FORESTRY COMMISSION

HISTORY

OF

INCHNACARDOCH

FOREST

N(S) CONSERVANCY

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

H I S T O R Y

of

I N C H N A C A R D O C H F O R E S T

1919 - 1951

NORTH (SCOTLAND) CONSERVANCY

INCHNACARDOCH FOREST HISTORY

C O N T E N T S

HISTORY of INCHNACARDOCH FOREST

CHAIRMAN'S COMMENTS.

My first recollection of the forest is of walking along the main access road in company with Lord Lovat and Mr. Acland just before it was acquired. They had agreed that the Commission should acquire and when I remarked that such an area was often more difficult than it appeared from a distance and a survey should first be made, I was over-ruled. Soon after I addressed myself to the problem of systematizing procedure for acquisition and evolved the form of Report which, with minor amendments, has been since employed.

Undoubtedly we went ahead too fast - partly because of the rivalry between Scotland and England & Wales to make the bigger planting programme - and the wholesale checking of spruces (even after allowing for their known tendency to check) was a source of anxiety. On several occasions I made a close inspection with Frank Scott and Home, the earliest of which I have a record being that of September 21/22, 1925 (on File 394/30). The note reads as follows:-

"The Nurseries

The Nurseries were in excellent condition and with few exceptions the very large stocks of plants were of excellent quality.

Plantations

Inspection was confined to the area lying between Auchterawe and Port Clair Forest. Under favourable soil conditions spruce, Japanese larch and Scots pine are making good progress in the plantations formed from P.20 onwards. On the poorer soils, particularly on the hard ground and of course on the Scirpus areas, spruce has hung completely. It has made no growth, is very yellow and is apparently going back. It cannot be said with certainty that spruce will fail on a great part of this area but it will certainly remain in the check stage for a very long time. On the other hand spruce in the Molinia and Molinia/bog myrtle flats is doing reasonably well and with a little more weeding a full crop would have resulted in many cases. There is no doubt that on these hard faces we shall have to revert to Scots pine, the crop would then

mainly consist of Scots pine on the hard faces and spruce and Sitka spruce in the hollows and better ground.

I discussed the situation with Messrs. Scott and Home and went over P.26 with Mr. Home. If the use of Scots pine in the above way entails an alteration of the working plan the necessary instructions should be given."

Sir John Stirling Maxwell, writing to me on 5th February 1929, makes the following remark:

"As I am writing I may add that I spent a whole day looking over the experiments at Inchnacardoch. They are interesting and cover the whole field of peat planting so completely that they ought not to require much extension. In this forest, as elsewhere on difficult ground, I felt that we ought to use more Scots pine as a nurse for spruce if not as the ultimate crop."

There was consequently a fairly clear realisation from 1925 onwards that Scots pine had been neglected.

There is a note (Appendix III) of an inspection by Sir John Stirling Maxwell and myself on October 6th, 1930. My observations (of 12.11.30) on it were as follows:-

"I am anxious that the experiment on lifting and slagging checked spruce and Sitka spruce should be put in hand this year without fail, since if it is successful it may be the prelude to operations on a somewhat large scale. The experiment is similar in most respects to that proposed for Achnashellach and since the latter will be in charge of the Experiments Officer this one should be similarly controlled"

The experiments were put in hand (James Macdonald's report of 14th July 1931) but the results were disappointing and so far as I know the method was never used on a large scale.

Mr. Sangar's report of 30.6.32 is illustrated by photographs, one of which (No. 32/25: Panorama of upper part of P's 26 and 20/21) shows vigorous growth of P.26 Scots pine, and established clumps of P.20/21 Norway spruce, so presumably my instructions of 1925 were carried out.

My later inspections have been adequately covered in the history. The most interesting single point, in my recollection, was gradual appreciation of the way in which pine brings checked spruces to health and vigour.

