

FORESTRY COMMISSION

HISTORY

of

CULLODEN FOREST

1924 - 1951

NORTH (SCOTLAND) CONSERVANCY

HISTORY OF CULLODEN FOREST

	<u>Contents</u>	<u>Page</u>
<u>CHAIRMAN'S COMMENTS</u>	...	1
<u>DIRECTOR'S COMMENTS</u>	...	2
<u>GENERAL DESCRIPTION OF THE FOREST</u>	...	3
Situation	...	3
Area and Utilisation	...	4
Physiography	...	6
Geology and Soils	...	6
Vegetation	...	8
Meteorology	...	9
Risks	...	9
Roads	...	11
Labour	...	11
<u>SILVICULTURE</u>	...	12
Preparation of Ground	...	12
Choice of Species	...	12
Planting	...	13
Ploughing	...	14
Beating up	...	15
Weeding	...	16
Mixtures of species	...	16
Rates of Growth	...	17
Past treatment of Established Plantations	...	17
Utilisation of Produce	...	18
Research	...	19
Conclusions	...	20
Comments by Conservator	...	21
<u>APPENDICES</u>		
I	Notes from Inspection Reports	24
II	Record of Supervisory Staff	26
III	Schedule of Height Growths	27 - 28
IV	Photographs	
V	Map of Forest.	

HISTORY OF CULLODEN FOREST

CHAIRMAN'S COMMENTS

I agree that this is an excellent history, well written and illustrated by good photographs. In those respects it is one of the best histories that I have yet examined.

The first inspection of which I have a record was with Messrs. Scott and Oliver in September 1929. The two points of main interest were:

- (1) The treatment of the poorly stocked Scots pine woods (Compartments 40, 47, 48, 49) adjoining Culloden Moor.
- (2) The thinning of the acquired plantations (P.06) which I had evidently commented on at an earlier (unrecorded) inspection.

With regard to (1), what we did to begin with was largely guess-work, and I gather not attended with much success. The planting of Tsuga has apparently had some success, but there is a risk of butt-rot at an early age. As we now know, deep cultivation is the key to success on these moorland soils, but time was required to find appropriate methods.

As regards (2), we were late in beginning thinnings and did not consistently stick to the job. (Sixteen years later I noted (a) the difficulty of getting thinnings made on a systematic plan; (b) the way in which fast growing plantations tend to get out of (thinning) control). Thereby we run unnecessary risks of windblow and though in the event there was not much of it, I think we were luckier than we deserved to be. The last time I saw these plantations they looked very well.

In 1947 I criticised the over-elaborate roads in the "Battlefield Area", for which I could see little if any justification.

R.

3/3/52.

DIRECTOR'S COMMENTS

Culloden is among the most interesting of our forests: it has a wide range of soil conditions, varying from the fertile loam of the lower north facing slope above Culloden house to the hard packed drift covered by shallow tough peat of the area near the battle field or Dundavie Moor: it has the exceptionally fine P.06 stand of Douglas fir which has given us so much thinning experience; and the whole area, excluding the most recent acquisition, is largely growing into a mixed uneven aged forest, which is probably the most desirable development we could hope for.

Mr. Fraser's comment to the effect that we should not be too alarmed by signs of butt rot in the Douglas fir and his general remarks on natural regeneration are very sound.

H. C. E. P.

31st January, 1952.

HISTORY OF CULLODEN FOREST

GENERAL DESCRIPTION OF THE FOREST

Situation

Culloden Forest proper is situated in the Culloden district of Inverness-shire in the parishes of Inverness, Bona, Petty, Croy and Dalcross. The Cairn commemorating the battle of that name stands on the boundary of the forest. The area lies 4 - 6 miles by road due east of Inverness, and is served by two main railway lines, with stations at Allanfearn and Culloden Moor. They are 2 miles and $\frac{1}{2}$ mile respectively from the nearest points of the area. The whole forest is well served by public roads.

Dundavie section of the forest, which is a recent acquisition, lies approximately 4 miles south east of Inverness in the parish of Daviot and Dunlichity. It is bounded on the east by the main road from Inverness to the south, and on the west by the old Edinburgh road. Near the southern boundary, a public highway intersects the area. The Daviot railway station is one mile distant from the nearest point of Dundavie. From the northern end of Dundavie to the Culloden sawmill is 4 miles.

Dalcross section, another recent acquisition, is situated in the parish of Croy and Dalcross. It is 7 miles east-north-east from Inverness. The main Inverness - Culloden - Cawdor road passes the extreme south corner of the area. Part of the north east boundary is formed by a good county road which connects with the Cawdor road. Culloden Moor station is $1\frac{1}{2}$ miles distant by road from the south end of the area. The distance between the nearest points on Culloden station section and Dalcross by public road is $1\frac{1}{2}$ miles.

Area and Land Utilisation

Acquisition details and land utilisation as at 30.9.51 are given in the following tables (Tables I and II).

TABLE I

From	By	Date	Plantations acquired	Plantable excl. Col. 4.	Nurseries	Agricultural	F. W. H.	Unplant- able excl. Col. 4.	Other Land		Total
									Description	Acreage	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Culoden Trustees	Fen	25.7.24 2.9.25	94.2 91.3	535.097	-	-	-	3.4			
<u>Dispositions</u> To Mrs. J. A. Donald or Thomson	Sale	1926	-	- .224							
Inverness County Council	Fen	8.9.27	-	- .034							
Resurvey Jan. 1949 increased area by			-	+ 2.400							
Plantations felled 1939-45			-39.9	+39.9							
Total areas on hand Culoden proper			145.6	577.139				3.4			726.139
J. A. Mackie	Pur-	25.11.49		855.5				10.5			866.
Mrs. Anne Warre	Fen	19.11.49	10	288				4			302
Totals	-	-	155.6	1720.639				17.9			1894.1

Unplantable
Housing sites
St. Mary's Well area
Hydro-Electric power lines

7.1 acres
.3 acre
10.5 acres

TABLE II

(a)	<u>Plantations</u>		
	Acquired	155.6	
	Formed by Forestry Commission	1055.6	1211.2
(b)	<u>In hand awaiting planting</u>		
	Blanks after felling		
	Burnt areas		
	Other Land	365.0	365.0
(c)	Nurseries	-	
(d)	Agriculture	-	
(e)	Forest Workers' Holdings	-	
(f)	Unplantable land in hand	10.5	10.5
(g)	Grazing let temporarily	300.0	300.0
	Housing Site (Culloden)	3.1	3.1
	Housing Site (Dalcross)	4.0	4.0
	St. Mary's Well Area	.3	.3
	Totals	1894.1	1894.1

Unplantable land (f) will remain permanently unstocked - Hydro-Electric power lines.

