measured, 1 plot was remeasured and 4 plots were established. The temporary measurement was one of Sitka Spruce. Permission was obtained to proceed with a second comparative plot of Abies grandis at Novar. The existing plot there was remeasured. A single Douglas Fir plot was laid down at Inverliever. The remaining 2 plots were of Scots Pine, established in the valley of the Spey. Work is proceeding on a plot in the Natural Larch in Tominuird, Strathspey.

Temporary Plot 416.
Sitka Spruce - Glenbranter.

The opportunity was taken of securing data from a small plot of this species, in a wood about to be felled. A group of Norway spruce was measured in the same wood for comparison. The figures were:- Age, 41 years; Av.Ht. 77 feet. Av.girth, 8¼" Q.G.; number per acre, 465; Q.G.vol. 7700 cu.ft. and Form factor, .403. The Quality Class of the Norway Spruce was I, and the corresponding figures from the Yield Table are:- Age, 40 years; Av.Ht. 66½ ft. Av.girth, 8¼" Q.G.; number per acre, 410; Q.G.vol. 5250 cu.ft. and Form factor, .407.

The M.A.I. for the Sitka Spruce is 188 cu.ft. Q.G. and for the Norway Spruce 132 cu.ft. This is not the fastest growth of Sitka Spruce recorded; cf Plot S 57 at Dunach and E 41 at Dunster.

Abies grandis. - Novar, Ross-shire.

We have been very fortunate in securing permission to establish a pair of comparative thinning plots in the 20-year old plantation of Abies grandis at Novar, at an elevation of feet. At present, these are our most northerly plots. Plot 35 was laid down in October 1921 and then measured, but no thinning was made. The figures then were :- Age, 18 years plante No. of stems per acre, 2855; Av.Ht.36 feet, Av.Girth, 13½"; u.b.vol. 3895 cu.ft. and Form factor .389.

In 1923, this plot was remeasured, when the data were:- Age, 20 years; No.of stems, 1820; Av.Ht. 43 feet; Av.Girth,16 u.b. vol.4615 cu.ft. and Form factor, .396. A moderate low thinning was applied, by which 1035 stems were removed, with average height of 31 feet, an average girth of 8½" and a volume of 314 cu.ft. The total volume was, thus, 4840 cu.ft. and the M.A.I. was 472 cu.ft. for the 2 year period, or 12.1%.

Plot 36 has just been established last October, and although not quite up to the standard of Plot 35, should make a good comparison with it. A heavy low thinning was applied, by which 50% of the number of trees was removed. The Main crop figures were :- Age 20 years; No.of stems, 1355; Av.Ht. 42 feet; Av.Girth, 15½"; u.b.vol. 2965 cu.ft. and Form factor .39 In addition, 1540 stems were cut out, of mean height, 33½ feet Av.Girth, 11" and u.b.vol. of 1035 cu.ft.

Douglas Fir: Inverliever, Argyllshire.

A single plot, No.63, was established in Compartment 1, in the crown forest at Inverliever. The area is small, but the plot is fairly uniform. So far, the Quality Class is II, nearly I.

The figures were :- Age, 16 years; number per acre,1510 Av.Ht. 33½ feet; Av.girth, 13"; u.b.vol. 1550. A fairly heavy thinning was applied, removing 895 stems with a volume of 385 cu.ft. The total volume was, thus, 1935 cu.ft. and the M.A.I has been 121 cu.ft.

Though the plot is small, it fills a gap, which is occasioned by the scarcity of uniform areas on the West Coast, suitable for plots.

Scots Pine: Seafield Estates, Morayshire.

Two plots, Nos.64 and 65, were established in Tom na Culagan Plantation, Strathspey. These plots have been thinned to different degrees of thinning, one light and the other moderately heavy, but they were not sufficiently alike before treatment to give an accurate comparison. The figures were :-

Plot 64. "B" Grade. Age, 42 years; number per acre, 1581; Av.Ht. 35 feet; Av.Girth, 15"; u.b.vol. 2444. 283 stems per acre were removed with a volume of 74 cu.ft. The total volume was thus 2518 cu.ft. and the M.A.I. has been 60 cu.ft. The Quality Class is III (40').

This plot is remarkably free from squirrel damage, and the trees are of good type. The stocking is very high. The slow rate of growth, type of ground and the untouched and undamaged nature of the crop, render this plot valuable.

Plot 65. "C" Grade. Age, 42 years; number per acre, 1204; Av.Ht. 36½ feet; Av.Girth, 16"; u.b.vol. 2186. 532 stems per acre were removed with a volume of 528 cu.ft. The total volume was thus 2714 cu.ft. and the M.A.I. has been 65 cu.ft. The Quality Class is III (40').

This plot is to some extent damaged by squirrels. The thinning was mainly directed against squirrel damaged dominants, of which per acre were cut out. The plot will be useful for the observation of squirrel damage and its effect upon the crop. At the same time it may indicate how the removal of severely damaged trees improves the crop.

These are the first Scots Pine plots in Scotland of this Quality Class.

General Notes.

On the accompanying map the location of plots established in previous years, is shown by black dots. Plots remeasured are shown with a blackcircle or a red circle, for past and present year remeasurements respectively. New plots in 1923-24 are shown as red dots.

It will be seen that some plots have been placed in parts of the country, hitherto untouched.

Final summaries of plots dealt with this year are attached in full.

In addition to the ordinary plot work, a felled plot was dealt with in January in the Tintern woods to test a method of measuring sample trees, without having to fell them. The result was generally satisfactory. This forms the subject of a separate report.

30th September, 1924.

FINAL SUMMARIES OF SAMPLE PLOTS ESTABLISHED

IN THE YEAR 1923 - 1924.

lot No.	Species.	Date.	Age.	MAIN CROP. No.of Stems.	Ht.of Largest Trees.	Aver. Ht.	Form Factor.	Aver. Girth.	Basal Area.	U.B. Volume.	Bark.
NGLAND.											
1	Larch.	Dec/13.	43.	300	74'	70'	.398	27"	123	3420	15%
"	"	Dec/16.	46.	230	77½'	74'	.395	29½"	111	3255	-
"	"	Mar/19.	48.	230	81'	77'	.392	30½"	118	3580	-
"	"	Feb/24.	53.	165	83'	80½'	.380	34"	104	3180	18%
2.	Larch.	Jan/14.	51.	310	75'	71'	.387	27½"	129	3535	17%
"	"	Dec/16.	54.	245	77'	73½'	.388	29½"	118	3380	-
"	"	Mar/19.	56.	245	78'	75'	.378	30½"	124	3520	-
"	"	Feb/24.	61.	190	81½'	78'	.367	32"	106	3020	20%
3.	Larch.	Dec/13.	35.	590	52½'	49½'	.403	18½"	109	2175	18%
"	"	Dec/16.	38.	425	56'	53½'	.407	20½"	103	2240	-
"	"	Mar/19.	40.	426	58½'	56'	.400	22"	113	2530	-
"	"	Feb/24.	45.	310	62'	61'	.396	24"	101	2440	20%
4.	Oak.	Mar/24.	46.	182	55½'	53½'	.393	23"	53	1117	18%
"	Beech.	"	"	342	56'	43'	.352	13"	32	491	6%
"	Standards.	"	-	12	-	-	-	57½"	23	469	16%
"	Total.	"	-	536	-	-	-	-	109	2077	-
5.	Oak.	Mar/24.	46.	173	54'	52'	.387	22½"	48	967	18%
"	Beech.	"	"	352	54½'	44'	.337	12½"	31	457	6%
"	Standards.	"	-	9	-	-	-	55½"	15	296	16%
"	Totals.	"	-	534	-	-	-	-	94	1720	-
6.	Oak.	Mar/24.	46	205	55'	52½'	.378	21"	50	984	18%
"	Beech.	"	"	356	57'	49½'	.363	14½"	40	725	6%
"	Total.	"	-	561	-	-	-	-	90	1709	-
11.	Larch.	Jan/15.	23	546	45½'	43'	.379	15½"	73	1186	17%
"	"	Jun/17.	-	26	Thinnings removed........						
"	"	May/19.	27	397	50'	47'	.365	19½"	83	1423	20%
"	"	Apl/24.	32	192	55½'	52'	.372	22"	51	994	21%
12.	Larch.	Jan/15.	25	628	50'	46½'	.389	17"	100	1813	18%
"	"	Jun/16.	-	48	Thinnings removed........						
"	"	Apl/19.	29	453	54'	51'	.358	20"	102	1859	24%
"	"	Apl/24.	34	262	58½'	54½'	.358	22½"	74	1449	22%
13.	Larch.	Jan/15.	25	661	49'	46'	.381	16½"	97	1703	18%
"	"	Jun/16.	-	72	Thinnings removed........						
"	"	Apl/19.	29	470	54½'	51½'	.355	20"	103	1878	24%
"	"	Apl/24.	34	273	59½'	56½'	.363	22"	75	1532	22%
14.	Larch.	Jan/15.	25	602	47'	45'	.370	15"	75	1251	18%
"	"	Jun/16.	-	20	Thinnings removed........						
"	"	May/19.	29	485	53½'	48½'	.378	18"	86	1574	21%
"	"	Apl/24.	34	268	57½'	54'	.407	20½"	61	1334	19%
18.	Douglas.	-/13.	33	350	-	74'	-	33"	213	5594	12%
"	"	1915 &-18.	-	85	Thinnings removed........						
"	"	May/19.	39	232	95'	81'	.392	40"	205	6518	12%
"	"	Jun/24.	44	223	95½'	85½'	.396	42½"	220	7467	-
19.	Douglas.	-/12.	43	215	-	94'	.321	47½"	269	8213	12%
"	"	May/19.	50	196	110½'	106'	.330	50½"	274	9590	-
"	"	May/24.	55	174	115½'	112½'	.344	53"	268	10392	13%
20	Douglas.	-/12.	29	205	-	66'	.351	39½"	175	4048	14%
"	"	May/19.	36	177	84½'	78½'	.341	40½"	161	4314	14%
"	"	May/24.	41	163	93'	88'	.344	43"	168	5097	15%
41	Sitka.	Aug/21.	13	1643	38½'	32½'	.323	13"	157	1649	13%
"	"	Jun/24.	15	981	47'	42'	.380	16"	143	2285	12%
83.	Corsican	Jun/24.	37	465	67'	65'	.418	28½"	210	5691	19%
84.	Ash.	Jun/24.	22	979	38'	35½'	.193	10"	54	372	9%

For continuation (Thinnings) See next page.

FINAL SUMMARIES OF SAMPLE PLOTS ESTABLISHED

IN THE YEAR 1923 -1924. (Contd.)

Plot No.	Species.	THINNINGS. No.	Av. Ht.	Av. Girth.	B.A.	Vol.	TOTAL B.A.	Vol.	Periodic Increment B.A.	Vol.	M.A.I. B.A.	Vol	B.A. of Thins. over Total B.A.		
ENGLAND.															
E. 1.	Larch.	185	65	19½"	39	940	162	4360	-	-	-	-	.241	C2.	I.
"	"	75	70½	24½"	24	710	135	3965	12	545	4	180	.178	C1.	"
"	"	-	-	-	-	-	118	3580	7	325	3½	162	-	-	"
"	"	65	75½	28	28	800	132	3980	14	400	3	80	.212	C2.	"
E. 2.	Larch.	125	65½	21	31	730	160	4265	-	-	-	-	.194	C2.	II.
"	"	65	69	23½"	20	510	138	3890	9	355	3	120	.145	C1.	"
"	"	-	-	-	-	-	124	3520	6	140	3	70	-	-	"
"	"	55	74½	27½	23	645	129	3665	5	145	1	30	.178	C2.	"
E. 3.	Larch.	-	-	-	-	-	109	2175	-	-	-	-	-	-	III+
"	"	165	51	17	25	480	128	2720	19	545	6	182	.195	C2.	"
"	"	-	-	-	-	-	113	2530	10	290	5	145	-	-	"
"	"	115	56	19½	25	540	126	2980	13	450	3	90	.198	C2.	"
E. 4.	Oak.	109	45½	15½	14	232	67	1349	7	-	1½	-	.210	C1.	-
"	Beech.	25	51½	18	5	93	37	584	4½	-	1	-	.122	D.	-
"	Standards.	-	-	-	-	-	23	469	-	-	-	-	-	-	-
"	Totals.	134	-	-	19	325	127	2402	13	-	2½	-	-	-	-
E. 5.	Oak.	96	44	15½	13	207	61	1174	6½	-	1½	-	.211	C1.	-
"	Beech.	36	48½	19½	7	152	38	609	6	-	1	-	.198	D.	-
"	Standards.	-	-	-	-	-	15	296	-	-	-	-	-	-	-
"	Totals.	132	-	-	20	359	114	2079	14	-	3	-	-	-	-
E. 6.	Oak.	86	43	15½	11	169	61	1153	9	-	2	-	.183	C1.	-
"	Beech.	95	53½	22	26	549	67	1274	11	-	2	-	.392	D.	-
"	Totals.	181	-	-	37	718	127	2427	20	-	4	-	-	-	-
E.11.	Larch.	219	37½	12	18	200	91	1386	-	-	-	-	.199	C1.	I.
"	"	26	42½	15	3	32	-	-	-	-	-	-	-	-	"
"	"	123	41	14½	14	208	97	1631	-	-	-	-	.143	C1.	"
"	"	204	49	20	46	856	97	1850	14	427	3	85	.472	C2.	"
E.12.	Larch.	402	40½	11½	30	306	130	2119	-	-	-	-	.229	C2.	II+
"	"	48	46	14½	6	195	-	-	-	-	-	-	.256	C2.	"
"	"	128	47	16	17	272	119	2131	24	413	6	103	.144	C1.	"
"	"	191	50	17	42	806	116	2266	15	396	3	79	.361	C2.	"
E.13.	Larch.	476	41	11½	34	311	131	2014	-	-	-	-	.256	C2.	I-
"	"	72	45	13½	7	125	-	-	-	-	-	-	-	-	"
"	"	116	46½	15	14	214	117	2092	27	514	7	128	.122	C1.	"
"	"	197	53	19½	42	848	117	2380	14	502	3	100	.363	C2.	"
E.14.	Larch.	666	40½	11	45	456	120	1707	-	-	-	-	.375	C2.	II+
"	"	20	43	13½	2	30	-	-	-	-	-	-	-	-	"
"	"	97	45	14½	11	168	97	1742	24	521	6	130	.115	C1.	"
"	"	214	50½	18	37	747	98	2081	12	507	2½	101	.381	C2.	"
E.18.	Douglas.	5	-	-	-	76	-	5670	-	-	-	-	-	B	III
"	"	85	-	-	78	892	-	-	-	-	-	-	-	C1.	"
"	"	16	65	32	9	228	214	6746	-	-	-	-	.042	B.	"
"	"	10	-	35½	7	178	227	7645	22	1127	4	225	.030	B.	"
E.19.	Douglas.	-	-	-	-	-	269	8213	-	-	-	-	.000	-	I.
"	"	26	84	32	15	389	289	9979	-	-	-	-	.051	B	"
"	"	22	94½	41½	21	615	289	11007	15	1417	3	283	.071	B.	"
E.20.	Douglas.	-	-	-	-	-	175	4048	-	-	-	-	.000	-	II.
"	"	14	56	23½	4	55	166	4369	-	-	-	-	.027	B.	"
"	"	14	63	30	7	141	175	5238	14	924	3	185	.039	B.	"
E.41.	Sitka.	11	15½	4½	0	0	157	1649	-	-	-	-	.000	A.	-
"	"	662	33½	12	51	563	194	2848	37	1199	15	480	.261	C2.	-
E.83.	Corsican.	101	58½	20	22	465	232	6156	-	-	-	-	.097	B.	I+
E.84.	Ash.	642	31½	8½	24	92	78	464	-	-	-	-	.310	C2.	-

For Main Crop see preceding page.

FINAL SUMMARIES OF SAMPLE PLOTS ESTABLISHED

IN THE YEAR 1923 -1924.(Contd).

lot No.	Species.	Date.	Age.	MAIN CROP. No.of Stems.	Ht.of Largest Trees.	Aver. Ht.	Form Factor.	Aver. Girth.	Basal Area.	U.B. Volume.	Bark.
SCOTLAND.											
.35.	Abies grandis.	Oct/21.	20	2855	41½'	36'	.389	13½"	278	3895	8%
"	"	Oct/23.	22	1820	47½'	43'	.396	16½"	271	4618	8%
.36.	"	Oct/23.	22	1355	47'	42'	.390	15½"	182	2985	8%
.63.	Douglas	Nov/23.	16	1510	37	33½'	.318	13"	145	1550	11%
.64.	Scots.	Aug/24.	42	1581	39'	35'	.349	15"	200	2444	18%
.65.	Scots.	Aug/24.	42	1204	39½'	36½'	.353	16"	169	2186	19%
emporary Plot 416 in Quarter-Girth.											
416.	Sitka.	/23.	41	465	~~77~~	77'	.403	8¾"	248	7700	8%

Thinnings, etc., below.

lot No.	Species.	THINNINGS. No.	Av. Ht.	Av. Girth.	B.A.	Vol.	TOTAL B.A.	Vol.	Periodic Increment. B.A.	Vol.	M.A.I. B.A.	Vol	B.A. of Thinns. over Total B.A.		
SCOTLAND.															
.35.	Abies grandis.	-	-	-	-	-	278	3895	-	-	-	-	.000	-	-
.35	"	1035	31	8½"	43	225	314	4840	36	720	18	360	.137	C1	-
.36.	"	1540	33½'	11	99	1035	281	4020	-	-	-	-	.352	C2.	-
.63.	Douglas.	895	28'	10½"	52	385	197	1935	-	-	-	-	.264	C2.	II+
.64.	Scots P.	283	27'	9½"	14	74	214	2518	-	-	-	-	.065	B.	III
.65.	Scots P.	532	31'	13"	51	528	220	2714	-	-	-	-	.231	C2.	III

Main Crop above.

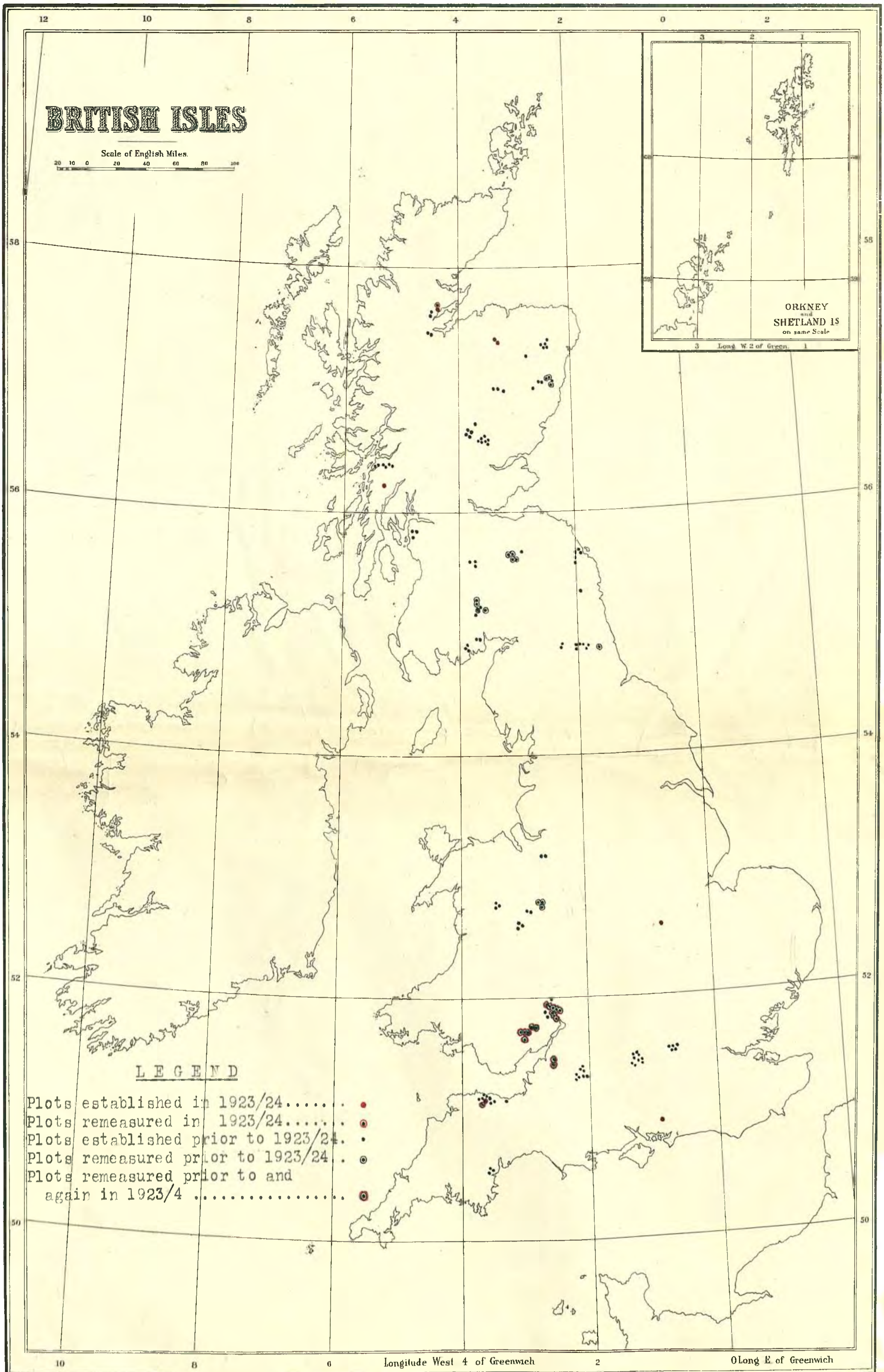
APPENDIX.

Some Actual Prices received for Thinnings from 1923-24 Plots.

				Age.		
European Larch.						
Plot	E.1.	800 cu.ft = 629 cu.ft Q.G.	@ 1/2d	53	= £ 36 - 13/10	Gross.
"	E.2.	645 " = 506 " "	@ 1/3d	61	= £ 31 - 12/ 6	"
"	E.3.	540 " = 424 " "	@ 1/-	45	= £ 21 - 4/ 0	"
Oak and Beech Coppice						
"	E.4.			46	= £ 6 - 7/7½	Nett.
"	E.5.			46	= £ 7 - 7/-	"
"	E.6.			46	= £ 12 - 13/9	"
European Larch.						
"	E.11.	856 cu.ft = 672 cu.ft Q.G.	@ 10½d	32	= £ 29 - 8/-	Gross
"	E.12.	806 cu.ft = 633 " "	" "	34	= £ 27 - 13/10	"
"	E.13.	848 " = 666 " "	" "	34	= £ 29 - 2/9	"
"	E.14.	747 " = 587 " "	" "	34	= £ 25 - 13/7	"
Sitka Spruce.						
"	E.41.	The number of thinnings per acre is 662. The price received for the largest of these runs from 10d to 1/- per pole. Say 300 poles	@ 1/-	16	= £ 15 - -:-	"
Ash.						
"	E.84.	No data available				
Abies grandis.						
"	S.35.			22	= £ 32 - - -	"
					26 - 12/-	Net
"	S.36.			22	= £ 8 - 2/6	Gross
					£ 5 - 14/6	Net
"	S.63.64.65.	No data available.				

--------oOo--------

MAP SHOWING THE DISTRIBUTION OF PERMANENT SAMPLE PLOTS IN THE BRITISH ISLES - 30th SEPTEMBER 1924.

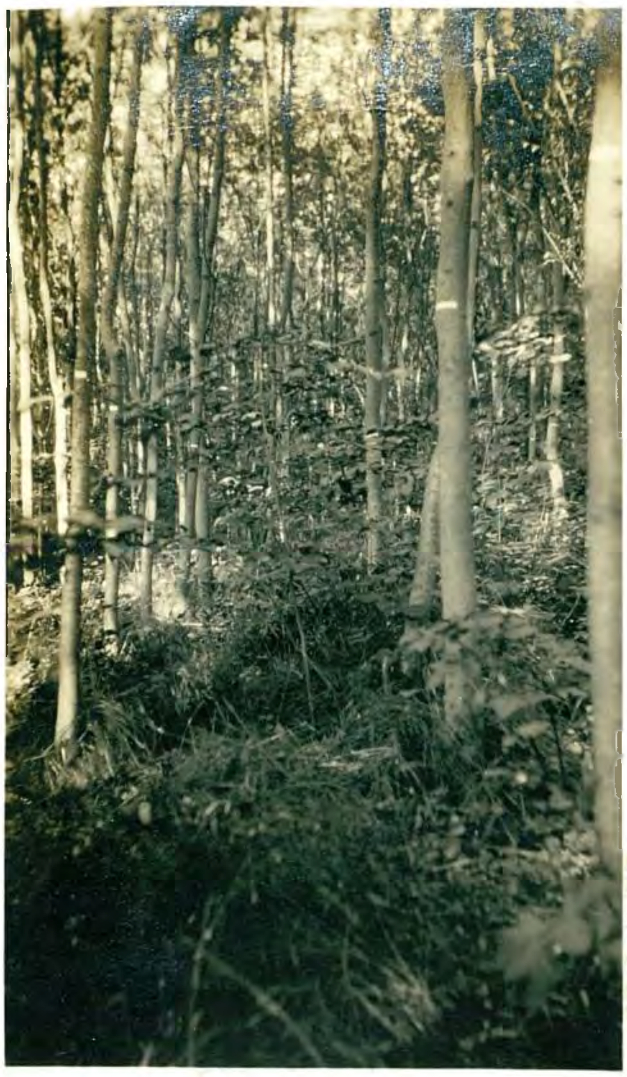


W. & A.K. Johnston, Limited, Edinburgh.

Plot E.4. Crowns and upper parts of stems of Oak.

Plot E.6. Oak & Beech Coppice after Thinning. 1924.

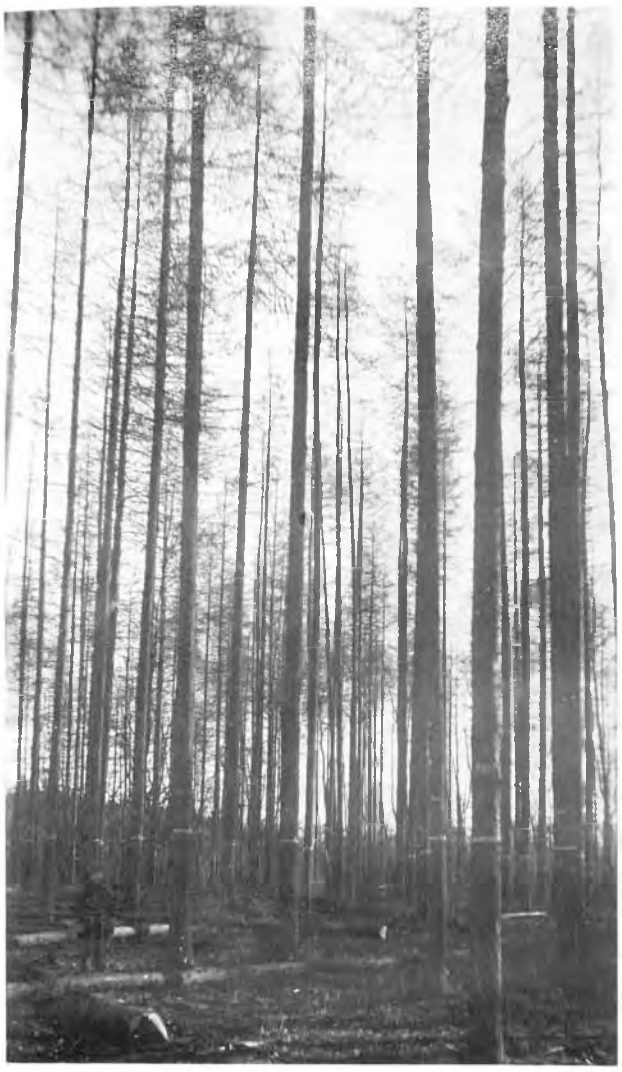
Plot E.4. Oak Standards in Oak & Beech Coppice.



Plot E. 84. ASH. Before thinning.

Same after Thinning.

Another View before Thinning.



E.3. EUROPEAN LARCH. "C"Grade.

E.19. DOUGLAS FIR. Tortworth.

E. 41. SITKA SPRUCE. "C" Grade before- and same after thinning.

Plot. S.35. "B" Grade thinning. 'Abies grandis' Novar.

S.36. 'Abies grandis' "C" Grade. after thinning.

S.65. "C"Grade. Strathspey Scots. Pine. Qual. Class III.

(1) <u>GROWTH OF SCOTS & CORSICAN PINE SEEDLINGS</u>.

(11) <u>GERMINATION OF SEED.</u>

F O R E S T R Y   C O M M I S S I O N.

REPORT ON RESEARCH WORK 1924.

W. E. HILEY.

I. The growth of seedlings of Scots and Corsican Pine during the first two years.

A statistical study was made of the growth of the seedlings in the following manner.

A. First year. (1) Seed was sown on May 15th and batches of the resulting seedlings were raised at intervals during the season, divided into size classes according to shoot growth, measured and weighed before and after drying in an oven. Each batch of seedlings contained about 80 plants and in the case of Corsican pine 27 batches were raised between June 14 and October 28, whereas in the case of Scots pine 23 batches were raised between June 30 and October 18.

The mean shoot lengths (distance from base of cotyledons to top of leaves), root lengths and dry weights of shoots and roots are shown in tables I and II and graphs A, B & C.

In each species the height growth was rapid at first but fell off almost entirely after August 18. Scots pine was slower in starting than Corsican pine but overtook it about July 18 and thereafter remained taller.

The roots of both species appeared to grow at an approximately constant rate during the whole season. The roots of Corsican pine were consistently longer than those of Scots pine and grew slightly more rapidly. The difficulty of extracting the roots entire renders the root measurements after August unreliable. They worked down into a hard stony layer of soil but they did not, as far as could be ascertained, penetrate far into this layer.

The changes in dry weight were followed right through from the dry seed to the end of the season's growth. It is evident that until green leaves are exposed to the light

Table I. Growth of Corsican Pine seedlings in first year.

Date.	Days from sowing.	Mean shoot length mm.	Mean root length mm.	Dry wt. per 100 seedlings in grams. Shoot	Root	Total without seed coats.	Water content % of dry wt. Shoot	Root	Root wt. ÷ Shoot wt.	
29/5	14	-	43	-	-	.55	-		-	
30/5	15	-	54	-	-	.61	-		-	
31/5	16	-	62	-	-	.60	-		-	
2/6	18	-	64	-	-	.52	-		-	
5/6	23	-	70	-	-	.61	-		-	
14/6	30	2.3	83	-	-	1.09	-		-	
18/6	34	7.3	98	-	-	1.34	-		-	
21/6	37	8.5	98	-	-	1.45	350		-	
25/6	41	10.8	121	-	-	1.77	328		-	
30/6	46	13.4	85	-	-	2.25	279		-	
4/7	50	12.3	82	-	-	2.25	210		-	
8/7	54	15.4	106	-	-	2.48	267		-	
14/7	60	18.1	115	-	-	2.90	250		-	
18/7	64	18.0	123	2-38	1.01	3.39	263	171	.42	
22/7	68	18.5	124	2.68	1.08	3.76	243	150	.40	
28/7	74	21.5	146	3.12	1.20	4.32	241	251	.39	.43
1/8	78	20.6	101	2.92	1.14	4.06	245	216	.39	
5/8	82	21.8	138	3.34	1.84	5.18	261	303	.55	
9/8	86	24.3	174	3.90	1.96	5.86	250	226	.50	
13/8	90	23.6	145	3.66	1.77	5.43	248	228	.48	
18/8	95	25.9	180	4.21	2.14	6.35	256	191	.51	.49
22/8	99	24.0	137	4.31	2.10	6.41	202	123	.49	
26/8	96	25.7	191	?	?	?	-	-	?	
11/9	110	25.0	197	4.75	2.36	7.11	261	231	.50	
15/9	116	24.3	192	4.26	2.22	6.48	249	187	.52	
19/9	120	25.5	207	4.40	2.35	6.75	270	376	.53	.50
23/9	124	26.2	202	5.13	2.32	7.45	267	343	.47	
30/9	131	25.7	199	5.07	2.99	8.06	265	391	.59	
7/10	138	25.8	222	5.25	2.74	7.99	259	368	.52	
14/10	145	27.6	241	5.48	2.93	8.41	268	328	.53	.53
21/10	152	26.9	223	4.74	2.40	7.14	295	341	.51	
28/10	159	25.3	183	5.45	2.63	8.08	240	293	.48	

4130.A. - 2.

Table II. Growth of Scots Pine seedlings in first year.

Date	Days from sowing	Mean Shoot length mm.	Mean root length mm.	Dry wt. per 100 seedlings in grams. Shoot	Root	Total	Water content % dry wt. Shoot	Root	Root wt. ÷ shoot wt.	
30/6	46	11.0	55	–	–	1.10	285			
4/7	50	10.5	57	–	–	1.20	252			
8/7	54	12.9	62	–	–	1.57	310			
14/7	60	17.5	84	–	–	2.21	272			
18/7	64	18.4	102	1.71	.66	2.37	269	157	.39	
22/7	68	22.6	113	2.28	.66	2.94	290	163	.29	
28/7	74	24.1	97	2.34	.71	3.05	298	282	.30	.35
1/8	78	24.7	119	2.01	.81	2.82	312	189	.40	
5/8	82	29.4	131	2.92	1.05	3.97	309	280	.36	
9/8	86	26.9	104	2.61	1.04	3.64	260	250	.40	
13/8	90	30.1	137	3.24	1.35	4.59	300	264	.42	
18/8	95	33.0	142	3.46	1.34	4.80	276	182	.39	.41
22/8	99	31.9	148	4.05	1.75	5.80	227	119	.43	
26/8	103	31.6	143	4.31	1.84	6.15	275	331	.43	
11/9	119	33.2	150	4.55	2.21	6.76	254	223	.49	
15/9	123	31.6	134	4.25	2.07	6.32	234	137	.49	
19/9	127	33.3	162	4.87	2.39	7.26	261	387	.49	.50
23/9	131	32.7	146	5.05	2.75	7.80	256	352	.54	
30/9	138	36.2	221	6.35	3.55	9.91	255	309	.56	
7/10	145	33.9	191	5.73	3.34	9.07	260	352	.58	
14/10	152	34.3	180	6.24	3.61	9.85	229	222	.58	.59
21/10	159	34.4	172	5.14	3.32	8.46	229	253	.65	

no carbon assimilation can occur and no increase in dry weight can be expected. In fact in the earlier stages of germination there must be a loss in dry weight owing to the store of food being used up. It was considered desirable to obtain an accurate knowledge of the actual changes in dry weights and the following experiments were carried out.

(2) Fresh seed. The mean weight of 100 fresh seed of Corsican pine in May (lot 24/13) proved to be 1,335 gms. The weight when oven-dried (mean of 9 tests of 200 seed each) was reduced to 1.205 gms. Thus the water content of 100 fresh seed was 0.13 gms. or 10.65% (10.5 to 10.8%) of the dry weight.

Further tests showed that the mean dry weight of 100 seed-coats was 0.52 gms., so that the dry weight of 100 seeds without seed-coats was 0.68 gms.

(3) Absorption of water on soaking in water. To test this seed was soaked in water for various intervals, the surface was dried by blotting paper and the seed weighed. It was necessary however to distinguish between the water actually absorbed and the water left clinging to the seed coats after drying with blotting paper. To determine the latter value 24 lots of 100 seed were stirred rapidly in water, dried with blotting paper and weighed. The increase in weight per 100 seed proved to be 0.08 gms. (0.05 to 0.10 gms.) In the following table this weight has been deducted from the ascertained weights of soaked seed.

Table III. Absorption of water on soaking seed at 25°C and 16°C. Mean estimated from 3 lots of 200 seed each.