The early set-backs at Inchnacardoch and elsewhere were not without value. They led to the realisation of our

ignorance of the best methods of planting the difficult types and to a determination to find solutions if such existed. Accordingly extensive experimental work was started and I was prepared to agree to anything which showed even remote promise. Some of the experiments on their face value may have seemed quite impractical, such, for example, as hand cultivation of the soil. The first thing was to find out the changes in soil and other conditions which would make reasonable growth possible, the second to find out economic methods of achieving those changes.

It so happened that by the time the value of soil cultivation was becoming apparent, the means of economic cultivation, using caterpillar tractors and heavy ploughs, was within sight. Although Inchnacardoch as a whole may not in itself be a good subject for such ploughing there were other units which were. Thus Inchnacardoch has contributed to the solution not only of its own difficulties but also to the solution of problems of wider application.

Another point of general application is the necessity of making periodic reviews of the results of experimentation and the initiation of new experiments based thereon, and also on improvements in large scale technique. This procedure is illustrated in the "competitive" plots laid down in 1947 (Experiment 135, Lon Mor), and entails close collaboration between executive and Research officers.

ROBINSON

February, 1951.

DIRECTOR'S COMMENTS

There can be few forests of greater interest than Inchnacardoch nor many for which it is more worth while to record the history. It has special interest because Glen Mor, in which Inchnacardoch lies, was the subject of a survey and report by Lord Lovat and his brother-in-law, Captain (later General) Stirling of Keir, published by the Royal Scottish Arboricultural Society in 1911, eight years before the Forestry Commission was born. The survey was made to demonstrate what great possibilities there were for forestry in the Highlands, and to give force to the view strongly held by Lord Lovat and others at that time that a forest authority should be set up to extend on a large scale the forest area of the country.

When, in fact, the Forestry Commission was formed in 1919, it was natural that a sheep farm and deer forest included in Lord Lovat's survey and which actually belonged to him should be handed over by feu charter to the Commission to form the first of the new State forests in Scotland - Inchnacardoch.

The forest is of special interest too for the lessons it has and will teach succeeding generations of foresters - lessons to be learnt both from successes and failures. These are well brought out in the history prepared by the present Conservator, Mr. James Fraser, to which I need only add some comments.

It was recognised in 1925 that much of the F.Y.20 - 23 planting was probably a failure. The main species used was spruce, notch planted, of which Sitka spruce formed some 10 per cent. and was confined to lower and more sheltered slopes. Scots pine hardly appeared at all. It is easy to understand the reason (which was not silviculture) for carrying out a large and ambitious planting programme from the beginning. If this had not been done, the Forestry Commission might have died almost as soon as it was born. It is less easy to understand the early choice of species, which seems to have been at variance with existing evidence and knowledge. For instance,

there were in existence small plantations laid down by Lord Lovat which could have pointed the way. There was a flourishing plantation of Scots pine on a morainic knoll and there was Japanese larch, badly deer damaged it is true, but otherwise healthy. Yet these two species were almost wholly neglected, although there was no evidence that Norway spruce, which was mainly used, would flourish on the peat-covered Calluna slopes that were first planted. Again, Sitka spruce was given the lower and more sheltered sites and Norway spruce was pushed up the hill, although ten years before John D. Crozier was writing in the Transactions of the Royal Scottish Arboricultural Society on "The Sitka Spruce as a Tree for Hill Planting and General Afforestation" and recommending Sitka spruce rather than Scots pine, European larch, or Norway spruce for exposed sites. In describing the Strathgyle plantations, he writes:- "But the Sitka spruce, even at the highest elevation, has withstood the blast, and indicates that on exposed moisture-holding soils, and sites, such as are common to the Highlands of Scotland generally, the altitudinal line for economic planting may be raised to a higher level than has hitherto been possible by the planting of any other tree." I do not suggest that notching of Sitka spruce instead of Norway spruce would have turned failure into success at Inchnacardoch, but the story of the early planting seems to show how important it is not to ignore any scrap of evidence or past experience, particularly when carrying out afforestation.