300 acres on Dundavie section are let presently to a sheep farmer. This will be resumed in 1952 for planting in F.Y.52/53.

Physiography

The original area of Culloeden lies on the ground sloping northwards towards the inner Moray Firth. It has a generally north aspect, varying in elevation from 200 ft. - 500 ft. above sea level.

On the Dundavie section, the greater part of the area is mainly flat. At the southern end the ground rises rather steeply from the River Nairn. The elevation range is from 540 ft. - 930 ft.

On Dalcross, the northern part lying next the High Wood is mainly undulating. South of the road from the Castle to Easthill, the ground is of a flattish nature. Elevation varies from 300 ft. - 450 ft.

Exposure is moderate, except on Dundavie where the ground is fully exposed to the north and west winds. At Dalcross, areas of natural pines on the adjoining property afford some shelter from the west winds.

Geology and Soils

The forest lies on the Middle Old Red Sandstone formation, and this is nearly everywhere overlaid with glacial deposits.

This glacial drift is of Old Red Sandstone origin, and contains pieces of shale, flagstones, etc., from this series, as well as pebbles of granite derived from the Old Red Sandstone conglomerate, large pieces of which may be found, together with other debris along the edges of the fields between east and west blocks. This glacial deposit is normally fairly deep with a high boulder content. It is a yellowish brown colour, and is practically impervious both to air and water, but, when broken and exposed, is capable of weathering into a brown coloured soil. Tree roots as a rule do not penetrate into the drift unless it is fissured.

In the main blocks of Culloeden, two main soil types can be distinguished. Within these two groups, there are minor variations, especially in the second group, but fundamentally these variations are slight and are dependent on the depth the drift layer lies below the surface of the soil. These two soil types are as follows:

Type I

This type covers the richer soils developed on the steeper slopes, and is formed by the movement by ice or water action of the top soil from the higher slopes to the lower; in other words, caused by the readvanced moraine. Such soils are to be found on the lower reaches of the steeper slopes. There is a greater deposition of soil on top of the drift

layer, and, owing to the freer water movement on the slopes, the drift layer is not so compacted. The soil depths in this type normally extend to a depth of 18 in. - 24 in. on top of the drift layer with distinct signs of leaching in the upper layers. This type is mainly confined to the areas lying to the north of the railway line and in particular to Compartments 1 - 6, or the acquired plantation P.06 and the Commission P.29 area. On the south side of the railway line opposite P.06, one finds the same type of soil, although slightly shallower, extending to one or two chains' depth from the railway line. The better quality of this soil is reflected in the volume production, as can be seen in Appendix III - Height Growths. The chief species on this type is Douglas fir.

Type II

The more general type of soil is to be found on "flats" where the drift layer is much nearer the surface. There are many variations within this type, as can be seen in Appendix III - Height Growths, but these variations and the consequent soil qualities are related to the depth below the soil surface at which is found the drift layer. Closely allied to this, is the degree of drainage impedence and its effects on the soil profile which vary from iron depositions to complete waterlogging of the soil to within a few inches of the surface with consequent gleying of the lower layers and a development of a deeper acid peat layer. Local variations are numerous, e.g. where streams traverse an area, greater soil depositions due to washing yield slightly better soils

As a general rule, the soils within this soil type are better in the west block than in the east block, as the area on the south side of the railway line lies on a gentle slope, whereas in the east block, apart from the north east corner, the ground is fairly flat. The chief species planted in the west block are Scots pine, Douglas fir, Norway and Sitka spruce, European and Japanese larch. In the east block, the species used are Scots pine, Norway and Sitka spruce, Corsican pine with a little European and Japanese larch and Pinus contorta.

On Dundavie the greater part of the area is overlaid by glacial drift. On the Strathmairn slopes, good stony loam occurs, but on the remainder of the area peat varying in depth up to 9 in. is found,

overlying, where shallow, a brown stony soil. On the peat area natural drainage is generally poor.

The conditions on the greater part of Dalcross are similar to the poor part of Dundavie. There is a tendency to the formation of peat owing to the impervious subsoil. At the northern end of the section, where the surface is undulating, drainage is better, and the soil is of a deeper nature (10 in. - 14 in.)

Vegetation

In the lower (west) block of Culloden, the plant indications point to a soil capable of growing the more exacting conifers. Prior to planting P.06 the ground vegetation was mainly bracken and soft grasses with small patches of heather on the low ridges. The ground also carried a crop of birch scrub. Generally, the description for P.06 would stand for the whole of the west block, except in Compartments 27 - 35 where no birch grew. At present, where there are breaks in the canopy of P.06 and P.12, soft grasses, bracken and Oxalis chiefly are to be found.

On the upper block, the vegetation is mainly Calluna, Erica tetralix and Erica cinerea, with Molinia and Myrica in the poor flushes. Where soil conditions are extremely poor, Scirpus is found in association with stunted Calluna. On a large portion of this block, the ground vegetation is being gradually suppressed by the young conifers.

In the Dundavie section, bracken and grass are dominant at the southern end on the steeper slopes. Patches of Calluna and Erica tetralix also occur. On the higher ground, which mainly comprises the woodland area felled during the war, the vegetation predominating is Calluna, Aira flexuosa and Agrostis. On the flat land to the north, which has been cleared of timber for over 40 years, Calluna and Erica cinerea are dominant, on the dry ground, and on the wet, Calluna and Erica tetralix, with Molinia in the better flushes. Where soil is shallow and rather wet, stunted Calluna, Scirpus and Narthecium are abundant.

