FORESTRY COMMISSION

HISTORY

of

INVERLIEVER FOREST

1907 - 1951

WEST (SCOTLAND) CONSERVANCY

History of Inverliever Forest

Contents

HISTORY OF INVERLIEVER FOREST

Chairman's Comments

Inverliever is one of the "ex-Crown" forests where I and those gradually associated with me up to the establishment of the Forestry Commission studied with the greatest care problems of British forestry and afforestation. Among others which are in some degree similar are Hafod Fawr (North Wales) and the Isle of Man Plantations; and also Corrour (Sir John Stirling Maxwell).

Boyd, the first Forester at Inverliever, came from Corrour. He was a very intelligent and experienced man and with Crosfield (my first District Officer) laboured valiantly at the tough problems which faced us. My direct responsibility for work at Inverliever ceased early in the first world war. Crosfield carried on until he died in 1919 and Boyd until his death in 1920. When the Commission was established Inverliever was transferred to the Assistant Commissioner for Scotland. I continued to visit the forest at frequent intervals until 1951. The Headquarters file 394/27 contains a number of detailed reports of inspections.

In 1923 I wrote the attached note on the early history of the forest and also that on Corrour. I was concerned at the time that proper use was not being made of the experience gained at Inverliever so that the original errors were being repeated elsewhere in Scotland. Attached to those two notes in the Headquarters file and now reproduced (Appendix III) is the original ecological/afforestation table drawn up for guidance in choice of species.

I desire to stress the point that Inverliever is and will continue to be a pilot scheme for many other forests.

R.

4.5.51.

INVERLIEVER

Inverliever was acquired as an experiment on large scale afforestation at a time (1907) when afforestation was in the air. It was thought to be reasonably typical of large areas of waste land in the West of Scotland. The acquisition was made on the basis of somewhat superficial reports which stated that practically the whole area was plantable with Scots pine.

The first year's planting was made hurriedly in 1909-10 without detailed examination of the ground and a considerable proportion of Scots pine was used on the poorer types of ground, but the forester (Boyd) had already recognised that it was not Scots pine ground and Norway spruce was used to a large extent. In subsequent years Scots pine was dropped and Norway spruce and Sitka spruce were planted on the poor ground, with occasional experimental areas of mountain pine and other species.

I first saw the area as a visitor in 1910 when inspecting the countryside for larch saw-fly but in 1912 at the invitation of Mr. Runciman (President of the Board of Agriculture) and Sir Stafford Howard, I was invited to report on operations. I pointed out broadly that large scale operations on the poor peaty and exposed ground had far outstripped contemporary experience and that much money might have been saved:

(a) By more careful surveys of the estate before acquisition and planting.

(b) By a considered scheme of experimental work in place of the large scale hit-and-miss planting on poor ground.

The estate was placed in my charge in the middle of the 1912/13 planting season and beyond stopping planting on some bad ground at the top of Block VI no change was made. As it happened the planting of Blocks I - VI completed the land in hand for Arichamish farm, and for various reasons it was determined to take up Barmaddy and Cruachan farms. The land was to be surveyed well in advance of planting and only those parts which presented reasonable expectations of producing good-sized timber were to be planted. The real difficulty was to find a safe basis for classifying the poor land. It was clear that two factors, viz. soil and exposure, played a leading part in limiting tree growth, while in all probability the existing vegetation was important first in its effect on the establishment of young trees

and second as an indicator of the character and condition of the soil itself and therefore (in conjunction with exposure) of the probable productivity of the locality. The ecological side of this matter was gradually developed by Messrs. Crosfield (who took over the direct management in 1914) and Boyd, and though neither was an expert botanist the method undoubtedly proved very useful. Mr. Boyd summarised his experiences in the attached statement (Appendix III) shortly before his death in 1920. This statement was not to be regarded as the ultimate criterion in the classification of land but was to be used in conjunction with other environment factors such as exposure.

Regarded as a large scale operation I have little to add to my early views. It is necessary to restrict planting operations within the limits of contemporary success on similar ground; outside these limits operations should proceed cautiously on an experimental basis.

Viewing the planting of poor land as a large scale experiment the outstanding feature is the behaviour of the spruces (Norway and Sitka). Areas which at the age of 4-5 years looked hopeless are gradually improving ten years later and will probably succeed. The process of improvement is very gradual. Groups of trees for one reason or another get away and the improvement spreads (particularly on the leaward side) to neighbouring trees until, it is hoped, the whole area is completely canopied. On the other hand areas apparently similar at the earlier age have now passed into an even more hopeless condition. The reasons are not apparent, but it is clear that success with spruce in the check stage on poor ground hangs on a very fine thread - whether mycelial or otherwise.

There are a great number of points of interest - such as the rapid decimation of Abies pectinata by Chermes - but broadly speaking the main interest in Inverliever to me is the object lesson which it provides on two points:

(1) Procedure in selecting and acquiring land for afforestation.

(2) The concrete alignment of the problems which occur as soon as we begin planting on other than "clean" ground.

R.L.R.

May 16th 1923.

CORROUR

The work at Corrour differs from that at Inverliever in the respect that whereas the latter has gone forward over good and poor land as if the whole were undoubtedly a commercial undertaking, at Corrour it has been recognised from the outset that conditions were very difficult and every apparent avenue to success has been explored or opened up for exploration. This applies alike to methods of afforestation and to species. The poor land at Inverliever is the subject for comparison with Corrour generally. The comparison does not appear to be all in favour of the former. Corrour plantations undoubtedly have a much greater elevation (1,300 ft. - 1,800 ft. against say 500 ft. - 900 ft.) and a more severe winter climate, but their exposure to the prevailing south-west winds is considerably less.

It is noticeable for example how little a species like larch has been affected by wind at Corrour. The effects of exposure are further reduced in the case of the more recent plantings by the fact that the planting areas are small and surrounded by Scots pine plantations 10 ft. - 25 ft. high. It is difficult to say whether there is anything to choose between the soils and the soil vegetations of the two places. Peat is all prevailing and it is to a large extent a matter of conjecture as to the depth and character of the mineral soil. My impression is that there is deeper and more open soil under the peat in most places at Corrour. As regards soil vegetation it should not be difficult to match any set of conditions at one place with those at the other.

Fundamentally, therefore, the value of the work at Corrour lies in the demonstration of what can be done on mountain peat of various kinds. The problem has been approached from two points:

(1) By providing artificial stimulus to Sitka and Norway spruce and to Abies nobilis at the time of planting or soon after planting in the expectation that if the young plants can be induced to grow during the first few years they will then be placed in a condition to look after themselves.

This has taken the form of applying a mixture of basic slag and sand to the roots or on the surface of the peat.

(2) By ameliorating the soil and general conditions by silvicultural means. This has taken the form of providing a foregrowth of (mountain) pine which prepared the way for Sitka spruce etc.

Time alone will show whether either or both of these methods will yield spruce (fir) timber of commercial dimensions but so far as I can judge from visits at intervals of two years there has been generally a distinct and gradual improvement in the condition of the plantations.

In the course of these visits to Inverliever and Corrour a number of spruce plants and two Abies nobilis have been dug up and their roots dissected. The Inverliever spruce showed that the circular spade method of planting the original roots of the spruce did little more than keep the plant alive. The plant proceeded at once to throw out from the collar long new surface roots, and so long as these roots were merely growing in length, the plant remained in the check stage. With the formation of "sinker roots" on the underside of the long roots the tree proceeded to put on longer leading shoots, until with the completion of the canopy and the death of all surface vegetation the peat becomes matted with surface roots from which numerous "sinkers" dip down to the limit of the oxidised peat.

In the case of Abies nobilis surface roots are formed but to nothing like the same extent, the main mass of an extremely bushy system penetrating the peat at an angle of perhaps 45°. It appeared that the more vigorous tree had simply developed the more bushy root system.

Where basic slag is applied to the roots it appears that the check stage is shorter with spruce which lives by means of its primary roots on the salts. It is not clear to what extent secondary "collar" roots are developed during this period. When this food is exhausted the spruce appears to enter on a second check stage which presumably continues until the formation of "collar" roots, "sinkers" and the canopy are complete. It is probable that a more intensive study of the character of root-systems would yield useful information.

Mr. Laing's researches on roots have demonstrated the importance of the fungus associates and indicate the necessity of further fundamental botanical researches on the subject.

As regards the relative values of Norway and Sitka spruces for peat planting, I am inclined to think that under the conditions at Corrour the Norway spruce is likely to prove the better. The Sitka gets away quicker and grows more quickly to begin with perhaps but its branch and needle

development is relatively poor. Thus as in the case of one or two groups which have closed up on the north side of the loch the trees, which should now be developing freely are not altogether promising. This appearance is due in part to an attack of Aphis but mainly to the very small crowns. It may very well be possible to improve them by thinning since the stand is extremely dense. On such a poor soil it is clearly necessary to give the individual stems ample growing space.