But perhaps the early failures brought some benefits, because most interesting results emerged from the replanting, largely with Scots pine, carried out from 1930 onwards, and the effect on checked spruce of introducing pine was well demonstrated by the remarkable recovery made by an appreciable proportion of the spruce.

I would add two further observations:-
First, about vegetation as an indicator in choice of species:-
Mr. Fraser has pointed out that Molinia is by no means always a

safe indicator for spruce; I would add - nor is bog myrtle. I was taught that, where bog myrtle grew, it should be safe to plant Sitka spruce after draining. The many bog myrtle flushes at Inchnacardoch, which held checked Sitka spruce, showed how wrong this was.

Second, about Birch:- There are indications in the history that a broadleaved "soil improver" was felt desirable. Alder was tried, but after a promising beginning has now almost wholly died out. Birch has been mentioned, but it has mostly been treated as a weed. A rather different view of birch is held today and yet little or nothing is known of its provenance or treatment and no attempt is being made to learn its possibilities. This comment has wider application than to Inchnacardoch only.

Perhaps the other outstanding feature of interest is the experimental work on the planting of high elevation peat-covered land of varying types. These experiments have had and will have far reaching effect on our technique of soil treatment and choice of species. It was, for instance, largely as a result of work on the Lon Mor that the use of phosphatic manure became normal practice in the North Conservancy as early as 1930. Amongst the vast number of experiments, I would only mention one other - the group planting of M.L. Anderson. Only quite recently has this method begun to show real promise and it may yet influence our technique more than was ever expected.

If some of my comments appear critical, that is not my object: it is rather to point to some of the experience that has and can be gained from work done at Inchnacardoch. The forest is now in a satisfactory condition and is being worked under a simple Plan of Operations. Already Lord Lovat's hopes for an afforestation scheme of this kind are in large measure fulfilled by the flourishing community of Forest Holdings and

the great increase in employment that forestry has brought to the district. I would even predict that in the future the extent of plantations may well be increased as our experience and skill develops.

H. BERESFORD-PEIRSE

Edinburgh,
February, 1951.

HISTORY of INCHNACARDOCH FOREST

GENERAL DESCRIPTION of the FOREST

Situation and Origin of the name "Inchnacardoch".

The Forest lies near Fort Augustus, at the western end of Loch Ness, in the County of Inverness.

The name "Inchnacardoch" is the name of a shooting lodge placed at the eastern end of the forest. The name is a corrupted form of "Innis na Caerdach." The literal translation of the words is "Island of the Smithy." "Innis", however, has also acquired the meaning of a green grassy island of land, and the name "Inchnacardoch" means the green grass land of the smithy. Three good Gaelic authorities have confirmed that translation. A name meaning "Valley of the Smithy" - Dalnacardoch - is a well-known parallel.

To whom the Inchnacardoch smithy belonged may be doubtful. At Dalnacardoch, the smithy was General Wade's.

Area Statement at 30.9.51.

	Acres	Acres
Plantations:		
Acquired	103.5	
Formed by F.C. on -		
Felled Woodland	172.0	
Scrub	257.0	
Other land	1611.5	
TOTAL		2144.0
Remaining to plant:		
Untenanted and not grazed by F.C.		
Felled woodland	-	
Scrub	-	
Other	107.0	
Let or grazed by F.C.		
Felled woodland	-	
Scrub	-	
Other	153.0	
TOTAL		260.0

	Acres	Acres
Not scheduled for planting:		
Agricultural tenancy under F.C.	5449.25	
Forest Workers' Holdings	86.5	
Other tenancies	28.75	
Nursery	33.8	
Lochs	3.0	
Land not used for any purpose	1162.7	
TOTAL		6764.0
TOTAL AREA		9168.0

Physiography.

The forest lies between the River Oich (and at the east end for a short distance, the south-west end of Loch Ness) and the main high ridge which forms the watershed between the River Oich and the River Moriston, the difference in altitude varying from about 100 ft. above sea level along the river and loch to about 1850 ft. above sea level along the ridge, although the upper planting limit is usually at about 850 ft. above sea level.