The Dalcross block was felled during the 1939 - 45 war. On the better land to the north, grass/bracken and Calluna/grass are chiefly found. On the main block, where soil conditions are poorer, Calluna, Erica tetralix, whin and broom are dominant on the dry ground, and on the wetter soil

Juncus squarrosus, Erica tetralix, Nardus and Molinia are mainly in possession.

Meteorology

Rainfall for the district is from 25 in. - 30 in. The drier part of the year is from April to June inclusive. In Culloden proper and Dalcross area, winters are not severe, owing to their proximity to the Moray Firth. Dundavio, being higher and more exposed, is subject to heavy snowfall at times. Prevailing wind is from the south west.

Risks

The chief danger to the forest has always been that of fire damage, mainly from the railway which runs through the west block and along the eastern edge of the east block. In the early years, small outbreaks were recorded every year, and an efficient system of firebreaks and patrols, in some cases by night as well as by day, was instituted, and has been maintained up to the present. The danger is now much less in the west block, where the woods are mostly established.

Other fire danger points are the site of the Battle of Culloden and Saint Mary's Well. The Battlefield with the Memorial Cairn and the Graves of the Clans lies on the main road, with forest on both sides and is visited by thousands of tourists every year.

Saint Mary's Well, known locally as the "Wishing Well" or "Cloutie Well", is the subject of an annual pilgrimage on the first Sunday in May, when a large part of the population of Inverness come there to make a wish. As the well is situated inside the west block, the danger is obvious, and an intensive system of patrols has so far prevented any serious fires.

The actual losses by fires over the years have been comparatively light, but a considerable sum must have been expended on protective measures during the period. The chief outbreaks are summarised below.

Spring 1929	- 9	acres P.25 and 27 burnt by fire from the railway.
Spring 1930	- 2	acres P.25 and 27 burnt by fire from the railway.
April 1936	- 4.3	acres P.29 burnt by fire from the railway.
April 1942	- 14	acres P.27 and 28 burnt by fire from the railway.
May 1942	- 5.6	acres P.29 burnt by fire from the railway.
April 1942	- 6.5	acres P.29 burnt, origin unknown
May 1946	- 3	acres P.34 burnt, origin unknown.

At Dundavie and Dalcross, fires might arise from muirburning, or might spread from the public roadside, but so far there have been no outbreaks.

Insect pests have given considerable trouble in the past, but are now of rare occurrence.

Pine Weevil appeared first in large numbers in 1927 in the east block, after old pines had been felled for planting. Two acres were attacked, and about 5,000 were trapped in that year. By the following year, 10 acres were affected, and a loss of 50% of the plants was estimated. This was the peak year of infestation, and 12,000 weevils were trapped using billet traps, fresh twigs and fresh sawdust. Thereafter, the numbers decreased, 8,500 being accounted for in 1929 and only 859 in 1930. The decision was then made to delay planting of the western end of the east block, which had been clear felled in 1929 - 30. The wisdom of this was shown by the trapping figures on this area for 1931 and 1932, which showed 80,000 and 89,000 weevils respectively. By 1933, the weevils were under control and the area was planted in 1934, although trapping was continued for a year or two.

The weevils were followed by an attack of Pine Sawfly which was at its worst from 1933 - 35. It was recorded that mountain pine and Pinus contorta were particularly affected.

Adelges cooleyi appeared in the P.06 Douglas fir in 1927, and by 1929 had noticeably affected growth and was spreading to the younger plantations. The attack was over by 1933 and the affected trees showed a good recovery.

After the war-time fellings, the pines in the east block suffered from attacks by Pine Shoot Beetle, but have generally recovered by now.

Damage from vermin has not generally been great. Squirrel damage was obvious among the old Scots pine in the east block, and considerable numbers of squirrels were shot during the early years. The forest is fenced against rabbits and constant trapping has prevented serious damage. A few roe deer seem to have been shot every year, but little damage from this source has been recorded. Their numbers appear to be increasing at present and some damage has been done to Pinus contorta in P.34.

Capercaillie were numerous in the east block, and considerable damage to Sitka was reported in 1932 and 1933. There are still a few in the forest, but these cause no obvious damage.

Heart rot was recorded in Douglas fir felled in P.06 during 1947 and appears to be of general occurrence. In Research Branch sample plots thinned in 1951, the proportion of stems affected among the thinnings was as follows:

"B" grade thinning	79 trees felled	27 affected (34%)
"D" grade thinning	54 trees felled	12 affected (22%)
Mixed plot Douglas fir and Japanese larch.	18 Douglas fir felled	All sound
	20 Japanese larch felled.	9 affected (45%)

The inference is that the rot is more prevalent in the denser parts of the wood.

Roads

The necessity for a road system did not arise until the first complete thinning of P.06, when sales of thinnings made it obvious that a better access to this wood was needed. Accordingly, 40 chains of road and three bridges were built by hand in 1931.

The general road system for the forest had to wait until the larger thinning programme after the 1939-45 war made it essential.

With one or two exceptions, the original ride system was found suitable for road lines.

Formation of roads commenced early in 1947. Main roads required were immediately metalled; others, on account of high costs, were bulldozed and drained only. Their use is restricted to dry weather periods.

The new roads facilitated extraction, so costs were thereby greatly reduced. Fire risks also were considerably reduced after these roads were constructed.

In Dundavie and Dalcross sections, all rides are graded where necessary so that they can be formed into roads at a later stage. Compartments are also sub-divided by narrow extraction tracks, set out at not more than 4 chains apart.

Labour.

Labour problems do not appear to have arisen until the 1939-45 war, but during the latter part of the war period the labour shortage became acute. Women were engaged on brashing and cleaning.

No provision was made for housing men until 1945/46, when three wooden houses were built. One of these was built for a horseman on ground leased from the Gulloden Estates. The other two were erected in Cullernie Wood, Compartment 37.

In 1948/49, 7 brick houses, including one forester's house, were also erected in Cullernie Wood.