Time of soaking.	Temp.	Wt. per 100 seed grams.	Water absorbed per hour	Time of soaking	Temp.	Wt. per 100 seed grams.	Water absorbed per hour.
o.	-	1.34	-	o	-	1.33	-
1 h.	25°C	1.48	.140	1 h.	16°C	1.45	+ .120
2 h. 40 m.	"	1.57	.054	3 h.	"	1.53	+ .040
4 h. 5 m.	"	1.64	.049	4 h. 10m.	"	1.57	+ .034
21h. 45m.	"	1.80	.009	22 h.	"	1.74	+ .009
1 d. 3h.	"	1.82	.004	1 d. 3h.	"	1.75	+ .002
2 d. 3h.	"	1.87	.002	2 d. 3h.	"	1.80	+ .002
3 d. 4h.	"	1.86		3 d. 4h.	"	1.82	+ .001
4 d.	"	1.83		4 d.	"	1.82	
9 d.	"	1.80		9 d.	"	1.79	
14 d.	"	1.78		14 d.	"	1.77	

It thus appears that water absorption is rapid during the first day, very slow during the second day and reaches its maximum at 25°C in the second day and at 16°C in the third day. After this there is a falling off, no doubt due to the exosmosis of dissolved substances.

(4) <u>Gain in wet weight and loss in dry weight on germination.</u>

Twenty four lots of 100 seed were weighed and incubated at 20°C in 8 batches of 3 lots each. Batches were weighed fresh and after oven-drying at intervals.

After incubating for days.	State of seedlings.		Increase in wet wt.per 100 seed.gms.	Decrease in dry wt.per 100 seed. gms.
		germinated.		
2	0.03%	o	+ 0.30	- 0.03
4	8%	-	+ 0.53	- 0.03
6	18%	-	+ 0.51	- 0.04
8	30%	-	+ 0.64	- 0.05
8 [x]	37%	-	+ 0.54	- 0.05
10	?		+ 0.68	- 0.05
12	(57% -) (radicles up to) (2½" long.)		+ 1.20	- 0.07
16	(66% germd.) (Cotyledons not) (yet showing.)		+ 1.77	- 0.11

The further changes are best seen from the results of weighing seedlings raised from the nursery lines.

[x] From here onwards was a separate experiment.

Table IV. Dry weights of seedlings at various stages of germination. (The weight of seed-coats has been deducted. Dry weight of 100 fresh seed after removing seed-coats = 0.68 gms.)

Stage of seedling.	Mean No. of days from sowing incubated seed.	Mean dry wt. per 100 seedlings gr.	Difference from fresh seed. gr.	Mean length of radicle. mm.
Angle of hypocotyl less than 90°	16	0.55	- 0.13	40
Angle of hypocotyl more than 90° Cotyledons not expanded.	18	0.58	- 0.10	65
Cotyledons expanded. Plumule less than 5 mm.	32	1.02	+ 0.34	83
Plumule more than 5 but less than 10 mm.	42	1.50	+ 0.82	106

From these tables it appears that the maximum loss in dry weight is about 0.13 gms. per 100 seeds, or about 19% of the dry weight of the seeds without their seed coats. Apparently carbon assimilation begins even before the cotyledons expand and subsequently proceeds at a rate of 0.03 to 0.05 grams per day per 100 seedlings.

(5) Dry weight increment of seedlings during the first year. Corsican Pine and Scots Pine.

The dry weight increment of the seedlings was estimated at various dates during the season and from July 18th. the shoots and roots were estimated seperately. The results are shown in tables I and II and on graph C.

The figures show that up to the end of June the dry weight increments of Corsican Pine followed the compound interest law, increasing at the rate of 4 per cent per day or doubling in 18 days. From this till the first week in August the rate was about 3 per cent per day, but after this the rate of growth fell off very markedly. There was, however, a continuous gain in dry weight till the end of September. The function $\frac{\text{Root wt.}}{\text{shoot wt.}}$ increased gradually from about 0.43 at the end of July to about 0.53 at the middle of October, whereas during the same period this function for Scots pine rose from 0.35 to 0.59. This is probably due to progress in storage of food supplies in the root.

It is difficult to determine the actual water content of roots since the roots have first to be washed and it is impossible to dry them to a fixed degree where they are neither wet on the surface nor beginning to shrivel. Consequently no great reliance can be placed on water contents. Nevertheless a few facts seem to emerge from the figures of water content which were calculated from June 21 onwards.

The water content of Corsican pine was at first high, up to 350 per cent of the dry weight of the whole seedling. It subsequently fell off to about 250 per cent and then remained nearly constant from the middle of July to the middle of September. During this period the water content of the shoot was about 250% of the dry weight and of the root about 200%. From then till the end of October the mean water content of the shoot was nearly 270% and of the root 350%. The reasons for these changes have not been conclusively determined, but it appears that in the early stages of growth when the volume of the seedling is increasing without there being any proportional increase in dry weight, the water content must become very high. The increased water content of the root in September is associated with a marked increase in the dry weight and may be due to the osmotic pressure of the root cells being raised by the large amount of sugar which is passed down from the shoot.

Comparison with §(9) shows that the seedlings examined in this experiment were very poor and their total dry weight was only about one third of the mean of seedlings sent from other nurseries at the end of 1923.

(6) Growth of Corsican Pine and Scots Pine seedlings during their second year.

On eight occasions from May 9 to October 10 lots of about eighty seedlings each were raised of Corsican pine and Scots pine in their second year. The roots of these seedlings were never raised whole, but their shoot height and the dry weights of shoots and roots were determined. The results are shown in tables V and VI and graphs D + E.

Corsican Pine. The mean length of the shoots on May 9 was 24 mm. Since the final shoot length of 1st. year seedlings on October 28 was 25 mm. it appears that the second year seedlings may be regarded as representative of the continued growth of the first year seedlings. The height growth was fairly continuous up to the middle of August but the subsequent growth was slight and is accounted for by the autumn extension of a few seedlings.

The total dry weight increment was very slight up to the middle of July but then rose suddenly and continued up to the end of September. The sudden increase in increment is associated with the opening out of the current years leaves. It is interesting to note that in large trees the dwarf shoots

Table V. Growth of Corsican Pine seedlings in second year.

Date.	Mean shoot length mm.	Wt. per 100 seedlings in grams. Shoot.	Root.	Total.	Increase per day.	Room wt. ÷ shoot wt.
9/5	24	6.91	4.33	11.24		.63
					.15	
23/5	35	8.80	4.56	13.36		.52
					.03	
6/6	32	9.52	4.28	13.80		.45
					.015	
20/6	47	10.01	4.10	14.11		.41
					.05	
18/7	64	11.00	4.51	15.51		.41
					.44	
15/8	87	19.54	8.24	27.78		.42
					.38	
12/9	92	28.00	10.51	38.51		.38
					.23	
15/10	95	31.11	13.79	44.90		.44

Table VI. Growth of Scots Pine seedlings in second year.

9/5	43	8.40	4.81	13.21		.57
					.33	
23/5	72	12.90	4.97	17.87)		.39
6/6	81	23.77	4.44	28.21)	.22	.19
20/6	95	19.73	4.31	24.04)		.22
					.29	
18/7	108	24.80	7.30	32.10		.29
					.04	
15/8	125	26.40	6.72	33.12		.25
					.64	
12/9	138	36.40	14.75	51.15		.40
					.58	
10/10	150	51.00	16.50	67.50		.32

of the current year do not expand until the height growth for the year is completed (i.e. beginning of July), but in seedlings the height growth is continued longer and the dwarf shoots begin to expand while height growth is still in progress. It is well known that carbon assimilation is very active in freshly expanded leaves but becomes sluggish in older leaves.

It is noticeable that both in Corsican pine and Scots pine the root weight does not increase but even may diminish up till June. As will be shown later starch is withdrawn from the root during the spring months so that a reduction in root weight is compatible with actual growth of the roots.

Scots Pine. The course of events in Scots pine is similar to that in Corsican pine with the following differences:

The shoot growth did not cease in August and bud formation was late.

The sudden increase in weight increment was about a month later than in Corsican pine; the weight increment in the spring was, however, much greater than for Corsican pine.

(7) Food storage in the roots of Corsican pine and Scots pine.

At the end of April the living tissues of the roots of one-year-old seedlings of both pines were densely packed with starch.

By May 25 a large amount of the starch had been extracted from the upper part of the root system. It was noticeable that the xylem parenchyma (medullary rays and cells round resin ducts) were the first to lose their starch and the pericyclic starch was absorbed less rapidly. Thus in a Scots pine seedling with a current year's shoot growth of 7 cms. the xylem parenchyma of the hypocotyl was entirely depleted whereas the pericycle still contained a little starch. At 2 inches down the xylem contained a little starch and the pericycle much; at 4 inches down the xylem content was moderate whereas in the pericycle the starch was dense. In a Corsican pine with a current year's shoot growth of 3 inches the only part that showed any loss of starch was the xylem parenchyma of the hypocotyl and top inch of root,

By June 10th. an active Scots pine seedling had its root nearly depleted of starch, whereas Corsican pine still showed dense starch below 6 inches. By August 1 Corsican pine was also practically depleted throughout the root.

No further observations on 2nd. year plants were taken until the autumn but on November 3 it was found that the starch content was very high.

The reserves in the shoot had by this time been converted into fat with the exception of a number of very minute starch granules in the phloem. In the hypocotyl both starch and fat were present and fat occurred in the outermost layers of the pericycle down to 2 inches below the surface.

First year seedlings of Corsican pine were also examined. From August 5 to September 30 the seedlings contained only a moderate amount of starch except in the case of two seedlings the radicles of which had been damaged about 3 inches below the surface. These radicles had both branched greatly but it was found that, unlike those of undamaged seedlings of the same age, they were heavily charged with starch.

By the end of October first year seedlings contained noticeably more starch. There was generally more starch in the upper portions of the roots than in the lower. It was noticed that portions of the root which were actively branching at this period contained more starch than those which were quite free of branches.

There are some indications that 1924 has been a bad year for carbon-assimilation. Thus seedlings at the end of 1924 contained much less starch than 1 year old seedlings in the spring. Also the 1 year old seedlings in April, though of the same height, were much heavier than first year seedlings in November.

(8) Examination of 2 year 1 year transplants of Corsican pine.

About 60 2 yr. 1 yr. transplants were raised from beds at Tubney for examination during January and February 1924. These beds were originally planted to show the effect of artificial manures on root growth, but it was found that variations in the soil were more than sufficient to obscure any effect from the manures.

The mean shoot growth of these plants in 1922 had been 2.8 cm; in 1923, after transplanting, it was 4.9 cms. When these growths were classified the following result was obtained.

Table VI. Relation between growth in the years before and after transplanting.

Shoot growth in 1922. cms.	No. of plants.	Mean growth in 1923. cms.	No. of dwarf shoots on 1923, main shoot.
1 - 1.9	8	2.5	17
2 - 2.9	33	3.6	31
3 - 3.9	13	5.5	42
4 - 4.9	8	7.4	58
5.- 5.9	5	7.6	80
6 - 6.9	1	11.5	73

This table shows that the rate of growth after transplanting was just about proportional to the rate of growth before transplanting. The seedlings were all originally raised from the same bed at Bushfield and this result does not necessarily bear any relation to seedlings raised from different beds. The number of dwarf shoots on the 1923 main shoot also bears a close relationship to the growth in the previous year. In this connection it should be noted that the number of dwarf shoots on a stem is the number laid down during the previous autumn in the bud which produces it. If an autumn growth occurs the dwarf shoots on this are additional to those laid down in the previous autumn. Now Scots pine normally makes a winter bud at the end of its first year's growth and each subsequent year; Corsican pine, however, does not normally make a winter bud at the end of the first year. At the end of the second year it normally does so, but an autumn growth may occur which generally reproduces the juvenile morphology of ordinary leaves without dwarf shoots. Such developments naturally interfere to some extent with statistical results.

Ten of the plants raised from one bed were especially examined for root morphology. The mean shoot growth in these plants was 3.3 cms. in 1922 and 5.1 cms in 1923 which was rather above the average. Their mean dry weight was 6.48 grams or rather below the average. The mean length of their radicles was 25.2 cm; the mean total length of secondary roots was 150 cms.; of tertiaries, 461 cms; of higher orders 172 cms. Thus the mean total root length, omitting small fibres, was 808 cms.(about 27 feet). The total number of secondary roots borne by the ten plants was 113. If after raising the plants the radicles had been cut off at 11 cms. below the lowest stem branch, half the laterals, comprising 68% of the whole root length, would have been left. If cut at 15 cms. 82% of the whole root length would have been left. It is thus apparent that the laterals borne on the lower parts of the radicles are unimportant in amount.

An attempt was made to find a single measurement which could be taken as a criterion of the quality of the plant. No measurement is very satisfactory, but if d is the diameter of the hypocotyl in mm. then the dry weight of the plant is generally about $\frac{d^3 + 10}{15}$ in gms for these plants.

The total dry weights of the plants varied from 1.7 gm. to 31.2 gm with a mean at 7.7 gm. The mean ratio of root weight to shoot weight was .58. Of the dry weight of the shoot 70% is made up of leaves and 30% of stems and buds.

A comparison of the dry weights of plants at the end of each year is shown in the following table.

Table VII. Mean dry weights of 100 Corsican pine at end of each year.

	Approximate Mean Dry wt. per 100 plants in gm.	Increase	Root wt. ÷ shoot wt.
Dry sead without coat.	0.68		
End of first year	8.5	12.5 times	.53
End of second year	45	5.3 times	.44
End of third year. (2 yr.1 yr. plant.)	770	17.1 times	.58

Since the plants were grown under different circumstances we cannot attach much importance to the figures and they must only be regarded as a rough indication. It appears, however, that the relation of root weight to stem weight does not greatly alter during the first three years. The comparatively small increase in the second year may be due to overcrowding in the nursery lines and the comparatively large increase in the third year may be due to the plants having more room. The measurements show that the three year old plants were not larger, when two years old, than the two year old plants when weighed.

(9) Examination of Corsican pine 1 yr. seedlings sent from various nurseries. (March 1924)

One-year seedlings were sent from several different nurseries and were examined. The method of examination was to sort each lot of seedlings into size classes and to pick out proportional numbers from each class. In some cases 10, in others 20, seedlings were carefully measured and weighed. The conditions under which the seedlings were grown are given in Table VIII, and the results of examination in Table IX. The following notes were also made:-

(i) This was a remarkable strong-growing lot, and all the shoots were branches though only seedling leaves were present. The roots, which were all broken in lifting, were heavily branched and actively growing (March 11).

(ii) Plants not large with few stem branches. Roots with very irregular, much branched laterals; they looked as though they had been unable to grow deep.

(iii) Roots much branched and radicles appear to have been damaged while growing. Surface roots actively growing (Mar.13)

(iv) Shoots mostly unbranched. Lateral roots numerous but very thin and often with very few dwarf roots attached.

(v) Shoots very long, but scarcely branched at all. Root laterals very thin; growth just starting.

(vi) Very small seedlings with very thin roots.

(vii) Very small seedlings with very thin roots.

Photographs were taken of typical seedlings of each lot.

Remarks. In no case were the roots complete and higher root weights would have been recorded if the seedlings had been raised without breaking. Investigation on the spot suggested that at Repley the roots failed to penetrate deeply and for this reason branched near the surface. This may account for the high $\frac{\text{Root wt.}}{\text{Shoot wt.}}$ value in (ii).

There are several variables that may affect the size and

Table VIII. Conditions under which Corsican

Pine seedlings were sown.

No.	Nursery.	Age of Nursery.	Soil.	Lot number of seed.	Date sown 1923	Treatment previous to sowing.	Drilled or Broadcast.	Density in bed when raised.
(i)	Rhinefield (New Forest)	6 yrs.	Light loam. little humus Stable manure	23/25	20/4	Soaked 6 days.	D	25 per sq.ft.
(ii)	Bagshot.	?	Sand gravel humus present Clay subsoil.	23/25	15/5	Malted.	B	88 " "
(iii)	Ampthill (Beds.)	4 yrs.	Sand. mod.humus farmyard manure.	23/30	3/5	Soaked & corvusine.	B	100 " "
(iv)	Woodbridge (Tangham nursery)	3 yrs.	Light loamy sand little humus Mineral manures.	23/23	24/ 4	Corvusine.	B	218 " "
(v)	Delamere (Linmere nursery)	5 yrs.	v.light sandy loam little humus farm-yard manure & lime.	23/23	18/4	Soaked 24 hours red lead.	B	84 " "
(vi)	Brandon (Elveden nursery)	2 yrs.	Light sand little humus No manure.	23/23	15/5	Corvusine.	B	2 " "
(vii)	Low Dalby (Yorkshire)	New	Heavy loam little humus no manure.	23/30	22/5	Soaked. Corvusine.	D	Scattered in drills.

Table IX. Results of observation of Corsican Pine Seedlings from various nurseries.

No.	Shoot length mm.	Length of radicle where broken or dead. cm.	No.of lateral roots more than 1 cm.long on top 15 cms.of radicle.	Total length of these laterals.cms.	Mean diameter of hypocotyl mm.	Mean Diameter cubed.	Dry wt.of 100 seedlings in gr.			Root wt. ÷ shoot wt.
							Shoot.	Root.	Total.	
(i)	32.8 ± 1.5	17.8	10.4 ± .8	35.1 ± 3.9	1.42	3.31	27.4	12.2	39.6	.45
(ii)	29.7	15.0	7.8 ± 1.1	32.1	1.22	1.88	19.5	13.1	32.6	.67
(iii)	33.3	18.3	10.9	37.7	1.30	2.65	23.9	10.8	34.7	.45
(iv)	33.5	25.4	9.4	31.5	1.12	1.47	18.5	12.1	30.6	.65
(v)	42.6 ± 1.3	18.7	11.2	30.5	1.28	2.16	18.1	7.8	25.9	.43
(vi)	20.7	20.7	9.8	28.5	.96	.89	6.6	5.3	11.9	.80
(vii)	22.6 ± .8	15.5	8.0 - .6	18.0 ± 2.3	.97	.93	5.1	5.6	8.7	.71

weight of the seedlings.

(a) The lot of seed. Lot 23/25 has given two good results; 23/30 has given one good and one bad.; 23/23 has given two fair and one bad.

(b) Date of sowing. There is an apparent correlation between the dry weight of the plants and the date of sowing. The correlation coefficient is $- 0.61 \pm 0.16$. (ii) is a notable exception in that it was sown late but has given good growth, and it should be pointed out that if (vi) and (vii) (the poor growth of which can be otherwise accounted for) be omitted, no correlation is visible.

(c) Soil. All the soils except (vii) were light in character. We cannot say whether the bad growth of (vii) was due to the heavier soil. All the soils except (vi) and (vii) had either plentiful or additional manures, and as (vi) and (vii) are in a class by themselves (i.e. very poor growth) this is probably an important factor in growth.

(d) Density of plants. There is no apparent relation between density of plants and mean dry weight. It is noticeable, however, that (iv) with by far the highest density, is second in tallness of shoot but only fifth in thickness of stem.

The number of lateral roots show extraordinarily little variation. The total length of laterals show considerable variation and follows the total dry weights. It is noticeable that (vii), the only one on a heavy soil, has markedly less branching than the others.

In addition to the above lots of seedlings one lot of 2 yr. seedlings was sent from Cannock Chase. These showed a mean shoot length of 6.7 cms.; a mean stem thickness of 1.6 mm, and mean dry weight of 6.12 gms. (shoot 4.64 gms., root 1.48 gms.). They were particularly good seedlings with very much branched roots.

Root Pruning Experiment.

On account of the favourable results obtained last year from root-pruning first year seedlings during the summer, a larger scale experiment was carried out this year. Several methods of undercutting roots were tried. In each case the beds were built up with boarded sides so that the undercutting mechanism could be operated underneath the boards.

(1) Wire netting was laid under the beds and it was intended to pull this netting so as to break off the roots at any desired depth. This method failed as it was found that the resistance of the wire netting was too great.

(2) A taut wire, attached like the string of a bow to a frame of gas piping, was found to be insufficiently strong to stand the strain.

(3) A horizontal cross-saw with vertical handles was eventually used. This instrument can be worked along the bed under the boards, but the operation is tedious and it loosens the soil to an undesirable extent.

Seed of Corsican and Scots pine was sown at Tubney in raised beds on April 17. One year seedlings were also lined out. A part of these were undercut with the cross saw on three occasions, June 16, July 7 and August 7.

First year seedlings of Corsican pine were raised on September 18 and December 5. It was found that the undercut seedlings were distinctly smaller than those not undercut and they had made fewer lateral roots.

Corsican Pine seedlings raised December 5.

	Mean No. of lateral roots.	Mean length of lat.roots mm.	Mean dry wt.per 100 seedlings in gms.			Root wt. ÷ shoot wt.
			Stem.	Root.	Total.	
Control	14.2	34.0	11.1	8.0	19.1	.72
Undercut	10.1	34.7	7.0	6.6	13.6	.94

It will be seen that the control seedlings had exceptionally well branched roots. The disappointing result of this experiment may be due in part to this fact; and it is possible that a repetition of the experiment under other conditions might give valuable results. It may be noted that in the undercut seedlings the root weight is extraordinarily high in relation to shoot weight.

II. Germination of Seed after treatment.

To test Mr. Steven's method of chemical stimulation of seed.

Two experiments were carried out under this head, both with European larch (24/11).

In Exp.1 the following treatments were compared.

L.N.	Control: sown dry.	
L.B.1.	Soaked 24 hours in cold water: Temp. 10°C.	
L.B.7.	Soaked 7 days in cold water: Temp varied from 3°C to 14°C. Mean of daily observations 7.7°C.	
L.I.a.	Water 17 hours: Iodine solution 24 hours.	Temp about 10°C.
L.I.b.	" 23 " : " " 18	
L.I.c.	" 19 " : " " 12 " . water 10 hours.	
L.I.d.	" 17 " : " " 6 " : water 18 hours.	
L.20.7.	Incubated on damp filter paper at 20°C for 7 days (About 3% of the seeds had germinated when sown and a few radicles were up to 2 cm. long).	

The soaking in iodine in this experiment was not satisfactory since the counted lots were kept separate in muslin bags which absorbed the iodine so that the solution lost most of its colour. On this being discovered further iodine crystals were added, but even this did not make the experiment satisfactory.

Each lot contained 300 seed and 7 lots of each treatment (8 controls) were sown in alternating drills on April 16. The number of seedlings was counted three times a week and dead seedlings were counted and removed. The total number of seedlings (including those that died) produced per 100 seed for each treatment is shown in column 1 of Table X.

In Expt.2 no muslin bags were used and the iodine treatment was performed by placing each lot of seed in a separate bottle of iodine solution. The following treatments were compared.

L.N.	Control: sown dry.	
L.I.	Water $8\frac{1}{2}$ hours: iodine soln. 18 hours.	at about 15°C.
L.W.	Soaked $26\frac{1}{2}$ hours in cold water	
L.W.7.	Incubated on damp filter paper at 20°C for 7 days.	

Table X.

Germination of larch seed after various treatments. (Seed lot 24/11 Germination per cent 44).

Treatment.	Total plant per cent to 25/8/24 incl. losses.	May 12.	June 6.	Sept. 9.	Mean ht. of seedlings Oct. 30th. cms.
Exp. 1 sown Apr. 16.					
L.N.	15.8±0.8	1.0±0.3	9.6±0.8	13.0±0.7	3.6
L.B.1.	34.4±1.0	21.0±1.1	32.3±1.0	27.9±0.6	5.8
L.B.7.	38.1±0.8	28.5±1.1	37.0±0.8	31.9±0.8	5.2
L.I.a.	31.0±0.7	20.4±0.7	29.6±0.8	25.8±0.9	4.9
L.I.b.	35.9±1.2	26.4±0.8	34.0±1.2	29.4±1.3	5.7
L.I.c.	33.6±1.4	22.5±1.4	32.3±1.4	27.9±0.9	5.5
L.I.d.	36.6±0.4	27.3±0.7	34.9±0.4	29.5±0.9	5.1
L.20.7	26.4±0.9	32.1±0.8	33.9±0.9	28.9±0.9	5.3
Exp.2. sown May 5.		May 21.	Aug.25.		
L.N.	18.3±1.4	0.7±0.4	15.6±1.5		3.3
L.W.	39.4±0.5	17.9±0.5	36.1±0.4		4.9
L.20.7	29.7±0.6	19.7±0.8	25.6±0.7		5.1
L.I.	38.6±0.4	17.6±0.1	34.6±0.3		5.0

Each lot contained 300 seed and 7 lots of each (8 controls) were sown in alternating drills on May 5. The number of seedlings were counted three times a week and an analysis of losses has been made.

The plant per cents as determined at various dates in these two experiments are shown in Table X and Graphs F & G.

Conclusions.

(i) Treatment with soaking in cold water. Both experiments show that soaking in cold water prior to sowing greatly increases germination; in fact in each experiment it has more than doubled it. In Exp.1 soaking for 7 days gave an appreciably better result than soaking for 1 day.

(ii) Treatment with Iodine solution. The mean of all the iodine tests in Exp.1 gave a plant % of 34.3 whereas soaking for 1 day in cold water gave 34.4. This experiment was admittedly inconclusive but in the second expt. soaking in Iodine gave a mean plant % of 38.6 whilst soaking for the same time in water gave 39.4. Thus the only result that can be deduced from this experiment is that the presence of iodine in the water in which the seed is soaked has no effect.

(iii) Incubation. In Expt.1 gave a slightly worse result than soaking for 7 days and rather better than soaking for 1 day, but the differences are not significant. In Expt.2 incubation is significantly worse than soaking in water or iodine for 1 day.

In 1923 incubation for 6 days gave 50% better plant per cent than soaking, a result which is contrary to that of this year. The following considerations throw some light on this divergence.

In each year the incubated seed germinates much more rapidly than seed treated in any other way. Nearly all the incubated seed that are going to germinate will have appeared above ground 3 to 4 weeks after sowing, whereas the other seed germinates from a few days to a few weeks later. In 1923 from April 25 to May 9 the mean daily temperature did not fall below 45°F. In this period nearly all the incubated seed and a few of the other seed appeared above ground. From May 10 to May 17 only one day showed a temperature above 45°F and there was a very marked slowing off in the rate of germination. This low temperature during the period when most of the non-incubated seed should have germinated appears greatly to have reduced their subsequent success. In 1924 on the other hand the mean daily temperature fell below 45°F on only two days between April 16 and May 31 and these does not appear to have been any check in the germination in any of the drills.

Further a special lot of controls sown in 1923 ten days before the other seed gave a very much better result than those sown at the same time as other seed.

It thus appears that the weather which occurs at the time when the seedlings are coming above ground has a very important effect on the number of seeds that germinate successfully; and this factor is one of the chief sources of error in all these germination experiments.

It will further be noticed that, with the exception of the controls, the heights of all the lots are about the same. This is in agreement with the conclusion reached in previous years that the height of seedlings in any given bed is chiefly determined by the time they have had to grow in. Those lots which germinated early grew the tallest.

(2) Incubator tests of the Iodine treatment.

In order to test the effect of iodine on germination in the incubator the following experiments were carried out.

Expt.3. 6 lots of 100 larch seed were placed in water for 6½ hours and iodine solution for 18½ hours. At the same time 6 lots were placed in water for 24½ hours. This soaking was performed at 20°C. Each lot was then laid out on damp filter paper in the incubator at 20°C. They were arranged in 4 batches each containing 3 lots. Batch No.4 (water treated) was inadvertently allowed to become dry at the beginning of the incubation which retarded the germination of the seed.

Table XI.

Numbers of Seed germinated.

	5 days	6 days.	7 days.	12 days.	29 days.	
Batch No.1. (Iodine)	23	33	36	39	42	
	22	25	26	28	31	
	23	29	30	35	38	Mean 41.3 ± 2.0
Batch No.2. (Iodine)	39	43	43	47	52	
	23	27	30	33	39	
	29	38	44	46	46	
Batch No.3. (water)	30	36	38	40	42	
	29	32	32	35	36	
	27	33	40	42	45	Mean 42.2 ± 1.7
Batch No.4. (water)	0	0	7	30	37	
	0 v.dry.	1	7	34	40	
	0	0	9	44	53	

A further expt. was carried out along the same lines but 200 seed were here included in each lot. The whole was carried out in the basement at a temperature which varied from 15° to 17.5°C.

Table XII.

Expt.4. Germination per cent after soaking in Iodine and Water.

	6 days.	7 days.	8 days.	15 days.	36 days.
Iodine.	4.6	11.5	18.1	42.2	46.9 ± 2.2
Water.	4.6	11.1	17.5	41.5	54.4 ± 2.2

Under the conditions of these experiments it does not appear that treatment with iodine solution materially affects the germination.

(3) Rate of Germination and Losses.

The number of seedlings in each drill was counted three times a week and dead and dying seedlings were removed and counted separately. From these figures the average number of new germinations and the average number of losses per day can be calculated. They are given in Table XIII columns 2 and 6.

In order to observe more accurately the effect of weather on germination, the daily rate of germination has also been expressed in terms of the number of seeds which subsequently germinated. Thus from May 5 onwards 4770 seed germinated in Expt.I. From May 5 to May 7 1528 new seed germinated, or 764 per day. Expressing these figures as per thousand of those which actually did germinate then or subsequently we find that for every thousand 320 germinated in ten days, or 160 per day. The figures calculated in this manner are given in column 4. In column 8 will be found the daily losses of seedlings expressed per thousand of those present. Columns 3,5 and 9 give similar values for Exp.II.

In Graph H is shown the numbers of germinations per day per thousand of those still to germinate for each experiment, and also the mean temperature for the period. The two experiments do not show a close agreement and the factors which cause seedlings to appear when they do are obscure. These figures are receiving further attention.

In Graph K are shown the losses per thousand per day for the two experiments. Here there is a very fair agreement between the two experiments and there is evidence that the seedlings die off principally on a rising temperature, and in the absence of rain.

Observations made periodically on the dying seedlings showed that they were killed by many causes. (1) A few showed the typical features of "damping off"; (2) a few showed the effects of high surface soil temperature, and (3) a few had their roots eaten by insects. (4) The majority, however, simply shrivelled, the whole seedling drying up, and it appears that this is due to feebleness in the absorption of water by the roots.

Table XIII. Germinations and Losses per day. Expts.I and II.

Date 1924.	Fresh seed germd. per day. (Nearest Integer)		Expressed as % of those remaining to be germd.		Losses per day.		Losses per 1000 existing seedlings.	
	Exp.I.	Exp.II.	Exp.I.	Exp.II.	Exp.I.	Exp.II.	Exp.I.	Exp.II.
30/4-2/5	28		5		0.		0	
2-5/5	173		33		1.0		1.3	
5-7/5	764		160		0		0	
7-9/5	422		130		4.5		1.4	
9-12/5	215		90		0		0	
12-14/5	98	8	56	3	2.5	0	0.6	0
14-16/5	91	60	59	22	17.0	0.5	4.1	3.3
16-19/5	57	239	42	94	2.7	0	0.6	0
19-21/5	99	155	82	85	5.0	0	1.1	0
21-23/5	31	46	31	31	6.5	0	1.4	0
23-26/5	32	76	34	54	2.3	2.7	0.5	1.7
26-28/5	30	219	35	185	8.0	5.5	1.7	2.8
28-30/5	47	72	60	97	15.5	18.0	3.2	8.7
30/5-2/6	61	69	88	116	1.0	0.7	0.2	0.3
2-4/6	59	28	117	73	0.5	5.0	0.1	2.2
4-6/6	30	6	77	19	2.0	2.0	0.4	0.8
6-11/6	16	16	48	50	2.2	1.8	0.4	0.7
11-13/6	25	12	101	50	4.0	7.5	0.7	3.1
13-16/6	10	8	48	36	3.7	4.7	0.7	1.9
16-18/6	11	29	67	153	6.0	7.0	1.1	2.8
18-20/6	19	10	127	75	9.0	1.0	1.7	0.4
20-23/6	5	0	48	0	3.7	2.3	0.7	1.0
23-25/6	4	8	42	75	4.5	3.0	0.8	1.2
25-27/6	2	0	23	0	24.0	13.0	4.6	5.3
27-30/6	3	1	37	14	10.7	6.0	2.0	2.5
30/6-2/7	0	0	7	0	17.5	11.0	3.3	4.5
2/7-4/7	0	0	7	0	4.0	4.0	0.7	1.6
4/7-7/7	0	1	5	7	0.7	1.3	0.1	0.6
7/7-9/7	0	0	0	0	1.0	2.0	0.2	0.8
9/7-11/7	0	3	7	39	10.5	12.5	2.0	5.2
11/7-14/7	0	0	5	4	22.3	5.3	4.4	2.2
14/7-16/7	14	1	213	12	25.5	3.5	5.0	1.4
16/7-18/7	(-2)	0		0	5.0	0	1.0	0
18/7-21/7	0	0		0	1.0	1.7	0.2	0.7
21/7-23/7	0	0		0	1.5	1.0	0.3	0.4
23/7-25/7	0	0		0	0.5	2.5	0.1	1.0
25/7-30/7	4	3		106	0.4	0.2	0.1	0.1
30/7-1/8	4	9		60	1.0	2.0	0.2	0.8
1/8-4/8	3	2		68	0.3	0.3	0.1	0.1
4/8-6/8	1	8		140	0	0.5		0.2
6/8-8/8	0	5			0	1.5		0.6
8/8-11/8	0	3			0	0.7		0.3
11/8-13/8	0	0			0	0		0

4130.A.-29.

In the early stages the losses were on the whole greater than in the later stages, but during August and September many seedlings were cut off above ground by cut worms, and though in most cases a few green leaves were left so that the seedling continued to live, these seedlings would have been very little value for lining out.

Improvement of Germination Experiment 1923.

The seedlings raised in this experiment, which was reported on last year, were lifted during April 1924. Each lot was divided into three classes, sound, living but damaged and dead. The losses were high, chiefly owing to cut-worm and many seedlings had been cut off at the soil surface so that they had been overlooked the previous autumn.

Table XVI shows the plant per cent and mean heights in Oct. 1923, the plant per cent - total and sound only - in April 1924, and the mean dry weights - shoot and root - of the sound seedlings in April 1924.

It will be seen that the seed which had been incubated for 9 days gave the heaviest plants; those incubated for 6 days gave the greatest number of sound plants and the second highest mean weights.

Table XIV. Improvement of Germination 1923. European Larch.
(Germ.p.c.31.)

Treatment.	Plant % 6/10/23.	Mean ht.cm.	Plant % Apr.1924. Living & dead.	Plant % Apr.1924. Sound.	Dry wt.per 100 seedlings (Sound seedlings only). Shoot. Grms.	Root. Grms.	Total. Grms.
Soaked 14 days 10°C.	9.9	3.6	11.9 ±1.5	7.6 ±0.9	10.0 ±0.4	6.8 ±0.2	16.8
Soaked 10 days 10°C.	9.9	3.8	12.0 ±1.4	8.2 ±0.8	10.1 ±0.3	6.6 ±0.2	16.7
Soaked 6 days 10°C.	8.5	4.5	9.7 ±1.2	7.5 ±0.8	11.0 ±0.4	7.6 ±0.3	18.6
Soaked 9 days 20°C.	2.4	3.8	3.4 ±0.4	2.0 ±0.3	11.0 ±0.5	7.3 ±0.4	18.3
Soaked 6 days 20°C.	2.5	4.1	3.7 ±0.6	2.2 ±0.3	10.8 ±1.2	7.3 ±0.7	18.1
Soaked 3 days 20°C.	4.6	3.3	6.6 ±0.9	3.3 ±0.3	10.0 ±1.0	6.3 ±0.5	16.3
Incub.9 days 20°C.	8.6	5.8	11.8 ±0.9	6.5 ±1.0	16.1 ±0.5	11.7 ±0.3	27.8
Incub.6 days 20°C.	13.2	5.7	17.9 ±1.6	10.4 ±0.8	14.4 ±0.3	9.7 ±0.4	24.1
Incub.3 days 20°C.	6.8	4.4	10.8 ±1.8	5.4 ±0.4	12.5 ±0.8	8.2 ±0.3	20.7
Control sown dry	5.5	3.2	8.4 ±1.3	3.7 ±0.6	8.7 ±0.7	5.9 ±0.5	14.6

Improvement of Germination Experiment 1922. European larch and Douglas fir.

These experiments have been reported on for the last two years. For each species the seedlings were divided into two parts.

(i) Some were lined out in Bagley Wood nursery

(ii) Some remained in the seed beds and were raised and weighed when two years old.

(i) These were lined out in order that the subsequent growth of seedlings, produced from incubated seed, might be watched. The main object was to test the criticism that the additional seedlings produced by incubation might, on the average, be weaker than those produced normally.

The losses in the lined out beds were high. The seedlings died in certain patches without any observable attack of insects or fungi. Soil tests have been made without elucidating the cause, but the nursery has been continuously cropped for 20 years and the soil appears to have become compacted and ill-drained. 10 out of 131 labels were lost and the consequently doubtful numbers were assessed on a basis of proportions.