With the exception of the extensive flat moor lying between the River Oich and the Bunoich-to-Auchterawe road, comprising some 700 acres, the ground rises in a series of slopes and flats or basin-like shelves towards the water-shed. Only at the south-west end of the forest is there a steep, almost precipitous drop to the River Oich at the lower edge of the area. There are two extensive basin-like depressions between slopes, one being the Lon Mor and the other behind Auchterawe Wood.

Numerous burns run down from the watershed through the area but they are very small except when in full spate. Hard rock is generally met with within a foot or two of the surface, except in the depressions, so that no big gorges or deep cuts have been made by the streams and they affect to a very limited extent only the general aspect which is predominantly south-east

Geology and Soils.

A full and interesting report was written by Dr. John

Simpson in 1938. In broad terms, the underlying rock formation is of two main types.

1. Over the greater part of the area, with the exception of what may be termed the Sanitorium end, and the western half of the moor area, the rocks are of rather poor Moine schists.
2. At the Sanitorium and the western half of the moor areas, the rocks are of foliated granite, or granite gneiss.

These two main blocks can be sub-divided on the basis of the overlying boulders and subsoil.

1(a) That area lying north and east of a line running roughly west-south-westwards from the south end of Wade's military road, slowly rising until, at the east end of P.30, it coincides with the top of the planted area of P.30 and P.24, to the west end of our plantations on this slope. Here the rock is overlayed with grey drift in hollows and pockets; elsewhere in this area the soil is very shallow and is covered with peat. This soil cover is generally speaking the "blanket moor" of Tansley.

1(b) The remaining area is overlayed with material deposited by the readvanced moraine. This is slightly modified on the west end of the moor, by an outwash of sand and gravelly hummocks.

2. This area also comes entirely within the boundaries of the readvanced moraine, with the west end of the moor taking the form of kettle moraine.

Meteorology.

There is a rain-gauge and a maximum and minimum thermometer at Inchnacardoch. Recordings are complete from 1939 and a tabular statement is appended (Appendix V) showing for the period 1939-1950 (twelve years) the following information:-

(1) Annual rainfall by months.

(2) For each year, the dates of the first frost, the last frost of the main frost period, and the date of any exceptional late frost.

(3) The number of frost-free days in the year.

The table (Appendix V) shows that the average annual rainfall is 48.77 in. The driest year was 1941 (39.91 in.) and the wettest 1948 (60.31 in.). The rainfall is fairly evenly distributed throughout the year, the driest month on the average being May (2.4 in.) and the wettest November and December (5.2 in.). Heavy snowfalls are rare, and snow seldom lies within the plantation areas for more than a day or two.

There are, on the average, about 300 frost-free days in the year. Out of the twelve years, in only two years did the first frost occur in September (2nd and 21st). In six years the first frost was in October, and in four years it was not till November. During the first six years, the fairly continuous frost period ended by the first week of April, though a late frost occurred in the first or second week of May in three of those years. During the last six years, there were occasional frosts of a few degrees up to the last week of May in five years: only in 1947 was the last frost recorded in April (on 11th).

Temperatures seldom fall below 15° Fahrenheit.

From records maintained at the Abbey, Fort Augustus, it appears that the maximum temperature ever recorded was 87°F. (September 2nd, 1906) and the minimum 2° F. (January 6th, 1893).

The prevailing wind is from the south-west to which this forest is considerably exposed, but gales of an intensity likely to cause serious damage are most unusual. Some wind-blow does occur but it is mainly confined to areas where the shallowness of the soil and sub-soil over the solid rock, usually combined with inefficient drainage, predisposes the crop to such damage. The species most susceptible is Douglas fir but losses from this cause are slight.

Vegetation.

The vegetation on the moor area is predominantly Calluna with a fair amount of Erica with some Scirpus mosses and lichen,

and rushes in the wet depressions, and a few patches of Eriophorum. On the slopes from the moor edge down to the river, there is Molinia in the wetter depressions with mainly fine grasses, bracken, some heather, wood anemone, wood rushes and mosses.