It does not appear to me that the discussions have done much to clear up the relations of surface vegetations to plantability beyond indicating that the subject is likely to prove very complex on closer examination. It must not be lost sight of, however, as in practice most foresters are guided to a considerable extent by the vegetation.

R. L. R.

May 16th, 1923.

The Future

The experimental role of Inverliever as the first large-scale afforestation project is by no means concluded. We have seen how, after the initial problems of forming plantations, there arose those connected with thinning, extraction and marketing of small poles, water transport, roading, and large scale housing. In none of its main aspects (climate, soils, topography, situation in relation to labour supplies and to markets, etc. etc) is Inverliever wholly straightforward or easy and the first selection of ground for planting did not help. Nevertheless the very presence of the resulting problems has been a spur to finding solutions which have been of great value both locally and in the conduct of afforestation operations elsewhere.

This is a convenient time, therefore, to consider what the next experimental steps should be. They can be grouped under two heads, viz: silviculture and utilization.

Silviculture

1. Emergence of spruces from prolonged check. This extraordinary phenomenon is worthy or detailed examination, which will entail, among other things, laborious examination of rooting systems.
2. New planting experiments based on modern methods such as ploughing and mixtures. Some at least of these experiments can be located in close proximity to old plantations which are still checked or slowly emerging from check.

Utilization

Transport (whether from the compartment to a hard road or from the forest to the point of final utilization) is the key to efficient utilization. It is essential therefore not to move, at any stage, any component which is useless. Such components are bark and water in the round pole or log and slabs and sawdust from saw logs.

It seems probable that by strict attention to such details the weight of the wood removed from the forest could be reduced to at most one-third of the total weight green. Further, marketing as near as possible to the forest saves transport. Such considerations suggest the following experiments:

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GENERAL DESCRIPTION OF THE FOREST

Name and Situation

The forest name is derived from that formerly given to the area when it formed one of the sporting beats of Poltalloch Estate and from the River Liever which runs for its entire length throughout the area.

The area was acquired by H.M. Office of Woods in 1907 from Poltalloch Estate and is situated in the parishes of Kilmichael-Glassary and Dalavich-Kilchrenan in the County of Argyll. It stretches for nine miles along the west bank of Loch Awe from Ford in the south to Dalavich in the north and its most westerly point is within a mile of the sea at the head of Loch Craignish.

The Eredine section on the east bank of Loch Awe is now part of Inverliever Forest but this history is concerned only with the original 1907 acquisition.

Area and Utilisation

The acquired area extends to 12608 acres and at the time of purchase the Estate was divided into four farms carrying the undernoted stock:-

Name of Farm	Area	Sheep	Cattle
Salachry	503	300	-
Torran and Ford Pendicle	3076	1900	30
Arichamish and Inverliever Lodge	4962	2700	-
Barmaddy and Cruachan	4067	1750	-
Total:	12608	6650	30

The above area included 197 acres of scrub and 76 acres of coniferous plantations.

Scrub consisted of oak, ash, birch, alder, rowan and hazel and was growing on the lower slopes along Loch Aweside and up the more fertile and sheltered valleys.

The acquired plantations extended to 76 acres and were divided into four blocks of mixed conifers situated close to the lochside. The species in each of these blocks was a mixture of Scots pine, European larch, Douglas fir, Norway spruce and Silver fir. A few hardwoods were intermixed and these were chiefly oak and birch.

Most of the acquired plantations were in a neglected condition and the only feature of note was the rapid growth of Silver fir which at 35 years had attained a height of 70 ft.

Apart from a few scattered Silver firs and Scots pines near Cruachan and the mixed conifer plantation extending to seven acres on Inverliever Island, all these acquired plantations have been felled and 57 acres replanted.

It was thought at the time of acquisition that of the total acreage of 12,608 acquired some three quarters of the area could be put under timber. The poor results obtained from early planting led to a detailed land survey being carried out between 1914 and 1917, and this showed that the first estimate was too optimistic and that only about one third was capable of carrying a tree crop.

The following table shows the result of the survey:-

Name of Farm	Total Area	Plantable	Unplantable
Barmaddy and Cruachan	4067	1414	2653
Arichamish and Inverliever Lodge	4962	2517	2445
Torran and Ford Pendicle	3076	1026	2050
Salachry	503	254	249
Total:	12608	5211	7397

As stated previously the Estate was given over almost entirely to sheep and cattle grazing and it was essential in order to keep these farms going as economic units to allocate to them a certain amount of plantable land. Further areas of good land were also allocated towards the formation of small holdings.

The good plantable land allotted for the above purposes amounted in all to approximately 2,000 acres and the position as to utilisation of land after making these allowances is as shown in the following tables:-

/ Table I

TABLE I

From	By	Date	Acquired Plantations	Plantable excl. Column 4	Nurseries	Agricultural	F.W.H.	Unplantable	Other Land				Total
									Land Perm. transferred		Land Temp. transferred		
									Description	Acreage	Description	Acreage	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Poltalloch	Purchase	1907	76	2903	8	190	6	288	-	-	Barmaddy Torran Arichamish Salachry Dalavich Croft	2542 2574 3372 503 146	12608
Totals			76	2903	8	190	6	288	-	-		9137	12608

Notes

Column 4. Only 7 acres of acquired plantations now remain standing in Inverliever Island and replanting of the felled areas is being completed in the current forest year (P.52).

Column 5. Includes 124 acres ex Arichamish Farm and 356 ex Torran Farm to which entry will not be available until the present tenants of the above farms retire. Also included is 104 acres which it is proposed to resume from Barmaddy Farm in 1953 for planting in F.Y.54.

Column 6. The nursery is at present being rested after producing crops of young plants for 40 years.

Column 7. Includes small holdings at Cruachan, New York, Kilmaha, Inverliever Lodge grounds and Ford Pendicle. It is not intended to form plantations on any of this ground.

Column 8. Includes 4 acres small tenancies, forester's house and feus.

Column 9. Is enclosed unplantable only.

Columns 12 and 13. The areas shown against each farm include plantable land to the extent of approximately 1,900 acres. This is all located on the lower slopes and is considered to be necessary for winter grazing and the retention of the farm as an economic unit. The 1,900 acres also includes some 76 acres of land in close proximity to the loch and farmhouses, which is under cultivation. Dalavich croft area includes 12 acres since resumed for the Dalavich housing scheme.

TABLE II

(a)	Plantations			
	Acquired		7 acres	
	Formed by Commission		2361 "	2368 acres
(b)	In hand Awaiting Planting			
	Blanks after felling		12 acres	
	Burnt areas		-	
	Other land	584 +	15 "	611 acres
(c)	Nurseries			8 "
(d)	Agricultural			
	No. of Tenancies - 10			9327 "
(e)	Forest Workers' Holdings			
	Number - 5			2 "
(f)	Unplantable Land in Hand			288 "
(g)	Other Land			4 "
			Total:	12608 acres

(a) All that remains standing of original acquired plantations is 7 acres.

Plantations formed by the Forestry Commission include those laid down by H.M.Office of Woods.

2,304 acres have been afforested and 57 re-afforested.

(b) 12 acres of felled woodland on acquired plantation sites. 15 acres on land reclaimed from unplantable. 584 acres have been shown under this heading and notice of resumption has been given in respect of 104 acres ex Barmaddy and the balance of 480 acres will not be resumed until the retiral of the tenants of Torran and Arichamish Farms.

(c) See notes under this heading for Table I.

(d) Includes all land leased for agricultural purposes (colums 7 and 13 of Table I).

(e) Five Forest Workers' Holdings only.

(f) Only enclosed unplantable recorded here.

(g) Small tenancies, forester's house and feus.

The first plantations were laid down in 1909 on the north-east section of Arichamish Farm on the south side of Cruachan Burn. The area resumed from Arichamish extended to 1,100 acres. On this area the P.09 to P.14 plantations covering 800 acres in all, were formed.

From P.15 to P.23, 968 acres of plantations were established on 1305 acres resumed from Barmaddy and Cruachan Farms and parts of Torran and

Arichamish Farms were resumed for the P.years 24 to 28 inclusive where 466 acres were established.

P.29 - P.32 plantations amounting to 70 acres in all were established piecemeal throughout the enclosed area on land considered doubtful at the time of first planting. In addition 57 acres of acquired woods were re-planted. The total area enclosed and compartmented extends to 2,870 acres.

As a result of the resumption of land for afforestation purposes the sheep stocks for the estate as a whole have been reduced from 6,500 to 4,500 but cattle stocks have increased from 30 head to 85 head.