The losses to date are shown in Tables XV and XVI. From these tables it will be seen that in each case the controls show the highest per cent of losses, and this may be accounted for by the fact that they contained the largest proportion of poor plants when lined out. It will also be seen that with each species incubation for 7 days at 20°C has given the highest number of plants.

These transplants are now (Dec.1924) 1 yr. 2 yr. and are being planted out on an area of about 2 acres in Bagley Wood. The woodman is destroying plants which he would normally regard as culls and the remainder are being planted and labelled. The subsequent growth will be recorded by Mr.Champion who is taking over this together with other Bagley Wood experiments.

(ii) Those left in the seed beds were raised during May 1924. Their growths in 1922 and 1923 were measured and the dry weight of roots and shoots. With larch there were remarkably few losses in those seed beds and the plant per cents of the living plants raised (Table XV, last column) were much higher than those of the lined out seedlings. The mean dry weights of the seedlings in each drill varied from 0.50 gm. to 1.39 gm. Correlation coefficients were calculated to show the connection between dry weight and (a) size of seedlings at end of first year and (b) their density. The evidence deduced from these correlations is that the dry weight is influenced positively by (a) and negatively by (b), but that density has a greater influence than size in the first year. As the tables involved in this work are long they are not reproduced here. The Douglas fir grew badly during their second year in the seedbeds. Their height growth was small and their losses were heavy (see Table XVI, last column.) The mean dry weights of the seedlings (mean of each drill) varied from   to   .

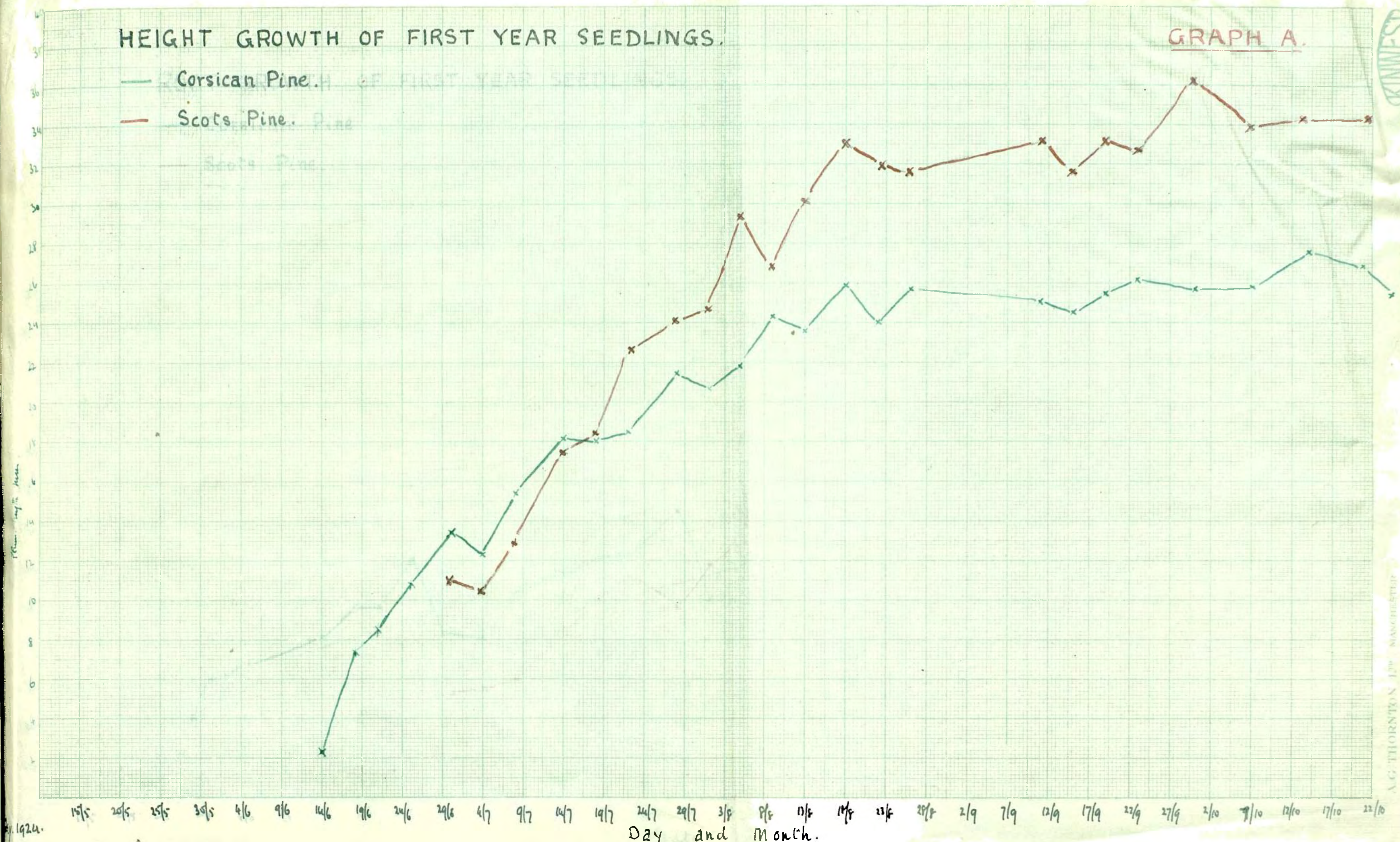
Table XV. Improvement of Germination Experiment 1922.
European larch. Germ. p.c. 47

Treatment.	Plant % 30/10/22	Plant % 20/8/23	Plant % 18/10/24	Loss per cent. 30/10/22 to 20/8/23	20/8/23 to 18/10/24	30/10/22 to 18/10/24	Plant % of those left in seedbeds. May 1924.
Incub. 7 days 20°C.	25.8	19.2	17.8	26	7	31	22.5
Incub. 3 days 20°C.	18.1	15.2	13.5	16	11	25	18.5
Incub. 1 day 20°C.	17.3	15.6	13.4	10	14	22	18.2
Incub. 7 days 25°C.	15.0	14.3	12.4	5	14	17	16.2
Incub. 3 days 25°C.	21.0	17.6	15.7	16	11	25	23.2
Incub. 1 day 25°C.	17.4	14.8	13.3	15	10	24	15.3
Incub. 12 days 30°C.	9.5	7.4	6.8	22	8	28	11.0
Incub. 7 days 30°C.	15.0	13.5	12.1	10	10	19	15.8
Incub. 3 days 30°C.	20.7	19.1	17.5	8	8	15	22.0
Control sown dry.	10.5	7.5	6.5	29	13	38	10.4

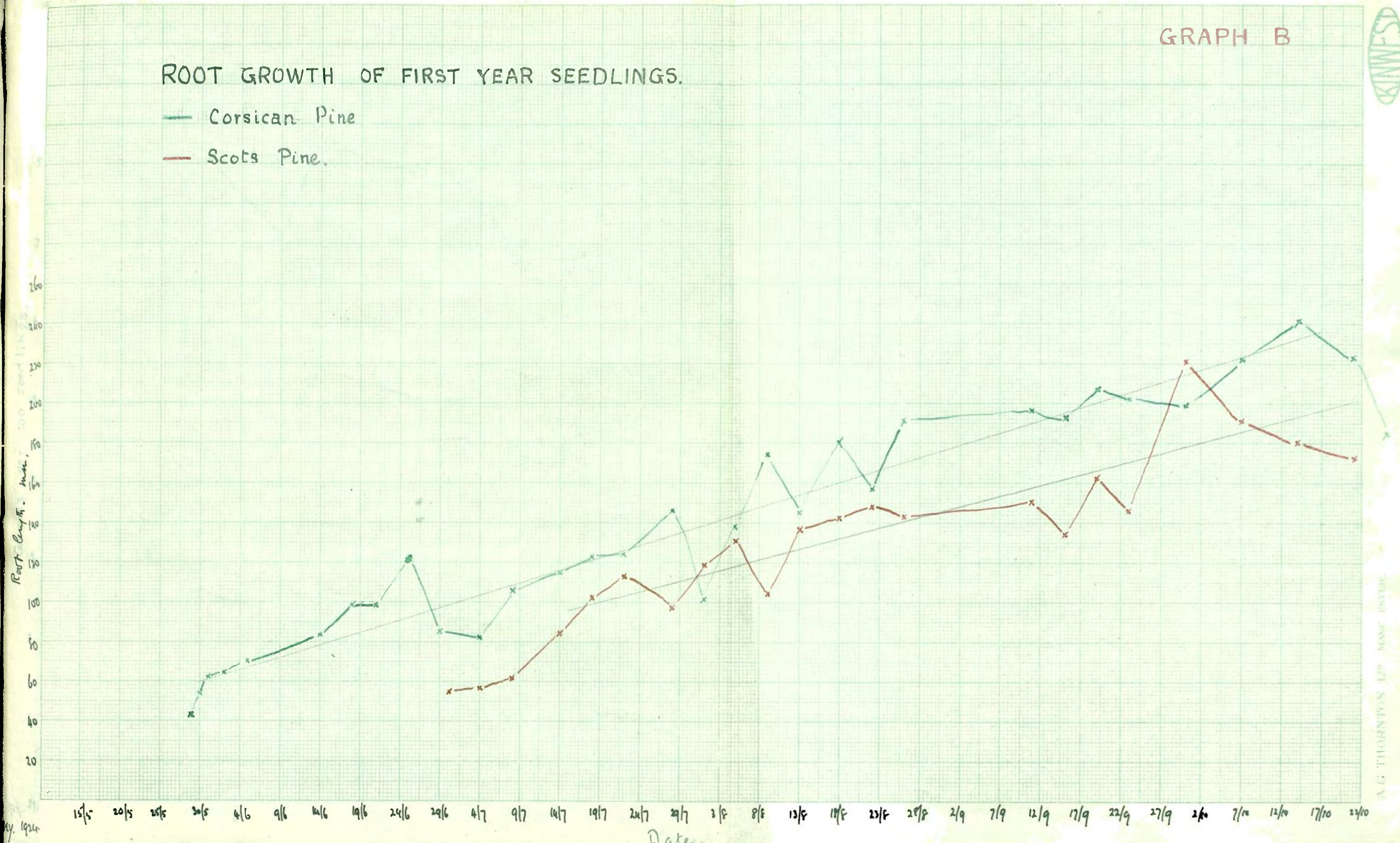
Table XVl. Improvement of Germination Experiment 1922.

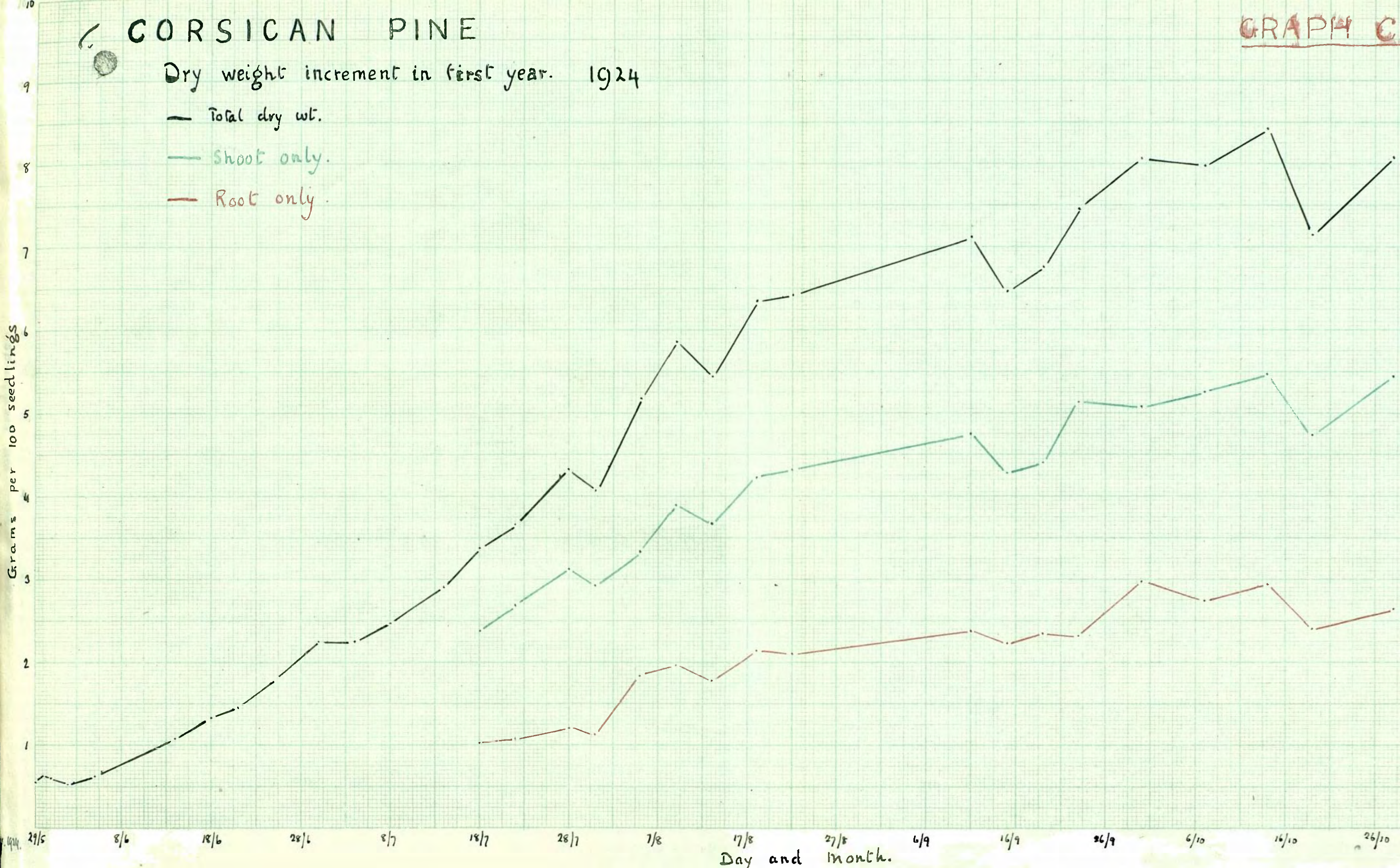
Douglas fir. Germ. p.c. 74.

Treatment.	Plant % 6/10/22.	Plant % 20/8/23	Plant % 18/10/24.	Loss per cent. 6/10/22 to 20/8/23.	20/8/23 to 18/10/24	6/10/22 to 18/10/24.	Plant % of seedlings left in seedbeds May 1924.
Incub. 12 days 20°C.	34.7	22.6	17.8	35	21	49	15.4
Incub. 7 days 20°C.	41.0	26.4	23.1	36	12	44	14.0
Incub. 3 days 20°C.	38.7	24.3	21.3	37	12	45	13.8
Incub. 7 days 25°C.	28.9	15.9	13.4	45	16	54	13.7
Incub. 3 days 25°C.	22.7	14.1	12.0	38	15	47	10.3
Incub. 1 day 25°C.	31.4	19.9	19.3	37	3	39	13.9
Incub. 12 days 30°C.	30.6	20.0	16.4	35	18	46	12.4
Incub. 7 days 30°C.	28.0	17.2	14.2	38	17	49	17.7
Incub. 3 days 30°C.	26.1	16.1	14.0	38	13	46	16.7
Control sown dry.	23.8	13.5	10.9	43	19	54	13.0



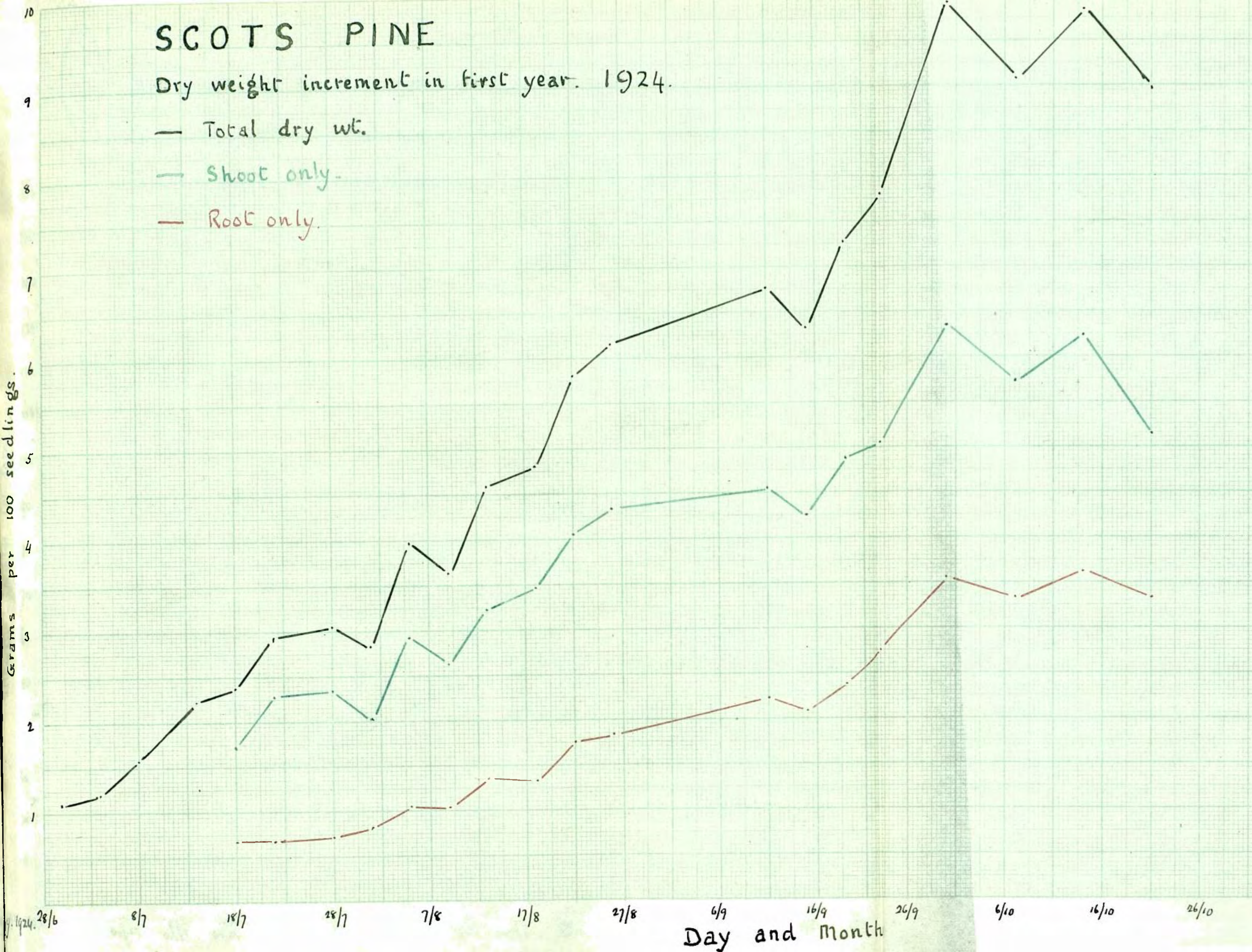
HEIGHT GROWTH OF FIRST YEAR SEEDLINGS.
GRAPH A.
Corsican Pine.
Scots Pine.
15/5 20/5 25/5 30/5 4/6 9/6 14/6 19/6 24/6 29/6 4/7 9/7 14/7 19/7 24/7 29/7 3/8 8/8 13/8 18/8 23/8 28/8 2/9 7/9 12/9 17/9 22/9 27/9 2/10 7/10 12/10 17/10 22/10
Day and Month.


GRAPH B
ROOT GROWTH OF FIRST YEAR SEEDLINGS.
Corsican Pine
Scots Pine.
Root length. mm.
20
40
60
80
100
120
140
160
180
200
220
240
260
15/5
20/5
25/5
30/5
4/6
9/6
14/6
19/6
24/6
29/6
4/7
9/7
14/7
19/7
24/7
29/7
3/8
8/8
13/8
18/8
23/8
28/8
2/9
7/9
12/9
17/9
22/9
27/9
2/10
7/10
12/10
17/10
22/10
Date.



C CORSICAN PINE
GRAPH C
Dry weight increment in first year. 1924
Total dry wt.
Shoot only.
Root only.
Grams per 100 seedlings
10
9
8
7
6
5
4
3
2
1
29/5
8/6
18/6
28/6
8/7
18/7
28/7
7/8
17/8
27/8
6/9
16/9
26/9
6/10
16/10
26/10
Day and month.

GRAPH C'

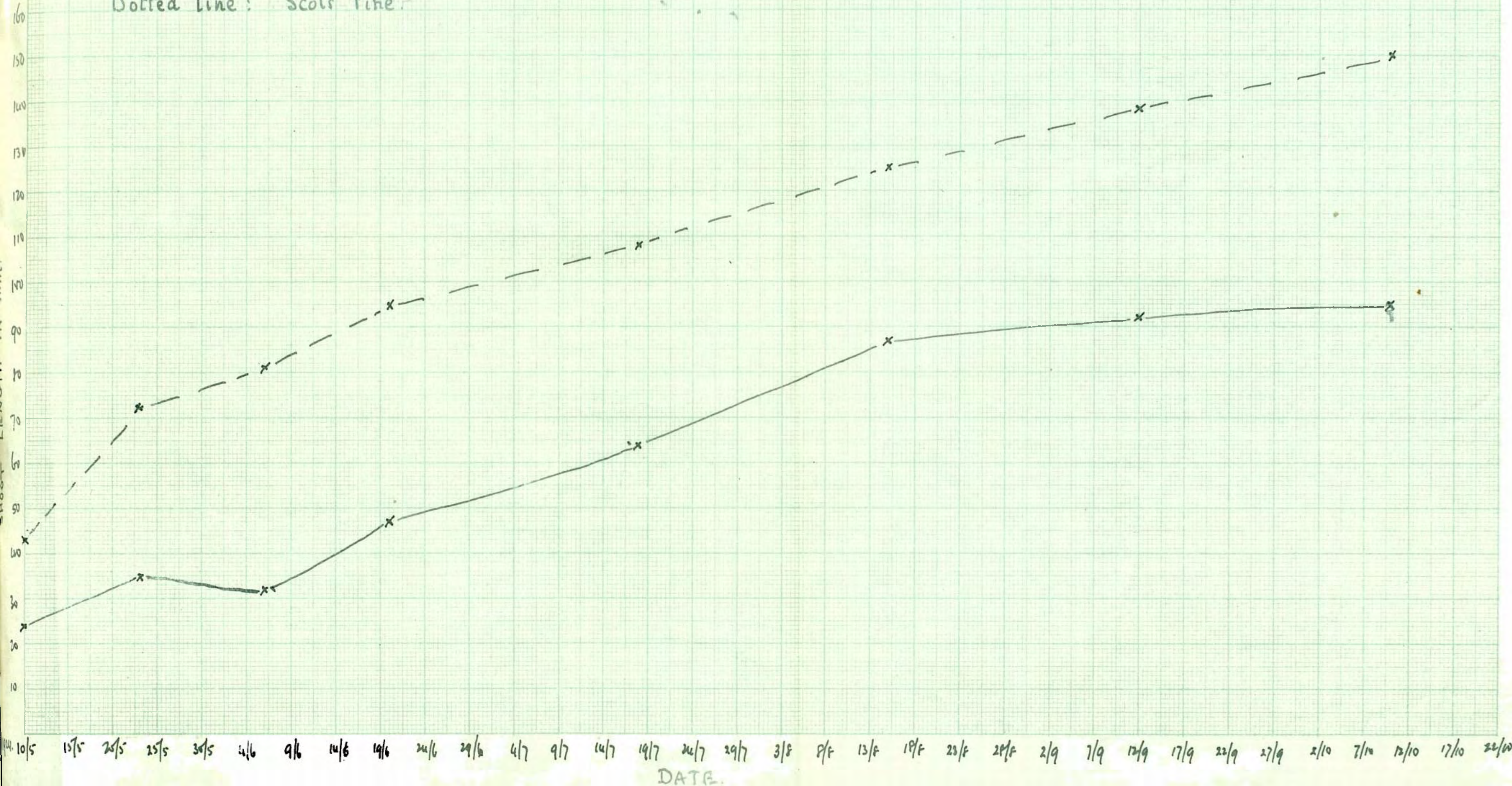

SCOTS PINE
Dry weight increment in first year. 1924.
— Total dry wt.
— Shoot only.
— Root only.
Grams per 100 seedlings.
10
9
8
7
6
5
4
3
2
1
28/6
8/7
18/7
28/7
7/8
17/8
27/8
6/9
16/9
26/9
6/10
16/10
26/10
Day and Month

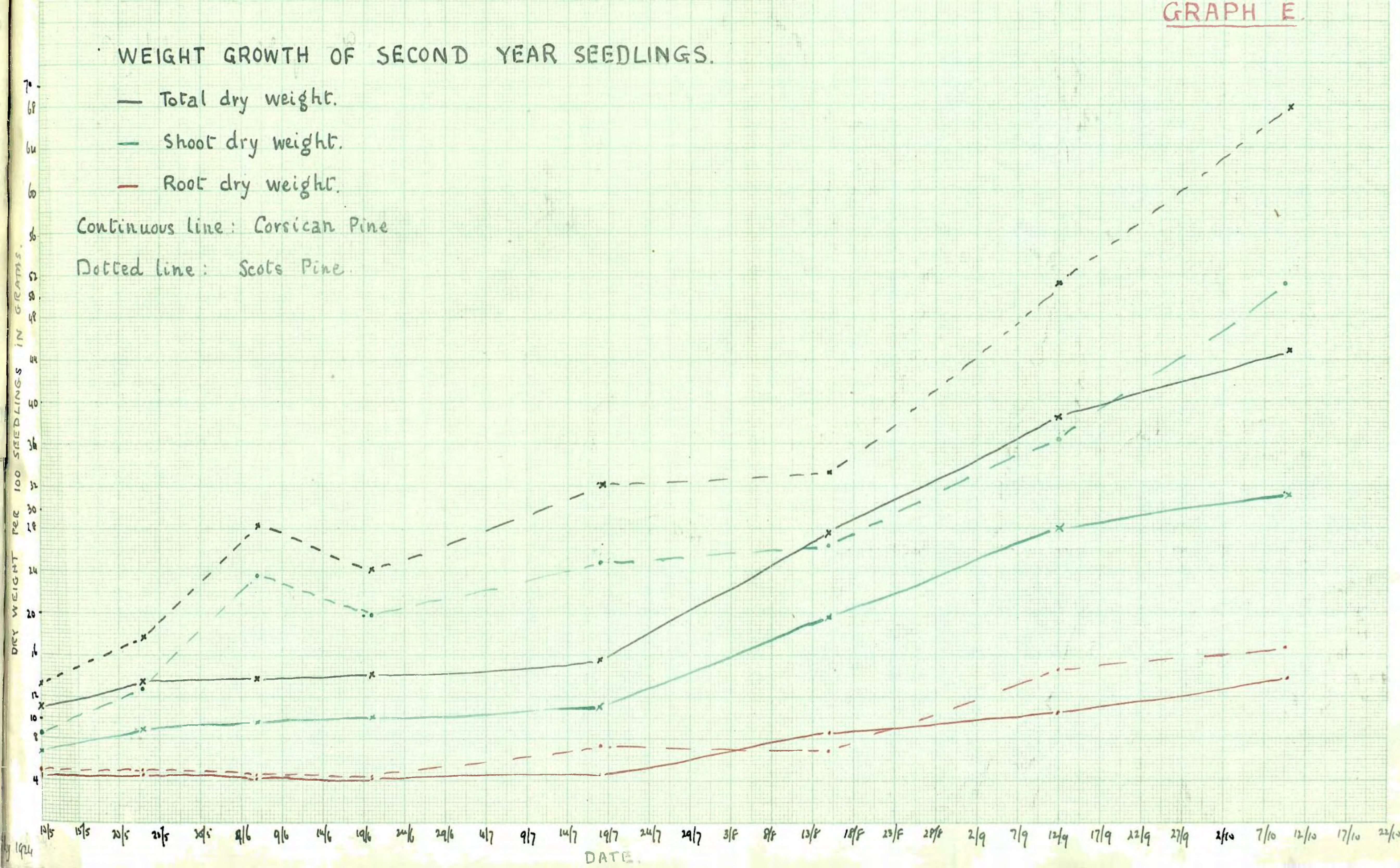
GRAPH D

HEIGHT GROWTH OF SECOND YEAR SEEDLINGS.

Continuous line: Corsican Pine

Dotted line: Scots Pine.



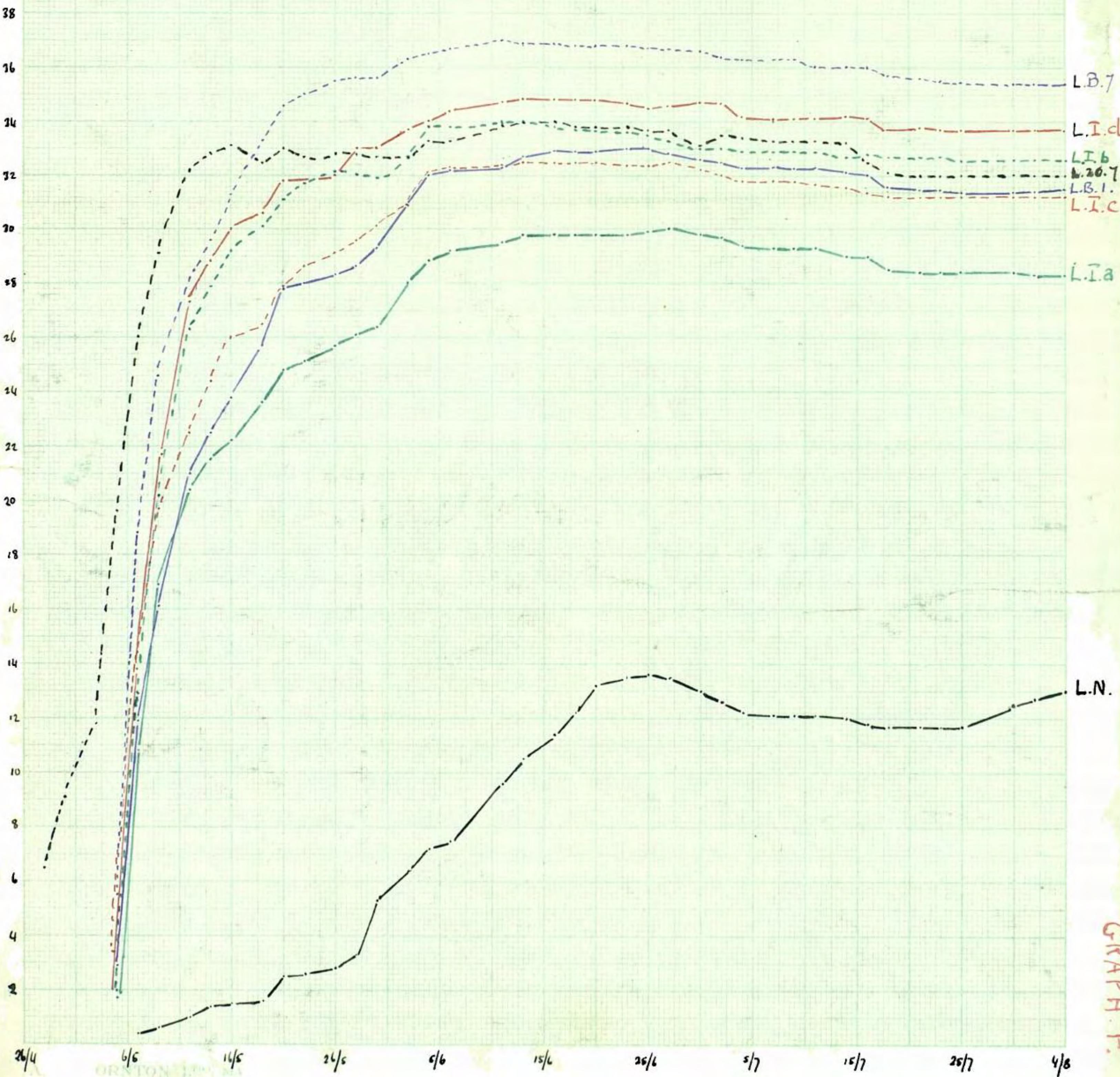

GRAPH E.
WEIGHT GROWTH OF SECOND YEAR SEEDLINGS.
Total dry weight.
Shoot dry weight.
Root dry weight.
Continuous line: Corsican Pine
Dotted line: Scots Pine
DRY WEIGHT PER 100 SEEDLINGS IN GRAMS.
DATE.
13/5 15/5 20/5 25/5 30/5 4/6 9/6 14/6 19/6 24/6 29/6 4/7 9/7 14/7 19/7 24/7 29/7 3/8 8/8 13/8 18/8 23/8 28/8 2/9 7/9 12/9 17/9 22/9 27/9 2/10 7/10 12/10 17/10
4 8 10 12 16 20 24 28 30 32 36 40 44 48 50 52 56 60 64 68 70

GRAPH. F

EUROPEAN LARCH.

Germination per cent. of treated and untreated seed. 1924.

Experiment I



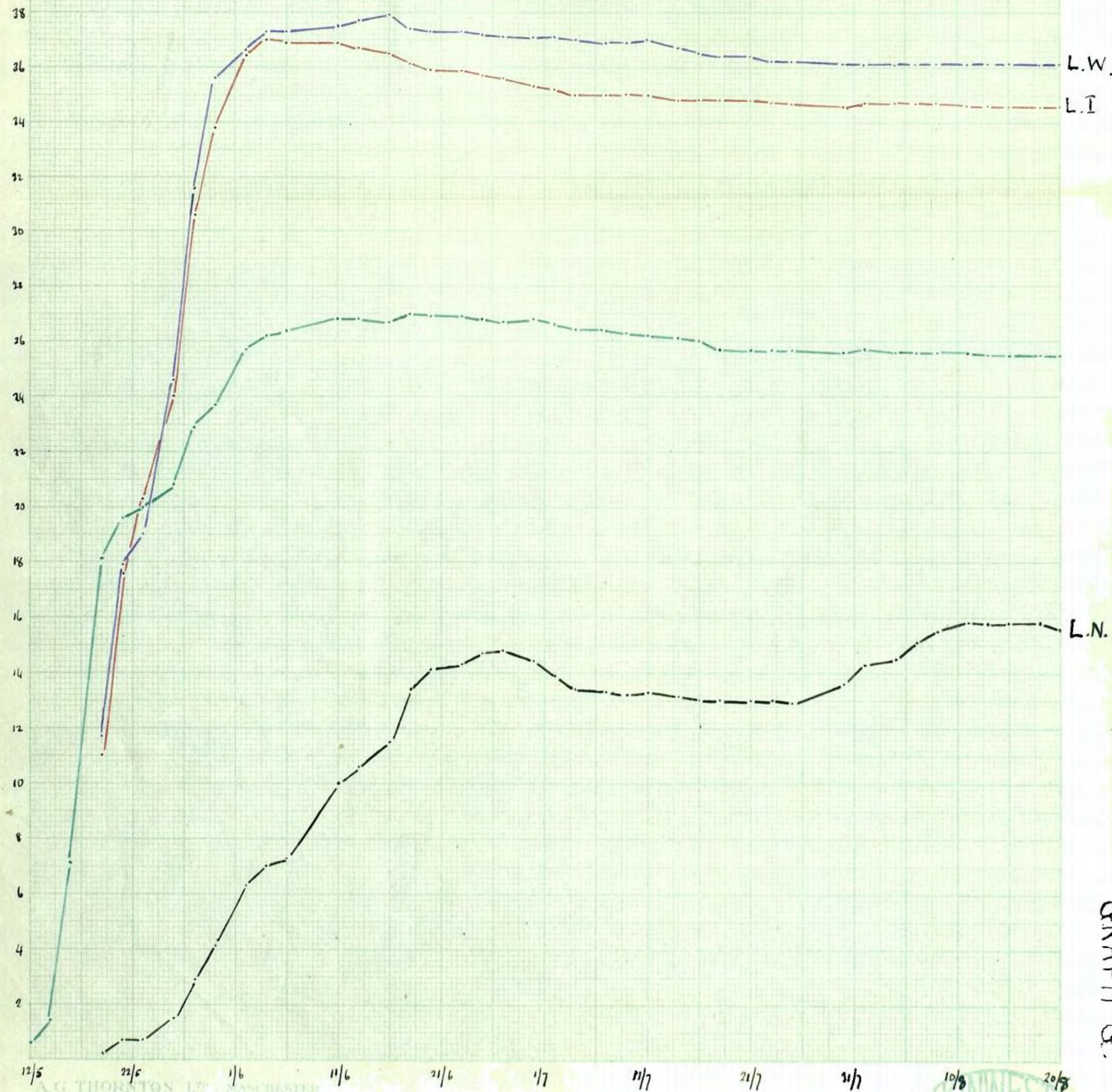
GRAPH. F

GRAPH. G

EUROPEAN LARCH.