SILVICULTURE

Preparation of Ground

The greater part of the west block is naturally well drained and little drainage work was required. Up to 1930, the average intensity of drainage was about 3 chains of drain per acre. This was found to be insufficient in the poorly drained east block, and drainage was more intensive in P.34.

Mounding was done for 3 acres of underplanting with Sitka in the east block in 1930, and it appears that much of the P.34 area was mounded.

Birch scrub in the west block was cleared and the brush burned, a certain amount of firewood being sold. In an area of particularly dense scrub in Compartment 18 (P.26), 2 acres were treated on the drift system. An 8 foot wide strip of scrub was left standing alternating with a 4 foot strip cleared. The brush was burned. During weeding operations, the standing birch was cut back as necessary. This method has not proved very successful.

Heavy growths of bracken and heather were burned and some 40 acres of old pine slash in P.26 area had to be burned.

In accordance with present day practice, the whole of Dundavie has been ploughed with standard ploughing equipment, while, in so far as possible, Dalcross has been disc ploughed.

Stock-and rabbit-proof fences were found to be necessary. Fences of a sort existed on all the boundaries except on part of east block at the west end, where the only existing fence was on the north boundary. A certain amount of new fencing was done and permission obtained from the Railway Company to hang rabbit netting on all railway fences on the boundary.

Choice of Species

In P.06, Scots pine, Douglas fir, Norway spruce, Sitka spruce and European larch may be seen in close proximity. Consideration has obviously

been given to selection of species, but for volume production the Douglas fir has surpassed all the others. Sitka spruce is next best, with the Scots pine showing a lower volume than any.

In the Commission planted areas, choice of species has been generally good. In the lower block a large area of Douglas fir planted from 1925-29 has grown successfully. No doubt, those responsible were guided by the success of the P.06 Douglas fir. In some cases where Scots pine has been planted, Sitka spruce might have been the more suitable species.

In Compartment 28 a small area of Pinus strobus was planted in mixture with Corsican pine. The Pinus strobus has to a large extent been a failure, owing to disease.

Scots pine planted in P.27 Compartment 34 was mainly a failure. They were replaced by larch (Japanese larch and European larch) in 1929. The European larch has not made very satisfactory growth, but appears to be responding to thinning.

Japanese larch and European larch planted in P.34 Compartments 53, 54, 55 and 58, are of poor form. Spruce would have given better results. Natural European larch growing under similar conditions in Compartments 61 and 64 and 65 are much superior. These were about 3 ft. to 5 ft. high in 1933, and at the time of planting were left untouched.

Scots pine and Pinus contorta planted (notched) side by side on a poor Calluna site in P.34 Compartment 53 are making slow progress.

Amongst old pines in Compartment 47 and 48 on a Calluna area, groups of Tsuga heterophylla have been planted about 1928. They have made satisfactory growth, but have suffered to some extent from interference by pine branches.

Planting

In the acquired plantations P.06 and P.12, spacing was close, possibly about 3 ft. The areas planted by the Commission had wider spacing as follows:- Douglas fir, 5 ft. 6 in; Sitka spruce, 5 ft; Norway spruce and pines, 4 ft. - 4 ft. 6 in; Japanese larch varied between 4 ft. 6 in. and 6 ft.

Very few seedlings, if any, were used except in recent plantings (P.50 and 51). The age of transplants was chiefly 2 + 1, 2 + 2 and 2 + 3.

A nursery was started in 1925 and was closed down in 1929. Between 1926 and 1929 a substantial proportion of the planting requirements for the forest were supplied from this, but the first year's planting and part of the succeeding years' plants were supplied chiefly from Seaton, Beaufort and Inchnacardoch.

The normal planting method was notching with a Mansfield spade combined with screening of heavy vegetation from P.26 onward. A limited amount of pit-planting of Douglas fir was done in P.28, but P.29 Douglas was all notched.

Mound planting was done with Sitka in the east block in 1930, using a deep turf, and the method was used in subsequent planting where it was considered desirable.

The rate of planting varied in the earlier years, but in no case exceeded 118 acres which is the figure for P.25. In P.51 the area planted was 322 acres. Between P.34 and P.50 no planting was done except replanting of burnt areas and the part of P.12 felled during the war.

Manuring was only done to a very limited extent in the earlier period, but from 1949 plants on all the poorer soil types were treated.

Seedlings which have been used extensively in the plantings of P.50 and 51 on ploughed ground have not given, up to the present, very satisfactory results, chiefly due to drought following planting and subsequent poor growing seasons.

Ploughing

No preparatory work was necessary prior to ploughing. The disc machine was used for the first time in the upper block of Culloden in 1948, in Compartments 40 - 44. Cultivation was carried out in blank Calluna-Scirpus patches in the old pine wood with a view to obtaining natural regeneration. This machine was again operated in the Dalcross section on a poor type of old woodland prior to planting in 1950.

Ploughing commenced in Dundaivie in the winter of 1949 - 50. Two ploughs were operated, the single and double furrow Outhbertson. Later, a Haddington plough and Elane's Killifer were successfully tried out. Very little was undertaken by the single furrow Outhbertson, its use being confined to a wet area at the north end of the acquisition.

Plants used on the prepared ground were generally small. The ages are 2 year, 1 + 1 and 2 + 1. Spacing of furrows is approximately 5 ft. and as, up to the present, conditions have been rather wet, plants have been inserted at the side of the turf and not in the furrow.

Although a statement on condition and progress of plants is rather premature at this stage, there is now no doubt about the ultimate success of plantings on ploughed ground.

Beating up

It appears that Douglas fir, although now a well grown and promising crop, was extremely difficult to establish, and in every year there was a larger death rate in this species than any other. Repeated beating up was necessary and P.25 was definitely beaten up three times (P. year 26, 27 and 28) and probably more, as it is still recorded as gappy in 1931.

It was considered that the failure was due to the use of large plants (2 + 2 in P.25, 2 + 2 + 2 and 2 + 2 in P.26) and drought following the planting season, and in the later years an effort was made to get smaller plants. In P.28 and possibly P.27 the standard practice in the Division was to pit-plant Douglas, but this method was abandoned in P.29.