The area was of considerable sporting value and game consisted of red deer, roe deer, grouse and blackgame. There were small numbers of pheasants on the lower ground. Good fishing was available in Loch Awe and on a few of the many hill lochs. The beat was also equipped with a shooting lodge situated on the north bank and near the mouth of the River Liever.

Physiography

Topographically the area is divided into three main divisions.

(i) A steep rise from Loch Awe which gives way to

(ii) a series of ridges and valleys running in a north-east to south-west direction which in turn give place to

(iii) a high exposed flattish area.

The elevation of the ground rises from the south-west and north-east to the centre of the area where it culminates in Dun Corrach, 951 ft. above sea level and 834 ft. above Loch Awe. The ridges separating the valleys and the high plateau area are fully exposed to the strong south-west prevailing wind. Dun Corrach affords some shelter to the more undulating north-east area.

The steep slopes above Loch Awe have an easterly aspect and the high moorland area generally a westerly aspect.

Geology and Soils

Two main types occur:-

(i) Epidiorite sill which occupies most of the area, and

(ii) Loch Awe grits which are confined to the north-east part of the area.

The epidiorite series varies from definitely igneous massive rocks,

such as andesite and epidiorite to strongly metamorphosed schistose rock such as chlorite schist and even calcareous lenticular slates and occupies the forest area from Ford in the South to an irregular line just south of Cruachan.

In the north-east section, from Cruachan and Barmaddy to the northern boundary of the Forest, the grits or quartzite, which often contain a slight admixture of chlorite, are of a greyish or greenish colour and are generally coarse in texture

The moraines which occur in the vicinity of Cruachan are coarser in character than the grits, having been washed free of the finer materials.

Soil derived from the epidiorites is a heavy stiffish yellowish loam and is generally shallow in depth except along flats and hollows where depth has been increased by deposits resulting from creep and water action. Owing to the steep slope on which these soils occur they are generally well drained but are moister and often wet on the flats and hollows.

Soils originating from the Loch Awe grits are of a more open and loose texture.

Above 500 ft. the soil consists mainly of peat of varying depths and textures and with a high moisture content. Amorphous flush type peats are found in some of the hollows but by far the largest extent is covered with deep fibrous peat.

Ridge slope soils which occur in this area are better drained and are either pure mineral or mineral overlaid with a thin layer of peat.

Vegetation

Vegetation varied according to whether soils originated from the epidiorites and the grits or in the peat overlying the podsols.

On the soils arising from the epidiorite and grits and up to approximately the 500 foot contour where peat becomes prevalent, vegetation consisted of scrubby oak, ash, birch, alder, hazel and rowan, with bracken, Aira flexuosa, Agrostis species and Holcus species forming the ground vegetation on open spaces. Brambles although not common were also to be found.

On the moorland area above the 500 foot contour vegetation varied from Molinia/heath/bog myrtle associations to Scirpus/ling/bog asphodel with deep

Sphagnum mosses. Cotton grass and Erica tetralix were common where stagnant conditions prevailed. Bracken and finer grasses were to be found on the better soils on the lee side of the ridges and knolls which occur throughout the moorland area.

Meteorology

The rainfall is between 80 - 85 in. per annum, and weather conditions may be said to be mild and cloudy. Heavy snowfalls and severe frosts are unusual, but late spring frosts are harmful.

The prevailing wind is south-west and often reaches gale force during the winter months. The high moorland area is exposed to these. The slopes above Loch Awe are more sheltered from the prevailing wind but are open to winds sweeping up Loch Awe valley and these too are often severe.

Risks

The danger to plantations is not considered to be great from any source although normal protective measures are taken against danger by fire, rabbits, deer and blackgame. Rabbits and blackgame have been the most serious pests to date and the latter severely damaged pines and larches in the early years. Underplanted, replanted and natural regeneration areas also require protection by fencing against deer and stray sheep.

Damage by fungus has been negligible and confined to honey fungus attack on individual trees planted in scrub areas. It is doubtful if the recent "die-back" in Sitka spruce can be wholly attributed to the fungus Nectria cucurbitula, or Stereum sanguinolentum, the fructifications of which have been found on dead stems.

Most of the European larch suffered from larch canker in the early stages but the older stems now show complete recovery.

Insect attack to date has been most severe on Silver fir (Abies pectinata) which was almost entirely eliminated by Adelges nusslini. Neomyzaphis abietina has caused some defoliation but death from this source has not been observed.

The recent improvement to the road running through the Forest is likely to lead to increased fire danger and damage by trespass. It is considered, however, that this new danger is more than offset by the speed with which the area can be reached and the ease with which it can be

patrolled during danger periods.

Roads

Original access routes consisted of the Ford-Kilchrenan road and a branch road from this to Barmaddy Farm. Both these roads were, until 1950, incapable of carrying heavy wheeled transport and removal of produce up to this time had almost entirely been routed across Loch Awe. In 1950 by arrangement with Argyll County Council the Ford-Kilchrenan road was reconstructed to carry ten ton loads.

At present these two routes, the Loch and the County road, form the main arteries of the access system with the Ford-Kilchrenan road scheduled to carry approximately 80% of the produce and the Loch 20%. All the produce routed across the Loch will come from the steep slopes in the Kilmaha and Arinechtan regions.

Further road construction is being carried out, and feeder tracks, of fair weather type, are numerous and radiate from the main through road to all areas where thinnings have been done.

Lengths of the various types of roads are as follows:-

All weather roads (9 miles) 4½ miles of which have been reconstructed by Forestry Commission.

Forest tracks of fair weather type - 14 miles.

Roads now under construction are the Ford-Kilchrenan road from Cruachan to Dalavich, the Barmaddy Farm road and a completely new road from near Cruachan Bridge running through Compartment 138, then along the ride separating Compartments 140, 141 to the junction of Compartments 127, 128, 140, 141 and 142 (known locally as Crewe Junction) thence along the ride between Compartments 126, 127, 128. At this point it leaves the ride and cuts through Compartments 125, 121, 117, 118 and then through one of the Barmaddy fields to where it connects with the existing Barmaddy Farm road. This road will serve P.17, P.20, P.21 and P.22.

Roads of the all-weather type scheduled for construction in the near future run from New York in the north to just beyond Cruachan Burn in the south and closely following the shore line. This will tap produce from P.34, P.15, P.16 and part of P.09.

It is also proposed that a road capable of taking medium transport, running more or less parallel with the Ford-Kilchrenan road, be constructed

from "Crewe Junction" in the north through P.20, P.09, P.10, P.11, P.12, P.13 and descending through P.14 to connect with the Ford-Kilchrenan road in the South.

The standard of the existing feeder tracks or tractor roads are of low specification but have been fairly satisfactory for the removal of light thinnings but some improvement will be necessary as the timber increases in size. All of these roads are unmetalled but the softest stretches have been corded over with poles resulting from cleaning operations. Practically all the levelling in the construction of these roads has been done with forest labour although a bulldozer was made available for a short time during and just after the war. This type of road does not stand up to the concentrated use which a timber merchant is compelled to make in all weather if he is to keep within the completion date of his contract.

Forest rides in the north end of the forest, i.e. north of Cruachan Burn have been widely used for extraction purposes, but in the south area the compartments have been laid down on the grid system and have proved of little use for extraction work.

Type of equipment used on all weather roads is confined to rubber wheeled vehicles and fair weather tracks usually carry rubber wheeled and track-laying tractors with pole waggons.

For transport across Loch Awe the "Coileach Coille" a 35 foot long boat with a 10 ft. 3 in. beam and powered with a 30 h.p. Kelvin engine has been used. This was launched in 1936 and was designed to carry pitprops from the Forest to Durran on the east bank of Loch Awe. As the volume of produce increased it was decided that a central conversion depot be set up at Durran and instead of the produce being shipped in the hull of the "Coileach Coille", poles were dogged together into rafts and towed across the Loch. This method is still in progress where trees are dragged out to the Lochside but when brought down by pole waggon the whole load is encircled with the towing rope in preference to "pegging or dogging". This method has been very successful. It is estimated that three quarters of a million cubic feet have been shipped across Loch Awe.

Labour

The labour force employed at this Forest has, until last year when 37 new houses were completed and occupied, always been inadequate and the whole

of the delayed thinning and maintenance work can be attributed to this factor. It is interesting to compare the growth of the population on the estate and the number of employees engaged in afforestation from the time of acquisition (1908), in 1912-13 when afforestation was in the early stages and at the present time (1952) when three-fifths of the area has reached the thinning stage. Details are appended in Tables III, IV and V below (Joint Annual Report of Forestry Branches 1912-1913).