The slopes on the readvanced moraines carried a fair crop of birch at the time of acquisition, with vigorous bracken and heather between the birch stands. The plantations on all this type of ground have done well and are mainly established, and there is only residual vegetation left.

The slopes and depressions comprising almost all the remaining ground are covered with a vegetation typical of the "blanket moor" of Tansley, or the remnants of that vegetation in such parts as have now been successfully planted up.

The only remaining distinctive area is that of the south-west end of the forest around the Coille Torr Dhuin, where there was an extensive wood of birch and oak of good quality, with a ground vegetation of bracken and fine grasses together with a woodland flora of the type usually associated with such species. Plantations here were successful and only residual vegetation is now left with a few of the best oak stems still living.

Considerable, in fact almost complete, burning of heather was carried out in the first few years after acquisition.

Risks.

(a) Fire.

In spite of the fact that some 356 acres were destroyed by fire in May, 1942, the fire risk at this forest is not high. The main dangers are from road users along the main road, and on the Bunoich to Auchterawe road; from our own and other workers in the forest area (e.g. Hydro-Electric contractors, road-men, etc.) and from muirburning.

(b) Meteorological

Wind-blow, late frosts, drought and snow damage all have had adverse effects and have caused some damage from time to time, but, except in the nursery, none of them have been of serious consequence so far.

Frost lift has caused serious losses in the nursery, as also have early drought periods. Covering of seed beds with lathe or branch covers, and also with sand and peat, has minimised the loss from frost, but frost lift of freshly lined out seedlings has occurred on a serious scale from time to time.

(c) Animals and Birds

The deer fence has prevented serious damage by red deer, though damage has occurred and still does occur when red deer get in through broken fences, or over them, in winter.

Roe deer are rather numerous in spite of the fence and shooting, but damage of any consequence is small and confined to the more backward areas and the replanted areas after the fire, where it is occasionally appreciable. Black game are a serious menace to freshly planted Scots pine and require constant watching.

(d) Fungi

Fomes annosus attacks have occurred sporadically, and this is true of Armillaria mellea. They are not of serious consequence. The only serious fungal pest to date has been Dasyscypha calycina on European larch, which, combined with die-back, has caused many casualties in the past. But proper thinning treatment and natural causes indicate that further serious damage is unlikely.

(e) Insects

Cockchafer damage in the nursery has been serious in the past and has caused heavy losses. There has been no heavy attack in recent years. Aphis attacks on Douglas fir and Sitka spruce have been frequent, but have generally only checked growth and seldom caused death or heavy losses. No serious Neomyzaphis

attacks have been noted.

Roads

The only roads serving this forest until very recently were the main Inverness to Fort William road which forms the lower edge of the plantations at the extreme eastern end of the forest, and the Bunoich to Auchterawe road running westwards from this road to Auchterawe. An old military road to Glenmoriston, over the watershed, starts near the point where these two roads meet. This old road was derelict until 1951, when it was made serviceable by the Hydro-Electric contractors, to enable them to take up pylon materials. It is now of value to us as a means of getting fire equipment up the hill, if necessary. Numerous tracks penetrate the plantations, which were used at the time of planting and left unplanted. In the last two years, a system of roads, and tracks for tractor extraction, has been worked out, and work started in 1951 on the main additional road required, namely an extension of the Bunoich to Auchterawe road beyond Auchterawe to the Sanatorium, where it will join a private road which runs from the Sanatorium to meet the main Inverness to Fort William road at Oich Bridge.

A further short branch from Auchterawe up into the plantations behind Auchterawe has been surveyed and may be constructed this year. These will, with a road along the river side on to the moor, complete the requirements of lorry roads, but feeder tracks for tractors will be made from these roads as required.

Labour and the Development of Housing.