Germination per cent. of treated and untreated seed, 1924

Experiment II

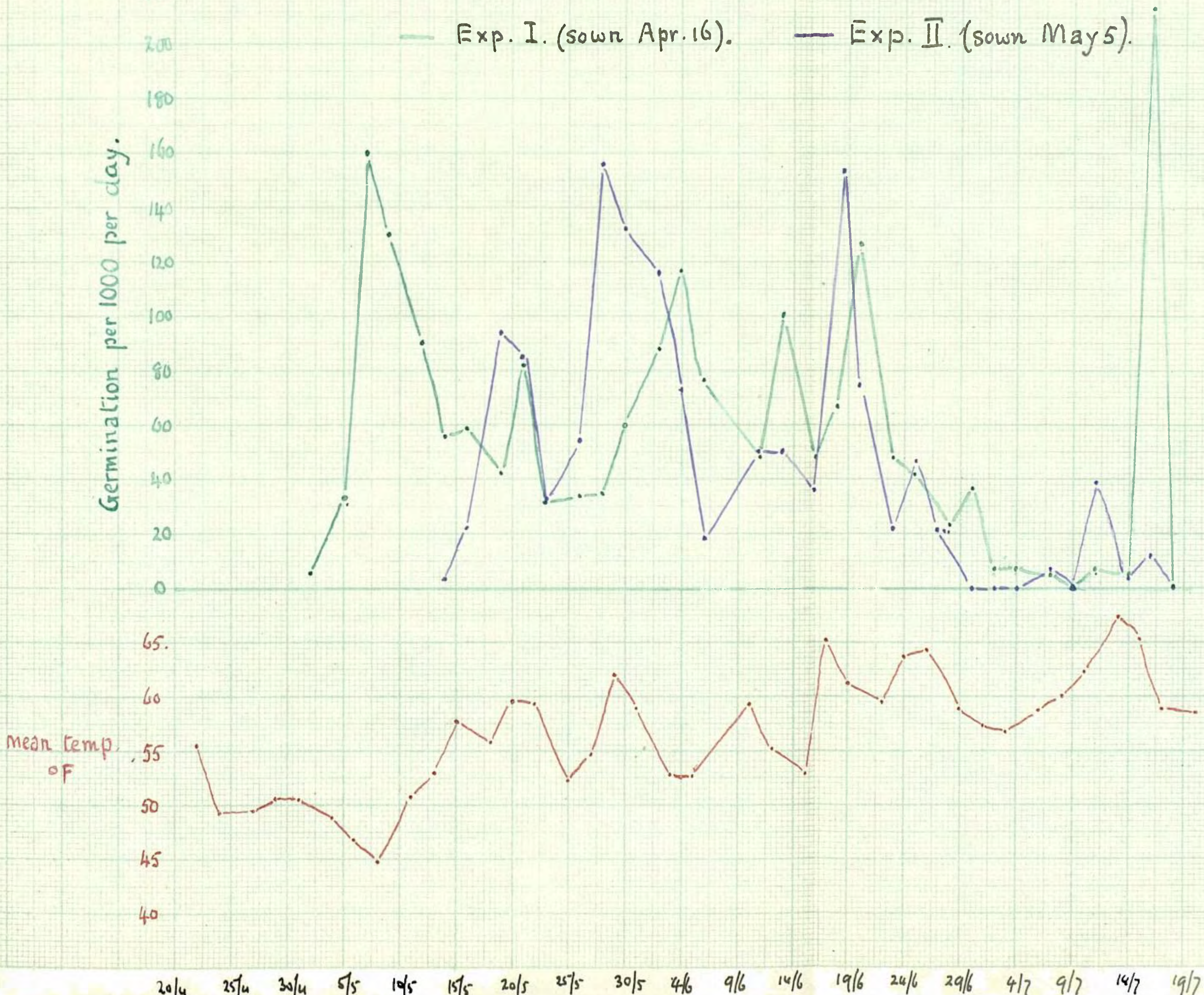


GRAPH G.

GRAPH H

LARCH SEEDLINGS.

Germination per 1000 of those still to germinate.



GRAPH K
LARCH SEEDLINGS.
Losses per thousand per day.
Exp. I. sown April 16.
Exp. II. sown May 5.
65°F
60
55
50
45
40
1.0.
.5
Inches of Rainfall.
1/5
6/5
11/5
16/5
21/5
26/5
31/5
5/6
10/6
15/6
20/6
25/6
30/6
5/7
10/7
15/7
20/7
25/7
30/7
4/8
9/8
14/8
19/8
24/8

COMPARATIVE GROWTH OF NORWAY & SITKA SPRUCE SEEDLINGS IN ORDINARY AND PEATY SOILS.

REPORT ON PROGRESS OF RESEARCH. 1923-24.

During the year 1923-24, the study of the Physiology and Structure of Norway and Sitka Spruce has been commenced with special reference to root action and development embodying the continuation of the Mycorhiza investigation.

It is proposed in this report to outline the work done under the following heads (1) Root development, (2) Mineral requirements of Norway and Sitka Spruce, (3) Structures in these plants indicating environmental conditions, (4) General.

1. Root Development.

(a) Anatomical work on the origin and nature of Spruce roots has been in progress.

(b) Experimentally the controversial point as to whether the tap root of Spruce does or does not persist during the first year has been studied. Seed of Norway and Sitka Spruce was sown in glass jars in ordinary Nursery soil in such a position that the radicle would grow down the side of the glass. Blackened paper being put over the containers to cut off the light from the roots, the growth of the radicle could be registered periodically. The conclusion was arrived at that normally the tap root of neither Norway nor Sitka Spruce disappears in the first year. This is for normal well aerated soil. The depth of penetration in this instance varied from 10-12 cms. measured from the collar for Norway Spruce and about 7 for Sitka Spruce.

(c) The tracing of the development of root systems in Norway and Sitka Spruce from seedling onwards to determine normal root systems in different soils has been commenced. The soils worked on this year have been Loamy soils from the Nursery and Peat.

A. Nursery Soil.

The following experiments have been done in boxes in the greenhouse with Norway and Sitka Spruce, where the factors could be stabilised and controlled.

1. To test the influence of depth of sowing on root development and shoot growth.

2. To test for differences in root and shoot growth in seedlings transplanted at normal level, too deeply and with root tips removed.

Depth of Sowing.

Boxes filled with earth from the Nursery were used and the depths of sowing made were respectively 0.5cm., 1.0cm., and 1.5cm. Most accurate work could be got by the formation of narrow drills of the required depth. The results are summarised in the following tables the data representing averages of a large number of measurements before removal from the soil, the soil level being marked on the plants with white paint.

TABLE 1.

Depth of Sowing.	Total length of shoots from Cots. to tips of terminal needles.	Length of shoots from Cots. to terminal bud.	Length of Hypocotyl from Cots. to first root.	Length of Hypo. below ground to first root.	Total length of root system.	Depth of plant below ground.	Total lateral extent of roots.		Germination %.	
0.5cm.	2.05	1.16	2.5	0.8	17.	6.4	11.4		29%)	
1.0cm.	2.10	1.25	3.0	1.4	14.9	7.1	9.0		41%)	Norway Spruce.
1.5 cm.	2.50	1.40	3.7	2.7	15.6	9.6	8.7		31%)	
0.5cm.	1.5	0.8	2.05	0.8	12.9	6.5	7.2		49%)	
1.0cm.	1.8	0.95	2.3	1.3	9.0	6.1	4.1		48%)	Sitka Spruce.
1.5cm.	2.4	1.6	2.4	1.7	13.9	7.5	8.0		46%)	

The conclusions drawn are:-

1. That depth of sowing has an influence on Total Shoot Growth, growth from base of cotyledons to terminal bud, length of total hypocotyl and length of hypocotyl below ground. Differences in total shoot growth are most marked in Sitka, in length of hypocotyl both total and below ground in Norway. As regards total length of plant parts above ground there is little difference in either Norway or Sitka. That depth of sowing would influence depth of surface

roots might be inferred but the differences are more pronounced than might be expected.

2. Total depth of plant parts in the case under examination increases slightly with depth of sowing but there is little actual difference in the total length of the systems.

3. Differences in Germination % (see Graph) are marked in Norway Spruce the best result being obtained with a depth of sowing of 1.0cm. Germination commenced sooner with the 0.5cm. depth, but the 1.0cm. sowing though later and slower to begin with was more regular and overtook and surpassed the 0.5cm. sowing. The 1.5cm. sowing was tardy the first seedlings appearing 5 days after the first 0.5cm. seedlings. With the increased depth of sowing however the size and vigour of the seedlings was markedly superior to the others.

With Sitka Spruce final germination for different depths of sowing show no appreciable differences. Speed however differed, the shallow sowing being much speedier (see Graph). With deep sowing 12% had appeared within 42 days and by the end of 59 days 49% had germinated. This delay is counterbalanced by larger plants.

4. Depth of sowing as influencing depth of top roots is of vital importance. In dry situations the further removed the top roots are from the soil level, the less risk of suffering from drought. The depth of sowing to give the best results for a given set of conditions would require to be carried out for each nursery, as undoubtedly a best depth of sowing must obtain for each soil and set of conditions.

5. It remains for future work to determine how far the large extent of Hypocotyl beneath the ground level obtained with the deeper sowing will affect the development of adventitious roots.

Depth of Planting of Seedlings.

Seedlings of Norway and Sitka Spruce raised from seed sown in Sawdust were lined out in boxes in the greenhouse. The seedlings were treated as follows:- (1) Planted at the same level as they were in the sawdust. (2) Planted very deeply. (3) Planted with root tips removed.

The results are tabulated in the following table.

TABLE II.

Treatment.	Total shoot from cots. to tips of terminal needles.	Length from cots. to terminal bud.	Total hypocotyl.	Hypocotyl from soil level to first root.	Total length of root system.	Total lateral roots.	Depth of plant parts below ground.	Greatest lateral extent of roots.	
Proper level.	1.80	0.90	2.40	1.00	22.20	15.80	7.40	4.0	Norway Spruce.
Deep planted.	2.25	1.30	2.50	2.30	24.00	20.30	9.60	5.3	Norway Spruce.
Root-tip removed.	2.00	1.00	2.50	1.10	28.00	21.00	7.60	6.4	Norway Spruce.
Proper level.	1.65	0.80	1.80	0.40	16.60	9.10	7.80	3.8	Sitka Spruce.
Deep planted.	1.70	0.75	1.75	1.75	13.70	6.50	8.95	2.8	Sitka Spruce.
Root-tip removed.	1.35	0.75	~~0.90~~ 1.70	~~1.00~~ 0.90	18.60	~~12.20~~ 12.30	7.30	6.0	Sitka Spruce.

Conclusions.

1. Appreciable differences in total shoot and stem growth (from cots to tip of terminal bud) are only shown in the case of Norway Spruce.

2. Transplanting yields in both increase of total extent of root system (see Table I).

3. In both Norway and Sitka Spruce the greatest lateral root length is increased markedly by removing the radicle tip.

4. In the case where the radicle tip has been removed, what appeared to be a tap root remained, penetrating deeply into the soil as far in fact as in the normally treated plants.

B. Rootgrowth of Seedlings in Peat.

In order to test root development in peat from seedling onwards Norway and Sitka Spruce seed was sown at Parkhill on (a) natural surface. (b) on screefed patches from natural surface. (c) on turfs reversed. (d) on screefed patches on burned area. As far as possible the conditions were otherwise equal in all cases. The surface of the screefed patches were broken up with the spade to ½ in. in depth to prevent caking of the surface. The ground chosen bore a Cotton grass, Erica, Calluna flora. In every case the seed was red-leaded.

The sowings on the screefed patches and turfs were very unsuccessful, due to the removal of the red lead by acid contained in the peat, and the ultimate shelling of the very great majority of the seed. The main destructive agent, as the seed was protected from birds, was thought to be mice as one was found dead on one of the patches. Sufficient seedlings were left however to trace root development, although insufficient remained to test the effect of the addition of fertilisers as had originally been proposed. On the natural surface on the other hand where the red-leaded seed had been simply laid on the peat without mixing but covered with Sphagnum until germination began quite a good germination was obtained. Of the Norway 20% established themselves but about 27% germinated. (Germination in ordinary soil 29%). With Sitka 12% became established, the total germination being about 20% (Germination in soil, 47%). Failure to establish themselves was found to be due to the inability of the radicle to penetrate the top surface of the peat.

Root development is interesting. On the natural surface the roots penetrated up to ¾ in. in the case of Norway Spruce, and ½ in. max. in the case of Sitka. Altogether the root system is extremely compact. (Plate I fig a.) many Norway showing tertiaries. On the screefed unburned patches only Norway became established unfortunately, but the root system is deeper and much more extensive. (pl.I fig.c.) being even more so however in the burned patches. (Pl.I fig.e.& f.) Here Sitka are as numerous as Norway. In contrast it is interesting to note the more extensive lateral growth of Norway at this stage than Sitka (Pl.I fig.e.& f.). The greatest depth of penetration is on the turfs however. (Pl.I fig.d.).

With the remaining seedlings protective measures have been taken to ensure observations being made in the second year of growth. Seedlings have been preserved in order to carry out further studies during the winter months.

The points of value which would appear to be indicated so far are:-

1. The failure of red-leading the seed of the whole of the seed is in contact with the peat. i.e. in breaking up the peat and in covering the peat the red-lead is removed.

2. Failure in seeding would be due primarily to biotic agencies.

3. Failures arise on unprepared surface due to non-penetration of the peat by the radicle.

4. Depth of penetration of the root system would appear in a general way to be correlated to the dryness of the top layers of peat.

C. Root Development of Transplants in Peat.

At Parkhill plots were laid down to test the effect of too deep planting on peat as affecting the death of the nursery root system and the development of an adventitious system and the growth of the shoot. This experiment has been carried out with Norway and Sitka Spruce on peat with an Eriophorum, Erica, Calluna vegetation, with patches of Sphagnum. This experiment has been so laid out as to show the effect of close planting on growth, half the duplicate plots having $4\frac{1}{2}$ ft. spacing and half 3 ft. spacing. Norway and Sitka plots were also formed on Heather Ground and Norway on an area of burned Heather ground. The plants used were 2 yr. 2 yr. It has been impossible up to the present to make other than field observations.

1. Sitka Spruce in every case are much better at the end of the first year than Norway. The Sitka Spruce have retained their normal colour whereas Norway has assumed the yellowish green so characteristic of the plant on moorlands. Some Norway however have developed abundant new roots and the needles of these plants are of a better colour. The deep-planted Norway are slightly better in colour than the shallow-planted owing to the protection afforded by the vegetation. Similarly the Spruce amongst the Heather are better in colour than on the burnt area. The conclusion arrived at is that the yellow colour in Norway is a combination of exposure and malnutrition. That protected shoots or branches of Norway retained their normal colour has already been noted at Inverliever. The bad colour is the result of the balance in transpiration and absorption being upset.

2. New roots in both species have developed in the drier peat and as the peat gets wetter the new root growth ceases. It is impossible to say definitely at this early stage whether the nursery system is dead. The new roots arise near the surface and proceed horizontally. In the shallow placed plants they arise from the old root system; in the deep planted from the stem.

3. Frosting on the Parkhill moor has been rather severe. Sitka has suffered most, 30% of the shallow plants and 50% of the deep planted being affected to different degrees. With Norway 3% showed signs of frost but the deeply planted suffered much more. In the heather the cleared plants suffered badly. On the burned area the Norway escaped.

4. Although the casualties from frost are greater amongst the deeper plants, those which have escaped tend to show slightly better growth for the year. Measurements were taken which gave the following averages:-

Sitka Spruce at Normal level - 2 ins. (1-2½ ins.): S.S.Deep planted - 2¼ (1-3).
Norway Spruce, Normal level - 1¼ ins. (1-1¾ ins.): N.S.Deep planted - 1½ (1¼-2).

D. Root Development of Transplants in the Nursery.

It is found that great variation occurs in the depth at which plants are placed in the transplant lines even in the same bed. This variation in depth of planting leads to variations in the production of adventitious stem-roots. For instance even in one line plants are found with little or no stem roots developed in others the majority of the roots are adventitious roots developed from the stem or even lower branches. Such diversity of root type must lead to variations in the general growth and behaviour of the plant when placed in the field. To test this 2 yr. seedlings of Norway and Sitka Spruce have been lined out at Seaton Nursery in the following manner. (1) Deeply planted. (2) Planted at the same level as in the seeds beds. (3) Very shallow transplanting. This should provide plants with different types of root system which following another year in the transplant lines will be put into the field.

As far as shoot growth is concerned in the first year of their transplanted life in the case of Norway Spruce there is little to chose between the deeply planted and those put in at the proper level. The shallow planted lines however show much poorer growth. In the case of Sitka the deeply planted are undoubtedly the best, the normal; level plants second and the shallow a bad third. The shoot growth of several lines of transplants was measured and averages taken to indicate variations.

	Deep.	Normal.	Shallow.
Norway Spruce.	1.90 ins.	1.90 ins.	1.40 ins.
Sitka Spruce.	3.50 ins.	2.50 ins.	1.90 ins.

In Sitka the deep plants are lighter in colour than the others.

As regards losses the two species have suffered as follows:-

	Deep.	Normal.	Shallow.
Norway Spruce.	13%	8%	18%
Sitka Spruce.	13%	11%	12%

With the deep Norway most of the losses appear to have resulted from crowding out by weeds particularly Poa and Chickweed. In the shallow Norway the losses are due to the failure of the plants to take a firm grip and thus losing their hold against wind. The deep planted trees are smaller and are more readily damaged by weeds. This does not hold with Sitka since even when deeply planted they are above the level of the competing weeds.

2. Mineral Requirements of Norway and Sitka Spruce.

Culture experiments to demonstrate the reaction in Norway and Sitka Spruce resulting from the absence of certain otherwise regarded as essential bases, the use of different concentrations of nutrient solutions, lack of aeration and the addition of Manganese Dioxide were set up in the beginning of June. These culture experiments are regarded as preliminary to further experiments next year. The solution used in the present instance was Crones Culture Solution. The solutions were renewed periodically and aeration carried out daily. Unfortunately the control with Sitka Spruce shows much discrepancies that the experiment may have to be repeated. The results, representing averages are herewith tabulated.

Tabulated.

	Norway Spruce (10 plants per jar).		Sitka Spruce (5 plants per jar).	
	Remarks.		Remarks.	
1. Control.	3.30cm.	Deep-green needles.	Ambiguous result.	
2. Sol.non-aerated.	2.10cm.	do.	3.20cm.	Deep-green needles.
3. Sol.Mang.Diox.	3.60cm.	Needles lighter green.	3.00cm.	Shoots very light-green.
4. Sol.-Potassium.	2.33cm.	Needles lighter than 3.	2.70cm.	Bluish-green needles.
5. Sol.-Nitrate.	1.32cm.	Needles dark dreen. Buds large.	~~8.00~~ 1.40cm.	Very light green.
6. Sol.-Iron.	2.11cm.	Cots.green; otherwise chlorotic.	~~1.40~~ 0.80cm.	Cots.green; otherwise chlorotic.
7. Sol.-Phosphate.	1.73cm.	Needles lighter than control.	1.14cm.	Deep green.
8. Sol.-Lime.	2.20cm.	Needles dark green.	2.20cm.	Deep green.
9. Sol.-Magnesium.	2.30cm.	Needles falling greenish-yellow	2.76cm.	Lighter green than without Lime.
10. Sol.½ concentration.	2.80cm.	Deep green.	3.05cm.	Slightly lighter green.
11. Sol. X 2 concentration.	2.10cm.	do.	2.60cm.	do.
12. Sol. X 3 contentration.	1.85cm.	do.	1.30cm.	Top needles very light green.

Height growth from cotyledon to tip of terminal needles.

Conclusions.

1. With both Norway and Sitka Spruce, the absence of Nitrate and Phosphate has the most decided retarding influence on growth.

2. Lack of aeration with Norway Spruce leads to loss of growth.

3. Addition of Manganese dioxide stimulates growth in Norway Spruce.

4. The most interesting result is due to lack of Magnesium which leads quickly in Norway Spruce to a yellowish-green coloration and a shedding of the needles. This does not happen with Sitka Spruce.

5. Too high a concentration affects growth adversely.

Further results may be expected from the examination of the root stem and leaf structure in these plants. This work is reserved for the winter.

3. Structural Features indicating environmental Conditions.

Trees (Norway and Sitka Spruce) in the check stage from different types of peat at Inverliever and Corrour (through the kindness of Sir John Stirling Maxwell) have been analysed. These analyses brought out a few points of importance.

1. In plants from certain peats more annual rings occur at higher levels in the plant than at lower levels. For instance in plants from Erica Calluna Scirpus Molinia peat an alalysis showed (Plate II. Fig.B.) that the old root system had become functionless immediately after planting out since at the base of the stem there were four rings and it may be assumed that the plants were 4 years old when planted. A short distance above the old system an adventitious system had developed and above this there were 5-6 rings. Then above this another adventitious system and still more rings above. The lateral shoot which had now become the main leader showed 9 rings at the base. None of the roots which could be said to be functional had more than 3 rings. A similar condition of affairs exists in trees in check in Sphagnum and in Heather (Pl.II.Fig.A.) The underground stem shows scars or marks where roots had been but which are now destroyed. In certain peat conditions therefore the tree simply survives as a result of the development of these adventitious roots and only the part above the new set of roots is growing. This successive adventitious root growth is the result of the growth of the vegetation particularly Sphagnum and some means must be found of preventing or retarding the growth of the peat.

2. Frost Rings are found to be of frequent occurrence in trees in peat, and more so in some peats than in others. In certain trees frost leaves its mark on the tissues of the plant (ref.Graebner, Sorauer) by forming cankerous rings characterised by swollen medullary rays, large production of parenchyma and general contortion of the annual ring (Plate III.Fig.). In some cases the frost mark is on one side only of the stem, in other cases it completely encircles the stem. It may occur in the spring

wood alone, the autumn wood alone or in both. It is thus possible by this malformation in the annual ring to tell the past history of certain trees as regards the action of frost on them. Sitaa Spruce develops these frost rings or marks very characteristically, Norway Spruce less frequently.

These frost rings may appear in a plant without any external frost effects being discernible. Growth will continue but it is small. For instance Sitka plants still in check stage from Erica Scirpus Cotton grass ground (Inverliever) sectioned this spring showed the shoot to contain frost rings as follows:- 1923, spring and autumn; 1922, absent; 1921, Spring and autumn; 1920, slight spring. Such plants from a superficial inspection do not show frosting effects.

In twigs with a more or less horizontal position, the forst ring very seldom encircles the twig but is confined to the underside. Twigs so affected show small growth and in this case also no browning of the needles.

Frost rings have been found in checked plants from the following types of peat.

Erica. Scirpus Cotton grass - Worst.
Erica. Cotton grass. Sphagnum. Myrica. - very bad. Similar contortion of the rings found in the roots.
Scirpus - Calluna - bad.
Calluna. Scirpus - bad.
Erica. Scirpus. Calluna. Molinia - frequent. Calluna - frequent.
Sphagnum clump.
Calluna. Molinia - occasionally.
Molinia - occasional.

These are observations based on the analyses of trees from these peats.

4. General.

1. Bag experiment. Mr. Robinson's Corrour bag experiment where bags are placed at the base of the checked trees in order to kill out the heather was repeated with smaller Norway Spruce at Inverliever in April. Although it is early yet to note any definite results a slightly better colour was appreciable in the plants in August. The heather will be weakened but the most

important point appears to be the change in progress of the peat. Fungi are beginning to develop on the top of the peat and in the moss beneath the bags.

2. Cleared plants. A few Norway Spruce plants in the check stage were cleared of heather in a few different parts of the area but if anything in August the cleared plants were more miserable in appearance than the uncleared.

3. Dying-back of Roots. The dying back of surface roots of Norway Spruce in heather is a point of vital importance to the plant since the roots are never allowed to penetrate into the peat or soil. On any heather ground it is a marked feature that the plants which are doing better have been successful in pushing the surface adventitious roots into the turf or soil whereas the checked plants have been unable to do so. The dying back may be due to frost or drought. Such roots are found in April following a period of dry weather. In August new roots are found growing from the collar or stem amongst the heather and moss. Such roots bear long root hairs very visable to the naked eye. Such root hairs are formed on Spruce on roots in dry soil or in water vapour, and drought may therefore quite easily be the causal factor. Frost is a possible factor. It has previously been noted in this report that frost rings have been found in the roots of trees in one type of peat.

4. Frost. Frost has done extensive damage to the Spruces at Inverliever this year. The young shoots have been nipped soon after bursting (early June). The actual visible damage is more frequent on the lower levels than on the higher moors and Sitka has on the whole suffered more than Norway Spruce. The lower shoots are much more affected than the upper shoots. For instance in one case all the frosted tips in a plantation of Sitka occurred at 30 ins. or less above the ground level. Further, frosting is worse on the shoots at or below the level of the herbage. This may indicate a frost level, but the frosting of these lower

shoots is probably principally due to the earlier bursting of the lower buds than the higher buds on the tree with corresponding likelihood of damage. It is remarkable how certain trees escape frost damage. Of two trees growing side by side and under apparently identical conditions one will be frosted and the other will escape.

5. Sitka Spruce is proving itself superior to Norway at Inverliever. It resists the wind much better and is of a healthier and better colour. This is particularly noticeable in the spring.

SUMMARY.

The research during the past year has been directed towards the determination of what is a normal root system in Norway and Sitka Spruce for different types of soil, to the determination of the mineral requirements of Norway and Sitka Spruce, to the determination of the effect of factors of locality on the tree growth and the modification of tree form and structure.

The carrying out of such determinations often brings to light points of immediate practical value. Those points which are considered to be of importance are:-

1. The influence of depth of sowing on the germination of seed both as regards speed and percentage obtained.

2. The influence of depth of sowing on the size of the plant and the depth of the top roots below the ground level. This point is of the utmost value in the drier sites.

3. That even in the first year transplanting increases the length of the root systems in the two species in question but does not increase shoot growth. If anything a slightly decrease of both total shoot and stem growth results. The greatest lateral roots are obtained by nipping off the radicle tip.

4. The non-success of mixing red-leaded seed with peat, but the comparative success secured by sprinkling the seed on the surface of the peat amongst the herbage and covering the

seed with Sphagnum to keep the seed moist until germination begins.

5. The absence of germination of tree seed on moorlands where natural germination might be possible would be due to biotic agencies.

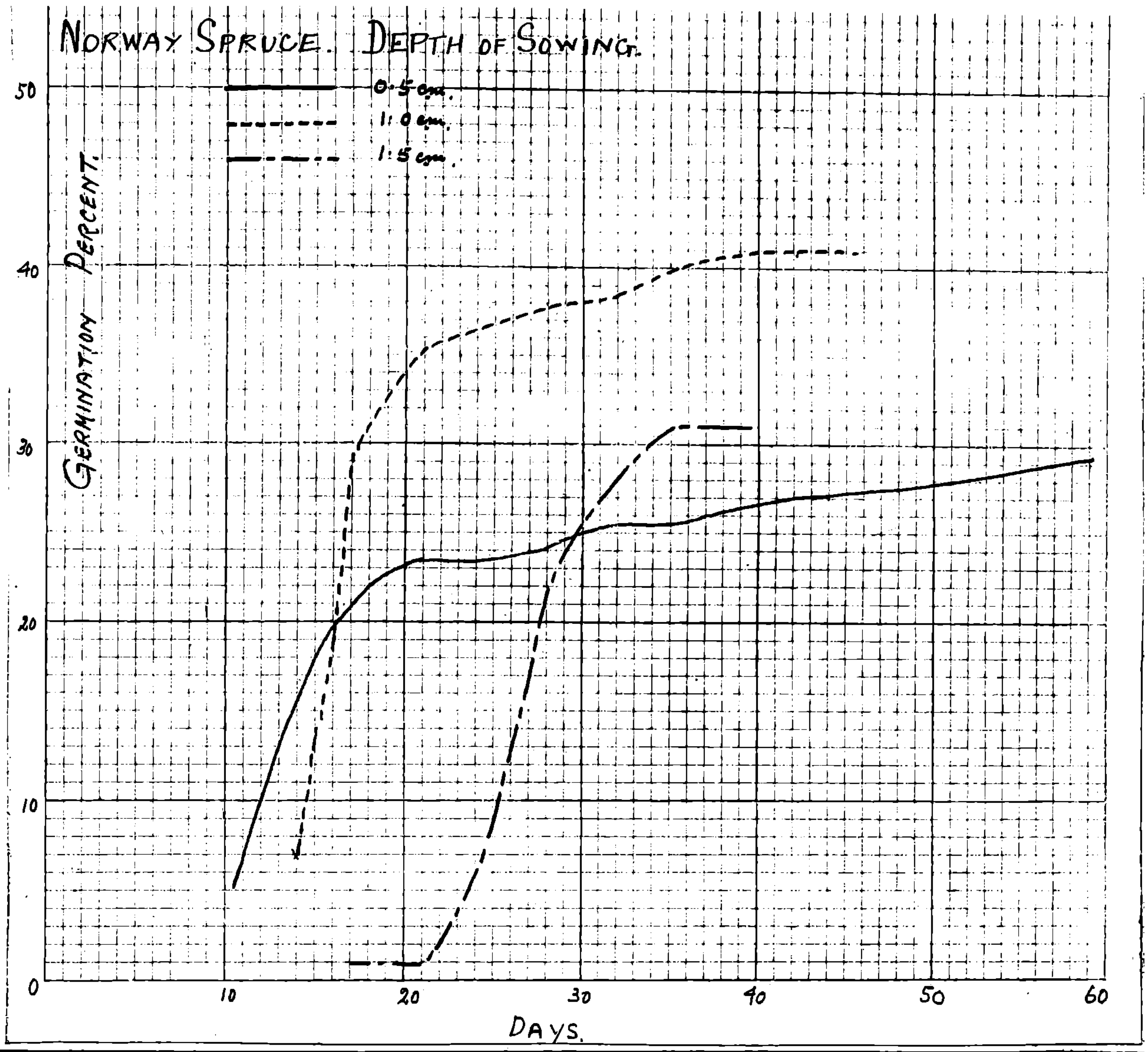
6. The different types of root system in seedlings on natural surface on screefed patches on natural surface and burned surface and on upturned turfs. The opener and drier the top of the peat the further the roots penetrate into the peat in the first year. This indicates peat drainage and tillage.

7. The effect of frost on the internal stem structure.

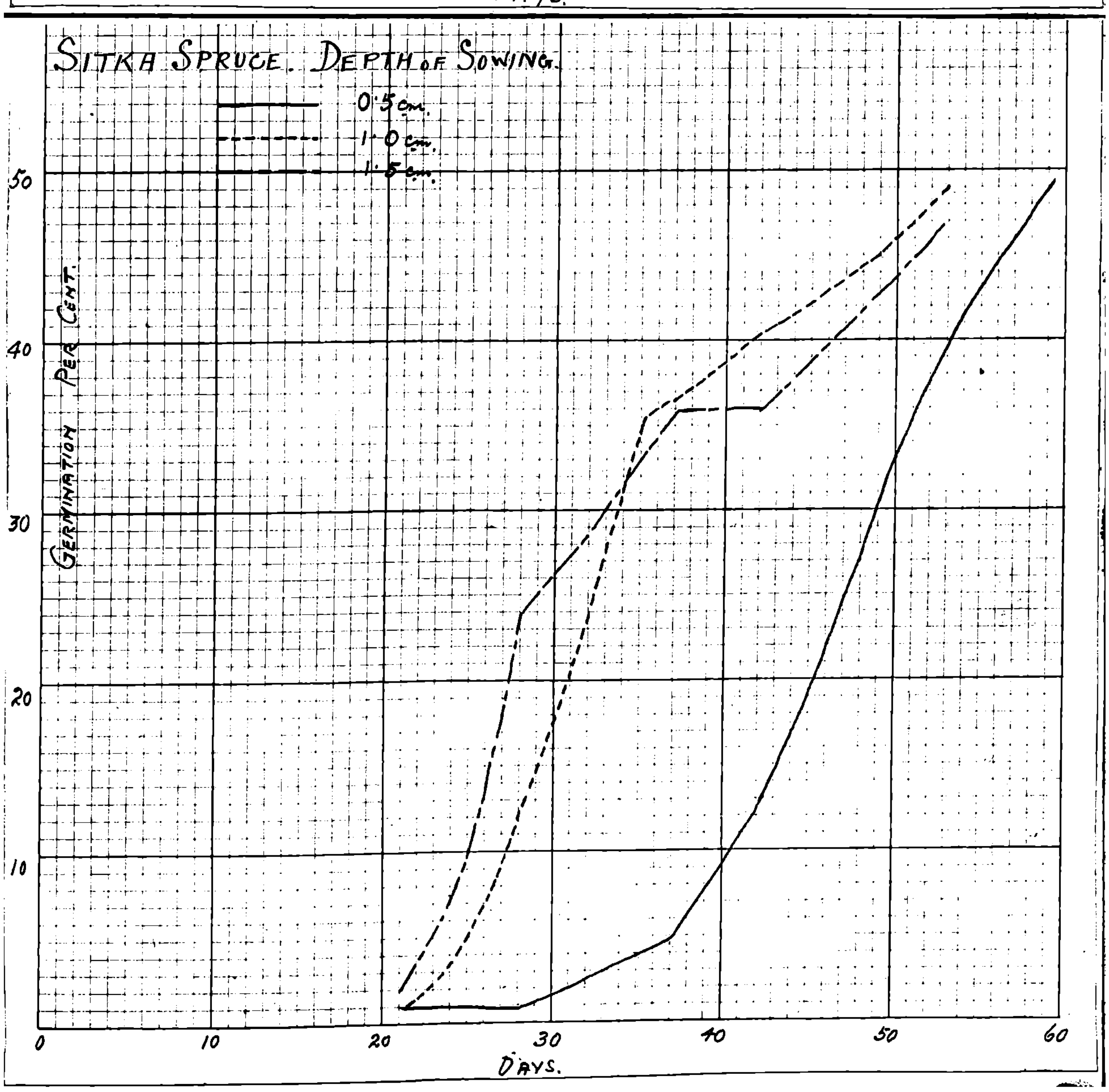
8. The killing off of successive parts of the stem by the growing vegetation particularly Sphagnum.

9. The very decided retarding influence of the absence of nitrates and phosphates on seedling growth of Norway and Sitka Spruce, and the effect of the absence of Magnesium on the colour of Norway Spruce needles.

10. The better appearance of Sitka as compared with Norway Spruce in the first year and later years of planting during check on peat.