TABLE III

Resident Population in 1908

Source of Employment	Males	Females		Children under 16	Total
		Earners	Dependants		
Farming pursuits generally	18	5	10	10	43
Game	3	1	3	1	8
Post Office	1	2	1	-	4
Resident only	-	-	-	-	-
Totals:	22	8	14	11	55

TABLE IV

Resident Population in 1912-13

Source of Employment	Males	Females		Children under 16	Total
		Earners	Dependants		
Farming pursuits generally	13	3	7	15	38
Game	3	1	3	-	7
Post Office	1	2	-	-	3
Afforestation	17	3	5	8	33
Resident only	1	-	1	4	6
Totals:	35	9	16	27	87

TABLE V

Resident Population at 1st April 1952

Source of Employment	Males	Females		Children under 16	Total
		Earners	Dependants		
Farming pursuits generally	10	6	6	5	27
Game	1	-	1	-	2
Post Office	1	3	-	2	6
Afforestation	72	12	50	98	232
" (Resident on Eredine)	4	-	4	5	13
Resident only	1	-	3	1	5
Totals:	89	21	64	111	285
Employed on afforestation not resident	6	3	-	-	9

Also included in Table V are 13 male workers, 5 dependants and 15 children accommodated in houses erected by timber merchants operating at Inverliever.

At the start of afforestation all workers were recruited locally but as the volume of work increased a bothy was erected at Cruachan to accommodate workers from outside sources.

During the first world war, losses caused by recruitment to the armed forces were made good by the employment of conscientious objectors and female labour.

Between the wars the majority of workers were local and the staff was increased by the building of Forest Workers' Holdings at Durran (4), at Ford (4) and at Kilmaha (1).

The increased demand for labour in post war years has been met by workers from the new houses recently built at Dalavich (31) and Ford (6). Inverliever Lodge has also been used to accommodate single workers who have been recruited mainly from industrial centres.

SILVICULTURE

(i) Preparation of Ground

Preparation of ground consisted of scrub clearing, bracken cutting and draining

In scrub clearing a thin over crop was retained for shelter purposes. This was later removed by ringing when it had served its purpose.

In the early years all bracken was cut on the areas to be planted in the summer preceding planting.

The whole of the planted area has been fenced against rabbits and sheep.

(ii) Choice of Species

For purposes of the selection of species, the forest fell into two categories, A and B, both as regards soil and exposure. The lower slopes (Area A) were comparatively sheltered but exposure on the high ridges and plateau (Area B) was severe with local shelter in the valleys.

Area A

From the Loch up to approximately the 500 foot contour soils were mainly mineral but overlaid with a thin layer of peat in places. Vegetation consisted of scrub growth of oak, birch, ash, alder and hazel. Open spaces between the scrub areas were covered with a mixture of bracken and various pasture grasses. Near the 500 foot contour, heath, Aira caespitosa, patches of fine bent grasses and Molinia were present.

The species selected to stock the lower slopes comprised Scots pine, European larch, Japanese larch, Douglas fir, Norway spruce, Sitka spruce, Silver fir and beech and were planted on the following sites:-

Scots pine was not extensively used on the lower slopes. It was generally planted on sites where heather predominated.

European larch was selected for the lower bracken covered slopes on well drained mineral soils.

Japanese larch was grown on a wide variety of sites on pure mineral soil and where mineral soil was overlaid by a thin peat layer. Vegetation varied from pure bracken to a mixture of heath, ling, some bracken and

fine pasture grasses. Sites were often fairly exposed.

Douglas fir. This species was chosen for the deeper soil sites previously under scrub, and on sites carrying bracken and various pasture grasses. Some sites were fairly exposed.

Norway spruce. This species was used on a wide variety of sites on both mineral and peat soil, in both sheltered and exposed situations.

Sitka spruce. Similar to Norway spruce and usually, but not always, on more sheltered situations, and on deeper soils.

Silver fir. Silver fir was selected for better class soils in sheltered situations.

Beech. This species was planted on more exposed sites in mixture with Silver fir and pure to form protective belts along roadsides.

Area B.

From the 500 foot to 950 foot contours on the flat plateau area and in the hollows between the ridges the soil consisted mainly of peat of various depths and textures, and with a high moisture content. Vegetation deteriorated from Molinia/heath/bog myrtle associations to Scirpus/ling/bog asphodel with Sphagnum and cotton grass.

Ridge slope soils were better drained and were either pure mineral or mineral overlaid with a thin layer of peat and vegetation consisted of a much richer growth of Molinia and some bracken.

There were no plantations growing locally in conditions similar to the area to be afforested and from which a guide to selection of species might have been obtained.

The species chosen were Scots pine, Norway spruce, Sitka spruce and Mountain pine, and these were allocated to the following sites:-

Scots pine. In the first three years, P.09 to P.11, Scots pine was extensively used on much of the exposed sites, particularly where heather was dominant.

Norway spruce. Norway spruce was selected for sites generally where heather was in mixture with grasses.

Sitka spruce was planted on the more sheltered sites and along valley bottoms and on better soils than the above two species. This species was not extensively used and in early years formed only 10% of the spruces used.

Mountain pine. This species was used in the poorest and most exposed sites. It was planted pure and also in mixture with spruces.

Planting

(a) Spacing

Apart from experimental work planting distances varied from 5 ft. to 6 ft. for the larches and Douglas fir, 3 ft. to 5 ft. for the spruces and Silver fir, and 4 ft. for Scots pine.

Mountain pine when planted pure were at 4 ft. spacing and when used as a nurse species at 8 ft. to 10 ft. apart.

Beech was the only hardwood planted and the spacing was $4\frac{1}{2}$ ft. to 5 ft.

(b) Type of Plants used and source of supply

Approximately 75% of the plants used were reared in the local nursery at Ford and varied from 1+1 to 2+3 transplants. The remainder were either purchased from the home nursery trade or were supplied from other Office of Woods nurseries

(c) Methods of Planting

The tool most commonly used was the semi-circular spade although mattocks were used on the harder heather knolls. With the exception of the small turfed areas all planting was direct. Screefing was done either prior to, or at the time of planting.

(d) Rate of Planting

The areas planted by P.years are given in Table VI below:-

TABLE VI

P. Year	Area	P. Year	Area
Acquired Plantations	76	P. 20	84.
P. 09	112. 5	P. 21	132.
P. 10	122. 75	P. 22	123.
P. 11	110	P. 23	189.
P. 12	158. 5	P. 24	140.
P. 13	94. 75	P. 25	75.
P. 14	201. 5	P. 26	56.
P. 15	179. 25	P. 27	120. 5
P. 16	101.	P. 28	74. 2
P. 17	72.	P. 29	36. 75
P. 18	45. 5	P. 30	9.
P. 19	42. 5	P. 31	15.
		P. 32	9. 5

Apart from some small areas of replanting, no planting has been done since 1932.

(e) Manuring

Manuring was not done on a large scale at Inverliever, although small scale experiments were carried out in the early years using sulphuric acid, quick lime, ferric hydroxide, superphosphate, basic slag and sulphate of ammonia. Best results were obtained where basic slag was used.

(f) Success or otherwise of establishment

Area A

Results on mineral soil sites were generally satisfactory. All species grew well, but much damage was done to the larches by blackgame. Douglas fir appears to have been the most difficult species to establish. In later years much of this species suffered from windblow on exposed and soft sites.

After a successful start Silver fir was almost completely destroyed as a result of Chermes attack.

Little change was made in selection of species in later years on this type of land, apart from the planting of Silver fir being abandoned and Douglas fir being allocated to more sheltered sites.

Area B

It was evident by the Summer of 1912 that all species used on the higher ground were going to be difficult to establish. Scots pine in particular suffered severely both from exposure and the unsuitable soil

conditions. In addition it had been badly cut back by blackgame.

Norway spruce had also checked badly and on the poorest sites many plants had failed to grow.

Sitka spruce on the better sites also checked, but the death rate was not so high as in the other two species.

Following the poor results obtained with Scots pine it was decided to abandon the use of this species. Blanks in the pine crop were replanted with spruces.

In view of the unsatisfactory growth on these upland areas it was decided in 1913 to survey the whole of the area scheduled for planting, using the vegetation as an indicator as to type and condition of soil. Other factors such as exposure were taken into account when classifying land as suitable for planting. (Vegetation chart resulting from survey attached, Appendix III).

The chief points arising from the survey which was completed in 1918 were the classification of plantable and unplantable land, the recommendation of choice of species based on experience gained from the early plantations and a prescription as to intensity of drainage required.

During the survey period planting was confined to the "good" land on the east section of Barmaddy Farm, on which P.15, 16, 17, 18, 19 plantations were formed. Land forming part of this farm was also used for P.20, 21, 22 and 23 plantations.

Choice of species from 1918 onwards followed the recommendations resulting from the survey.