Beating up in other species was not excessive, except for areas destroyed in the weevil attacks. It is probable that one of these areas was Compartment 34, P.27, where a change of species took place. The original crop was Scots pine which largely failed, and Japanese larch and European larch were planted. A few pines still remain in the area.

The east block, particularly the east end (Compartments 43 - 52), was difficult to establish and is not fully established even now. In 1933 work in P.26 included working the soil around each plant with a tramp pick to improve drainage, and also slagging. In 1936 it is reported that Sitka spruce thus treated had shown improvement. Intensive draining was carried out in 1936 in Compartment 46 to help get the crop established.

The acquired plantation P.23 Compartment 66 was found to be in a bad state and was beaten up in 1926.

The beat up of the P.51 area will be heavy, owing to six weeks drought following planting.

Weeding

Up to the present, this operation has been chiefly confined to the lower block of Culloden proper. The chief weed species were soft grasses, bracken, broom and whins. Birch coppice must also have been a source of trouble. No serious damage has been done to the canopy by neglect of weeding.

On the areas where plough and disc have been operating, practically no weeding has been required up to the present.

Mixture of Species

Generally throughout the earlier years species have been planted pure. Small areas have become mixed by beating up with different species or by natural regeneration of Scots pine and European larch.

In the east block, a fairly large area is shown on the map as being of uneven age. This consists of acquired Scots pine, natural regeneration of Scots pine and European larch at various stages of development, and planted spruces (Sitka spruce and Norway spruce), Japanese larch and groups of Tsuga heterophylla.

An uneven aged area of wood is also shown on the Dundavie map. This carried a sparse crop of immature Scots pine when the block was acquired. Planting of blank spaces was carried out with Japanese larch in 1950.

In Compartment 28, Corsican pine and Pinus strobus are growing in mixture. Pinus strobus have now largely died out with disease, but fortunately survived long enough to prevent very coarse branching of the Corsican pine.

Mixtures have been extensively used on the poorer types of soil in the later plantings. They are mainly Sitka spruce and Pinus contorta or Scots pine and Sitka spruce. European larch has been planted in mixture with Scots pine. This mixture is also found in the acquired wood P.06.

Except for underplanting of European larch and Japanese larch with beech and filling in of gaps in the old pine wood with Tsuga heterophylla, no underplanting has been done previous to 1931. As already mentioned, underplanting of European larch in P.12 commenced in 1951. The species used was Douglas fir.

Rates of Growth

The appended tables indicate clearly the difference in growth in the east and west blocks.

Note the satisfactory growth of the natural European larch in the east block. Reference is made to this elsewhere in the history.

Past Treatment of Established Plantations

The need for thinning in P.06 was emphasised by a gale in January, 1927, which did considerable damage in the plantation. Accordingly, a thinning was marked and carried out in the autumn of 1927. It appears that a large number of stems were removed, but the absence of any record of produce sales suggests that the thinnings were mostly small and worthless. In view of the planting distance of three feet, this seems reasonable. In all, 40 acres were thinned.

In 1929 it was decided that a second thinning was needed and this, starting in autumn 1929, went systematically through the whole wood and was completed in 1931. The wood was completely thinned again in 1932.

In January 1933 a south east gale blew a gap in the wood, and this may be the reason for the reluctance to do a systematic thinning during the succeeding years. From 1933 to 1941, the wood was worked over in small areas, some parts getting two thinnings and some only one. It was worked over again between 1943 and 1945 and once again some parts received more attention than others. A complete thinning in 1946 was followed by another in 1948-49, and the wood is now due to receive regular thinnings in accordance with the Working Plan proposals.

In 1936, when the Chairman visited it, he pronounced it windfirm, and said it should be thinned normally on a definite programme. That this was not done to his satisfaction is evident from his comments on his visit of 1943 which are quoted in Appendix I.

During the 1929-31 thinning, about 200 stems per acre were pruned to 6 ft. and during the 1932 thinning selected stems were high pruned to 18-20 ft.

The other acquired plantation, P.12, which was also close planted, was first thinned in 1935. The crop was very rough and most of it was felled during the war in 1941, when the remainder (European larch and Sitka spruce) received a thinning. It was again thinned in 1946 and 1948, the

larch being opened up for underplanting.

In the Commission planted areas and the acquired plantation P.23, no thinning was done until after the war, although a certain amount of cleaning, removal of birch, etc., went on during the war years.

Brushing started in 1943, most of the trees in the wood being treated. High pruning to 15 ft. of selected stems was done in 1951 in Compartments 7 and 10.

Thinning started in P.25 in F.Y.47 and continued in 1948 and 1949. At this time, the woods were 22 years old and much too thick, and growth was being somewhat reduced, but in parts thinned for the third time in the autumn of 1951 the trees seemed to have suffered no permanent injury.

There is now a regular thinning programme for the whole of the forest and the aim is to visit the faster growing species (Douglas fir, Sitka spruce and Japanese larch) every two years, and the slower growing species (Norway spruce and Scots pine) every three or four years.

Volume production of P.25 in the first thinning was indicated by the measurement of samples in Douglas fir to be high. In parts, a volume of 800 cu. ft. removed per acre was estimated. The actual average over the whole area was, however, about 235 cu. ft. removed per acre. A fairly high percentage of "wolf" trees was removed.

The area of old pine in the eastern half of the east block, which is presumed to be mainly natural, was found to be considerably damaged by squirrel. The worst stems were removed and gaps were planted with Sitka from 1926 onward, and in 1931 some underplanting with Tsuga was done. A certain amount of natural regeneration has also been obtained. In the last two years (1950 and 1951) a large number of the rough stems have been removed.

Utilisation

The disposal of the early thinnings from P.06 presented some difficulty and local markets had to be developed. The material consisted of light poles and some heavier stuff which would now normally be classed as pitwood. Advertisements in the local papers soon produced a steady demand for rustic poles, netting stakes, stack props, etc., but the disposal of the larger material was more difficult. Lengthy negotiations with a pitwood merchant in Hull resulted in a sample of peeled and seasoned props being prepared,

but high transport costs and low prices caused the scheme to be abandoned.