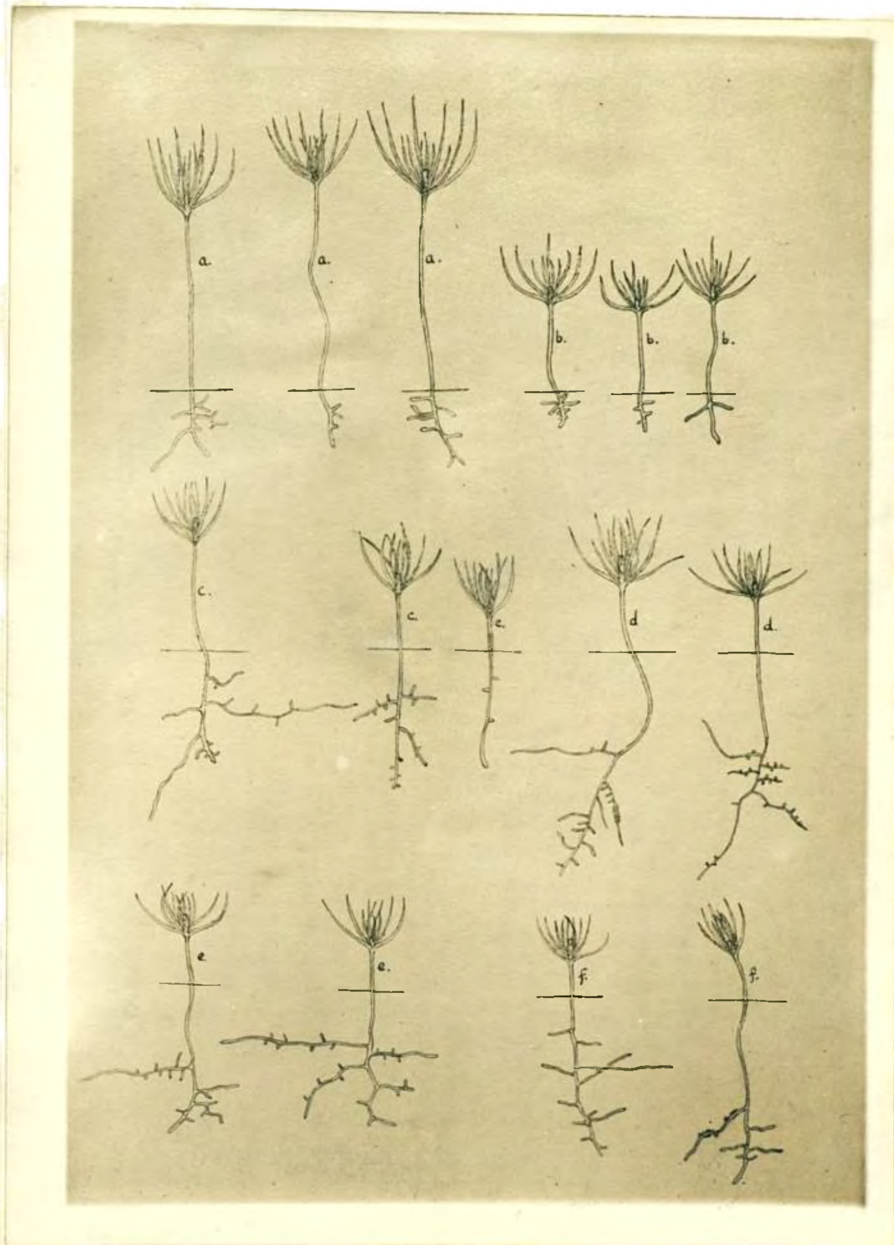


NORWAY SPRUCE. DEPTH OF SOWING.
0·5 cm.
1·0 cm.
1·5 cm.
GERMINATION PERCENT.
0
10
20
30
40
50
10
20
30
40
50
60
DAYS.



SITKA SPRUCE. DEPTH OF SOWING.
0·5 cm.
1·0 cm.
1·5 cm.
GERMINATION PER CENT.
10
20
30
40
50
0
10
20
30
40
50
60
DAYS.

PLATE 1.



Seedlings (1st. year) from peat.

(a) Norway Spruce on natural surface.

(b) Sitka Spruce on natural surface.

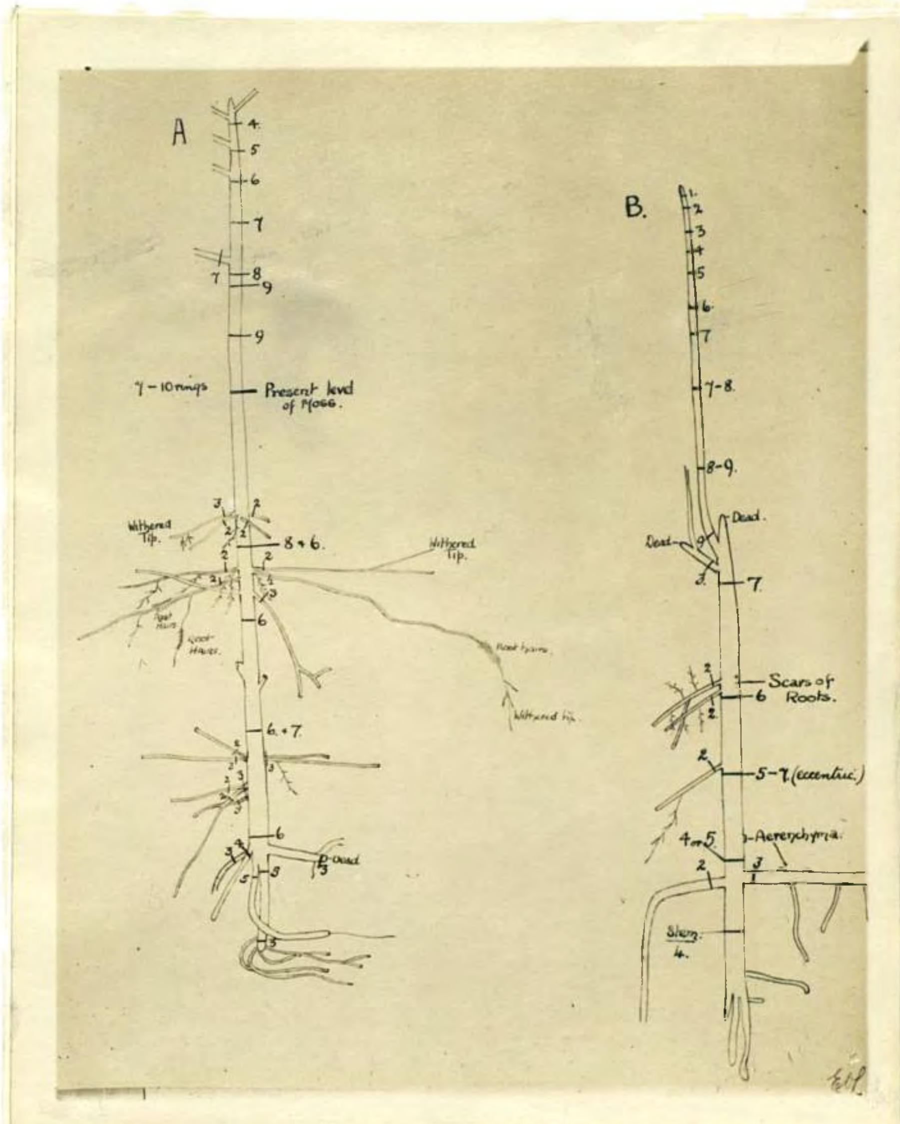
(c) Norway Spruce from screefed patch.

(d) Norway Spruce from upturned turfs.

(e) Norway Spruce from screefed patches on burned area.

(f) Sitka Spruce from screefed patches on burned area.

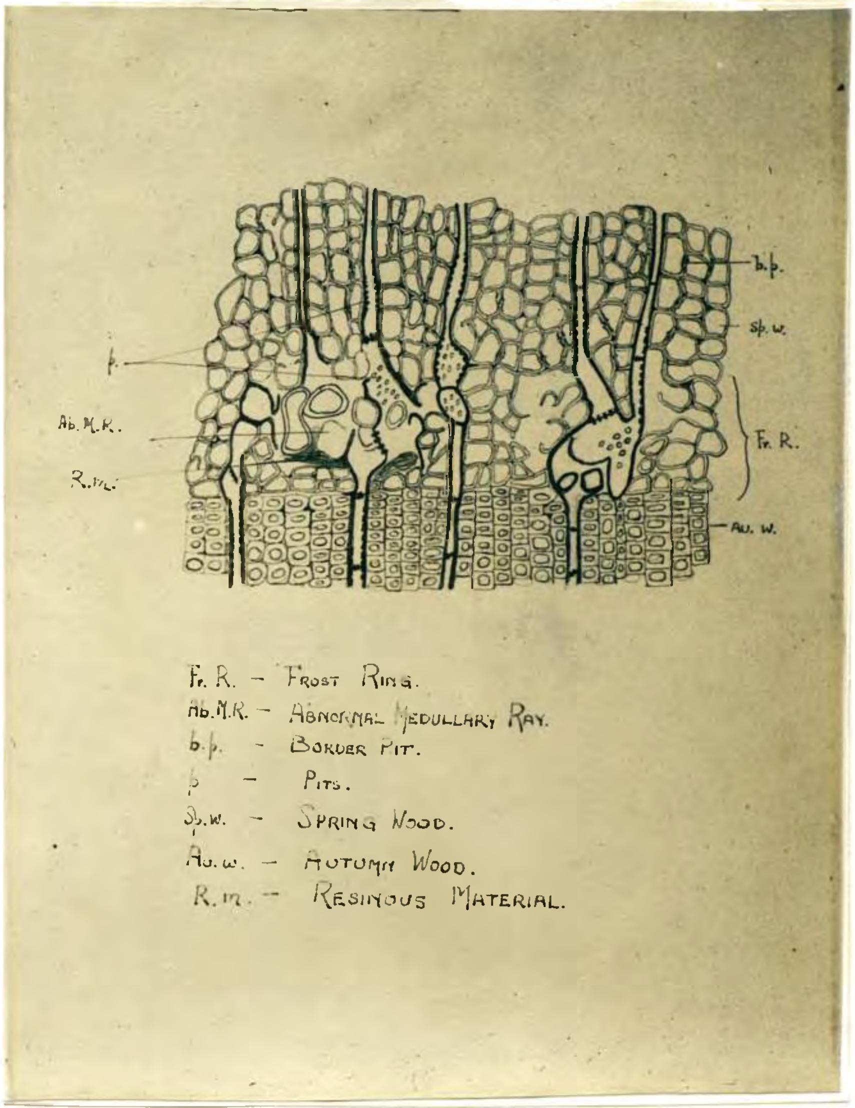
PLATE 2.



A. Norway Spruce from Calluna ground.

B. Norway Spruce from Erica, Scirpus, Calluna, Molinia Flat.

PLATE 3.



SITKA SPRUCE - Frost Ring.

P E A T   I N V E S T I G A T I O N S

(CHEMICAL & PHYSICAL EFFECT ON GROWTH
OF TREES).

REPORT ON PEAT INVESTIGATIONS. 1923-24.

GEO. K. FRASER.

SECTION I.

STUDIES IN PEAT DRAINAGE.

A Report was to have been submitted on Drainage in relation to the Inverliever research. A good deal of literature has been investigated for information on this question but the actual information obtained has been meagre and unsatisfactory owing to the lack of comparative data. It is hoped to obtain more information from Danish and Scandinavian sources and that this would be of more value to us. Otherwise any report would consist mainly of a repetition of text book dicta on Drainage.

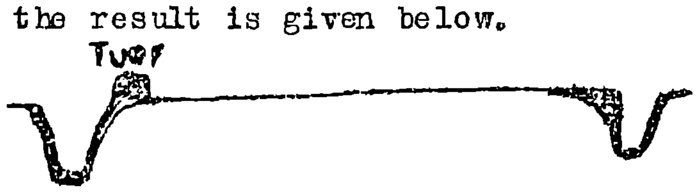
As it was felt that preliminary basic data were at once required a series of laboratory experiments were set on foot with a view to obtaining these.

At Inverliever we are dealing with a rainfall higher than is to be found anywhere in Europe in regions of the same or similar climatic conditions. Hence it was considered necessary to determine whether, were full opportunity given to natural factors inducing dryness, peat would become moderately dry at Inverliever.

Study of rainfall records and the wet and dry bulb thermometric readings at Ford (which is drier than Cruachan) show that periods of over a week without any rain occur only once or at most twice during the year, periods of a fortnight never, as far as the records go. Hence only very rarely does evaporation remove more than the water actually held on the surface by the vegetation, if it does that. There is no evidence that drying by evaporation to a condition of "drought" in the ordinary sense does occur except in one or two cases where the tops of Sphagnum mounds are evidently scorched on high exposed sites. The dry periods are accompanied by little wind, another factor in reducing evaporation.

In the laboratory it was found that evaporation of water from peat occurs very slowly after the first superficial water films are removed, so that even from bare peat surfaces evaporation affects only the first fraction of an inch within a fortnight if the air is at normal moisture content.

In the second instance water is lost by percolation. From the figures obtained by percolation experiments under a pressure of 1 foot of water, 1 foot of peat will allow free passage of only 0.2 ins of water on one day, in a fortnight 2.8 ins, but if water is not allowed to pass away readily the rate is much reduced and from peat at ordinary saturation, water does not drain at all after the initial loss due to handling. It is therefore necessary to produce some fundamental change in the peat itself before water passage can occur, as far as immediate results are concerned. Drainage effects only the removal of surface moisture and permits of the aeration of a slightly deeper surface skin of peat. In verification of this since aeration produces darkening of the peat a series of traverses were made between drains at Inverliever in order to obtain field evidence on the point. Diagrammatically the result is given below.



The shaded areas represent the peat, darkened by aeration, on a deeper peat. That is to say apart from the immediate vicinity of the drains no good effect is produced (on deep peat at least) by drains, apart from the removal of the surface water. The problem now becomes one of determining whether a change may be brought about in peat of such a nature as to permit of drainage occurring.

Peat belongs to the class of substances called colloids the principal properties of which from our present point of view is their power of retaining quantities of liquid, with which they enter into a loose physical union. Their ability to remain in a distended condition in contact with water is frequently influenced by the reaction of the water with which they come in contact. An experiment to determine the relation between the water retaining power of peat and Hydrogen Ion concentration or degree of acidity of the peat was carried out in the laboratory (Details Appendix IIa)

The results indicate that:-

(1) Peat of the type used (Scirpus-Calluna) belongs to a well recognised colloidal form (of which Albumin is the type example) in which

near the neutral, a point of greatest density of the solid matter occurs. (2) For the peat investigated this point lies at a pH value of approximately 5.5 on either side of which expansion occurs. Between this point and a pH value of 4.5 (i.e. with increase of acidity) the volume has increased, after which it diminishes with increase of acidity. From pH 5.5. decrease of acidity also causes increase in volume of the peat but it must be borne in mind that under soil conditions the presence of precipitating bases such as Lime tend to bring about an opposite effect.

Practical conclusions.

(1) Peats of the bad types at Inverliever have an acidity greater (pH average 4.5) than that at which the peat occupied the smallest volume (pH 5.5) and will at the same time support good vegetation e.g. Spruce. By increasing the acidity or by reducing the acidity the volume becomes smaller, that is to say from the practical point of view the peat retains less water and cracks up allowing more air to penetrate i.e. the peat becomes well-aerated. The addition of Acid to increase acidity appears on the surface to be impracticable since before trees can be grown, this acidity must be counteracted again, but it must be pointed out that acids are readily leached from peat, while Bases are not, so that the increased acidity might be followed by a rapid decomposition of the peat and hence a higher basicity. This can be determined only by experiment.

The addition of Bases e.g. Lime to increase the Basicity is the more obvious method of treatment. At the same time to bring about a rapid decrease in volume, large quantities of lime must be added and brought into close contact with the peat by mixing, other wise the process must be spread over a considerable period of time.

In order to test the efficiency of the results as applied to actual percolation of moisture a second set of experiments was carried out in which were measured rates of drainage from the same peat treated by different reagents. This series is detailed in Appendix II.

The results show that even when the water has a head of 12 in. drainage through 1 foot of Scirpus peat is very low, only.2 ins. per day. The addition of substances in solution to the drainage water has no good immediate effect, with the doubtful exception of Sulphuric Acid. In the field the lack of effect might not be so marked owing to surface movement of rain water, which was not allowed to occur in the laboratory. The addition of chemicals by impregnation of the peat with solution had little effect by itself, any apparent effect soon disappearing.

The effect of freezing was attempted on each of these cases when it was rather unexpectedly found that (1) Freezing alone increases the rate of percolation through peat by ten times (2) this effect is greatly increased by the addition of electrolytes whether alkaline, acid or neutral, so long as these do not cause solution or chemical distention of the peat (as does ammonia). No correlation was made between strength of solution, quantity of solution and quantity of peat owing to the difficulty of determining accurately the amount of water originally present in the peat, the strengths of the solution as originally added were equimolecular and equivalent to a saturated solution of slaked lime.

Conclusions.

The effect of the addition of electrolytes to peat depends on the method by which they are added. Simple application to the surface tends to precipitate a continuous impermeable skin on the surface and hinders permeation of water and consequently aeration, or at most does not improve it appreciably. The precipitation effect is beneficial if at all only to a slight degree when an electrolyte in solution is strongly mixed with the peat.

After freezing, precipitation or contraction of peat occurs thus allowing the percolation of water through (and over) the peat and hence increasing aeration, but this effect tends to wear off in time. When however electrolytes are added to the peat before freezing occurs the effect of freezing is enhanced and is apparently more permanent, the effects of freezing alone allowing of the passage of ten times the amount of water and of the addition of electrolytes with freezing of more than 100 times the amount of water that would pass through an unaltered peat.

It may be noted that the falling off of the beneficial effect in the experiment is probably largely due to subsidence of the peat in the water. An observation made during the experiment was the low temperature frequently necessary before freezing actually took place in peat, often more than 5°F below freezing point, while the low conductivity of the peat allowed considerable variation in temperature within very small distances throughout the peat. Hence even although surface temperatures may be below freezing point yet it does not follow that the peat is frozen or even that when frozen more than the merest shell on the surface is affected.

These points would indicate that if any attempts at manuring of peat are carried out in practice they ought to be made during or immediately before the winter so that their full benefit may be obtained. They also offer an explanation of the method by which flush peat irrigated by water carrying soluble salts tends to become granular and permeable while seepage slopes from higher-lying peat are not affected by frost to nearly the same extent. In the one case granular peat is formed, in the other, although darkening of the colour occurs, the peat as a whole remains impermeable and badly aerated, since the lack of soluble material reduces the effect of freezing. Probably one of the most important results of turf planting lies in the exposure of the turf to the action of frost which opens it up in this way, hence the preparation of turves should take place at least one winter previous to their being planted.

The absence of prolonged winter frost is apparently one of the principal factors conducing to the formation of peat of the Scirpus type on the west coast of Scotland. The powdery form of shallow heather peats is probably produced by climatic action of this kind since they occur on wind-swept slopes. When the depth of peat becomes sufficient to prevent the conduction effects of mineral soil, then the peat tends to become impermeable and develops into the Sphagnum type (this also occurs however owing to direct invasion of the heather by Sphagnum)

Conclusions with regard to drainage of Peat at Inverliever.

1. Surface drains remove only the surface water from peat areas apart from the margins of the drains themselves.

2. Deeper drains would tend to consolidate the lower strata of peat only; the surface peat would tend to be better drained only in so far as it is rendered more subject to the action of frost and drying wind, a process which would likely take some years to act.

3. The addition of the chemicals tested to peat to increase drainage by precipitation of the peat is useless unless (a) thorough mixing of peat and manure is performed or (b) the process is carried on by adding small quantities of chemicals over a protracted period.

4. Any process which renders peat more subject to the action of winter frost must tend to decrease its ability to absorb and retain moisture and this effect is enhanced by mineral manures, soil etc., which give into solution precipitating electrolytes.

SECTION II.

PEAT AERATION.

The question of methods and causes of aeration is necessarily an aspect of the question of drainage and falls to be treated as such as in Part I.

This section deals with condition of the peat in situ as regards availability of air for the immediate needs of plants growing in it.

The data obtained last year have been revised and extended, an improved method of taking and transporting samples having been used so that the present data are considered more satisfactory although they are only of general practical value owing to difficulties of technique.

It is hoped to make determinations during the winter by electrometric methods and so reduce these data to a more accurate scientific basis. At the same time it is expected that these may be correlated with the availability of nitrogenous food supply in the better aerated types at least. (Table of results in Appendix III).

The results obtained definitely confirm the opinion expressed in last year's report that

1. The amount of readily oxidisable material, and thus inversely the degree of aeration varies in different peat types, and that this variation corresponds in a general way with the health of the forest crop on the peat.

2. The degree of aeration can be correlated also with the quantity of mineral matter (especially in an active condition or easily soluble) in the peat.

3. In all deeper peats this amount tends to become the same ~~permit~~ percent of organic matter.

4. The worst peat types show at least partly anaerobic condition even within a fraction of an inch from the surface.

In connection with the aeration of tree roots growing amongst moss and sphagnum the observation had been made that even on dull days Sphagnum, especially in the hummocky form, feels warmer to the hand than the surrounding vegetation. This was tested by a thermometer and it was found that when such Sphagnum is quickly exposed to the air, an appreciable rise in temperature occurs. This is in itself an indication of oxidation and that such Sphagnum acts as a preventive of aeration of the roots of trees, even when still growing or recently dead. The same result was not obtained in the case of the looser Sphagnum societies although these also appear warm when pulled out.

SECTION III.

TEMPERATURE AND PEAT.

The question of temperature variations on peat with reference to Inverliever was studied from the already known data, while during the year a series of temperature readings were made at Cruachan in order to obtain supplementary information. From the graphical figures in appendix I which represent the average (of four year's data) number of nights in each month on which the minimum thermometer reaches 32°F and under, and 36°F and under at Cruachan; and Fig.II. The total number of nights for each week beginning at the first of January on which 32°F and under occurred during these four years.

Conclusions from the data.

There are only two months or a period of eight continuous weeks in each year in which frost has not occurred during the past four years at Inverliever, while frost is practically certain to occur any week from October to the end of May. If we include the 36°F record as being a more likely index of frequency on the higher ground in general, then frost may occur on occasional nights throughout the whole year. Certainly July and August are the only months on which frost has not occurred at the level of the Bothy at Cruachan and even at that level minimal temperatures of 36°F are reached in both of these months.

Since temperature investigations on peat published both in Europe and in America show a much greater frost frequency on peat as compared with adjacent mineral soil and rock, records were made both over and in peat on the frost hollow near the gate at Cruachan Farm at about the same level as the Bothy station. The records are in a general way similar to those at the Bothy, but do not bear out the investigations mentioned, the periods and intensities of frost being practically the same. Comparing the temperature at 3 feet above the peat and the temperature at a depth of 1 ins. below the peat, the latter are found to be almost invariably higher throughout the whole period so far determined. As examples the figures for May are given from the Bothy, above the peat and in the peat (only alternate days 1st,3rd,5th etc.)

Bothy 38,37, 28, 28,32,32,34,36,36,34,44,47,36,39,38,45.
Above. 30, 38,29, 35,22,43,34,37,38,36,44,47,39,45,43,48.
In. 43, 43,41, 41,39,44,44,45,46,46,46,50,46,47,49,51.

These figures are also interesting in relation to temperature records taken during the day at various stations on Inverliever. It was found that in April extraordinary rapid temperature transitions occur at the surface of peat and peat vegetation, while at a depth of 1 foot the temperature is apparently stable throughout the 24 hours and for a fortnight on end. e.g. in April 44°F.

The point is illustrated by the following temperatures taken April 5th at 10.30 in full sunshine.

Air 3 ft above soil	45.5°.F
Air 1 ft " "	48.5 F
Air 2ins. " "	50.0 F
Surface of moss	72.0 F
2ins.below surface (i.e.surface of Peat)	50.0 F
2ins.below surface of peat	42.0 F
6ins.below surface of peat	39.0 F
1foot " " " "	44.0 F
2feet " " " "	44.5 F

Much cannot be said with regard to these figures since the physiological effects of variations of temperature of this kind do not appear to be known; but from general principles the opinion is perhaps justified that such variations are sufficiently great to produce serious derangement in the root-transpiration balance in conifers, and it is suggested that this may be in part at least the cause of leaf-casting of Spruce in these exposed sites, an effect usually ascribed to wind. It was noted that Red Sphagnum reacted more rapidly to the sun's rays than the greener types, Rachomitrium lanuginosum more rapidly than Sphagnum rubellum.

SECTION IV.

PEAT ANALYSES.

During the year a considerable number of analyses of peats were made from samples of the various types.

Although it cannot be said that each type has a definite and unvarying analysis yet on the whole each type varies in analysis within definite limits, any exceptions occurring being due to obvious causes such as the presence of pieces of grit or stone in the sample taken for analysis, as happens frequently in the case of shallow peats and near rock slopes.

From the first set of Tables (Appendix IV) it may be concluded that although considerable variations occur in the total ash-content of peats of one type yet the ultimate analyses of these ashes indicate that the less suitable a peat is for forest plant growth the lower the soluble food material tends to become while the presence of larger amounts of mineral material generally tends to improve the peat, an effect which is probably physicochemical as much as nutritional.

The second series of analyses is added in order to show that in a general way ash content varies to a fair degree with the growth of Spruce even within small limits of area the two series comprising samples from two areas of not more than 50 yards square, each in one valley near Dum Corrach.

Other analyses were carried out but require to be completed before inclusion in the report; Hydrogen Ion concentration tests by colorimetric methods both in the field and in the laboratory give results difficult of interpretation, and it is felt that colorimetric methods are unsuitable for peat pH determinations owing to technical difficulties. These tests are being repeated electrometrically.

SECTION IV.

MANURING. Note on work in hand.

During the year manuring experiments were carried out in the field at Parkhill and at Inverliever, using varying quantities of the usual agricultural manures and various methods of application, Results will not be available until next season. Also attempts have been made to destroy Sphagnum

Sphagnum with various reagents of which the most satisfactory seem to be salts of Ammonia or strong acid. The duration of these effects also can only be determined next season.

Similarly plots at Inverliever have been treated in different ways to determine whether plants on the ground may be affected by ameliorative measures such as removal of Sphagnum, its destructions, addition of manure to the ground etc.

It is intended to extend these experiments next year.

SECTION V.

REPORT ON CONDITIONS AT INVERLIEVER.

General factors of locality at Inverliever as influencing growth of peat vegetation and of forest trees.

Climatic. Lying as it does on the West of Scotland, Inverliever belongs to the region of high Rainfall, low Sunshine and of moderate thermal conditions, apart from liability to extreme minimal temperatures throughout the year.

The Rainfall probably varies considerably within the limits of the estate itself as for instance there is an average annual difference of Rainfall of practically 10 ins. between Ford and Cruachan and it is highly probable that the rainfall on the higher plateau above Kilmaha is still higher than Cruachan. The occurrence of rain during practically $\frac{3}{4}$ of the days of the year indicates that rate of evaporation is extremely low and that therefore all, excess moisture must be removed by drainage.

Temperature. Its proximity to the western seaboard results in a comparatively low summer and high winter mean temperature, other things being equal. Although westerly winds prevail, it almost of necessity occurs that east winds of windless, cloudless, nights following on bright days cause a rapid fall in the air temperature while the lack of conductivity of the soil (peat) accentuates this fall. Hence unseasonal frosts are to be expected. And an analyses of the temperature data for Cruachan confirm this idea, showing that during the four years' period studied, night frost does not occur only in the period

period approximately represented by the months of July and August; and since temperatures of 36°F occur even in these months at Cruachan lower temperatures are not unlikely to occur on the peat areas above.

With regard to exposure to wind, it is difficult to conclude that Inverliever is subject to wind to any remarkabale degree.

Topographically. Inverliever consists of a central hill mass projecting in a S.E. direction into the Loch Awe basin; flanked on the S.E. face by a fairly steep, almost continuous slope, while on the Southerly and N.Easterly flanks a series of valleys descend to the lower levels marginal to the loch. On the former side these cut from the central plateau through the hill ridge terminating in Dum Corrach, and fall rapidly into a common valley; while on the latter the hill mass breaks down into a series of undulating ridges and knolls descending finally as a whole upon the glacial flats round Cruachan and New York.

Geologically, the area under consideration lies upon the series of igneous and metamorphic rocks characterised as the Loch Awe Epidiorite Series, named from the Epidiorite mass which lies as a whole to the N.W. Hence although Epidiorite occurs as a rock at Inverliever the bulk of the rocks are not Igneous but Metamorphic consisting of slate-like Schists, and flagstones, nearly all of greenish or bluish appearance, and containing notable quantities of Ferro-magnesian minerals, and apparently impregnated with considerable quantities of Calcite, especially on the lower ground. These rocks have a general dip to the North-East, that is to say for the most part drainage must occur across the strata of the rocks; the "lie" of the rocks tends to hold up drainage. By their decomposition there is formed a series of soils varying in their physical texture but agreeing in having a large proportion of clay; they are all heavy, plastic and impervious; the soil itself tends to retain water and to hinder satisfactory drainage. The soils are, on the whole, however, comparatively shallow, a result of the high rainfall and steep gradients which are common. Glacial soils occur toward Cruachan and beyond to Delavich and these are distinctly opener in texture although this advantage tends to become minimised through the formation of Iron pan.

Other rocks such as andesite and Basalt occur but these dykes apparently are too narrow to exert any appreciable influence on surface soil conditions. Grits come to the surface mainly toward the Northerly side (well developed at Delavich) and to the lower side of New York pier; although these are limited in area yet the change to grit seems to be accompanied by the development of opener-textured soil showing less evidence of bad aeration than do the soils of Epidioritic origin.

Definite bands of Limestone (formerly used for agricultural purposes) occur below Kilmaha but these do not come into the area dealt with, and no Limestone has been ~~formed~~ found in contact with peat. The soils are not in themselves infertile.

<u>Conclusions.</u> The fundamental factors of locality at Inverliever are (1) Heavy rainfall; (2) Impervious rock; (3) Shallow impervious soil; (4) Low sunshine; (5) Liability to night-frost; all of which combine to give (6) short or inefficient growing season.

<u>Vegetation:-</u>

The above factors of locality tend to produce a specialised flora and this flora will be developed primarily in such sites as emphasise these factors. Such sites are these especially in which drainage is at a minimum e.g. in the high, level valleys and on the high plateau, and at lower elevations on flat areas and collecting basins. In all of these there has become dominant, at least temporarily, a vegetational type which is characterised by dominants suited to the factors detailed, of these the outstanding plant is Sphagnum especially Sphagnum rubellum. This is accompanied by species of higher plants also adapted to these conditions of which the principal is Scirpus caespitosus. Another species which seems to play an important part in initiating the development of the special vegetational condition at Inverliever is Eriophorum vaginatum, which is however found at its principal development, not on flats and valleys but on long, very much exposed flat slopes, and especially those having a Northerly and North-Easterly aspect. Here it takes the place of Scirpus.

The development of plant societies characterised by these plants is accompanied by the formation of peat of the infertile "Hoch-moor" type, and such societies tend to fill up hollows, overflow from basins, and especially do they from centres of distribution from which Sphagnum tends to progress in all directions reproducing as it goes the unsatisfactory soil conditions in which it originated and thus by its nature tending to over-run the soil completely. At Inverliever this has occurred with small exceptional areas throughout the whole of the region roughly above the road. Below the road the canopy formed by semi-natural Oak-Birch coppices has checked its advance to a large extent. Above the road (apart from rock faces which are also invaded in time) the only parts to escape the advance of the Sphagnum are the steep slopes on the hill-tops lying above the plateau, and one or two steep valley sides i.e. those sites in which drainage is good, where grass and heath can occupy the soil in sufficient density to prevent the development of Sphagnum. Even there, there are indications that soil water-content becomes approximately that of Marsh (see Photo. with Rushes; top of D.Corrach No.L). On large tracts this development of Sphagnum is more or less recent as is evidenced by the condition of the grazed land in the neighbourhood; and the rate of growth and mode of development of the Sphagnum appears to be influenced by the species of higher plants originally present before Sphagnum invaded. Thus grasses may resist Sphagnum for a considerable number of years while open clumps of heather, Bilberry etc. apparently afford that amount of shelter which gives optimum conditions for the growth of Sphagnum, and so on.

This vegetational progression has given rise to a series of peats of different types which are of varying composition and character, and which therefore, act differently as media for the growth of coniferous trees.

These are now characterised and notes of observations are made upon the growth of trees on these as well as of other points which may be of value.

The previous classification of peats has been considered too diffuse and it is now felt that the high-moor and sub-Alpine Inverliever peats can be classified under the following groups.

	Distinctive Character
A. Fibrous peats.	Yellow colour; with difficulty torn apart or broken up.
B. Pseudo-fibrous peats.	Yellow colour; easily torn up and moulded by the fingers.
C. Brown nodular peats.	Dark to yellowish-brown; somewhat fibrous but consolidated enough to break or cut cleanly.
D. Black granular peats.	Black at least for about 6ins. on the surface. Having a somewhat granular appearance unless puddled; clay-like below.
E. Black powdery peats.	Like black clay, where these overlie dark clay it is difficult to see the transition from peat to clay.

Notes.

1. Transitional forms occur.
2. One type may over-lie another
3. Observation should be made whenever the peat is exposed.
4. Weathered peat such as old hags, turves etc., cannot be used as indexes.
5. Observations as to toughness etc should be made apart from the effects of living or recently dead parts of plants.

Soil conditions and Spruce Growth at Inverliever.

On mineral soils provided there is no peat Spruce, especially Sitka, grows well on any site provided sufficiently large blocks can be formed to give the plants mutual protection. e.g. Photo 2, where Spruce is seen on exposures from full West to S.E. at an elevation of nearly 800 ft on Dun Corrach.

On peat, conditions and results are totally different.

A. Fibrous Peats.

These are the result of the death of plant remains (in a loose condition as a general rule) below stagnant free water, the plants concerned being usually Eriophorum angustifolium, and Carices as well as Sphagnum. They are exceedingly tough for about one-foot, below which they become sludgy i.e. the water supports the fibres not vice versa as in most peats. When dried without breaking up these peats become tough like. Chemically they are characterised by a low ash-content and a low percentage of Lime, Potash and Phosphate in their ashes. They occur (a) as the result of the marginal advance of Sphagnum into stagnant water e.g. small lochs; and (b) where for one cause or another surface water collects e.g. on rock basins, panny soils, depressions on peat etc.

Vegetation. (a) Sphagnum with Sedges and broad-leaved cotton-grass. Calluna usually invades; then Scirpus etc. transforming these into type B. (b) Sphagnum, Sedges, both Cotton-grasses, Scirpus with a grey appearance due to Erica Tetralix which is strongly developed in this type. Details listed Appendix V,A.

Growth of Spruce. (a) is unimportant and it is local in character and cannot be planted without complete drainage of the loch which it invades.

(b) Such basins are invariably frost holes. The rate of growth of the trees seems to be so slow, however, that the buds either do not develop or are frosted while bursting. Sitka usually assumes a branch-like habit as if bent and blasted on one side by the wind but that this is not due to wind is obvious, as bending occurs in different directions in adjacent plants. The cause is not determined but is probably frost. Growth very bad.

Possible improvements of locality. Large areas of this type are not frequent but should be treated as unplantable. Smaller areas should be treated by a deep central drain to remove the underlying water while seepage water from adjacent slopes should be led away by a surrounding ditch. Turf planting would probably not be of any great advantage without thorough drainage owing to the subsidence of the turf in the sodden peat (Photo 3. central area shows this type and No.4 in the foreground).

B. Apparently fibrous peats. These peats occupy extended areas at Inverliever and are the results of long continued growth of Sphagnum (a) under the shelter of sub-shrubs like Heather, Vaccinium etc.which finally become dominated by Scirpus caespitosus in the typical forms or (b) under the shelter of Eriophorum vaginatum which apparently remains dominant at least for a very prolonged period. The former finally assumes a raised centre and for that reason is called High-moor (the latter does not show this feature so strikingly) when this occurs beyond a certain point the weight of water held by the peat causes its collapse along certain lines, the peat mud flows to the lower ground and peat "Hags" are formed. These may develop secondary vegetional types (e.g. Molinia, strong Calluna, or, in hollows "Fibrous" peat) Photos 11, 5 etc.

These peats are yellow or light brown in colour practically to the surface; the light colour changes to black soon after exposure to the air. They contain a large amount of fibre which in the fresh condition is quite inelastic and can be squeezed to mud in the hand (when exposed to air the fibres become tough and on prolonged leaching the peat becomes spongy). They have a low ash-content with an ash comprised mostly of siliceous cuticles of the plants forming the peat (Sometimes there are localities where Iron oxides collect under the action of Iron bacteria when the ash content is higher). The ashes have a very low food value.

Two types (a) Scirpus (Calluna) type, occurring in flat areas level valleys, and developing upon water-formed peats such as Types A above. Here the typical vegetation consists of Scirpus caespitosus amongst which grows short Calluna vulgaris, Narthecium ossifragum, both Cotton grasses, Tormentil, Erica Tetralix etc. in scanty but variable amounts. Of mosses, in the typical form Sphagnum is not necessarily the principal moss, occurring mainly in somewhat small patches or where water would tend to collect; Hypnum schreberi, H.Cupressiforme, Rachomitrium lanuginosum are quite abundant and generally occupy as much space as Sphagnum. Sphagnum rubellum is the principal species but others such as Sp.intermedium, Sp.tenellum also occur.