From 1918 a much higher proportion of Sitka spruce was used to stock spruce areas. These were allocated to more exposed sites and in later years. P.24 - 28, accounted for almost 90% of the spruces used.

Little drainage was done on the steep slopes and this was confined mainly to the small flats and flushes. On the high exposed wet peat areas drainage was more intensive but seldom exceeded 20 chains per acre. For example, drainage on the P.13 planting area amounted to 1,792 chains of ordinary drains and 802 chains were cut utilising the upturned turves for planting. The area planted in P.13 was 94.75 acres.

Turf planting was in the experimental stage in the early years and the turfs were utilised only on selected sites. In later years turfs were

more commonly used but turf planting never became general as most of the area was planted before this technique became general Forestry Commission practice.

Ploughing

Nil.

Beating Up

Failures in the early Scots pine planting were made good with Norway spruce and Sitka spruce but blanks generally were replaced with the original species and work was commonly done the year after planting.

Heaviest losses were suffered on the high moorland area where most of the planting was direct. To improve the survival rate many of the replacements were turf planted. Official reports indicate that much over-beating up was done by replacing sickly looking checked plants. On the lower slopes beating up was less necessary and more successful. Plants used for this purpose were of top grade and generally 2+2 transplants.

Weeding

Weeding was almost wholly confined to the lower mineral soil slopes and consisted of the keeping in check of coppice shoots, bracken and heavy growths of grass. This operation and the removal of the overhead scrub shelter by ringing were done without any damage to the young crop.

Mixtures

The only mixtures planted were of beech and Silver fir, and Norway spruce with Sitka spruce. Both of these have been failures owing to the Silver fir being killed out as a result of an attack by Adelges nusslini and in the second case by the inability of Norway spruce to maintain the same rate of growth as Sitka spruce which resulted in death by suppression.

Restocking

(a) Natural Regeneration

Restocking by natural regeneration has so far proved unsuccessful. Sitka spruce regenerates quite freely in the shade of parent trees and on bare soil resulting from extraction operations. In the shade of the parent trees seedlings generally live for a few years and then die off probably as a result of the dense shade. On bare ground the competition from other vegetation is too severe for them to survive.

Investigations into natural regeneration are being carried out by Research Branch and a plot of Sitka spruce planted in 1916 has been set aside for this purpose.

(b) Replanting

The area replanted extends to 163 acres. The species used have been mainly Norway spruce, Sitka spruce and Tsuga.

Most of the replanting was done in F.Y.28 when 108 acres, the bulk of which was formerly stocked with Silver fir, was replanted. Other areas required restocking as a result of windblow and clear felling.

In the shelter of surrounding woods all three species have grown well and especially on areas of small extent. Sitka spruce growth under these conditions is very rapid as evidenced in Compartment 178 where 36 in. growth are common. On the larger and more open areas on the lower slopes of P.11 and 12 formerly stocked with European larch and Douglas fir, growth is slower. Norway spruce was used largely to replace Silver fir and has developed evenly. Tsuga was not extensively used but is most promising.

(c) Underplanting

79 acres have been underplanted and the overcrop, with the exception of a small plot of Douglas fir underplanted with Tsuga heterophylla, is European and Japanese larch.

The species used for this purpose were beech, Norway spruce, Sitka spruce, Abies grandis and Tsuga. Beech and Norway spruce have been most extensively used. Much of the area underplanted has been damaged by grazing.

The species which have succeeded best are beech and Tsuga. The former has grown well under open European larch in P.15 and P.16, the Tsuga has done well under rather open Douglas fir in P.15. Norway spruce under Japanese larch in P.18 has suffered as a result of the rather dense shade and would be more successful if introduced at a later stage and under a reduced canopy.

Rates of Growth

Silviculturally, the most striking feature of Inverliever Forest is the quick growth of all species and particularly Sitka spruce on the lower mineral soil slopes and the contrasting slow progress made by species on the high moorland areas.

Area A

(a) European larch

European larch has been most successful on soils derived from the grits and located in P.15 and P.16. On the more shallow soil and exposed sites in P.11, 12 and 13 rate of growth has been slower and results of blast are evident in the sparseness of the crown on the exposed side.

After recovering from blackgame damage suffered in the early years it grew rapidly but suffered in the dense pole stage from canker. A very heavy thinning was made in 1937 of the quicker growing plots in P.15 and 16. Later light thinnings followed in 1940, 1941, 1942 and 1943. The crop now stands at from 100 to 170 stems per acre with a volume of from 1,200 to 1,800 cu.ft. per acre. Most of the cankers have now healed over and there is a big improvement in crown development. Much of the larch has been underplanted with beech, Norway spruce and Tsuga. Larch is heavier where underplanted with beech.

(b) Japanese larch

This species also suffered severely from blackgame in the early years. It has suffered less on exposed sites than European larch, but on such sites stems are often coarse. On sheltered sites growth is rapid and stems cleaner. Best stands of the species occur in P.23, P.24 and P.27.

(c) Douglas fir

On exposed sites Douglas fir suffered severely from windblow and twisted stem formation. On the deeper soils, where planted in succession to scrub, the crop has grown rapidly. Best formed stems are found near the lochside in P.16 on what appears to be a raised beach. This species also suffered from delayed thinning but is now improving steadily.

(d) Norway spruce

The rate of growth of Norway spruce on the sheltered and mineral soil sites has been very satisfactory. Where planted on shallow and exposed sites growth is appreciably slower.

(e) Sitka spruce

This species is probably the most successful of all the conifers planted at Inverliever both as regards productivity and adaptability. On high exposed difficult sites it succeeds better than any other conifer whilst trees in the region of 100 ft. are not uncommon on the sheltered deep

soil areas in P.09, 15 and 16. Sample plot No.S.116 shows a periodic mean increment of 387 cu.ft. U.B. for the 17th, 18th and 19th growing seasons and increased to 456 cu.ft. U.B. for the following three growing seasons.

Because of its rapid growth Sitka spruce requires timely and regular thinnings. Failure to do this particularly on moist sites invites loss from windblow. Planting too close to drainsides also often leads to windblow. Sitka starts its growth early in the mild wet weather conditions and damage from late spring frosts is suffered on low lying sites. Growth normally continues well into October.

A disturbing factor affecting this species is the occurrence of dieback which has been found in four parts of the Forest in Compartment 137, P.16; Compartment 126, P.21; Compartment 139, P.17 and Compartment 193, P.28. Affected areas are as yet of small extent and do not exceed $\frac{1}{4}$ acre in the first three, and a single tree in P.28. First indication of the disease is a yellowing of the needles which is followed by rapid and complete defoliation. Investigation of the root system of infected trees reveals them to be completely dead. The causes of dieback are being investigated.

(f) Silver fir

Only a few trees of the original crop now remain. After decimation resulting from Adelges nusslini attack the area was restocked with Norway and Sitka spruce in 1926 - 1928.

(g) Abies nobilis

Nobilis occurs only in a few small groups throughout the Forest and were planted by Forester Boyd in the course of the vegetation survey. The groups are mainly sited on exposed sites. This species is windfirm and does not suffer unduly from exposure.

(h) Thuja plicata

Thuja plicata occurs only in small groups and is the only species so far which shows evidence of heart rot (apart from a small group of Sitka spruce in P.16 Compartment 134).

(j) Beech

Beech on exposed sites is short and bushy but under larch is of better form. The types planted have not been good.

Area B

Growth on the exposed high ridges and plateau has been irregular and slow.

(a) Scots pine

Scots pine which was fairly extensively planted in the first three planting seasons has almost completely failed. The area now under Scots pine is 12 acres. Growth is slow and except for a plot on the scree slopes of Dun Corrach, appears unhealthy.

(b) Norway spruce

This species, which covers the larger part of the area, has progressed very slowly and large areas still remain in check. In addition to the effects of exposure, rate of growth has undoubtedly been affected by the lack of adequate drainage and by the direct method of planting employed in forming the plantation. On the best of these poor sites and for reasons not apparent, small groups consisting of a few trees start putting on growth often after having been in check for many years. These groups slowly enlarge to the leeward side.

Much of the land similar to that planted with Norway spruce in the early years was, as a result of the survey of 1914-1918, classified unplantable.

(c) Sitka spruce

Sitka spruce has been the most successful species under these conditions. It is not uncommon to find Norway spruce and Sitka spruce growing side by side 1 ft. and 20 ft, high respectively. In Compartment 183, P.14, where Sitka is growing at an elevation of 850 ft. trees are up to 60 ft. high with Q.G. at B.H. of up to 9 in. Sitka has suffered less from exposure than Scots pine and Norway spruce.

(d) Mountain pine

Mountain pine has in many cases not succeeded in colonising the ground. As a nurse species its very slow rate of growth made it of doubtful value.