The labour supply from Fort Augustus has never been sufficient to meet the demands of the forest. A supply of older men, young women and girls and boys is fairly certain, and we shall always be able to count on that class of labour. The young men of the village have always looked on the forestry work as being theirs to claim as a right when more profitable work is not

to be found; they have even claimed that imported labour should be displaced to allow temporary employment of local labour. The attitude can be understood, but it is difficult to build up an efficient squad from temporary labour. At one time, 1922, special huts were erected to house a squad of unemployed labour imported from Fort William. In the earlier years it was customary to bring a large imported squad together in spring and to dismiss most of them in autumn. An imported squad of the best men was retained throughout the winter. The big labour demand was due to the heavy demands for nursery labour, and, as housing was scarce, the system was inevitable. Inchnacardoch supplies a large number of plants required for the planting programme of the Conservancy. On account of the difficulty of obtaining suitable nursery land in the earlier years, very poor nursery land was taken in for nursery work at Inchnacardoch. That also seems to have been inevitable. As suitable nursery land became available elsewhere, it was possible to reduce the area of the Inchnacardoch nurseries and to reduce the squad. For a time, it was even possible to dispense with imported labour and to work the forest and the nurseries with the labour from Commission houses and from Fort Augustus. In this period, planting of the better land had been almost completed and the thinning programme had not become pressing. The hostel was leased temporarily to the Scottish Youth Hostels Association. When the demands for thinning labour came on, and there came at the same time an increased planting programme in the Conservancy, it again became necessary to employ imported labour and to reopen the hostel for our own imported labour at the end of 1946, and a hostel for about 20 men has remained in being ever since then.

The housing acquired with the land was very inadequate for the labour to be employed. Auchterawe House, Achandarroch Croft House and an old ruin inhabited by Jean the Post were the only Commission houses. Auchterawe House became available for

Commission use when the farm lease ended in 1920. The croft house was too far away to use for forestry labour. The ruins of Jean the Post's house are close to the new buildings now used as a Forester's house and as an office.

The first building erected to house workers was a temporary building in the area now known as P.20. By June of 1921, a new bothy had been erected on the site of the present bothy, and it was in use by that date. In 1922, two sixty-foot army huts were erected to house unemployed labour from Fort William. One of the huts is the iron house now used by the tenant of Auchterawe Farm. The hostel buildings as now used were reconstructed and reconditioned internally in Forest Year 1950.

The first cottages erected were iron buildings. Those were the two cottages on the east side of the hostel buildings, the cottage now occupied by the forester of the Research Branch and the cottage now occupied by the forester of Inchnacardoch. The building of the hostel or bothy on the present site and the building of the four iron cottages was completed in Forest Year 1921. The next increase in housing came in 1926 and 1927. By Whitsunday of 1926 the first three forest workers' holdings had been completed and tenanted; by Whitsunday of 1927 the other five holdings were also tenanted. In September 1950 the new housing scheme close to the Wade road was begun. The scheme includes eight workers' houses and two foresters' houses. The lay out of the ground has been arranged so that a further ten houses can be built at a later date.

The housing and hostel accommodation at Inchnacardoch must be considered in relation to Portclair, where it may be difficult to get housing sites. The housing at Inchnacardoch must also depend on the way in which the nursery is worked. When the full housing programme close to Wade's road has been completed there will be sufficient housed labour to dispense with the hostel provided that Portclair housing demand has been met.

Improvement in nursery technique and rearrangement of the sowing programme and the extended use of heathland nurseries and of seedlings for planting may allow us to dispense with hostel labour, even before the full building scheme on Wade's road has been completed. The full programme of building at this position, Wade's Road, is still justified as any available excess labour from Inchnacardoch can be very profitably used at Portclair, and any necessary adjustments in the full requirements of the squads can be made by reducing the casual labour supply from Fort Augustus. Sales of standing thinnings have reduced the probable housing demands. The hostel accommodation will still be of value for housing contractors' labour. The housing provisions as planned at Inchnacardoch are now very satisfactory.

When money was allowed, improvements were made in the earlier buildings and in the hostel buildings. The forest workers' holdings have been successful. The older tenancies are held on terms that are very favourable to the tenants, but even with the increased rentals that must now be asked for holdings, those holdings are attractive to our workers.