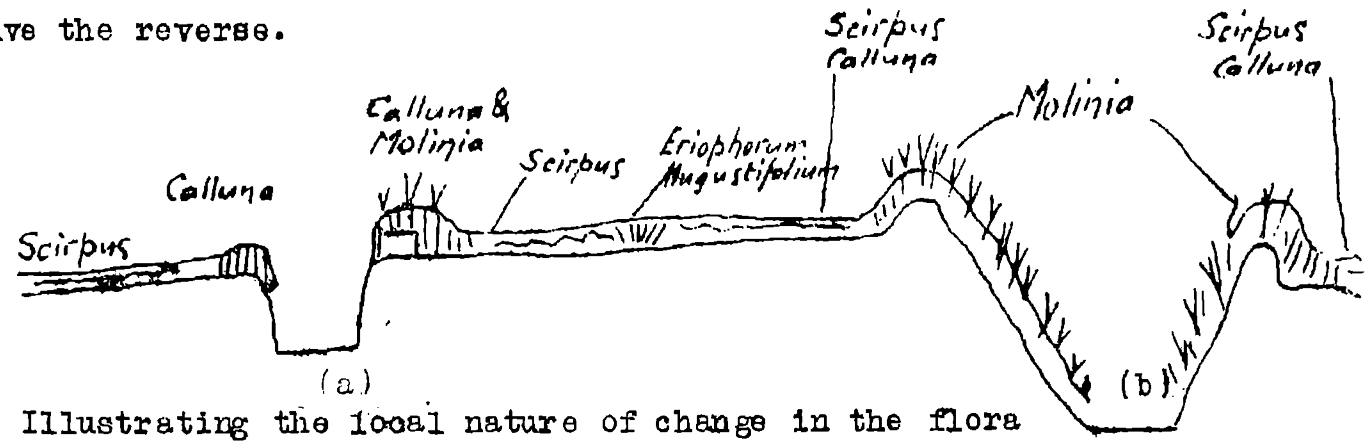
Growth of Spruce.

In the typical form ordinary Spruce dies out with little if any growth at all. Sitka is not much better. The principal cause would appear to be the lack of an aerated medium into which the plant roots can penetrate (the vegetation is scant) and lack of nutrient material, on the surface on which adventitious roots might grow.

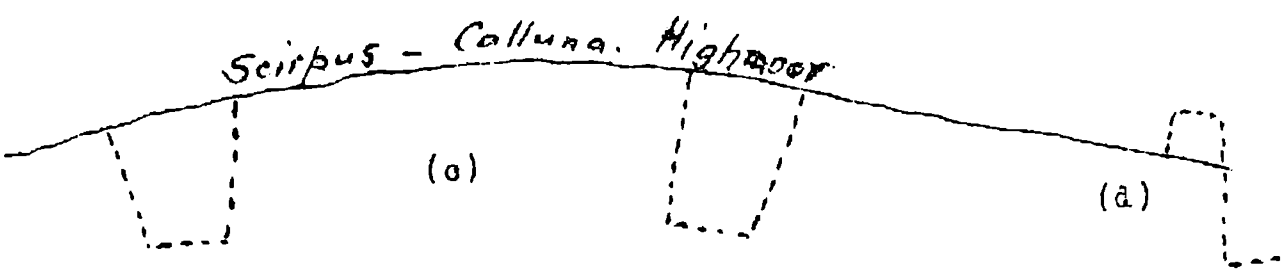
In the earlier stages of the development of this type of peat from shallower types where heather, Bilberry etc are fairly luxuriant the main type of moss is Sphagnum rubellum. This plant grows rapidly between and under the tufts of heather etc. and here growth of spruce is effectively prevented simply by the continued smothering of the roots by new deposits of Sphagnum. That this rapid growth of Sphagnum is due to the partial shelter afforded by the sub-shrubs is seen by the fact that the process goes on more rapidly in these areas planted with Scots Pine (or even Spruce) than where no planting has been done or where the pines are completely killed out. Again when it occurs in a sheltered site the sphagnum grows more rapidly than in an exposed site for example in the low valley above the road midway between Kilmaha and Cruachan. In this rapidly growing form Spruce grows somewhat better than in the deeper Scirpus type but it is doubtful whether anywhere either Sitka or Norway Spruce will overcome the Sphagnum.

Methods of Improvement. Main Type. Ideas for the improvement of these peats may be obtained by studying the variants and developments which occur on them. (a) When drains are laid out on these a more luxuriant form of heather develops in the margins of the drains. In this the plants remain alive for a longer time. Ordinary Spruce does not grow however to any appreciable extent. If, however, a general breaking up of the peat occurs then Molinia develops strongly as in well-weathered hags or deep, wide drains. Here rows of Spruce grow well for a time at least and would probably continue to grow provided they were in sufficiently large blocks (see Photo 6.). This result is evidently produced by the aeration of the peat by water percolating over it and by the loosening action of the Molinia roots. Hence it might be locally possible to flush such peat with fresh running water, when it might be expected that the improvement produced would enable Spruce to grow. This effect is produced naturally when flush water from soil or rocks in the valley slopes passes over Scirpus peat. Then the peat opens out, becomes granular and develops a Molinia, or Rush vegetation in which both species of Spruce grow quite well (Photo 7). This Molinia-Rush peat overlies considerable areas of Scirpus peat frequently in very small patches only but occasionally reaching a good many acres as in a wide valley recently planted above Cruachan Farm. Any means to induce this change would render the peat plantable. Certainly the frequent practice of cutting off flush water from such peat in attempts to drain is to be deprecated.

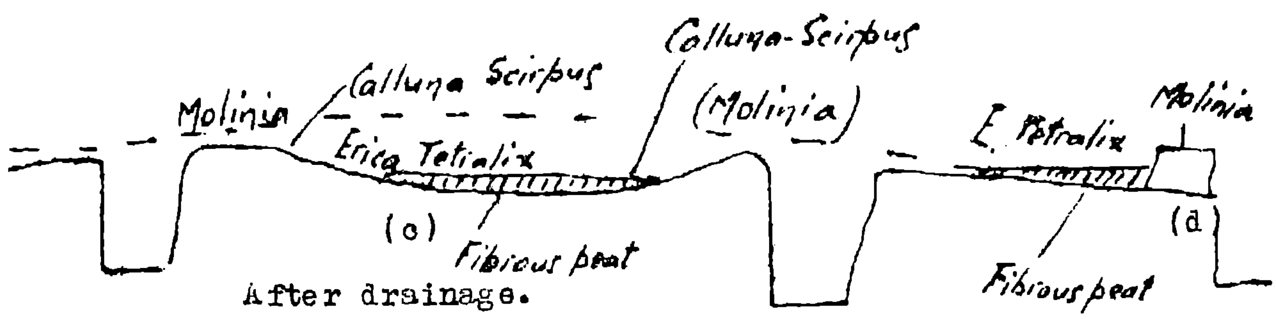
The laying out of an extensive drainage system of the ordinary type used results in very little advantage while it may give the reverse.



Illustrating the local nature of change in the flora produced by (a) smaller; (b) larger drains, on deep Scirpus peat.



Before drainage.



After drainage.

Illustrating (c) the effects of wide spacing of drains on deep peat and (d) effect of placing the turves along-side drains.

The improvement obtained is only in immediate contact with the drain, where Calluna and possibly Molinia become more luxuriant. This may be emphasised by leaving the turves from the drain in a ridge beside it. The effect on the area drained as a whole is often harmful since the intervening space tends to subside forming a hollow in which drainage is worse than before, and this applies also to better types of deep peat. The result is that the fibrous type A (b) tends to develop and the whole process of peat formation commences in a new circle. Hence unless close drainage is carried out in such peat or on deep peats in general they might as well be left alone, since the cutting of widely spaced drains does quite a definite amount of harm. The practice of laying the turves in a continuous ridge along the sides of drains also produces the same effect and this may be seen on almost any type of peat at Inverliever. Turves should be scattered or thrown to the middle of the area between the pairs of drains. The addition of manures would no doubt improve the quality of these peats but until physical improvement can be carried out the nutritional value of the manure is lost.

C. Greyish-black or brown peats form the bulk of the peat at Inverliever; at least are the most abundant of any individual type of peat. They vary in depth from a few inches but have not been observed much more than $1\frac{1}{2}$ feet in depth. When deeper than this the more rapid development of Sphagnum in mounds results in a shallower yellow peat similar to B type in structure. These peats are apparently the result of the invasion by Sphagnum of other types of vegetation which may not necessarily tend of themselves to form peat. Hence the flora is frequently very varied. The most abundant form of vegetation found occurs in the recently-grazed areas round Barmaddy and above Cruachan, where Molinia, Scirpus and Calluna are the principal higher plants. On the removal of grazing the last of these apparently at first assumes dominance (the great development of heather after enclosure is very noticeable) and finally Molinia is reduced in quantity and Calluna, Scirpus and Sphagnum form the bulk of the vegetation. A final development apparently occurs when the depth of Sphagnum weakens the Calluna and Scirpus, and Sphagnum predominates.

The heather knolls occurring on wind-swept valley sides and slopes are a development of this type apparently from Calluna heath. (see Photo 12)

Characters of Peat.

Brownish-black to black in colour, with a large amount of plant roots etc, giving a fibrous appearance; readily broken when only partially dry, the peat being composed of fairly large nodules, of a gelatinous rather than granular structure; ash-content usually fairly high; nutritional value of ash moderately high; a fair amount of soil is often incorporated in the shallower types.

Growth of Spruce. Varieties of this type are among the most disappointing peats at Inverliever. The peat is however incapable of supporting the growth of Spruce mainly for the reason of bad aeration, and drainage produces comparatively little result owing to reasons already set forth. Large areas have been planted recently and in these the plants are yellow, blasted-looking and wholly unsatisfactory. Not only so but the removal of sheep must tend to increase the growth of heather and these areas will almost certainly be a failure, as has been the case on ground of apparently the same type in the older plantations.

An experiment has been made of turf planting two years ago near Barmaddy, and the results are very satisfactory as far as they go. The neighbouring plants (both Sitka and Norway) are as usual yellow and unhealthy; casualties 5-10% Sitka; Norway 10%. On the turves Norway is quite bright and green the plants on the whole are bushy and show no signs of blasting; casualties 2½%. (On this area the peat is deeper than is usual on this type). Although, therefore, it cannot be said that on such peat turf planting is a definite means of success, yet so far as the first few years are concerned turfing would at least appear to give the plants a good initial send off.

The necessity for the addition of manure in order to increase the initial growth and allow canopy to close sufficiently early may become obvious later on, but in most cases rate of growth last year ranged from 3-6 inches, that is in the first year after proper establishment. The planting of Spruce into such peat without amelioration of any kind is useless.

Black Granular Peats. Types D.

The typical form of black granular peat is found where peat develops under flush conditions, that is where fairly rapidly moving, and hence well-aerated water percolates over and through the peat. This occurs principally where water moves rapidly down from rotten rock slopes and exposed soils upon the peat below. A similar effect is produced by the crumbling down of yellow peat when a peat hag collapses. Again the action of mineral matter in solution and in suspension in drainage water shrinks the peat and renders it granular thus allowing surface water to pass through and aerate it. If for any reason the passage of this mineral-bearing water is inhibited i.e. if it becomes stagnant, then fibrous un-decomposed peat, not black peat results, with Deschampsia flexuosa - Erica Tetralix flora. Such peats on the higher areas are occupied by quite typical vegetation, Rushes (Juncus inflexus) and Molinia caerulea (Appendix V. D. 4 and 5). In the absence of the former the latter occurs as comparatively large definite clumps or tussocks round which water frequently trickles. This is the typical good Molinia (Appendix V; D.3.) On the poorest types of Molinia ground the grass may be more or less continuous but the plants are small and have not coalesced into definite tussocks, while as a general rule noteable quantities of Eriophorum spp. and Erica Tetralix etc. are diffused throughout the Molinia. (App.v.D.1 & 2).

The peat found under these associations is black in colour (occasionally blue-black owing to mineral matter) and is composed of irregular grains or "crumbs", which readily separate from each other. It is intermediate between the Scirpus or "Highmoor" type and the calcareous peats of the Fens or muddy peats of river and lake margins known as "Lowmoor" types, of which approximate examples are to be seen in the Iris flats occurring here and there near Loch Awe. When dried by drainage or by the action of a crop of spruce they become somewhat more consolidated, forming a clay-like peat or even a vegetable loam, both excellent for tree growth. Chemically as compared with the highmoor and alpine peat types hitherto described, it is characterised by either a high general mineral content, or at least by a high lime and nutritive-mineral content. This may act, as already indicated, in two ways; either by allowing increased growth, or by increasing aeration and decomposition of the peat itself and thus providing a suitable medium for the roots.

The Molinia and Rush types of peat occur (1) either as direct developments on soil, (2) or as secondary peat strata super-imposed on other types by some recent change in conditions; as (1) near streams, (2) by the passage of a stream (or drain) through or upon another type causing the development of Molinia with or without Rushes.

Growth of Spruce.

On Rush and Molinia, Rush, and tussocky Molinia types the Spruces grow at their best. The principal danger of these lies in the fact that such types frequently lie in low positions as compared with their immediate surroundings. For this reason the plants are very subject to frost during the first few years. Thus frost-blanks are frequently to be found in the midst of excellent patches of both Norway and Sitka Spruce (especially the latter). Another cause of such blanks to which attention may be drawn is the drowning out of the plants by the luxuriance of the vegetation. For the first years the plants must be cleaned in the autumn at least; after winter they are frequently found, even four years after planting, bent down by the weight of lodged Rushes and grass. Both these difficulties might be coped with by using larger plants since in no case is there any danger of drought in planting such areas.

The less satisfactory types of Molinia peat are apparently always of more recent origin frequently, occurring in patches within the deeper peat types.

They are frequent along drains, on mounds formed from drains and on the debris deposited by decomposing peat hags especially in the moderately sheltered areas. When a drain cuts deeply into the peat and causes a general shrinkage of the peat in the neighbourhood, Molinia develops. This may be only temporary since if the ameliorating process is retarded reversion may take place not only to yellow peat but more frequently to fibrous Erica Tetralix-Eriophorum types.

As compared with the better qualities these Molinia peats are (1) of lower basic mineral content (2) of shallower depth so far as the black surface peat is concerned (usually not more than 4 (6) inches). (3) and frequently more wind-swept. They correspond to a considerable degree to the undrained Molinia peat of the Hertogenwald.

The growth of Spruce on these depends mainly on the depth of the black, decomposed surface stratum which can be correlated to a fair degree with the condition of the Molinia. Where it is in tussocks and luxuriant the black peat is deep, where the Molinia is short, stiff and even it is shallow. Growth of Spruce is frequently irregular and check occurs for a considerable period but even ordinary spruce does fairly satisfactory for a time at least on such vegetation. Frequently, however, the areas occupied by it are very small in extent and unless the developing plants are afforded shelter they become blasted and fall off in growth (samples of this may be seen in Photo 6 where the plant in the centre of the Molinia is now, to all intents, dead after good growth).

Sitka Spruce does distinctly better than Ordinary Spruce on these poorer Molinia types although suffering in the same way when developing in small numbers or as individuals. Photo 7 shows a cluster of Sitka (on the right centre) about 8ft high as compared with Norway (the narrow dark line on the right side) 3-4ft high.

On Rush and the better Molinia peats so far as soil conditions are concerned, it does not appear that soil amelioration is necessary apart from satisfactory removal of surface water.

If however, as Belgian foresters claim, the additional cost of the turf system planting is balanced by cost of cleaning the young plantation then the reduction of the losses due to weeds and of the time during which the plants are subject to frost should be a clear gain if this system were used. On the poorer Molinia ground the Belgian system would just effect the improvement necessary to bring the peat into the better condition required to make it suitable for planting especially in places where Erica, Eriophorum spp., Narthecium etc are mixed with Molinia and it is certain that surface drainage is not sufficient and that water is collecting on the area.

In connection with Molinia types it may be noted that so far as observations at Inverliever indicate, the total depth of a peat has per se no bearing on the rate of growth of Spruce, certainly for a considerable part of the life of the tree (which is as far as the existing material permits observation to be made). E.G. the depth of peat on which Sitka is shown growing so well, photo 4, varies to over 3ft. And at the north of Cruachan Bothy similarly, good Sitka and Norway are growing on Molinia and Molonia Rush peat of over 1 foot in depth which lies on a yellow sphagnum peat over 4 ft. in depth, a total depth of something over 6ft; the situation is similar to that of the Spruce surrounding the bad area in the centre of photo 4 where the peat is much shallower (and the trees are not so satisfactory). Peat analyses No.3 shows how the peat differs in ash content from the central Scirpus area it surrounds; the extra surface ash consisting largely of mineral debris washed down from the surrounding soil slopes. Here also we have a Molinia peat overlying a deep Scirpus type.

Calluna Types.

The type of peat considered under this head is frequently not considered a peat at all but must be included as a peat under any satisfactory definition of that substance. It may be called Heath Peat, and is composed of the well-weathered debris of plants like Heather, other Ericaceous plants and mosses like the Hypnums but little or no Sphagnum, i.e. that is plants with a low waterholding capacity. These plants are of low basic ash content and perhaps for this reason after a certain point decomposition of their remains slows up and a black peat, powdery when dry, is the result. This acts, like clay, as an impervious soil and is in itself of low nutritive value. After a certain depth has formed it tends to be badly aerated and forms a bed for the development of Sphagnum, especially under the high rainfall of Inverliever. This change has happened almost all over at Inverliever but here and there where slopes are steep, and where Sphagnum invasion can take place only in an upward direction, the surface peat is black and shallow, as it had been when grazed.

The vegetation found in this, peat ranges from Deschampsia flexuosa grassland, to heath grassland (Grass, Vaccinium, Erica cinerea, Calluna etc) (E.1, App.V); and Calluna heath (Calluna and Erica cinerea). The heath grassland appears to have succumbed to the invasion of Sphagnum except on the tops of hills, the Calluna except on very steep slopes; the result is either a brown Sphagnum-Calluna peat or a rapidly developing yellow Sphagnum of the types earlier described, the latter varying in vegetation as did the earlier heath or grassy heath facies.

The grassland forms, where they exist are quite satisfactory for Spruce. Where Calluna develops to any extent however, Spruce is only moderately good. The cause of this has not been satisfactorily determined and it seems that the idea that Calluna produces definite anti-Spruce toxins is probably correct. Sitka is again distinctly better than common Spruce but at the same time does not (with one or two exceptions) promise well on anything like pure Calluna.

The peat is so shallow in this case that the soil might be mixed with it and turned up to the surface by means of a mattock and plants inserted in these prepared patches. On the continent before planting Spruce on Calluna ground the heather is frequently burnt; in this way the plants come away before the heather has time to affect them.

The other method of dealing with the problem is to attempt the growth of species like Pinus cembra)and Mountain Pine which are
P.murrayiana)
not affected and can tolerate the heavy rain; even if these reach only pole size Spruce might be introduced under their shade.

CONCLUSIONS.

From observations made at Inverliever it is concluded that.

1. Variations in the topography are accompanied by characteristic variations in vegetation and in the peat formed by these vegetational societies, resulting in similar variations in the growth of Spruce. (See Diagrams of actual traverses of areas at Inverliever App. V.).

2. Bad growth of Spruce at Inverliever is the result of two main edaphic factors:-

(a) Bad aeration or water-logged peat
(b) Lack of available food supply for plants.

3. These factors as a whole run concurrently, since well-aerated peat decomposes sufficiently rapidly to liberate food material sufficient to the requirements of Spruce. (Exceptions to this may occur in the case of disintegrating hag peat).

4. The principal methods of remedying these defects are:-

(a) Efficient drainage
(b) Manuring.

5. Drainage is not satisfactorily accomplished by ordinary methods owing to the retentive power for water of (a) Sphagnum which prevents evaporation and percolation and thus prevents even partial drying of the peat below; (b) of the peat itself which tends to retain water to an extraordinary degree against the force of gravity. Hence:- surface drainage must be accompanied by improvement of the consistency of the peat and by removal of Sphagnum. This is most satisfactorily accomplished as far as present methods go by the Turf-planting system; (c) On peat, surface drains are ineffective as waters collectors if placed widely apart owing to the subsidence of the intermediate peat. Therefore drains must be as closely spaced as can be economically done.

6. Of the peat types occurring Calluna-Heath, and the many varieties in which sub-shrubs allow the rapid growth of mounds of Sphagnum, would not be helped by drainage as a general rule; Rush and Molinia types of the better class do not require much drainage although improved by drainage which removes surface water and thus lessens the risk of reversion to bad types. Other types of peat will not grow Spruce without drainage of an intensive kind.

7. Chemical amelioration by the addition of manures is, as far as can be stated at present, only supplementary to drainage.

8. The destruction of Sphagnum by some means (likely chemical) is the only mode of attack of some vegetations e.g. rapidly growing Sphagnum.

9. The continuance of planting operations on a general scale on peat areas like Inverliever without intensive preliminary ameliorative measures is not advisable, owing to small area covered by better quality peat.

Notes.

Except where otherwise definitely indicated reference is made to the earlier planted types of peat only. The effects of grazing and the changes occurring when grazing is removed are very remarkable. This applied specially also to vegetational descriptions.

In applying the vegetational lists to the identification of any area it must be borne in mind that the vegetational facies varies from season to season. It appears that July to August or even later to early December is the best time for observing the total vegetation. Before that time a considerable number of plants are scarcely noticeable, after that time the earlier plants disappear.

In the Appendices are included the analyses of these peats upon which along with field observations these notes are based. Appendix V contains lists of the principal plants and the frequencies with which they occur on the various classes of peats;

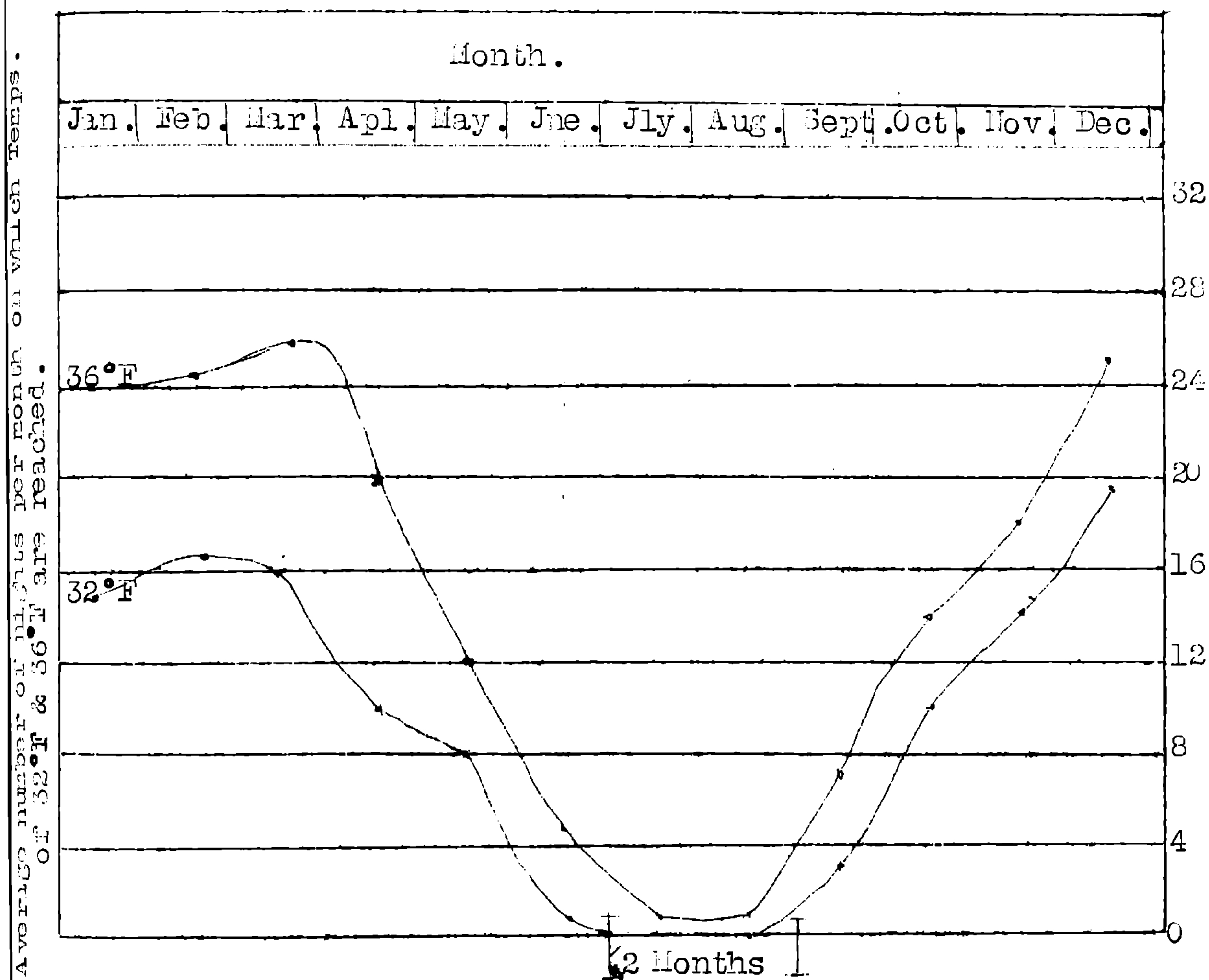
while two graphical sketches are included of traverses through charactoristic areas chosen from those which have run out and included as fairly good evidence of the variation occurring in the growth of plants in close proximity but upon different vegetations, which in turn correspond to variations in topography and produce different classes of peat. (The depths of peat are not indicated as the skotch would be overcrowded, they may be inferred from the genoral notes).

Photographs are addod as illustrations to prints mentioned in the text and to give a general idea of the appearance of vegetational typos noted.

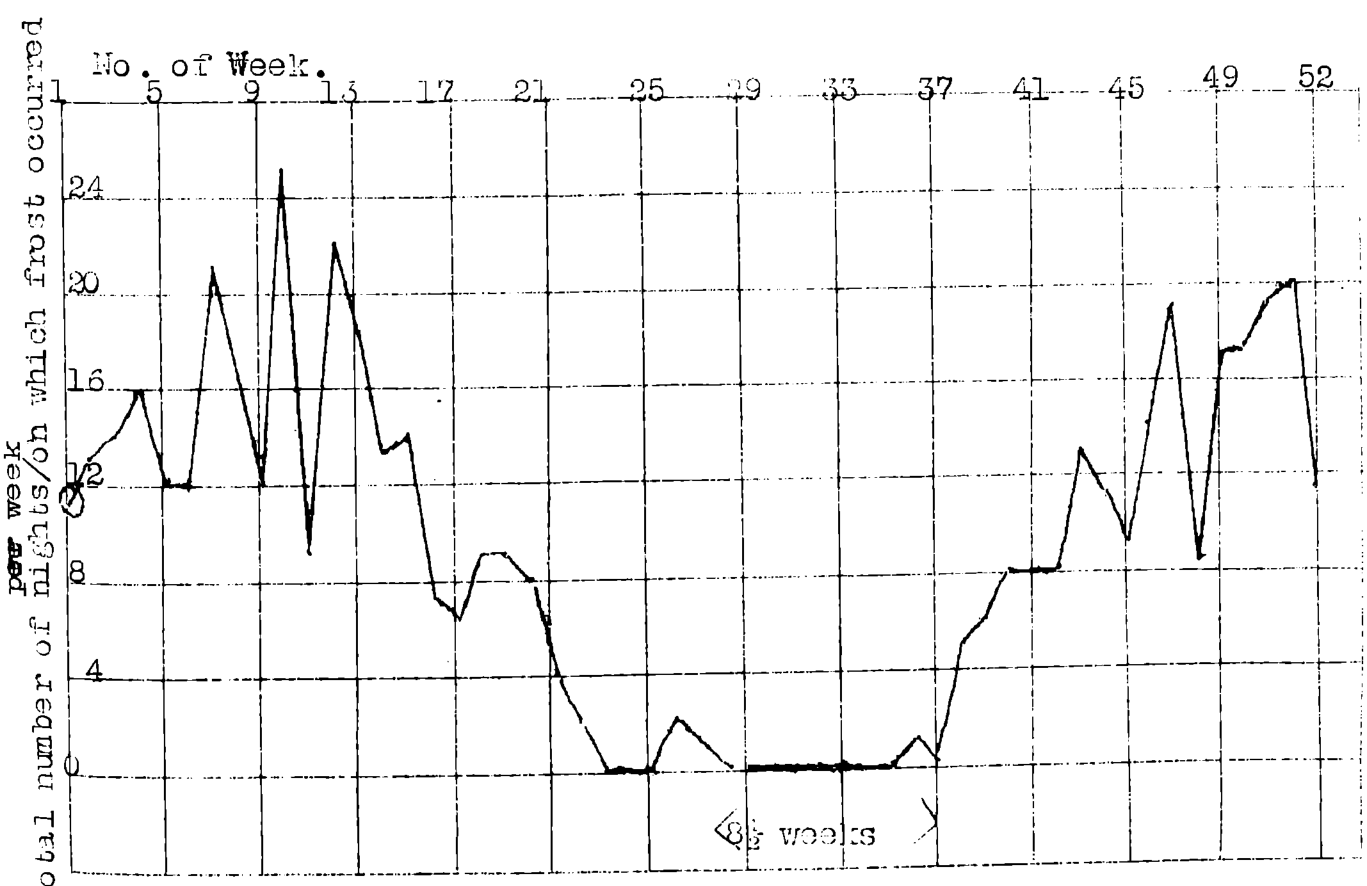
APPENDIX No.I.

DIAGRAMMATIC CURVES OF TEMPERATURE AT CRUACHAN.

MINIMA.



Monthly Frequency of Frost at Cruachan.



Weekly frequency of Frost at Cruachan.

(Totals for four years.)

APPENDIX No. II.

RATE OF FLOW OF WATER THROUGH PEAT TREATED BY VARIOUS REAGENTS & BY FREEZING.

(Figures in inches per day ;perfoot of depth of peat ;under pressure of one foot of water.)

No. of day	Peat untreated Unfrozen	Peat untreated Frozen	With Ferric Chloride Unfrozen	With Ferric Chloride Frozen	Sulphuric acid Unfrozen	Sulphuric acid Frozen	Calcium Hydrate Unfrozen	Calcium Hydrate Frozen	Ammonia Not Frozen	Peat dried Without $FeCl_3$	Peat dried With $FeCl_3$
1	.57	5.04	.51	60.0	.60	98.0	.50	65.0	.43	3.90	.83
2	.49	4.72	.20	31.0	.31	80.0	.50	29.0	.31	2.10	.68
3	.47	3.54	.20	30.0	.28	52.0	.48	28.0	.28	.98	.57
4	.33	3.35	.20	29.5	.28	43.0	.28	28.0	.24	.83	.35
5	.24	3.11	.20	29.5	.28	39.0	.24	27.5	.18	.59	.35
6	.20	2.95	.20	29.0	.24	35.0	.22	27.5	.16	.47	.35
7	.20	2.76	.20	27.5	.22	33.0	.20	27.5	.15	.35	.35
Average 8 to 15	.20	1.96	.20	20.8	.20	24.0	.20	22.3	.12	.28	.28
15	.19			8.26		9.0		10.10			.20

Rates of increase of Drainage due to the above methods of treatment. (Untreated peat taken as unit.)

Day	Unit	Multiplied by	By	By	By	By	By	Multiplied By	By	By	By
5th	1	13	0.83	125.0	1.17	165.0	1.0	110.0	.75	2.5	1.5
7th	1	14	1.0 1.3	140.0	1.10	160.0	1.0	140.0	.75	1.8	1.8
14th	1	10	1.3	100.0	1.00	120.0	1.0	110.0	.80	1.4	1.4

APPENDIX IIa.

Preliminary test of the amount of water held by peat at saturation under varying pHvalue.(Degrees of acidity.)

Blocks of Scirpus peat were cut from air-dry peat,all being of similar size and shape and consistancy.They were allowed to come to a water-equilibrium in solutions of differing pH values. They were then carefully wiped and weighed, and the increase in weight per cent was determined.

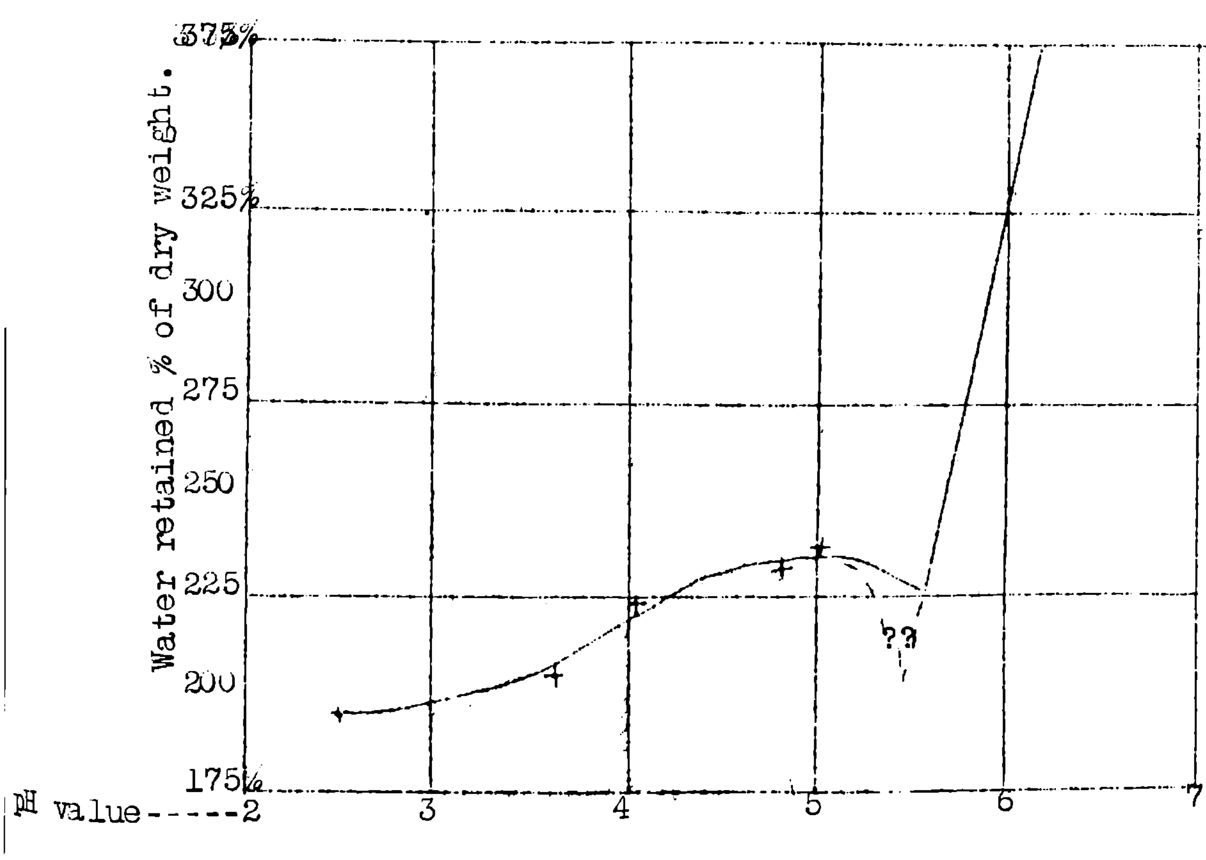
Following are the results;-

pH	No.1.	No.2.	Average (approx.)
	Water per cent of dry weight.		
2.5	199.0	188.8	195
3.6	201.2	205.8	203
4.0	221.4	229.6	225
5.0	232.8	239.8	236
5.6	229.2	227.0	228
6.7	463.2	534.6	500
11.0	580.5	554.0	560
4.8""	229.3	232.1	231

""(The liquid here used was distilled water; otherwise Sodium-Acetic mixtures were used.)

The approximation of the paired results is very satisfactory,considering the difficulty in obtaining exact similarity in the blocks of peat, and of evenly removing the surface-moisture.

Below is a Graphical representation of these results.



APPENDIX III.

AERATION OF PEAT . TABULAR STATEMENT OF RESULTS.

The relative reducing-power of various peats, or relative Air-requirements, a measurement of lack of aeration.
(The figures are relative---deep Scirpus peat, at 2 ft. being take as showing 100% of bad aeration; averages of 2 or 3 samples.)