Details of height increment in stands of the five major species will be found in Table VIII on page 34.

Past Treatment

(a) Brashing and Cleaning

This type of work started in 1927 when European larch, Japanese larch and Douglas fir and some of the quick growing stands of Sitka spruce received attention. Brashing and cleaning were done at the same time in the early years and in the case of the larches sticks were used to clean the stem of dead branches but saws were used for other species.

Since the war little has been done in the way of cleaning and dead trees are allowed to stand unless they interfere with extraction operations.

The area brashed is just ahead of the area thinned and is approximately 1,800 acres.

(b) Pruning

Apart from experimental high pruning of Sitka spruce carried out by Research Branch in Compartments 177 and 178, very little pruning has been done at this Forest

(c) Thinning

For management purposes Inverliever is divided into two thinning series - North and South with the Cruachan Burn forming the boundary between the two. The thinning plan is based on a three year cycle and the north and south areas are sub-divided into three.

T.S. North

Block I consists of P.16, 17, 20 and part 21
Block II consists of P.15, 22 and 33
Block III consists of P.18, 19, 22, 23 and remainder

T.S. South

Block I consists of P.13, 14, 24, 25, 27 and 28
Block II consists of P.11 and 12
Block III consists of P.09 and 10

Light thinnings, cleaning and brashing commenced in the late twenties in the larch and Douglas fir area but it was in the middle thirties before intensive thinning commenced. Up to and including F.Y.39 the volume removed amounted to ,000 cu.ft. consisting chiefly of European larch, Douglas fir and Sitka spruce. The area thinned during this period was 345 acres.

From 1940 to 1945 rate of thinning was greatly accelerated to supply

war demands. Most of the thinnings during these years came off the steep slopes immediately above Loch Awe (P.09 to P.18 inclusive). The species consisted of European larch, Japanese larch, Douglas fir, Norway spruce and Sitka spruce.

In addition to thinning 66 acres of European larch and Douglas fir were clear felled. Many of the faster growing stands received light annual thinnings in 1940, 1941, 1942 and 1943, and the remainder two thinnings. Over this period the volume removed in thinnings totalled 816,000 cu.ft. 75,000 cu.ft. resulted from clear fellings. This latter area included Torran Wood and part of New York Wood.

In post-war years, F.Y.46 to F.Y.51 inclusive, thinning operations have been confined almost wholly to first thinnings on the higher and more inaccessible sites comprising part of P.17, 20, 21, 22 and 23 in T.S. (N.) and P.24, 25, 27 and 28 in T.S.(S.). Volume resulting from thinnings during this period amounted to 483,686 cu.ft. of which 190,372 cu.ft. were sold standing. The area thinned was 969 acres.

The total area in thinning stage to the end of F.Y.51 is approximately 1,715 acres and total timber yield to the end of F.Y.51 is 1,435,688 cu.ft.; this figure includes the volume from clear fellings.

The following table, Table VII, shows the acreage thinned and volume removed by Forest years:-

TABLE VII

F.Y.	Area (acres)	Volume (cu.ft.)
Up to F.Y.35	90	16,829
" 36	54	6,136
" 37	40	3,843
" 38	85	10,419
" 39	76	23,773
" 40	225	176,583
" 41	255	186,934
" 42	247	103,426
" 43	315	232,860
" 44	105	110,021
" 45	125	81,178
" 46	127	41,510
" 47	60	40,537
" 48	123	63,820
" 49	153	65,732
" 50	163	80,413
" 51	343	191,674
Totals:	2,582	1,435,688

The timber from thinnings has been primarily converted into pitprops particularly from first and second thinnings, but the larger sized logs now being removed from the better sited quick growing stands in the older P. years are being converted into boards and battens for building purposes. It is estimated that of the total volume of 1,435,688 cu.ft. removed, approximately 200,000 cu.ft. have been used for this purpose.

European larch

Of the various species in the thinning stage European larch (117 acres) has almost reached the final crop stage on the better sites. On exposed sites where growth has been slower further light thinnings will be necessary. The rapid growth of this species in early years makes early thinning necessary and much of the canker experienced at Inverliever was probably partly caused by the impaired state of health due to delayed thinning. The rapid healing of the cankers and the very improved condition of the crown and the overall appearance of vigour now evident are indicative of the open condition preferred by European larch. On lower slopes density is from 100 - 170 trees per acre. Trees are up to 60 ft. with a B.H. Q.G. of up to 12 in. Volume per acre varies from 1,200 cu.ft. to 1,800 cu.ft. per acre.

Japanese larch

The area stocked with Japanese larch extends to 101 acres. During the war years this species was fairly heavily thinned and stocking at present varies from 300 - 450 according to rate of growth. Thinnings are desirable at three year intervals.

Douglas fir

Douglas fir area 87 acres, because of its susceptibility to windblow requires careful thinning on all sites and particularly on exposed sites. All of this species is now in the subsequent thinning stage with the exception of P.28 which received its first thinning in F.Y.50. Volume removed per acre amounted to 550 cu.ft. Much of this area has suffered from wind damage and affected stems were removed. The standing crop is fairly rough but now appears to be stable. This was a scrub area prior to planting. In Compartment 134 a plot of Douglas thinned in 1937, 1940, 1941, 1942 and 1945 now stands at 260 per acre with an average Q.G. B.H. of $8\frac{3}{4}$ in. and an average height of 67 ft. to $2\frac{1}{2}$ in. top diameter. The

volume per acre is 4,600 cu.ft. Thinnings are desirable on a three year rotation.

Norway spruce

Of the 1,154 acres stocked with Norway spruce approximately 450 acres are in the thinning stage and are located below the county road and on the more sheltered areas above the road in P.14, P.17, P.18 and P.19. Because of its use as a utility species up to the early twenties the rate of growth is most uneven and varies with the character of the soil and the degree of exposure. The thinning stage is reached in groups. On the deeper soils and where sheltered light thinnings at three year intervals and on the slower growing exposed sites thinning at six year intervals is sufficient.

Yields per acre from first thinnings vary from 200 cu.ft. to 300 cu.ft.

The best stands are to be found in P.14 and P.16 on the lower slopes where stocking is 550 per acre, average timber height to $2\frac{1}{2}$ in. top diameter is 50 ft. and average Q.G. B.H. $7\frac{1}{2}$ in. Volume per acre is just over 5,000 cu.ft.

Sitka spruce

Sitka spruce area 800 acres. The bulk of this area has reached the thinning stage. Growth is rapid and thinnings are required at three year intervals. Yields are heavy in comparison with other species. First thinnings in the P.27 area Compartments 197, 198, 199 and 200 carried out in F.Y.48 gave a yield of 600 cu.ft. per acre. Second thinnings due in current year (F.Y.51) have been marked and measured in Compartments 199 and 200 and thinnings amount to 640 cu.ft. per acre. Rate of growth in the P.27 area is similar to Research Sample Plot P.24 where the annual increment is 410 cu.ft. per acre at 26 years.

Subsequent thinnings in the older stands done in the current year average 800 cu.ft. per acre. Stocking on these sites varies from 300-370 stems per acre, overall timber height is up to 74 ft. and average Q.G. B.H. $9\frac{3}{4}$ in. The volume per acre is around 7,000 cu.ft.

Many trees are approaching 100 ft. and the following measurements are of one of these in P.15.

Height	102 ft.
Q.G. B.H.	$18\frac{1}{4}$ in.
Q.G. Half height	12 in.
Volume	102 cu.ft.

The following table, Table VIII, gives particulars of some of the best stands:-

TABLE VIII

Compt.	Species	P.Yr.	Age	Geology and Soil	(a) Altitude (b) Aspect (c) Slope (d) Exposure	Mean Height of Dominants (ft.)	Mean Annual Height Increment	Volume of Thinnings Removed (cu.ft.) (per acre)	Standing Volume cu.ft. per acre	Total Volume cu.ft. per acre
118	S.S.	22	29	Thin layer of peat overlaying moderately deep mineral soil. Moist.	(a) 470 ft. (b) S.E. (c) Moderate (d) Moderate	50	1'8½"	751	4320	5071
136	E.L.	16	35	Mod. deep coarse mineral soil with good natural drainage.	(a) 230 ft. (b) E (c) Moderate (d) Sheltered	52	1'5½"	797	1820	2617
136	S.S.	16	35	Deep moist mineral soil on small flat.	(a) 240 ft. (b) S.E. (c) Gentle (d) Sheltered	74	2'1"	1984	6136	8120
132	D.F.	15	36	Mod. deep mineral soil, gravelly.	(a) 220 ft. (b) E. (c) Gentle (d) Sheltered	67	1'10"	1003	4454	5457
132	J.L.	15	36	Deep mineral soil, good natural drainage.	(a) 220 ft. (b) E. (c) Flat (d) Sheltered	59	1'7½"	648	3179	3827
137	N.S.	16	35	Moist shallow peat overlaying deep mineral soil.	(a) 380 ft. (b) N.W. (c) Gentle (d) Moderate	50	1'5"	607	5009	5616

Research

The Forestry Commission took over Inverliever Forest from the Office of Woods in 1920 but from the beginning Inverliever was one of the original State Forests together with Hafod Fawr in Wales and certain plantations in the Isle of Man acquired for experimentation in afforestation.