The suggestion was then made that the sawmill belonging to Culloden Estates should be hired and the heavier timber converted to fencing material. This was tried in the summer of 1930, and detailed costings showed the enterprise to be a profitable one, besides utilizing timber which would otherwise be lost.

In 1932 the sawmill was bought by the Commission and the site leased for 20 years. Between thinnings from P.06 and old pine cut from the east block, a small but steady outturn of fencing material for Conservancy use and for sale was maintained. A hot and cold creosoting tank was installed, and, despite much adverse criticism from time to time, this has served us well.

At the present time, the mill is kept working at full capacity to supply orders of fencing and building material for use in the Conservancy. The forest cannot at present supply enough saw-logs for continuous working, and the deficiency is made up from the neighbouring forests.

An important part of the work at the mill is the prefabrication of buildings such as offices, toolsheds, etc., for outlying forests, and two joiners are kept constantly busy.

The lighter thinnings during the war and after were converted to pit-wood in the forest by Commission employees. In the past two years or so, however, all timber, except European larch, unsuitable for the sawmill, has been sold in the length to timber merchants at roadside.

Research

In December 1926 two permanent sample plots Nos. 79 and 80 were established in a 21 year old acquired plantation at Culloden Forest. This wood had been planted with a mixture of Douglas fir and European larch, but few larch survived the first thinnings and now the stand is pure Douglas fir. Plot 79 has been thinned to a heavy low (D. grade) scale at intervals of 5 years and for comparative purposes, Plot 80 has been given light low (B. grade) thinnings. When last measured in 1946 the D. grade showed a mean annual increment of 169 cu. ft. (Q.G.U.B.) per acre as against 147 cu. ft. (Q.G.U.B.) in the B. grade. Total production from thinnings in the D. grade has been 3239 cu. ft. (Q.G.U.B.) compared with 1175 cu. ft. (Q.G.U.B.) in the B. grade.

Miscellaneous Plot 1 was also laid down in 1926, in a 19 year old mixed plantation of Douglas fir and Japanese larch. The purpose of this plot was to try to maintain a mixture and although the Douglas fir now dominate the Japanese larch by almost 20 ft. additional height, the object has to a certain extent been achieved for the present stand comprises 91 Douglas fir and 104 Japanese larch. The average (breast height) girth of the Japanese larch is, however, only $29\frac{1}{2}$ in. while that of the Douglas fir is 43 in., so that with such a disparity of growth it is unlikely that this mixed plot can be preserved much longer. Altogether 2600 cu. ft. (Q.G.U.B.) per acre has been removed by thinning, of which volume 75% came from the Douglas fir and 25% from the Japanese larch.

Plot 191 is in an excellent stand of Quality Class I Norway spruce in Compartment 7. This plot was established in 1949 when the crop was 24 years old. Top height was then 51 ft. and the total crop yield 2784 cu.ft. per acre (Q.G.U.B.)

All these sample plots are due for thinning and remeasurement in 1951.

Conclusions

A considerable sum of money has been spent on protective measures along the railway side, but with modern methods such as the use of a bulldozer a saving could be effected. The earth track formed would make a useful addition to the existing road system. The grazing of a strip of land on the railway side, which is now recognized practice, would in this case be uneconomic on account of the narrow area involved.

Growth in parts of the upper block has been very irregular owing to unfavourable soil conditions. The present method of dealing with this type of ground would be to break it up by ploughing, if practicable, or disc, before planting.

Culloden Forest History

Comments by Mr. J. Fraser, Conservator (North) Scotland

Thinnings

The thinning comments of most importance refer chiefly to the thinnings of P.06 Douglas fir, and, in assessing now the value of the comments and the results obtained, the undernoted facts appear to me to be true and to be worth consideration.

The first removal of the rogues and the first thinnings were too long delayed, and in that delay we were in error. At the time when first thinnings did begin, the thinnings made were too light, and the fear of wind damage following on removal of rogues was too big. There again we were in error. At that time, there was a wide-spread fashion of making bold thinnings because those had not proved very harmful in many places. We had, however, received a few lessons that there were risks, and caution in making bold thinnings was fully justified. One thinning grade or one method of thinning is not necessarily the correct prescription over a whole wood, even over a small wood. At the present time, there are parts of P.06 where advocates of bold thinning may state that the number of trees is too high. When the most adverse criticism of our thinning has been made, it is still true that a wood which was in a dangerous condition was successfully dealt with and taken through a critical period with very little storm damage. Success is indicated in the fact that the trees are still growing vigorously and are wind-firm, and the trees still possess the power of responding to thinning. The size and the rotation of this crop in the end will probably be fixed by the time which the trees can stand up against root rot.

In P.25, A.M. Fraser's courage in dealing with Douglas fir rogues in his thinning of P.Y.47 and 48 is worth remembering, and to his credit it should be recorded that he was careful not to attempt complete removal of those in one operation. In the Forest Year 1951 the same woods required thinning, and rogues still remained after the thinning. Scarcity of labour in war years had delayed an operation which possibly might have been done in one operation, if the removal had been done sooner. In P.25 also, it can be claimed that the main crop has not been damaged. In P.25 also, A.M. Fraser has tried to keep a cover of suppressed trees in small holes where

the crowns of dominants do not yet cover the soil.

Root Rot

On the evidence which we have been given up to date, there is no need to conclude that root rot is related to the thinning grade. If an examination is made even yet of the prevalence of root rot in the stands of European larch in the High Wood (belonging to the Earl of Moray and lying very near to Culloden), the results are surprising. The crop was big sized larch of fine growth and appearance; the subsoil is a compact gravel. The larch crop was a very open crop. War fellings of Douglas fir of excellent quality grown at Conon were heavily infected with root rot. Much safer conclusions might be to accept the risk of root rot in Douglas fir and to plan rotations in an uneven aged crop so that we can harvest the crop when the loss of wood becomes significant.