Description of sample.	Relative lack of air. %of Dry Weight	%of Organic Matter.
Deep Scirpus peat.		
@ 2 ft.	100	100
@1 ft.	100	100
@ 2ins.	98	98
@1 ins.	83.5	83.5
Scraped from surface.	25	25
@ 1 ft., exposed over night.	33	33
3 Brown peats.		
Scirpus-Calluna-Molinia.		
@ 6 ins.	50	85
@ surface.	23	38
Scirpus with Molinia.		
@ 6ins.	57	85
@ surface.	22	32
Eriophorum with Molinia.		
@ 6ins.	42	50
@ surface.	20	24
2 Fibrous types.		
Molinia-Erica.) @surface.	15	16
Erica-Aira-Molinia.) @surface.	13	15.5
Heather, shallow.		
@ 4 ins.	9	15
@ 2 ins.	5	8
Molinia, deep flush.		
@ 2 ft, (=deep Scirpus.)	100	100
@ 1 ft.	21	23
@ 6 ins.	7.5	10
Surface 2 ins.	7	8.5
Molinia-Rush flush.		
@ 2½ ft. (yellow)	100	101
@ 2 ft, (dark)	18.5	19
@1 ft.	10	12
Surface	7	9

APPENDIX. IV.

TABLES OF RESULTS OF PEAT ANALYSES. (ASH-CONTENTS.)

I. GENERAL.

A. Fibrous types, (in order of solidity.)

B. Deep peat --Scirpus (Max. (Min. (Mean. i0 samples for ash-content.

C. Deep peat--Eriophorum (Max. (Min. (Mean. 5 samples.

D. Molinia on deep peat. (Max. (Min. (Mean. i0 samples.

E. Recent "Hag" Molinia, one sample.

F. Rush-flush, on & near deep peat (Max. (Min. (Mean. 7 samples.

G. Dark-brown "cheesy" peats, 4 types.
(Scirpus. (contaminated.?)
(Scirpus-Molinia-Calluna.
(Calluna.
(Erica Tetralix-Eriophorum etc., mixture.

H. Shallow Heath peats, three typical samples.

	Organic matter	Ash total	Ash soluble	Ash insoluble	Fe_2O_3	Al_2O_3	CaO	MgO	K_2O	P_2O_5
B.	97.33	2.67	--	--	--	--	--	--	--	--
	97.26	2.74	.83	i.9i	.i8	.i9	.i4	.i7	.023	.073
	96.90	3.i0	.85	2.25	.i8	.i8	.i4	.i5	.035	.070
	95.44	4.56	.95	3.6i	.20	.i8	.i7	.i5	.04i	.07i
C.	95.65	7.69	i.73	6.5i	.49	.82	.23	.30	.07	.09
	92.3i	4.35	i.i6	3.38	.30	.48	.i6	.i6	.02	.06
	94.3i	5.69	i.49	4.20	.33	.7i	.i7	.i9	.04	.06
D.	94.86	ii.i7	5.i5	5.92	--	--	--	--	--	--
	88.83	5.i4	i.38	3.75	--	--	--	--	--	--
	93.ii	6.89	i.96	4.93	.56	.56	.20	.3i	.04	.05
E.	9i.47	30.3i	i9.89	22.42	i4.39	io.i4	i.03	.i6	.i6	.ii
	69.69	8.53	4.32	5.68	3.22	i.2i	.63	.09	.09	.07
	78.46	2i.54	8.30	i3.27	5.65	4.93	.75	.i0	.i0	.09
F.	93.3i	6.69	2.i7	4.52	.62	.75	.3i	.2i	.07	.05
G.	90.3i	22.67	20.23	i8.87	i0.96	i4.23	2.46	.43	.20	.20
	77.33	9.69	4.39	4.35	.67	i.3i	i.i2	.i0	.06	.0&
	86.28	i3.72	5.57	8.i5	i.28	i.53	i.46	.2i	.09	.i5
	ASH	sol.	insol.							
H.	42.00	i5.3i	i6.69							
	ii.54	4.40	7.i4							
	i3.ii	4.86	8.25							
	i0.03	3.99	6.04							
I.	22.58	5.86	i6.72							
	40.3i									
	73.07									

PEAT ANALYSES. 2.

I. Contd.

Variations occuring within short distances .

Series (a) I. Shallow peat,Molinia on bare soil.
2.Molinia flush.
3.Molinia with Erica Tetralix.
4.Molinia with much Erica Tetralix.
5.Molinia-Eriophorum vaginatum.
6.Erica Tetralix-Eriophorum.

Series (b) I.Rush slope.(Probably includes soil.)
2. Molinia-Calluna
3.Calluna-Eriophorum-Molinia.
4.Erica-Molinia.
5.Eriophorum-Aira flexuosa.

Series	No.	ASH Total	Soluble	Insoluble	Growth of Spruces.
(a)	I.	61.46	20.15	41.31	V.Good.
	2.	8.53	4.11	4.42	V. Good.
	3.	7.85	3.99	3.86	Fair.
	4.	4.46	2.83	1.63	Variable--F.to Bad.
	5.	4.03	2.51	1.52	Fair to Bad.
	6.	2.67	1.95	.72	Very Poor.
(b)	I.	33.77	16.76	17.01	Good.
	2.	13.50	4.88	8.62	Poor.
	3.	8.79	3.71	5.08	Very Poor.
	4	11.82	4.17	7.65	Sitka G.,Spruce Poor.
	5.	13.16	6.14	7.02	Sitka fairly Good.

APPENDIX IV.

PEAT ANALYSES 3.

Table of ash contents at different depths of Scirpus, Molinia and Rush indicating that the two latter develop above the former on the addition of mineral matter.

Depth of Peat	Scirpus	Molinia	Rush (Molinia)	
1.	4.77	3.40	9.93	
2.	4.40	21.54	16.51	
3.	4.60	5.40	11.30	
4.	5.03	5.18	5.83	
5.	6.05	5.10	5.09	
6.	.33	5.43	5.20	
7.	84.75	6.22	8.37	Soil
8.	92.37	7.97	20.99	
9.		38.57		

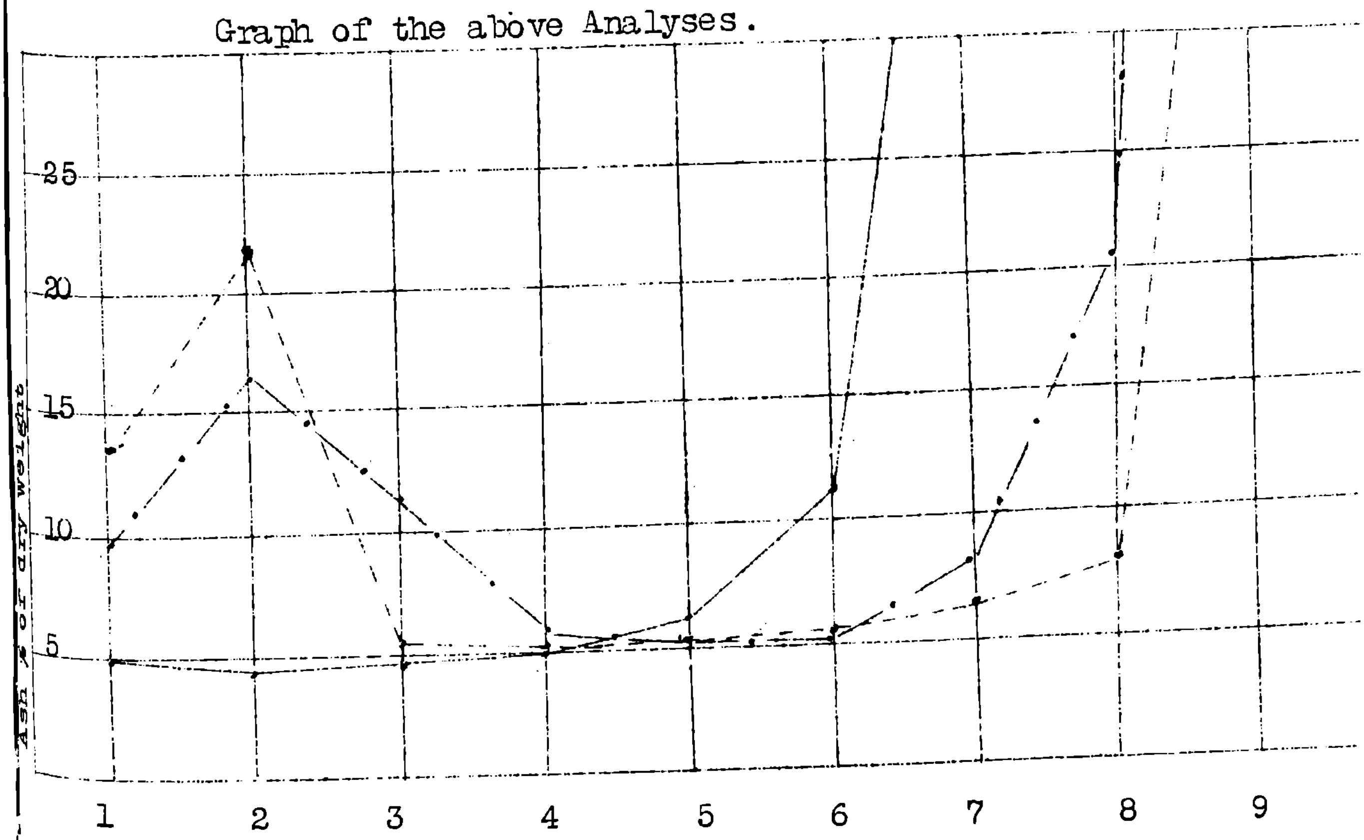
These are actual examples from adjacent areas. Other surface samples vary in detail but each series shows similar tendencies.

Scirpus ——————

Rush-Molinia – – – –

Molinia - - - - - - - - - - - - -

Graph of the above Analyses.



Records of the principal Plants found on the principal Vegetational types at Inverliever.

Outline description of types recorded.

A. 1.Marginal Sphagnum-Carex peat of lochs and moderately deep water.

FIBROUS types.

2.Typical Erica Tetralix-Sphagnum fibrous peat.

3.Fibrous peat of "mixed vegetation" type

4.Deschampsia flexuosa-Eriophorum vaginatum type.(Into which mineral matter is being carried from near-by slopes.)

B. 1.Typical "High-moor" Scirpus.)
2.Old "Hag",with variable conditions.) Deep Scirpus.

YELLOW DEEP

3.Typical Eriophorum vaginatum peat)

4. Ditto.,under grazing.)

BLACK. GRANULAR.

D.1 1.Recently developed on old Scirpus Hag.

2.Of older developement on Hag.

3.Flush MOlinia.

4.Molinia-Rush.(

5.Rush flush peat.

E. 1.Shallow Calluna heath slope with "powdery",black peat.

BROWN Up to 2ft

C. 1.Intermediate Calluna-Sphagnum type.

2.Calluna-Scirpus-Molinia.

4.Scirpus type.

Note;-Very rapidly developing types of Sphagnum are not detailed, since there are so many different facies,depending on the earlier vegetation.
Grazed associations have a very distinct appearance from un-grazed identical types.

Key to frequency symbols.

v------------very
D------------Dominating the type;partly excluding other spp.
l------------(before symbol or alone.) Occurring locally.
r------------rare ,once or twice only.
o------------occasionally throughout the area.
c------------as scattered units or tufts;common.
g------------generally diffused but not in masses.
f------------frequent,not quite abundant.
a------------abundant,forming continuous masses,and giving its general appearance (facies)to the type.

The numerals (1234)after the symbols indicate the degree of luxuriance of the species.e.g.,for Molinia

1---Well-developed tufts of large plants.
2---Moderately large plants or tufts.
3---Small tufts of plants.
4---Occurring as weak individuals.

VEGETATIONAL FREQUENCIES ON INVERLIEVER PEATS. **APPENDIX V.**

Type No.	A				B			
	1	2	3	4	1	2	3	4
Name of Species.								
Viola sylvestris	-	-	-	r	-	-	-	-
Viola palustris	r	o	c-o	c	-	o	r	r
Polygala serpyllacea	o	c	c	c	r	o	-	o
Stellaria uliginosa	-	-	-	-	-	-	-	-
Potentilla erecta	g	g	g	g	g3	g3-2	g2	g3
P. palustris	o	o-f	-	r	-	-	-	r
Drosera rotundifolia	o	g	-	-	o-r	l	-	o
Angelica sylvestris	-	r	o	o-f	--	-	-	-
Galium palustre	o2	o2	r3	r3	-	-	-	-
Scabiosa succisa	o	o	f	f	-	l	r	o-c
Vaccinium Myrtillus	-	c3-4	g3	g2	r-o4	l3-4	o-c3	c4
V. Vitis-Idaea	-	c	c	o	-	l	o	o
Oxycoccus quadripetalus	c	g-f	c	c-g	6	l	-	o
Calluna vulgaris	rl	ol	g2-3	g1-3	a3-4	al-4	o	o4
Erica cinerea	-	-	-	-	-	r	-	-
E. Tetralix	f	a	va	va	c	l	g	g-f
Menyanthes trifoliata	f	g-f	r	l	rl	l	r	o
Myrica gale	-	o	o	-	-	?	o	?
Empetrum nigrum	-	o	o	o	r	l	r	o
Salix cinerea	-?	-?	r4	r4	?	l	r	-
Listera cordata	-	r	-	?	-	-	-	-
Narthecium ossifragum	o-f	vf	vf	f	g	l	l?	g
Juncus conglomeratus	r	-	-	r	-	lr?	-	-
J. inflexus	-	-	-	-	-	?	-	-
J. squarrosus	l	l	l	l	o	o	-	o
Luzula multiflora	-	r	r	g	-	r	o	-
Scirpus caespitosus	l	o	g	o-c	Dva	va	o	o-c
Eriophorum angustifolium	c	vf	f	o	f	la	r	f
E. vaginatum	r2-3	g2-3	f2	g1	o3	lo	Dval	va2
Carex inflata	f-g	f	l	l	-	lo	-	-
C. sylvatica	-	-	-	r	-	?	lf-g	-
C. panicea	lr	r	o	o	-	-	-	r?

~~Carex sylvatica~~								
C. echinata	R	o	c	o	-	l	r	o
C. muricata	-	-	o	o	-	l	-	-
C. pulicaris	c	gf	c	c	r	lo	-	o-c
Agrostis canina	r	o	l	g	-	l	o	r4
Deschampsia caespitosa	r	o-g	c	a(f)	r	lc	o-c	r-o
Molinia caerulea	r3	g3	g-f3	f2-3	o4	g,la 2-4	o3	o4
Festuca ovina	r	o	o	oc	-	r	r	o
Nardus stricta	r	r	r	r	-	-	-	o?
Blechnum spicant	-	-	-	-	-	-	r?	-
Hypnum schreberi	lo	lc	lf	f-a	f-a	lflf	o	o
H. cupressiforme	lo	lc	lc	f	f-a	lf	?	o
Aulacomnium palustre	c	c	c	o	o	lc	-	c
Rachomitrium lanuginosum	o	o(lf)	f	lc	a	al	c	f
Sphagnum cymbifolium (group)	a	a	f-a	f	f-a	la	a	a
Sphagnum rubellum (group)	Dvl	va	vl	a	a	lva	f-a	va
Cladonia rangiferina & spp.	o	c-g	c	c	f	f(la)	-	g
Jungermannia spp.	c	f	o	r	g-f	f(la)	-	f
Name of Species.								
Type No.	1	2	3	4	1	2	3	4
	A				B			

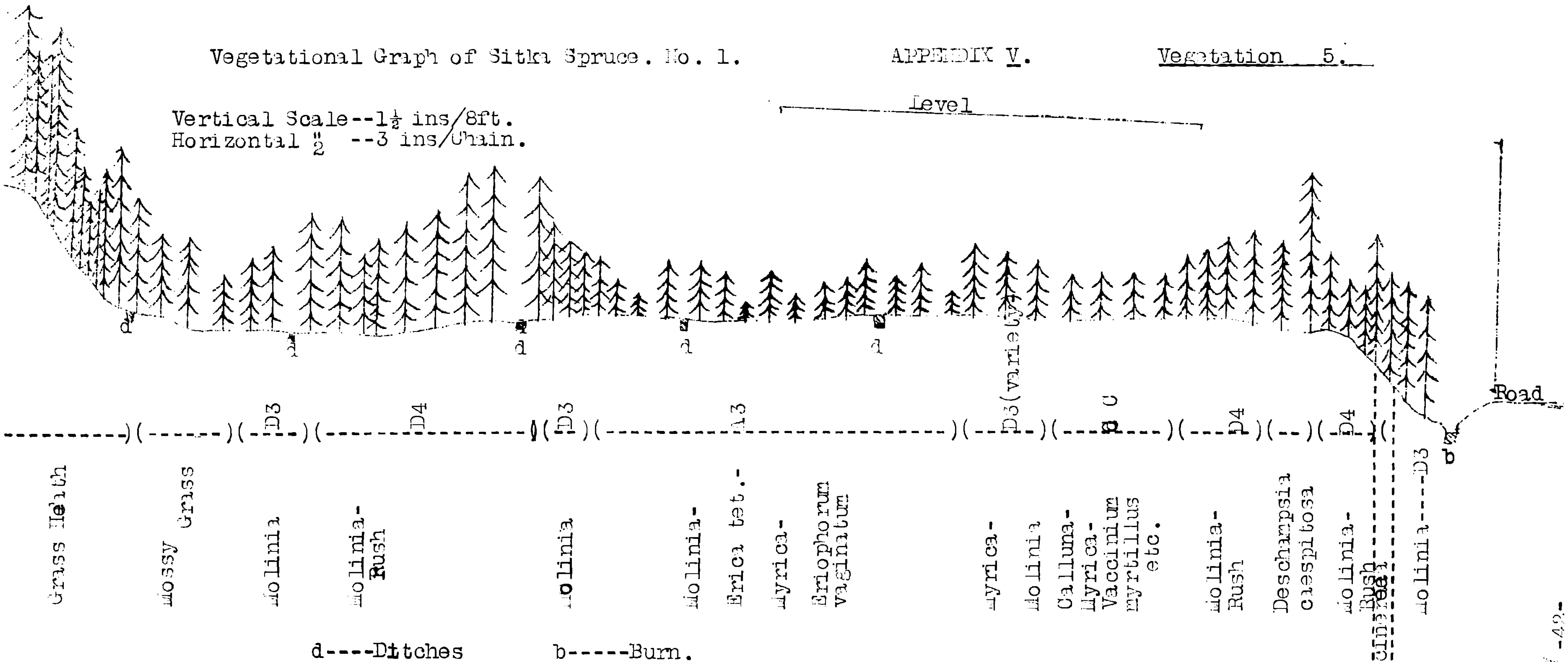
VEGETATIONAL FREQUENCIES ON INVERLIEVER PEATS.   APPENDIX V.

Type No.	D 1	D 2	D 3	D 4	D 5	E 2	C 1	C 2	C 3
Name of Species.									
Viola sylvestris	-	r	o	o	r	o	o	-	-
Viola palustris	o	g	g	lf	lg-lf	-	r	-	-
Polygala serpyllacea	o	o	-	-	-	o	o-g	o-c	r-o
Stellaria uliginosa	-	r	f	f	fla	-	-	-	-
Potentilla erecta	ol	cl	fl	g-fl	g-fl	g2-1	g2	g-o2-3	g-o2-3
P. palustris	-	r	-	-	-	-	-	-	-
Drosera rotundifolia	-	-	-	-	-	-	-	-	-
Angelica sylvestris	-	o	o	g	g	-	-	-	-
Galium palustre	o2	o2	gl	gl	gl	gl	-	-	-
Scabiosa succisa	r	o	o	o-g	o-c	o	o-c	o	r-o
Vaccinium Myrtillus	o-f2	o2-3	-	-	-	o3-1	c2	g2-3	g3
V. Vitis-Idaea	-	-	-	-	-	-	r	c	o
Oxycoccus quadripetalus	-	-	-	-	-	-	-	l?	-
Calluna vulgaris	gl	ol	o	o-r	r	Dval	Dval	lDal	al-3
Erica cinerea	-	-	-	-	-	lDf-vf	r	lr	-
E. Tetralix	a-g	c-o	r	r	r	o-c	c	g	g
Menyanthes trifoliata	-	-	-	?	lo	-	-	-	-
Myrica gale	lc	c	o-c	lf	lo	-	-	lf	lo
Empetrum nigrum	-	-	-	-	-	-	-	lo	o
Salix cinerea	?	o2	al	ol	lD ofl	?	-	o3	o3
Listera cordata	-	-	-	-	-	g	o	r	vr
Narthecium ossifragum	lg	o	o	-	-	-	c	f-a	g-f
Juncus conglomeratus	l	l	l	l	lf	-	-	-	-
J. inflexus	o	c	c	a	Dva	-	-	-	-
J. squarrosus	-	-	-	-	g	g	g	g	g
Luzula multiflora	o	o-r	c	c	c-o	o	r	r	r
Scirpus caespitosus	o	-	-	-	-	o-c	g	a	Dva
Eriophorum angustifolium	o	r	r	-	-	o	gc	g	c
E. vaginatum	o	r	r	-	-	o	g	f-g	g
Carex inflata	-	-	-	-	o	-	-	-	-
C. sylvatica	-	-	o	o	c	g	c-g	c	r
C. panicea	-	-	-	-	o	r	o	o	o

Name of Species.	D 1	D 2	D 3	D 4	D 5	E 1	C 1	C 2	C 3
Carex sylvatica	l								
C. echinata	-	-	-	c	c	o	c	c	c
C. muricata	-	-	-	r	oec	-	r	o	-
C. pulicaris	r	-	-	o	o	-	o	o	o
Agrostis canina	c	c	lg	g	g	o	-	c	o
Deschampsia caespitosa	o	-	-	o-c	c	g	c	c	c
Molinia caerulea	Dva	Dva	Dva	Dva	va	o	c	f-a	f
Festuca ovina	r	r	r	o	r	r	r	ro	r
Nardus stricta	-	-	-	-	-	lc	o	o	-
Blechnum spicant	-	-	-	-	o?	g	c	-	-
Hypnum schreberi	g	o	g	g	g	f	f	g	c-g
H. cupressiforme	f	f	f	f	f	g	g	g	g
Aulacomnium palustre	-	-	-	-	-	o	g-f	g-f	f
Rachomitrium lanuginosum	-	-	-	-	-	c	g	g	f
Sphagnum cymbifolium (group)	c-g	c-g	g	g	g	-	c	c-g	g
Sphagnum rubellum (group)	o	o	r	r	-?	c	vc-a	va	va
Cladonia rangiferina	r	-	-	-	-	g	g-f	lvf	f-a
Jungermannia spp.	-	-	-	-	-	r	f	g	f
Type No.	1	2	3	4	5	1	1	2	3
			D			E		C	

Vegetation.4.

Vegetational Graph of Sitka Spruce. No. 1. APPENDIX V. Vegetation 5.



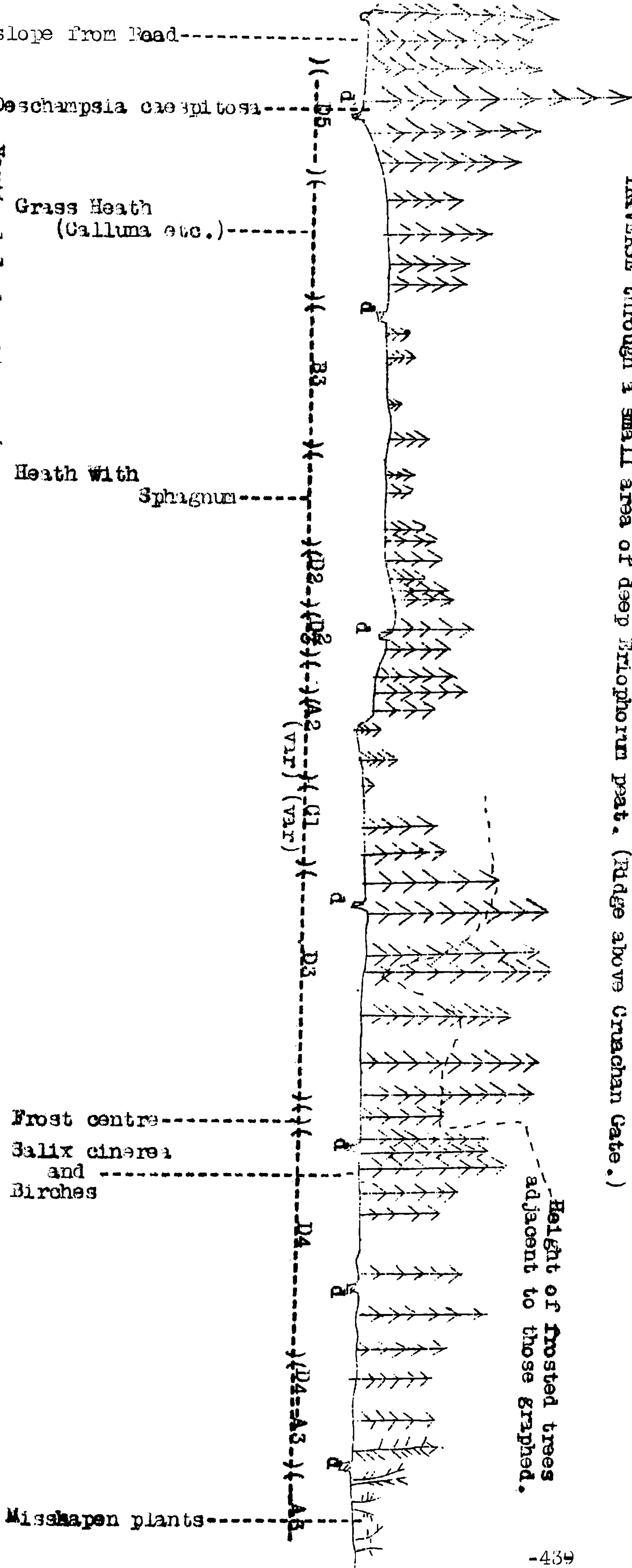
Symbols (D3 etc) within the dotted line indicate types as detailed in Appendix V.

Diagrammatic sketch of a vegetational traverse through a series of types, showing the relation which exists between topography, vegetation and growth of Sitka Spruce. (Frost Flat at Cruachan Stone Bridge)

APPENDIX. V. Vegetation. 6.

Vegetational Graph of Sitka Spruce No. 2.

TRAVERSE through a small area of deep Eriophorum peat. (Ridge above Cruachan Gate.)



Vertical Scale--1¼ ins./8ft. Horizontal Scale--4 ins./Chain.

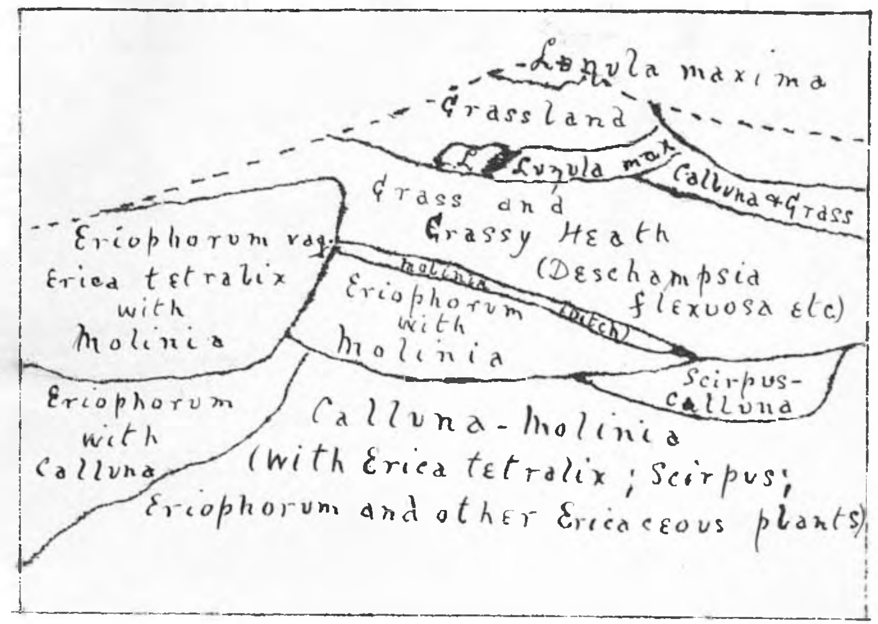
Symbols as in Traverse No. 1.

1. Showing Luzula maxima above, and Juncus conglomeratus on the slope(left above) and on a flattish patch in the upper centre where there is running water. under snow.

2 & 2a. Showing the relative growth of Norway Spruce on Heathy Grass (no peat), as compared with that on a more sheltered site with peat; on the lower sheltered ground only a few later-planted Sitka are left, foreground.

2. TOP OF DUN CORRACH.

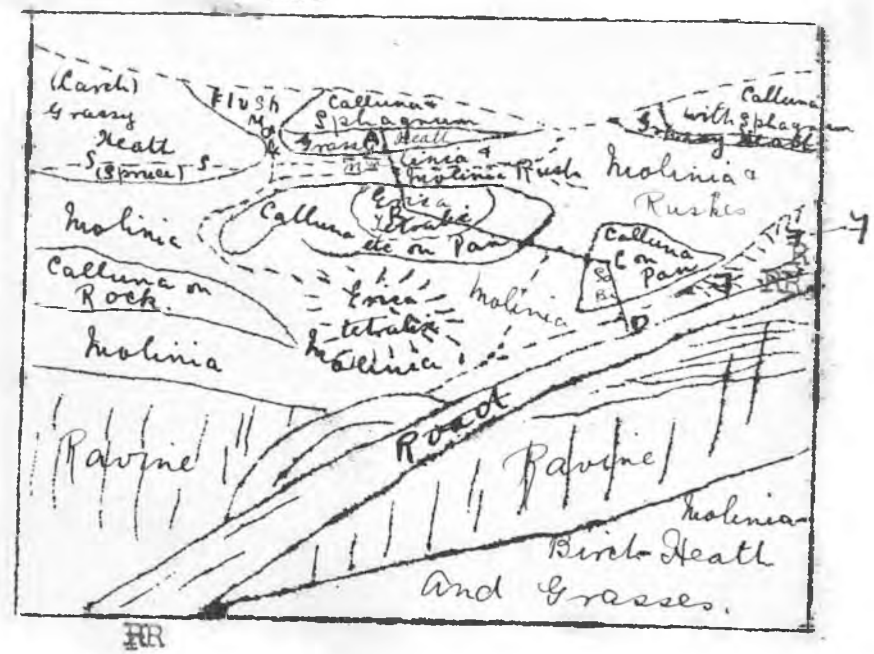
2a. SKETCH OF 2.



Grassland with larch;Calluna in the background with very poor Pine and Spruce;Erica tetralix, etc.(fibrous peat,waterlogged) in the upper centre surrounded by Calluna on Pan___growth very poor.

Sa.--------streams,apart from horizon.
A-B-C-D--traverse 1(Appendix V.)
Sa----willows.
Bi----birch.
F-----Deschampsia caespitosa.

RR-------RR Road.

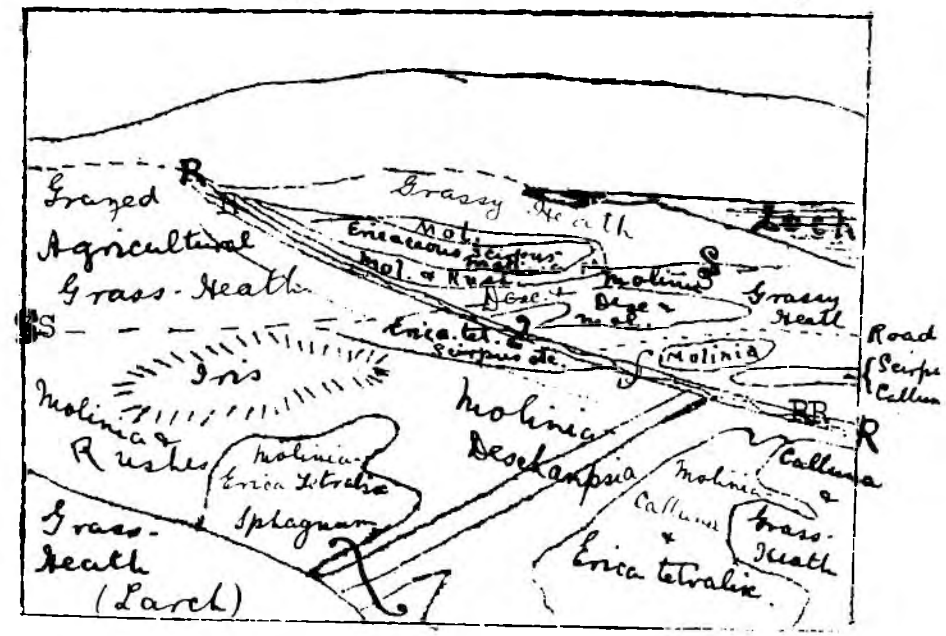


4.SITKA SPRUCE AT CRUACHAN GATE.

4.Iris flush----- Good growth.
Molinia"" " "
Mol.-Erica tetr.--Fair "
Calluna-Eriophorum-Scirpus-etc.---Deep yellow peat---
Very bad growth.
Larch on Grassy Heath.

4a.S---Stone fence.
R---Road.

4a.



5.MOUNTAIN PINE ON DEEP PEAT.
(NEAR CRUACHAN BRIDGE.)

5a.DISINTEGRATING DEEP SCIRPUS PEAT.
(HAG MARGIN OF UPPER PLATEAU.)

5, An old peat hag, now in a stable condition. Foreground;-Scirpus-Molinia etc. Middle background;-Scirpus-Eriophorum Calluna occupying the ridges and drier peat, as a rule. Growth of pine slow, apparently healthy.

5a. Scirpus & Scirpus-Calluna on the upper level, changing to Calluna & Racomitrium lanuginosum on the edges of the bare walls; Molinia with or without Calluna or Eriophorum (etc), on the drainage floor.

6 &6a. To illustrate the growth of Spruce on patches of Molinia. Good plants appear only on Molinia, the majority of these dying later by defoliation, due to exposure(?).
L---small Loch (not visible) in near background___the centre of peat formation. Transition;-Open water→Fibrous Sedge-peat→Sphagnum peat------→SCIRPUS→CALLUNA; in the last of which a wide ditch has produced the Molinia belt.
d----Spruce damaged by Deer.
e---- " " " " Defoliation.

6.SPRUCE ON MOLINIA PATCH.
(Molinia on large drain.)

6a.

NEAR THE TOP OF CRUACHAN BRAE.

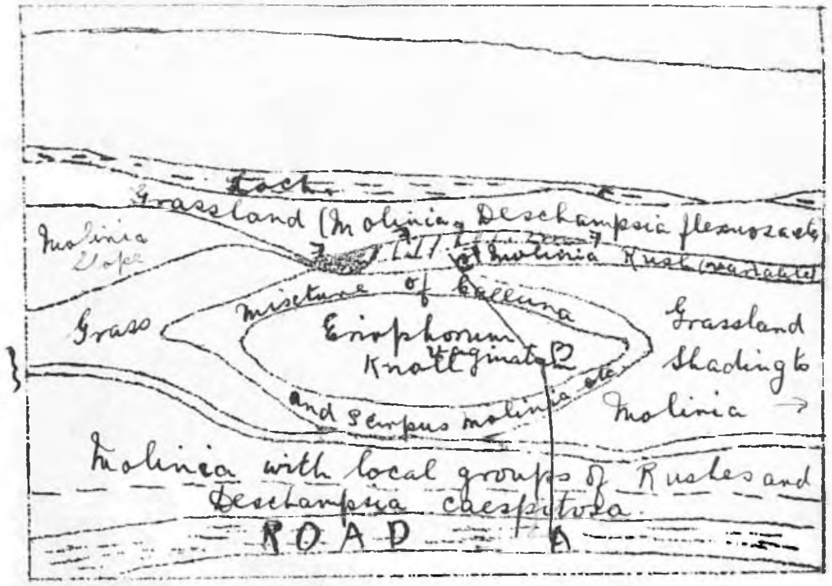
8.

Sitka Spruce on various types. (See transect, Appendix V.)

8a.

Shaded area ---Erica tetralix---
--A badly drained Frost-hole.
F F F F ---Approximate bounds of Frost-hole.
A-B-C-D--Transect, Appendix V.

narrow margin of a heath type }



7.TYPICAL VALLEY CUTTING THROUGH DUN CORRACH RIDGE.