The present Chairman of the Forestry Commission Lord Robinson (then an officer of both the Board of Agriculture and Fisheries and the Office of Woods and Forests), and John Boyd, the Forester resident at Inverliever laid down about 50 experiments, or more properly, demonstration areas, in woods planted between 1909, when the forest was acquired by the State, and 1920. Most of the original experiments were examined in 1927 by Commission Research Officers when a report on Inverliever as a pioneer plantation was drawn up, and twice since that date the original experiments have been scrutinised and records made of the conditions found in each. Many of the original experiments were on the poorest ground types, and, as turf planting was employed only in a few cases, a number of the original plantings failed badly.

Much of the most important research work, however, carried out by Robinson and Boyd at Inverliever in the pre-Commission days was their scheme of vegetation types, and the fact that the vegetation type was listed for each of the experiment sites was of remarkable interest and value during subsequent inspections. A copy of the original Inverliever vegetation types is appended, Appendix III.

The first experiment to be laid down by the Forestry Commission after the Forest was transferred to this new body was a spacing of Sitka spruce experiment in 1921. This had the fault of several of the earliest trials, in that there were no replications and the ground was too irregular. Furthermore planting was by direct notch often into wet peat so that failure of those parts was extremely heavy. By 1950 some of the close planting and best mineral soil slopes had grown into very large trees. The bulk of the areas was, however, still in check.

In August 1939, five permanent sample plots (Nos. 116, 117, 118, 119 and 120) were established in a sixteen year old plantation adjoining Arinechtan.

Of these plots, four were in Sitka spruce and one in Japanese larch. The thinning treatment, which was to be continued at three yearly intervals, specified that in the Sitka spruce plots 116 and 118 were to receive moderately heavy low (C/D) thinnings while for comparative purposes plots 117 and 119 were to be thinned to light crown (L/C) grade. A heavy low (D grade) thinning was to be carried out in the Japanese larch.

Although the Sitka spruce plots then had an average top height of 37 ft. competition was not yet severe and the trees had 75 per cent of live crown. The first thinning was therefore more on the lines of a pre-thinning, and was directed against ditch or drainside trees and misshapen dominants. In this way the volume removed per acre averaged 150 cu.ft. Q.G. U.B. By 1942 conditions had become crowded and this thinning yielded 964 cu.ft. per acre Q.G. U.B.

After the fourth thinning in 1949 the total yield from thinnings averaged 1,800 cu.ft. Q.G. U.B. and treatment will again be required next year. Top height at 26 years is now 65 ft.

With a top height of 41½ ft. at 16 years of age the Japanese larch surpassed the Sitka spruce, but has now fallen behind by almost 10 ft. The Japanese larch had a very poor appearance and stem form at establishment, but four heavy thinnings have removed the most defective and the present stand of 203 trees per acre with deep symmetrical crowns promises to give an excellent final crop.

In 1938-39 three experiments were laid out to investigate the effects of various intensities of pruning of the dominants in a pole sized crop.

The species concerned were Norway spruce, Sitka spruce and Douglas fir. The treatments planned to take place every four years included pruning to the lowest live branch, to the second live whorl and also a drastic treatment in which pruning was progressively carried to 50%, 66% and 75% of the total height of the tree.

In addition pruning at different times of the year was studied and also the effect of low thinning compared to crown thinning on the development of the pruned stems.

Pruning was to be carried to a height of 30 ft. and was practically completed in two stages in 1938 and 1946. (Owing to the war the original plan for treatment every four years was abandoned).

The preliminary results showing the size of the knotty core obtained under the different regimes are shortly to be written up and a brief summary of the results is:-

(i) Pruning of live branches is essential to keep the core reasonably small.

(ii) Pruning up to and including the second live whorl is a practical treatment and does not affect the vigour of the tree.

(iii) The need to make certain that only dominants are pruned and that thereafter competing trees are removed so that they are not suppressed and the expenditure on pruning lost.

In 1948 at the request of Director (Scotland) a small plot was taken over by Research Branch to observe the development of regeneration under a crop of P.16 Sitka spruce. After two seasons' work it is apparent that the seedlings are making no progress while the numbers are decreasing.

Conclusions

(i) Preparation of Ground and Drainage

The methods adopted to prepare the ground for planting and the intensity of drainage are dealt with briefly in the text. In view of the fact that large scale planting ceased in F.Y.28 none of the modern methods of draining and soil preparation by means of tractor drawn ploughs were carried out at this Forest. There is little doubt that had the hinterland peats been plough drained much of the areas now in check would have been thriving pole stage plantations (if not carrying larger timber) at the present time.

(ii) Selection of Species

It was at this Forest that the first attempt to correlate the choice of species with existing vegetation types was made in this country. Inverliever Forest was, from the beginning, a large scale experiment in afforestation on ground considered to be typical of vast areas in the West of Scotland. The existing plantations at this Forest and elsewhere in the locality did not at the time provide any useful guide as to which species might be expected to thrive on the more exposed and poorer soil types since they had been formed on the richer slopes and valley bottoms. As might be expected certain initial mistakes were made, particularly with Scots pine on exposed sites, with Norway spruce on the hinterland and with Abies pectinata

and Douglas fir. These mistakes were quickly recognised and as a result of a careful survey which was made between 1913 and 1918 of the plantations which had already been formed and of the vegetation types on areas scheduled for future planting, the original assessment of planting sites was thoroughly revised. The selection of species in force from 1919 until planting was completed in 1932 is materially that adopted for similar sites at the present day. Certain sites originally planted would be classed today as doubtfully plantable even with modern intensive methods of draining but otherwise the choice of species subsequent to 1918 has proved to have been basically sound.

(iii) Future Plantations

Only some 600 acres of the original acquisition are scheduled for future planting. 480 acres of this will not be carried out until after the outgoing of the present tenants of Torran and Arichamish farms. The recent acquisitions of Moalochy and Barnalein, both of which march with the original area, will provide some 1,100 acres for planting (including some 250 acres of oak, hazel and birch scrub) in the near future at the rate of 200 acres per annum.

(iv) Rate of Growth and Volume from Thinnings

Details are given which indicate the extremely rapid growth of most conifers - particularly of Sitka spruce - on the rich slopes in this area of high rainfall. Many of the Sitka spruce have averaged almost 3 ft. in height growth per annum since planting and even in the older stands now some 43 years old, this rate of growth is being maintained. The heavy and frequently repeated thinnings also give evidence that volume increment has not yet reached its peak. By normal standards many stands of Sitka spruce would appear to have been drastically overthinned and yet when viewed on the ground there is not one area of thinned Sitka spruce which could not have had more trees removed with advantage or which appears to have suffered in any way from overthinning. This is borne out by the data from Sample Plot S.116 and general experience over a number of stands of the same species.

(v) Roads and Extraction

The road work completed and proposed has been detailed, and

mention has been made of other means of extraction. The Forest, up to the present, has demonstrated that water transport for produce, either as cargo on a launch or as rafts of poles, can be costly. It is also uncertain on such an exposed loch, and difficult due to lack of tides. Water transport should be avoided if the material can be put on wheeled transport at an early stage in extraction. The Forest has illustrated that stage construction of roads is a sound policy provided the main arteries are passable for ten ton loads. The conversion of feeder tracks (unmetalled) to main all-weather metalled roads should be the next stage of construction as the size of timber increases. Stage construction, however, is sometimes difficult where timber merchants are working in the area. Inverliever has shown us that Argyll County Council "B Class" roads may not stand up to timber traffic from our forests. This is an important point when so many forests in this county are served only by such roads.

During the period under review, horse drag, tractor drag, chutes, wire ropes and most forms of wheeled transport, together with water transport, have all played a part in extraction. It is felt that all are useful in certain circumstances and each must be perfected in detail to be integrated into a sound, overall, extraction system.

(vi) Labour and Housing

Tables III, IV and V are interesting and instructive. There may be few authentic records of this sort at other forests to give evidence of the general trend of employment and housing on large afforestation schemes. The tables show clearly the advantages of forestry in repopulating the West Highlands. They also serve a useful purpose in indicating the numbers of workers required at varying stages in afforestation per 100 acres of plantation. The tables must, of course, be read in conjunction with the History and allowances made in any general calculation for modern silvicultural methods and mechanisation.