Scots Pine Natural Regeneration and Burning

Although most of us have become convinced that burning is a necessary preliminary to natural regeneration in certain soil and vegetation conditions, Culloden gives a useful lesson in showing that burning alone is not sufficient in all cases to secure germination alone. The hard burnt area within the natural regeneration area at Culloden carries the poorest crop of seedlings. Although one would not expect successful growth on the area before it had been disced and drained, it would have been natural to expect a heavy crop of one year seedlings following on the heavy Scots seed year of 1948/49. We got poor germination and poor growth.

Natural Regeneration of European Larch

The easy germination and successful early growth of European larch both in P.34 and close to the railside in the Scots natural seeding area may supply some useful information, when considering the future regeneration of mixed Scots and Larch crops. The seedling larches appear to be able to establish themselves in a light grass cover more easily than does the Scots; larch appears to germinate most readily on good mineral soil with a natural cover of grass and heather. In Culloden as in Strathspey, the natural larches seem to get away in the cleared patches before the Scots.

"Other" Natural Regeneration

Small patches of Sitka spruce have germinated in conditions which appear to indicate that the tree might be regenerated without surface working of the soil. Very small patches of Japanese larch have been found. Even single seedlings of Douglas are rare.

What has been seen of natural regeneration at Culloden suggests that the forester should accept natural regeneration when he can get it at small expense, but that, until he learns more about the conditions necessary for natural regeneration, it is far cheaper and more satisfactory to rely on planting.

Selection of Species on Heather Ground

Work at Culloden always suggests to a forester that, if he knew and understood a little more about what conditions favour heather growth, he might be more confident in his selection of forest species. The changes in soil vegetation, soil quality and fertility within small areas are very quick on Culloden, and within the Scots natural regeneration area the changes are very quick and are difficult to understand. An understanding of the growth conditions in which heather thrives might be much more productive of results in forestry work than searches for toxins sent out by growing heather. If the toxins theory is tenable, it should be difficult to find fresh flushes within areas of heather knolls and at the bottom of long heather slopes.

Choice of Species of P.06

A. M. Fraser's remarks about the good sense of the first selection are well deserved, even with regard to the blown out strip of European larch in the Douglas fir area of P.06. With better artificial drainage, the site selected (now occupied by Sitka spruce) would have been sound by our present day standards, if we had made up our minds that we must plant some European larch at Culloden.

Appendix I

Notes on Inspection Reports

<u>Date</u>	<u>Inspecting Officers</u>
15.10.31	Chairman
7. 5.35	Sir Alexander Rodger
16. 7.36	Chairman, Assistant Commissioner
9. 6.38	Forestry Commissioners
19.10.38	Chairman
12. 2.43	Assistant Commissioner
17.10.43	Chairman, Research Officer (Scotland), Divisional Officer (West).
22. 3.47	Mr. James MacDonald, Conservator (Headquarters).
26. 9.47	Director (Scotland).
6.10.48	Director (Scotland).
18. 3.49	Chairman, Director General, Director (Scotland)

On a visit to Culloden on 15.10.31 the Chairman advised that future thinning should be light and frequent. He also proposed that the whole area should be thinned again in two years and thereafter, if thought possible, to extend the thinning cycle to three years. The guide must be the rate of development of the crop. Presumably, these notes refer to P.06. These directions are being followed in the treatment of the Commission planted crops.

Sir Alexander Rodger visited the forest on 7.5.35. He approved the heavy thinning of European larch in P.12 combined with underplanting. Part of this European larch was underplanted in 1951 with Douglas fir.

The Chairman again paid a visit in July 1936. P.12 was visited. After a short discussion on thinning, it was agreed that special type (e.g. heavy crown) thinnings are not as a rule desirable, and that ordinary thinnings with constant moderate breaking of the canopy are more suitable.

On a visit to Culloden on 12.2.43, the A/Assistant Commissioner expressed the view that a continuous tree crop along the railway side should be maintained and that beech should be used for the purpose of underplanting. Part of P.06 was underplanted with beech in 1947-48. This work will be continued.

The Chairman paid another visit in October 1943. There was some discussion on thinning in P.06, which was apparently still under-thinned. He emphasised the necessity for a thinning plan with proper control. The following observation was made by the Chairman on this visit and on previous reports:-

"They bring out clearly (1) the difficulty of getting thinnings made on a systematic plan, and (2) the way in which the quickly growing plantations tend to get out of hand. Even now - 16 years since the first complaint about over-stocking - the suggestion is made that thinnings cannot yet be made in a normal way. Nevertheless, the plantations look very well, and, with continued attention, should become a show place."

The last visit paid by the Chairman was in March 1949. By that time thinning operations had extended to Commission planted areas. An observation made by the Chairman was - "The woods continue to improve with systematic thinning."

APPENDIX II

Culloden Forest

Supervision

Divisional Officers

1925 - 1931	Mr. F. Scott
1931 - 1939	Mr. J. Fraser
1940 - 1942	Mr. D. Spraggan
1942 - 1945	Mr. A. Watt
1948 - 1949	Mr. J.T. Fitzherbert (S.F.O.)
1951 contin.	Mr. J.A. Dickson (S.F.O.)

Conservator

1946 contin.	Mr. J. Fraser
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District Officers

1925 - 1925	Mr. L. A. Newton
1926 - 1927	Mr. J.K. Leven
1927 - 1937	Mr. F. Oliver
1937 - 1940	Mr. T.A. Robbie
1939 - 1947	Mr. W. Denman
1947 -	Mr. A. M. Fraser

Foresters and foremen-
in-Charge

1925 - 1931	Mr. A. Rose (Forester II)
1931 - 1933	Mr. A. Macintosh (Foreman)
1933 - 1940	Mr. A. Macintosh (Forester II)
In 1940	Mr. S. Macmillan (Foreman i/o)
1941 - 1945	Mr. A. Campbell (Foreman i/o)
1945 - 1947	Mr. R. S. Brown (Foreman i/o)
1947 - 1949	Mr. D. MacDonald (Forester I)
1949 - 1949	Mr. D. MacLeod (Forester II)
1949 contin.	Mr. W. Mackay (Forester I)