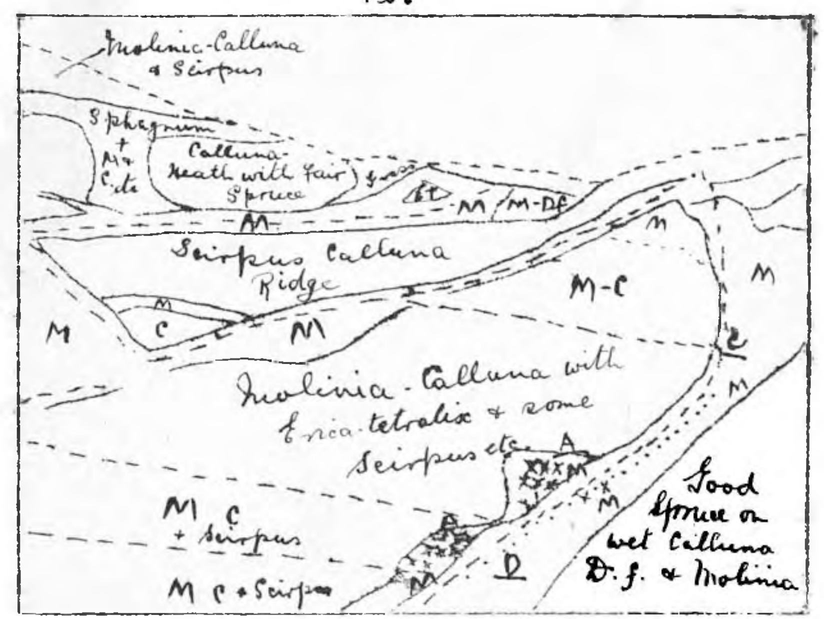
7.

Typical vegetation and results of planting it. Note also difference in growth of Sitka and Common Spruce. Sitka at A; line of Norway at C----D on Molinia-Rush near ditch at left.

7a..

M---Molinia. C---Calluna.
Et---Erica tetralix.
Deschampsia caespitosa.
Df---D. " flexuosa.
xxx ---Sitka Spruce.
::::---Norway "
----------Drains. (apart from horizon)

7a.

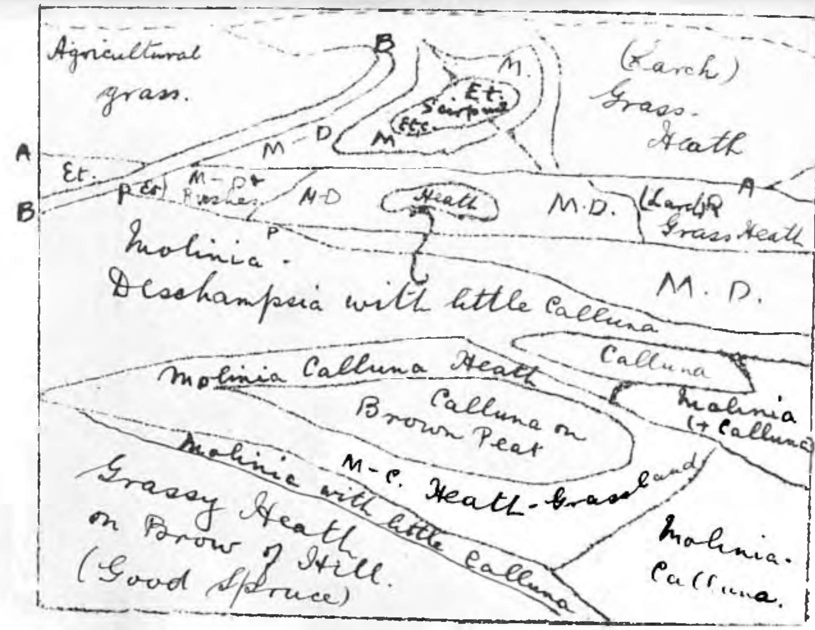


(Looking downward.)

Showing Grassy Heath; Calluna-Heath; Calluna-Sphagnum; Molinia; Deschampsia caespitosa; with variable growth of Norway Spruce.

9a.

P---path. Q---Quarry.
A---fence. B---road.
---------Ditch.
M D ------Molinia & Deschampsia.
C-----Calluna. Et---Erica tetralix.



10. VALLEY WITH NORTHERLY EXPOSURE; MODERATE ALTITUDE.

10.
Showing variability in growth of Spruce on Molinia with different degrees of luxurience and various concomitant species. A flat area with deep Peat.

10a.
Central flat--- Molinia with species indicated by letters:-
R---Rushes(J.inflexus).
C---Calluna.
Sc---Scirpus caespitosus.
Et---Erica tetralix.
Sa---Salix cinerea.
T-----Molinia in tufts.
---------- Ditch.
========== Ride

10a.

FROM DUN CORRACH.

Three wide level valleys with a bad outflow. After deep drains are formed (by erosion?), Molinia has developed on deep Scirpus peat. Previous photo. is that of the central valley here.

12.

To illustrate the development of Calluna-heath on exposed knolls and steep slopes on wind-swept aspects.

A --- CALLUNA.

13. SPRUCE ON LESS PEATY TYPES NEAR S ARAHAMISH GATE.

13.

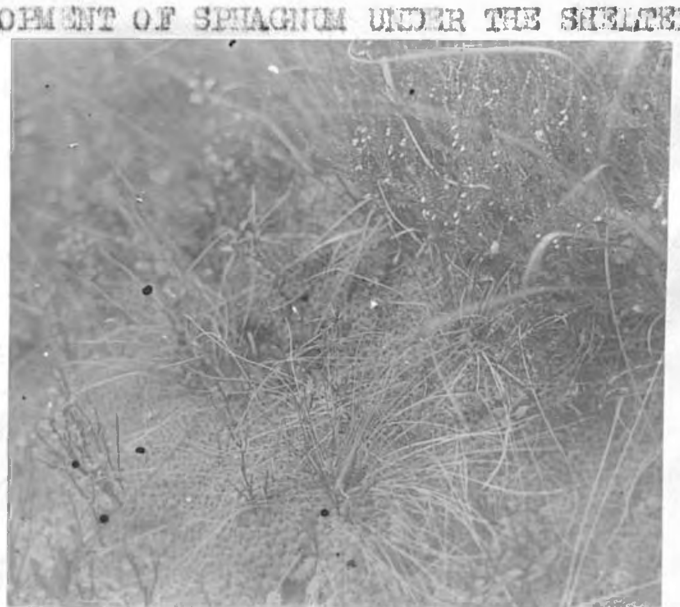
Spruce on Heath and Calluna types. Growth good in Foreground on Grassy-heath with Bracken, Birch, etc.; fair only, in heath with Calluna and a little Bracken; poor in the flatter area behind the central rock, where Bracken is absent and Calluna peat thicker.

A---Grassy Bracken-Heath (Birch, Willows, etc. to left.)
B---Calluna with grass and bracken.
C---Mainly Calluna.
D---Peaty.
M---Molinia flush.

14. FROST EFFECTS ON LOWER GROUND. A FROST-HOLE NEAR CRUACHAN.

Sitka Spruce affected by Frost; May, 1924.
→ ---indicates height to which plants are attacked.
} ----indicates destroyed shoots. (Not seen on higher ground.)

15. DEVELOPMENT OF SPHAGNUM UNDER THE SHELTER OF SUB-SHRUBS.



A mound of rapidly growing Sphagnum occupying the site of a dead Scots Pine, and now tending to swamp the surrounding vegetation, plants of Calluna, Vaccinium myrtillus, V. vitis-idaea, Molinia, Eriophorum vaginatum, Tormentil, etc.

FUNGUS DISEASES IN NURSERIES & PLANTATIONS.

Annual Research Meeting January 1925.

Report on Work done during the year 1923/24.

M. WILSON.

Meria laricis.

This fungus has been found in several nurseries causing serious damage to seedlings of European larch. At Halwill Devon both one-year and two-year seedlings are attacked. The leaves become infected turn brown and soon fall. The D.O. reports that the beds looked excellent up to about August but were then attacked and in October the seedlings appeared to be dying. He states that they hardly appear to be worth lining out next year.

At the Forest School, Beauly the larch seedlings are in a similar condition. Mr James Fraser states that the seedlings have made very poor growth and, if they survive without further attack, they will require to be kept an additional year in the nursery. Similar diseased seedlings have also been received from Bushfield Nursery and from Cumberland.

It appears that no methods for dealing with the disease have been attempted up to the present.

The fungus is confined to the leaves and removal and destruction of diseased leaves would no doubt prevent the recurrence of the disease but this is obviously impracticable.

The spores of the fungus are very thin-walled and apparently not highly resistant. They are probably present on the stem, in cracks of the bark, at bases of buds etc., and possibly between the scales, but it is not known whether they can last through the winter in a living condition. The mycelium has been shown to remain in a living condition through the winter in dead leaves and spores can be produced on these in the spring when the conditions are suitable.

Infection probably takes place in the spring from diseased needles of the previous year which are lying about on the ground. Seedlings which have been diseased during the first year will almost certainly be again attacked in the following year. The disease up to the present has only been found on European larch.

Meria laricis was recorded in Scotland in 1920 by Mr Hiley but there appears to have been no serious outbreak of the disease in nurseries in this country previously to this season.

The adverse weather conditions during the season may have influenced the spread of the disease. But in view of its wide distribution (from Devon to Inverness) it is possible that infection has been spread by seed. Steps should be taken to ascertain whether the seed was obtained from infected trees.

Distribution of diseased seedlings to nurseries, hitherto uninfected, will almost certainly spread the disease. The disease is not confined to nursery stock and observations should be made on slightly infected young trees which have been planted out.

It is proposed to carry out spraying experiments to attempt to check the disease. The following methods are suggested and these should be carried out in at least two widely separated nurseries.

Seedlings which have been previously diseased should be sprayed with copper sulphate solution (Copper Sulphate 4 lbs. water 100 galls.) in the early spring before the buds begin to open. The surface of the soil should also be soaked with the solution. (This solution should no be used on seedlings with expanded leaves.)

Seedlings should be sprayed with Bordeaux Mixture soon after the leaves expand.

In nurserios known to be infected the soil might be treated with Copper Sulphate solution (Copper Sulphate 1 oz. water 1 gallon) before the seed is sown.

Fomes annosus.

Although generally found on Conifers the fungus has been found attacking Bird Cherry (Prunus Padus) Rowan (Pyrus Aucuparia), Whitebeam (Pyrus Aria), Hawthorn (Crataegus oxyacantha), Beech (Fagus sylvatica), Alder (Alnus glutinosa), and Rhododendron sp.

Fomes annosus is causing extensive damage to the Douglas fir up to about 25 years old. The trees are often attacked shortly after planting out and are quickly killed.

The effects on the Douglas fir have been worked out by Mr James Macdonald. The following is a summary of his work.

(1) There is no definite heart rot as in the larch. The rot extends through both sap-wood and heart-wood; frequently a patch of sound wood occupies the centre of the stem.

(2) The fungus makes its way more rapidly up the stem than across it. As a result the infected part is roughly cone-shaped.

(3) The wound in the first stage of decay becomes pinkish; this is chiefly due to the accumulation of a dark-brown insoluble matter in the parenchyma of the rays.

(4) The black specks, which are typical of the rot in the spruce are not invariably found in the Douglas fir. They are altogether absent from young trees. In older trees when found they are situated in the sap-wood most frequently just below the bark and are also present in the bark itself.

(5) The rot results in the formation of numerous soft white patches in the wood consisting of delignified elements.

(6) There is often a marked swelling at the base of the infected tree. This is due to the abnormal development of one or two of the latest formed annual rings.

No definite results were obtained as to the method of infection of the trees but it would appear that infection started in the small, dead lateral roots near the surface of the soil.

At Glentress where the disease is common the Douglas is on an area previously stacked with Scots Pine. The stumps of the latter are almost all infected and it appears that these are the sources of infection for the Douglas.

In the Tay valley young trees planted out on an area previously covered with scrub birch and oak are badly diseased. Here there are no old stumps infected.

It is noteworthy that almost all the infected trees had been badly planted.

In the report for 1923 a fungus causing defoliation of Picea pungens and P. sitchensis was reported. This was provisionally placed in the genus Lophosphaeria. Further investigation has shown that it is a species of Rhizosphaera. R. Abietis was first described in France in 1907 as causing defoliation of the silver fir.

The species found on the spruce in this country clearly differs from R. Abietis and the name R. Piceae is proposed for it.

It is a serious disease of Picea pungens but no more specimens have been found on the Sitka Spruce.

In the report for 1923 a fungus causing defoliation of the blue Douglas fir was mentioned. This appears to be identical with Rhabdocline Pseudotsugae recently described as causing a disease of the Douglas in the United States.

In this country it appears to be at present confined to one area in the south of Scotland where it is causing very serious defoliation of the Douglas. The disease here appears to be confined to the blue Douglas but this apparently is not the case in the United States.

It is important that efforts should be made to prevent the spread of this disease from the small area where it is found at present. There is little doubt that it has been recently imported into this country.

An account of the disease of the Silver firs caused by Rehmiellopsis bohemica has been circulated.

The disease appears to be spreading rapidly in Scotland especially in the west and south-west. It has now been found attacking Abies pectinata A. nobilis, A. Pinsapo, A. Pindrow and A. cephalonica. It is possible that A. grandis may be also attacked.

Specimens of oak saplings have been received on two occasions from the Forest of Dean. These are evidently attacked by some fungus but owing to the condition of the specimens it has not been possible to identify the fungus with certainty. An investigation of the disease on the spot should be carried out.

Chrysomyxa Rhododendri (?)

This has not been looked upon up to the present, as a serious disease in this country. Specimens of spruce badly damaged apparently by the aecidial stage of this fungus have been received from Newtown stewart, Ireland.

Sclerophoma pithyophila has been found causing defoliation of Scots pine from Wokingham and Hythe, Kent. This has not been previously recorded as a parasite.

Brunchorstia destruens causing a serious disease of various species of Pinus has been observed in several localities.

The fungus attacks the terminal buds and kills back the shoot for some distance. The Austrian pine is particularly liable to the disease and the Corsican pine (P.laricio), Pinus montana, P. Cembra and P.excelsa are also attacked by this or a very closely allied species. Brunchorstia destruons is often associated with Cenanguim Abietis and some consider that the two are different stages in the life history of the same species but evidence from cultures indicates that this is not the case.

Both fungi produce the same type of disease. Cenanguim Abietis is causing considerable damage to Scots Pine in S.W. Scotland.

Corsican and Mountain Pine suffering from the disease have been found at Corrour, near Kelso and at Lake Vyrnwy (on P.Laricio only).

Pinus Cenbra is severely attacked at Corrour. It appears that in most cases the disease spreads from infected trees of P.austriaca to the other species.

It is suggested that before planting out Corsican Pine care should be taken to remove any old or diseased trees of Austrian pine from the vicinity and that Austrian pine should not be planted among or near the edges of plantations of Corsican pine.

A number of samples of seedlings of Douglas fir have been received suffering from attacks of Rhizoctonia and/or Botrytis.

It is suggested that in the coming season investigations should be carried out especially on the following:-

(1) Diseases of seedlings e.g. Meria, Rhizoctonia and Botrytis.
(2) Fomes annosus.
(3) Armillaria mellea.

(1) The diseases of nursery stock are causing large losses especially of Douglas fir and larch, at present. It is believed that these diseases can be checked to a large extent by suitable soil treatment and spraying. It is particularly desirable that these diseases should be recognised at an early stage and preventive measures taken. It is therefore proposed to visit as many nurseries as possible in the spring and summer.

(2) Fomes annosus is causing very extensive damage to several species. Investigation of the conditions under which infection occurs are particularly required.

(3) Armillaria mellea is also causing wide spread damage and here also the conditions under which infection occurs require investigation. The scarcity of fructifications of this fungus in Scotland and the abundance of rhizomorphs also needs to be investigated.

INSECT PESTS IN NURSERIES & PLANTATIONS.

Report on Research and Experimental Work in

Entomology, for 1924.

1. Pine Weevil.

(1) The experiments on the movements or migrations of Hylobius have not been carried out for lack of suitable site and facilities. The site best suited for them adjoined the burned areas at Montreathmont Muir and as arbitration was in progress between the Commissioners and South Esk Estate, Mr Annand desired to avoid any experimental work at Montreathmont Muir.

It is proposed to carry these experiments out next year.

(2) A study of parasitism of Hylobius was made at Middleton Wood and there of 67 larvae found in the stumps 23 were parasitised Batches of cocoons of the parasite were collected and brought to Kew on July 29th but unfortunately all emerged in transit and died without reproduction.

The difficulty here is a frequent one; material collected in the field, unless it can be dealt with rapidly, is rendered of no value. Technical assistance in the laboratory would remove this difficulty.

(3) Experiments to test the attractiveness of Pinene and Terpineol for Pine Weevil.

These were conducted at Kew. Terpineol was found too pungent even in the open and finally Vanilin, of which Pinone is the main constituent, was chosen.

A saturated solution of Vanilin in water was painted on the bark and billets used. These billets were of elm and Scots pine and in addition elm and pine twigs were used to test feeding habits.

The first four experimental tests were spoiled by heavy rain which flooded the cages and drowned many weevils and finally the remaining experiments had to be conducted indoors.

Two sizes of cage were used a small (18" x 9" x 9") and a large 4' x 2½' x 2½'. As in 1922 no definite result was got from the small cages. This seems to be due to the saturation of the air in so confined a space with the essential oils used.

In the large cage the results showed :-

1. That elm bark, elm billets and elm twigs were gnawed as readily as pine by the weevils if painted with vanilin but that elm twigs etc. unpainted were not touched in the presence of pine.

2. That painted elm bark was attractive only for a time the weevils leaving it in a few hours (6 to 8) apparently when the outer bark was nibbled and the inner bark proved unattractive.

3. No appreciable difference in attractiveness between Scots pine painted with Vanilin and unpainted pine was observed. Both were equally favoured by the weevils.

4. In the absence of pine and of vanilin painted elm,

untreated elm twigs were gnawed by the weevil.

5. A piece of elm bark treated with vanilin was used by the weevils for oviposition after pine bark in the same cage had become dry. Untreated elm bark was gnawed but no eggs were found in it. I do not attach much importance to this observation because Hylobius if driven to it will lay its eggs in the soil.

The results of these experiments indicate that vanilin is attractive to Hylobius but that it does not sufficiently enhance pine logs to make it worth while using it to counteract the drying up of bark-traps or billets. Dry billets of pine except when wet from painting were no more attractive than untreated pine.

I do not propose to extend these experiments as I think better results will accrue from field observations on the weevil under natural conditions. As is referred to later, it seems that the moisture content of bark and cambium are far more important factors in attracting weevils and bark beetles than the essential oil constituents. Or more correctly that the essential oil constituents of the bark and cambium, if they are attractive to such insects are so under certain conditions among which the moisture content of the bark and cambium is of chief importance.

(4) The effect of poisons on Hylobius.

Experiments in the outdoor cages were spoiled by wet weather. In the laboratory owing to rapid drying of painted twig and stems these soon ceased to attract the weevils. Lead arsenat and corrosive sublimate were used but if these were swallowed by the weevils they were rapidly passed out for except when the weevi were taken in the act of feeding little food was found in the alimentary canal. Lack of time - the Tortrix caterpillars required close attention during this time - prevented sufficient ca being given to these experiments which will be repeated next spri

(5) To ascertain whether trapping of the weevil in pine wood about to be felled results in a reduction of the ensuing outbreak

The site selected for this experiment was Hawkhill Inclosur in the New Forest. Owing to delay in felling the experiment has been held up but is now definitely arranged for and will be begun next month.

(6) To determine whether any relation exists between the ag of felled areas and the age of the weevils present.

Dissection of weevils from Rendlesham, Elvedon, Wokingham, Bagshot, Bournemouth and Culbin sands showed that weevils of all ages may occur in any area but that in the earlier months June and early July old weevils are most numerous and in the later months young weevils preponderate. This supports the hypothesis that Hylobius is an inhabitant of standing woods for in a recent felli at Elveden most of the weevils collected in July were old weevils which had produced two broods, indicating that their first broods were reared in dead trees or branches in the neighbouring woods or in the felled wood itself while it was standing.

(7) To ascertain if spraying of plants renders trapping more effective in young plantations.

Wet weather rendered the conduct of this experiment difficu and the experiment will be made next spring.

(8) The literature on Hylobius has been revised, information collected by myself has been gathered together.

2. Bark beetles.

(1) Progress has been made with the Bark beetle Bulletin which however has not been pressed on as I understand the Publications Officer wishes Dr Wilson's Phomopsis Bulletin to precede it.

(2) A report on experiments conducted on Elm Bark beetles at Ravenscourt Park accompanies this summary report. The main results of these experiments are :-

(i) That Scolytus destructor and S.multistriatus do not attack elms in full vigour.

(ii) That severe root pruning on transplanting renders elm trees liable to Scolytus attack.

(3) That late planting renders them liable to attack.

(4) That the moisture content of the bark and cambium is an important factor in favouring bark-beetle attack. Too dry stems are not attacked. Moderately wet stems are immune. Stems unduly wet owing to faulty transpiration or faulty root action are attacked.

(5) Carbolineum emulsion sprayed on trees has no deterrent effect on the bark beetles unless applied during their swarm period.

3. Aphides on roots of Conifers.

Lack of material prevented work on these aphides. Pemphigus species common on Poplar and Ash at Kew in 1922 and 1923 were wholly absent this year probably owing to the wet weather. Prociphilus species on pines in my small nursery plot at Kew dwindled in June and died off.

4. Spruce aphis.

Everywhere the prevalence of Spruce aphis has been less. The main features of the insects status this year are contained in my reports to the Technical Commissioner under file heading "Entomological Reports".

5. Field Mice and Voles.

A box trap, self-setting, tried at Kew was effective in trapping the Bank Vole Evotomys glareolus.

Experiments with anti-rodent smears and washes planned with the co-operation of Mr J.M.Murray were delayed by wet weather and finally abandoned for the reason given below.

Experiments with screeving or clearing of the ground round young poplars proved wholly successful against voles at Duror. This is due to the voles dread of crossing bare soil where it is exposed to attack by the Kestrel hawk, Falco tinnunculus.

7. Oak Tortrix.

Special attention has been given to the Oak Tortrix moth. The eggs hitherto not located in nature were found first in the laboratory experiments and then in the field. They are laid in pairs on the twigs of the previous year most frequently at the base of the leaf scar and commonly on the scars left by fallen twigs which are such a feature of the oak.

The eggs are invariably concealed by a covering of lichen, (? Proto-coccus) and of scales from the moth. In the laborator where oak twigs, free from lichen were supplied to the moths the covered the eggs with scales from the brush at the tip of the abdomen. On brown or dark brown twigs the scales used were dar gray on green twigs the scales used were green and dark green. In such cases towards the end of oviposition the scales covering th eggs ceased to show protective resemblance probably because suit able scales were no longer available.

The eggs are laid in June and July and remain unhatched al winter. Small Tortricid caterpillars found on twigs and within the buds of oak in winter and early spring are not those of Tortrix viridana. They appear to be those of a Coleophorid moth.

The first eggs hatched in the laboratory on April 12th. These came from various sources; from twigs supplied to captive moths, from twigs collected last winter at Esher and Coldharbour and from twigs used in outdoor experiments at Kew.

Detailed studies of the hatching of the egg, of the first and subsequent stages of the larvae and of the pupae of T.viridana have been made but need not be given here. The main resul of the work is that the life-history of the moth is now known as it takes place in England.

Studies of the feeding habits of the Tortrix larvae were made and are of interest. First and second stage larvae are quite incapable of entering unopened oak buds and larvae fed on early opening shrubs such as Pyrus and Prunus all died before th second moult. The first three stages of the Tortrix caterpilla are the most exposed to climatic dangers and, as is referred to later, the climatic factor is probably of the first importance i favouring outbreaks on the one hand and reducing them on the other.

Experiments with carbolineum emulsion and lead arsenate sprays showed that the first, applied in winter, is destructive the eggs and that the second, applied just when the buds expand, is destructive to the first and second stage caterpillars, but i quite ineffective later as the caterpillars then feed within spu or rolled leaves which the arsenate spray failed to reach.

Parasites of T.viridana reared last year still await identi fication they belong to the Hymenopterous families Ichneumonidae and Braconidae and to the Dipterous family Tachinidae. Dr Wate ston and Major Austen, the authorities on those groups at the British Museum promise a report at an early date.

No parasites of the Tortrix were reared this year. In Richmond Park, at Esher and at Ashstead Forest the Tortrix attac broke down in June. Hundreds of caterpillars were washed to th soil by rain and were drowned. Others collected in these local ties and brought to the laboratory failed to feed, wandered about for a home and became flaccid and feeble. None reached the pup stage. This dying of the caterpillars was confirmed in July wh in most localities from Surrey to Hampshire few moths were seen and this winter eggs are few and infrequent at Esher, Richmond Park and Bere Forest.

The importance of wet, cold, spring weather in reducing the numbers of T.viridana is confirmed by various workers. Ratzeburg was the first to call attention to it in 1840, Garcia in Spain has described the collapse of an outbreak lasting from 1883 to 1892 as a result of a fall in temperature accompanied by heavy rain from May 6th to May 11th 1892. Silvestri in Italy observed the collapse of an outbreak in Bolognola in the spring of 1919 during May when the average temperature was 2.2°C. and drizzling rain fell for a fortnight.

Supervision of Research.

The work of Messrs Chrystal and Fisher on the Chermesidae and Scolytidae has received due attention. Mr Chrystal's reports on his work to the Scientific and Industrial Research Department will be available at the Research Meeting. Dr Fisher's reports are at present in the press awaiting publication.

I arranged for Mr Chrystal to study the Silver fir Chermes in Denmark and a report on his work there is in the hands of the Research Officer of the Commission. Dr Fisher has now left my laboratory to study, on my recommendation, under Professor Silvestri of Portici near Naples.

Miscellaneous.

Many minor studies of various insects submitted by Divisional Officers and others have been made. The studies are not sufficiently extensive to be termed research work but will doubtless form the basis for research at some future time. As it now proves, advisory and routine work employs most of my time and some technically trained assistance is required to cope with research work. The programme for next year will include weevil work, studies of cock-chafer Chermes cooleyi, Oak Tortrix, Pine Tortrix moths and Megastigmus.

The scope of work in these subjects will be raised in discussion at the Research Meeting. Meanwhile some arrangement whereby proper care of research work can be ensured during my absence from the laboratory on field work is urgently needed.

J.W.M.

11.11.24.

INVESTIGATION OF THE LARCH HYBRID.

LARCH HYBRIDISATION.

Notes on Experiments at Bowmont Forest, 1924.

J.L.S. SMITH.

From the Diary.

17th March. Observations commenced. In Shank Plantation the Jap. ♂ and ♀ flowers well developed and pollen shedding. 17 year old.

19th March. Kale Banks. Jap. flowers as above. 14 year old.

21st March. No.I. Flowers of European at various stages of development but none fully out.

Shank S.E. European flowers not yet showing. Jap. flowers shedding pollen.

No.II. Jap. (North Block) shedding pollen.

No.VIII. European ♀ stages from bud to fall flower. ♂ not showing stamens.

Dean Strip. S.W. exposure but at the same stage as in No.I and No.VIII. No flowers showing colour.

Kale Banks. Jap. ♀ and ♂ well forward. Pollen in clouds. Many ♂ not quite mature.

Grahamslaw Glen.- Top End. European showing a few ♂ and ♀ flowers.

22nd March. No. II. North Block - East of kennels. Jap. ♂ just showing. ♀ showing a little.

27th March. Langdale's Strip. At low end the European showing ♀

Caver's Hill. European showing ♀ fully developed

Kale Banks East. An old European showing both ♂ (well advanced) and ♀ (very few)

Kale Banks. A Jap.with reflexed bract scales giving a thatched appearance.

31st March. Kale Banks. As for 27th March.

Glen (Grahamslaw) N.E. corner. European ♀ well developed. Tree near centre sheltered and showing ripe pollen. Slight dissemination. Attempted on 27th to pollinate Jap ♀ at Kale Banks with European pollen taken from the above tree in the glen.

1st April. General Note. Though Japs. are shedding much pollen the flowers are at all stages of development. Very few ♀ flowers are fully open.

2nd April. No. I. near S.E. corner. European ♀ and ♂ just beyond bud stage.

No.II. Heather Flat. Collected some Jap. pollen.

3rd April. No.II. More Jap. pollen collected.

5th April. No.II. More Jap. pollen collected.
No.II. N.W. Some European pollen collected.

7th April. Kale Banks. Old European showing fully developed ♀ flowers. The Jap. showed no increase of ♀ flowers with reflexed bracts.

Glen (Grahamslaw). Slight dissemination of European pollen.

Caver's Hill. European ♀ flowers well advanced.

No.II Heather Flat. Jap. pollen collected. Very high S.W. wind.

8th April. Shank. Jap. pollen collected.

9th April }
10th " } Snow, hail and sleet.

12th April. No. IX. Some protected Jap. ♀ flowers - in bud stage (see F.)

15th April. Kale Banks. Some of European ♂ flowers empty of pollen. Jap. ♂ apparently empty. High wind.

16th April. Wind not so high.

No. I. A European with white ♀ flowers (see B.) shedding pollen fairly profusely.

17th April. No. I. European with red ♀ flowers (see A.) shedding pollen.
The Europeans on S.E. side other than the above showing very slight dissemination of pollen. The ♀ flowers in various stages of development. Many are in bud. On S.W. side the Europeans are not so far forward as the above.

18th April. Collected pollen from European with the white flowers (See B.)

19th April. Collected pollen from same.
Very slight dissemination of pollen from European in S.E. corner of Queen's Strip (See D.)

20th April. Kale Banks. Pollen collected from European. Also from those indicated by B. and D. Fair amount of pollen being shed from D.

21st April. No. VIII. Increased dissemination of pollen from D.

No. II. Some Jap. flowers not yet fully out and some just shedding pollen (Heather Flat), near Jap. H. which is also shedding pollen.

One of protected ♀ flowers of H dead, probably due to frost.
Two of ♀ flowers of K dead - frost.
Top of hill. Jap. pollen shedding.
Two of ♀ flowers of L dead - frost.

25th April. No. I. Next Kasnowe Field. Profuse shedding of European pollen and many ♂ flowers not fully out.

27th April. Kale Banks. One of pair of Jap ♀ flowers dead -frost.

No.II Heather Flat. Several Japs. shedding clouds of pollen.

General Note.

(Some Jap. ♀ flowers become "slated" and others
(show bracts reflexed. Most European ♀ flowers do
(not show reflexed bracts and only a small number
(have the "slated" appearance.
(Query - Are the "slated" flowers fertilised?

European pollen shedding profusely in general. Some bright red flowers have become dull and appear to have been pollinated e.g. on Caver's Hill and Kale Banks. European trees of all ages, even in exposed situations, show flowers well advanced at this date.

Removed muslin covers on specimens at Kale Banks.

17th May. Covers removed from all other flowers.

Note on Pollen employed.

A. Japanese.

This was collected on 2nd April in No.II Heather flat.
3rd " " No.II " "
7th " " No.II " "
8th " at Shank (10 year old)

The four were mixed.

B. European.

First collection from B. in No.I on 18th April
Second " " " " " " " 19th "
Third " " " " " " and from D in No.VIII and at Kale Banks on 20th April.

The three were again employed mixed.

Note on Aspect, Exposure, Soil and Altitude.

Aspect and Exposure.

For trees indicated by

A, B and E. These are situated on a ridge top and the slopes are to the South East and North West. Their particular exposure is S.E. (slightly). Shelter is afforded from a young plantation of 12 year old Scots and Spruce.

D. The slope is N.E. and N.
The tree has exposure to N.E. where a young plantation is rising as shelter.

C. Aspect slightly S. Easterly.
Exposure of tree - Easterly. Head of tree well exposed but young plantation rising as shelter.

F. General aspect - slope very slightly N.Westerly.
Particular exposure - nil.

G. Aspect - slope very slightly S. Easterly.
Exposure - nil.

H. & I. Aspect - fairly level area with tendency to a S.E. slope.
Exposure - nil.

J. Aspect - slight S.E.slope.
Exposure - westerly.

K. Aspect - N.W. slope.
Exposure of K. nil; of Block N.W. shelter rising.

L,M,N. Aspect - W. with very slight slope.
Exposure very slight to S.W. to ride. Plantation on opposite side of same age.

O. Aspect - S.S.W. gentle slope to river.
Exposure - nil in a fairly deep valley.

Note on Soil.

Generally it is slag on sandstone pan (old red formation). When denuded of forest it reverts to heather with some shallow dry peat. Specimen O. is perhaps on riverine soil.

Note on Altitude.

Among the trees treated during this experiment the one at the highest altitude is K. and that at the lowest is O. Exclusive of O. the difference between the altitudes of all treated specimens is not very great and is within the limits of 50. Altitude of O. is 200 and K. is 600'. Most lie between 550' and 600'.

Note on Exposure.

The exposure may have the greatest influence on the times of flowering of the larches within the area. The test of altitude is too limited.

Number of cones for trees with protected flowers.

A.	2	European
B.	4	
C.	9	
D.	3	
E.	5	

F. 2)
G. 6)
H. 4)
I. 1)
J. 2)
K. 1) Japanese
L. 3)
M. 4)
N. 3)
O. 3)

Number of cones for trees with unprotected flowers.

A. 1 European.

H. 2)
I. 1) Japanese.
J. 2?)

<u>Hybridisation of Spruces.</u>

Experiments with the same care have been carried out with:

P. sitchensis ♀ and P. excelsa ♂

P. alba ♀ and " " ♂

P. excelsa ♀ and P. alba ♂

HYBRIDISATION EXPERIMENTS 1924.

1. Larch
2. Spruce.

Tree - European Larch.

	When protected with Muslin.	No. of ×o flowers.	Casualties before pollenation.	When pollenated.	Post pollenation casualties.	Locality of tree.	Exposure (see separate Note)
A.	March 18th	7		April 2 April 17	April 17, 1 dead and 1 doubtful	No.I. The East tree of two with red flowers.	
	(One flower was marked and unprotected.			This was pollenated on April 5)			
B.	March 21st	6	One unsatisfactory and one imperfect.	April 21		No.I. The West of two with white flowers.	
C.	March 18th	10		April 5 April 17 April 28		No.VIII. Near north end on east side of plantation Red flowers.	
D.	March 18th	8	1 dead 1 broken off. March 19th. 1 broken off April 21st.	April 5 April 12 April 21		No.VIII. Near Queen's Strip end. Red flowers.	
D.	April 19th	5		April 21	All eaten by squirrels (observed August 7th).	"	
	Unprotected	5		April 5	Damaged by frost April 12th	"	
	Do.	5		April 21	Branch cut off by human agency (observed July 3rd)	"	
E.	April 20th	6		April 26	1 dead July 3.	No.I. Tree east of ride, nearest gate.	

Tree - Japanese Larch.

	When protected with Muslin.	No. of flowers.	Casualties before pollenation.	When pollenated.	Post pollenation casualties.	Locality of tree.	Exposure.
F.	March 18th	4	1 rejected April 3 1 dead in bud stage April 12th.	April 21st. 1 looked healthy 1 brownish as if pollenated		No.IX. Caverton Ride	
G.	March 19th	7		April 21st.	1 feeble and probably worthless - July 3.	No.VIII. Caverton Ride.	
H.	March 20th	5	1 dead, probably due to frost April 21.	April 21st		No.II. West of two trees in Heather Flat.	
	Unprotected as check 2			April 21st			
I.	March 20th	3	2 dead April 14th	April 21st	Last one dead April 27th.	No.II. East of two trees selected in Heather Flat.	
	Unprotected as check 1			April 21st			
J.	March 20th	6	2 dead April 14th	April 21. 1 brownish at top, not looking normal.		No.II. N.W. of south block of pure Jap.	
K.	March 22nd	5	3 dead April 21st	April 21st	1 died off July 3.	No.II. Top of hill. Pure block of Jap.	
L.	March 19th	7	2 dead April 12th.	April 21. 3 showed brown tips.		No.VI. Broad Ride. West of three selected.	
M.	March 19th	6	1 dead April 12th.	April 21. 4 brown at tips.		No.VI. Broad Ride. Centre of three selected.	
N.	March 19th	6	1 dead April 12th	April 21. 5 brown at tips.		No.VI. Broad Ride. East one of three.	
O.	March 19th	6	2 dead April 15th 1 dead April 27th	April 27. 3 brown at tips.		Kale Banks. Jap. Block - west edge next Spruce.	