The Forest has also given proof, if proof were needed that the days when adequate labour could be recruited in the surrounding district have gone and that the only solution to this problem is to house our workers on the Forests. Even so, the volumes of thinnings are such that Commission employees cannot cope with all the produce in addition

to the necessary silvicultural work and it has proved necessary to call upon the Timber Trade to carry out much of the thinning. This in turn has pointed to the need to provide housing and sawmill sites for the Timber Merchants.

(vii) Risks

This Forest has demonstrated that it is possible to free a large area of rabbits, less possible to keep out sheep and completely impossible to rid it of roe-deer. The presence of roe-deer will always subject areas of natural regeneration, replanting and underplanting to damage from browsing but this damage can be reduced if sufficiently large areas are tackled systematically in blocks and stalking and driving are sensibly planned. Fencing off areas of regeneration and underplanting internally should only be resorted to if all other measures fail.

Wind damage has been observed at Inverliever for a number of years. In every case it has been possible to discover the reasons for the damage. In some cases this has been due to serious neglect in thinning or draining, in others to clear felling for road lines and in yet others to the planting of shallow soils over rock. Nevertheless, the hurricanes in the first week of January 1952 have indicated that winds of gale force can be capricious and that there will always be blows even in areas where silviculture and management have been sound. It is encouraging to note that although the wind velocity in in the gales of January 1952 exceeded 100 m.p.h., less than .3% of the volume at risk was blown.

(viii) General Conclusions

Inverliever Forest is now at the stage which many West Coast Forests will reach 10 to 15 years hence and for that reason it is of exceptional interest. An examination of its silviculture and management can provide, in advance, warning of the problems which are likely to arise elsewhere in areas of rapid growth and inadequate labour and road systems and suggest how these problems should be solved.

Perhaps the most interesting lesson in silviculture that this Forest offers is the ability of Sitka spruce to survive 40 or more years of check and then, as soon as there is an amelioration in conditions, its ability to make growth every bit as rapid as in any newly

planted area. This phenomenon can be observed on the inadequately drained hinterland peats where what was once an irregular patchwork of checked areas and strongly growing stands along the sides of the burns has been gradually filling up for many years to form substantial blocks of established plantations. The reasons for this rejuvenation of the Sitka spruce are not fully understood - probably increased mycorrhizol activity, shelter and improved drainage spreading from the trees not in check all play their part - but what is clear is that it is unwise to write off any Sitka spruce until it is unmistakably dead. Much unnecessary beating up and replanting might have been avoided if this lesson had been more generally understood.

This object lesson in the need for patience will be nothing new to Continental Foresters but should help to curb the impetuosity instilled in many junior Forestry Commission officers by the phenomenal success of many of our younger plantations.

APPENDIX I

Notes from Inspection Reports and Other Documents

Inspection Reports

11.9.26	Chairman's Inspection
17/18.9.27	" "
30.5.31	" "
19.9.32	" "
11.6.34	" "
13.6.35	" "
31.5.37	" "
9/11.5.38	" "
2.9.40	" "
4.9.42	" "
10.7.43	" "
11.7.43	Report on Forestry Advisory Committee's Visit
30.8.44	Chairman's Inspection
30.10.44	Director's Visit
22.8.47	" "
8.4.48	" "
7.3.49	" "
17.6.49	Chairman's Visit
8.6.50	Director's "
10.6.51	Chairman's "
11.6.51	" "

Other Documents

1912-1913	Joint Annual Report of Forestry Departments
1912-1913	Forester's Annual Report
1918-1919	" " "
28.2.20	Chairman's memo. No.116 covering summarized statement of Mr. John Boyd's ten years' experience.
18.5.20	Chairman's memo. to Mr. J. Boyd
16.10.22	" " " Mr. J. Sutherland
10.5.23	" " Review of results up to 1923.
3.1.28	Chairman's memo. 394/27

Notes from Inspection Reports and Other Documents

Instructions and recommendations made in the reports and other documents cover all branches of forestry from the acquisitions of land to the final utilisation of the timber.

The earliest reports deal with the selection of species. It was noted early that Scots pine was not a suitable species and at a later date that Norway spruce was inferior to Sitka spruce for the more exposed sites. It was also considered that Douglas fir and European larch were being planted on a too wide variety of sites and instructions are given that these species be planted only on wholly suitable sites.

The classification of land suitable for planting is revised in view of the results obtained from early plantations and much of the marginal type of forest land planted in the earlier years is classified as unplantable. The need for a careful classification of land in acquiring bare land for planting is pointed out and attention is drawn to the difficulties of successfully stocking these bare land areas.

In dealing with drainage, reports refer to the necessity for locating drains in a position where they will do the maximum amount of work and drains other than the contour type are criticised. The need for trap drains at the foot of slopes and around flats is emphasised. The difficulties in stocking heather areas is dealt with and heather burning followed by mattock and circular spade planting plus an application of basic slag at the time of planting is advised on these sites. On other similar sites where plants were at a standstill improvement to drains by breaking the pan layer and the impervious clay is instructed. For stocking these areas a mixture of Scots pine or Sitka spruce with birch is recommended.

The replacing of sickly looking plants by beating up is condemned in many of the reports. Experience had shown that a great many of these plants eventually came away and beating up in addition to being a waste of time and plants caused overstocking. Instructions were also given that necessary beating up was to be completed on the lower better class sites before attempting to deal with the high exposed moorland areas. Further expenditure on these checked areas is not advised.

The need for selecting frost hardy species for low lying hollows is emphasised as repeated frost damage might lead to insect and fungi attacks which might not only be confined to frost affected trees, but become more widespread.

In reports dealing with thinnings the need to thin timeously is stressed again and again. In 1927 instructions were given that the absence of a market for produce resulting from thinnings should not be used as an excuse to delay thinning. Thinnings were to be done even if produce was to be left lying and this work was to be given priority over all other than necessary forest operations. The same instruction is issued in later reports regarding inaccessible areas where there were extraction difficulties.

From 1940 onwards the thinning of Sitka spruce is constantly referred to as being too light. A heavier grade was essential if a three years thinning cycle was envisaged.

In order to safeguard against damage by wind, attention is drawn to the necessity for timely thinning, maintenance of drains and the risk arising from planting too close to drainsides.

In restocking areas resulting from windblow instructions are given that where animals are present areas must be fenced, rides must be left for extraction purposes, necessary fellings must be made away from the restocked area and until stocking by natural regeneration is successful all restocking must be done by planting. The species recommended are Abies grandis, Tsuga heterophylla, Sitka spruce and beech. In all cases sufficient width must be left between the standing crop and the young plants in order to allow both to develop freely. In underplanting larches the use of Norway spruce and Tsuga is recommended.

Reports also deal with the various methods of extraction and these include the use of wire ropeways, railway, chutes, tractor and shipping across Loch Awe by boat.

The construction of roads within the forest and the improvement to the County road running through the forest is dealt with. In all road work the need for good drainage and the removal of overhanging trees is stressed.

More recent reports deal with the creating of a central conversion Depot, improvements in water transport and seasoning of produce.

APPENDIX II

Supervision

The officers in control of the area since afforestation commenced to date have been as follows:-

While under Office of Woods Management

Executive Officers

1909 - 1912	E. P. Popert
1912 - 1920	Mr. R.L. Robinson (now Lord Robinson)

Field Officers

1909 - 1920	A. H. Crosfield

Foresters

1909 - 1920	J. Boyd

Under Forestry Commission Management

Conservators

1946 - 1948	A. Watt
1948 to date	J. E. James

Divisional Officers

1920 - 1922	A. D. Hopkinson
1922 - 1934	J. M. Murray
1934 - 1938	O. J. Sangar
1938 - 1939	A. H. Gosling
1939 - 1945	J.A.B. Macdonald
1945 - 1946	A. Watt
1947 - 1948	J. E. James
1949 to date	H.V.S. Dier

District Officers

1920 - 1922	A. Graham
1922 - 1925	Vacant
1925 - 1938	W. H. Whellens
1938 - 1939	R. J. Waterman
1940 - 1944	H.V.S. Dier
1944 - 1947	T. E. Edwardson
1947 to date	J. Chrystall
	G. DAY N. PANNETT A. ALEXANDER P. QUELCH A STEWARSON
	J. Rees 1992 - 1996 - 1981 1981 - 1983 1985 - 1992 1983 - 1985

Foresters

1921 - 1929	H. Cameron
1930 - 1936	J.D. MacDonald
1936 - 1948	J. Kennedy
1948 to date	E. Crozier
	I McKENZIE
1971 - 1971	P ARMSTRONG
1971 - MAR 1984 - AMALGAMATED LOCH AWE	G FRANCEY