APPENDIX III

GLACIAL MOUNTAIN - Height Growth Figures - Test Block

Com- part- ment.	Species	Year	Age	Geology and Soil	a Altitude b Aspect c Slope d Exposure e Vegetation	Stem Form	Mean Height of Do- mants In Feet	Mean Annual Height Increment	Current Annual Height Increment during last 5 years	Remarks	Qualit Class
2	S.F.	06	45)	Glacial drift mainly of Old Red Sandstone origin but con- taining Granite, overlying glacial Old Red Sandstone flagstones. Soil Type I Drainage free. 4-0 1" leaf litter, etc. 4-1 1-2" Dk. brown or black humus. 4-2 3" Dk. Greyish Brown contain- ing leached sand grains. 18"-24" Yellowish Brown loamy sand, stony. C Drift layer.	a 250 b N.E. c Moderate d Moderate e Wood Sorrel, Mosses.	(Good	62	1'4 $\frac{1}{2}$ "	1'6 $\frac{1}{2}$ "		I
3	D.F.	06	45)		b N.E. c Moderate d Moderate e Wood Sorrel, Mosses.	(Good	83	1'10"	1'7"		III
2	S.S.	06	45)		c Moderate d Moderate e Wood Sorrel, Mosses.	(Good	82	1'10"	1'3"		II
4	R.L.	06	45)		e Fine leaved grasses. Brambles. Bracken.	(Good	69	1'6"	1'4"		II
10	D.F.	25	26	Glacial drift as above. Soil Type II 4-0 1-1" decomposing leaf litter, etc. 4-1 1-2" Dk. Brown fibrous peat. 4-2 4-5" Greyish fine sandy loam. Stony. 10" Brown fine sandy loam with ferric iron noddings. Stony. Yellowish glacial drift, very compact.	a 350 b N.E. c Moderate d Moderate e Wood Sorrel, Mosses.	(Fairly Good	60	2'3 $\frac{1}{2}$ "	2'10"		II
12	S.S.	12	39		c Moderate d Moderate e Wood Sorrel, Mosses.	(Good	58	1'6"	1'2"		III
12	R.L.	12	39		e Fine leaved grasses. Brambles. Bracken.	(Fairly Good	58	1'6"	1'8"		III
18	S.F.	25	26			(Good	40	1'6 $\frac{1}{2}$ "	1'9 $\frac{1}{2}$ "		I
14	J.L.	25	26	Soil Type I as above.	a 280 - 300 b N.E. c Moderate d Moderate e Wood sorrel, Mosses.	(Good	50	1'11"	1'11"		Rare I
14	S.S.	25	26		c Moderate d Moderate e Wood sorrel, Mosses.	(Good	57	2'2"	2'1"		II
14	R.S.	25	26			(Good	41	1'7"	1'10"		II
36	J.L.	29	22		a 30 b N.E. c Moderate d Moderate e Wood Sorrel, Mosses.	(Good	46	2'1"	1'8"		I
37	D.F.	29	22	Soil Type II as above.	b N.E. c Moderate d Moderate e Wood Sorrel, Mosses.	(Good	51	2'7"	2'8 $\frac{1}{2}$ "		II
38	S.P.	26	25			(Good	35	1'4 $\frac{1}{2}$ "	1'11 $\frac{1}{2}$ "		I

CHILDEN FOREST - Height Growth Figures - East Block

Com- part- ment	Species	P. Year	Age	Geology and Soil	a Altitude b Aspect c Slope d Exposure e Vegetation	Stem Form	Mean Height of Dom- inants In Feet	Mean Annual Height Increment	Current Annual Height Increment during last 5 years	Remarks	Quality Class
48	Tsuga		22)	Glacial Drift. Soil Type II - Drainage locally somewhat impeded.	a 470 b N. W. c Level-slight d Moderate e Calluna occ.	(Fairly Good)	30	1'4"	1'7"	Planted in groups among old S. P.	Below III
49	S. P.	Prob. Haben.	26	A.1 2" brown fibrous peat. A.2 6-9" brown sandy loam.	c Level-slight d Moderate e Calluna occ.	(Good)	14	6 1/2"	8"		Below III
49	S. S.	26	25)	B 3-4" greyish brown sandy loam with ferric iron mottlings. Compact and stony.	c Calluna occ. d Moderate e Solirpus Mosses	(Good)	15	7"	1'9"	S. S. in this area slowly growing out of oboc.	Below III
51	C. P.	26	25)	C Brownish grey glacial drift, very compact, almost impervious.	(Polytrichum dominant)	(Good)	32	1'3 1/2"	1'3 1/2"	Slightly better drained than C.49.	II
53	P. C.	34	17)	Glacial Drift Soil Type II - Drainage bad.	a 480 b N. W. c Level d Moderate e Calluna	(Fair (	12	8 1/2"	1'	In the better drained parts, e. g. at edge of a drain. Height 4'-5' in worse places.	Below III
53	S. P.	34	17)	A.1 6" brown fibrous peat A.2 2-3" black amorphous peat B 3-6" stony brownish com- pact silt loam. Stones stained with peat. C Brownish grey glacial drift very compact and almost impervious.	e Calluna f. tetralix Mosses (Polytrichum & Sphagn. domin.)	(Fair to poor)	9	6"	8"	In worst places height 1'-2'.	Below III
59	S. P.	34	17	Glacial Drift. Soil Type I - Drainage free.	a 490 b N. W. c Slight d Moderate e Mosses. f Calluna.	(Good)	19	1'1"	1'7"		II
				A.0 1" leaf litter, moss, etc. A.1 1-2" brown fibrous peat A.2 5" grey stony fine sandy loam. D 1/4" + dark brown stony loam, fairly compact, containing roots. C Drift layer.							
64	E. L.	Net- ural	18	Glacial Drift Soil Type II	a 500 b N. W. c Slight d Moderate e Calluna, Mosses.	(Good)	39	2'2"	1'11"		I
64	N. S.	34	17	A.1 2-3" fibrous peat. A.2 3-5" stony grey silty loam. B 6-8" yellowish silty loam with ferric iron mottling; com- pact. C yellowish grey drift. Very compact.		(Good)	19	1'1"	1'8"		III