SILVICULTURE

Plans and Work prior to Acquisition

The planting up of this forest in the Great Glen, near Fort Augustus, was forecast in a Forest Survey of Glen Mor, a report published by the Royal Scottish Arboricultural Society, compiled by Lord Lovat and Captain Stirling of Keir. The areas planted later by the Forestry Commission follow very closely the boundaries of plantable land as assessed and mapped in that report. Fortunately, however, the species planted did not follow so closely the suggestions made in that report which advocated the use of larch and Norway spruce to an extent quite incompatible with the nature of the ground.

Planting done prior to the acquisition of this forest comprised an area of some 60 acres planted with Douglas fir, European and Japanese larch, Sitka spruce and 2 acres of Scots pine, planted in 1914. At the time of acquiring the land, the effective area of plantation stood at about 47 acres (the rest having been almost completely destroyed by deer), and even this 47 acres required a 40% beat up, using the same species, which was the first work undertaken by the Forestry Commission. About 10 acres of the original acquired wood was sold for war fellings, 1939-45.

Planting

P.20 - 23

From the start of planting in P.20 until P.23, the species planted was almost pure Norway spruce with the exception of a total of 119 acres of Sitka spruce and 22 acres of Scots pine, as against 750 acres of Norway spruce.

This extensive use of Norway spruce was probably due to the very general use of this species at that time in the hope of obtaining heavy volumes, weighted by the fairly heavy rainfall in this area. No attention was paid either to the type of soil or to the vegetation indications. Up to this time, there appears to have been no dissatisfaction with the results achieved. Moreover, the belief of the time was that Sitka spruce was a species more sensitive to wind and frost injury than the Norway spruce, and in other planting of the Forestry Commission at the time, Sitka spruce was planted on the lower and richer slopes, and Norway spruce was planted on the higher slopes with poor vegetation cover.

The method employed was to clear all scrub and burn the heather, and to do a minimum of draining. The plants were put in by notching in with Mansfield, Schlich or garden spade, by direct notching in to the peat covered soil, except in the case

of a few big plants which were pitted.

P.24 and 25

In these years, the planting area comprised better ground over part of the area, and this is reflected in the use of considerable quantities of Douglas fir, while the increasing use of Sitka spruce is also noteworthy. The Douglas fir planted in 1924 and 1925 was planted on the lower slopes where there was an accumulation of deeper soil washed down from the slopes above. Norway spruce also was used, mainly in planting up the area cleared of degenerated birch scrub where remnants of the woodland flora still persisted. Only 2 acres of Scots pine were planted in P.24 and were replanted with Scots pine after a fire in 1930.

The method of planting and preparation of the ground was the same as before, except that in 1924 more plants (about 50%) were planted in pits and in 1925 most of the planting was done with the planting mattock in an attempt to get shallow planting, but without the use of turves. Turf planting, as understood to-day, was unknown at this time.

In these years also it was noted that Norway spruce, while doing well on the lower ground (i.e. that which we now know to be covered by the readvanced moraine) was in serious check on the higher ground of P.22 and P.23. On both these areas there was a good growth of birch which was all cleared before planting. This birch clearing caused serious adverse effects by destroying all protection from exposure, and by upsetting the vertical drainage effect of the scrub. It may be noted that the birch clearing, and also the burning of heather, was done far ahead of the planting work. The bulk of the heather had been burnt by the end of 1923 and almost all felling and girdling of birch was completed by about 1926 except 50 acres of birch. There remained also 70 acres of middle aged hardwoods, mainly oak, at the Sanitorium.

P.26 - 30

All the evidence goes to show that this was a transition period, brought about by the increasing realization that the earlier work was showing up as unsatisfactory over big areas. The Plan of Operations of 1927 - 1930 states that much of the higher land covered with peat must now be considered as unplantable until experiments indicate what methods or species could guarantee success.

There was a swing away from the use of Norway spruce, and in this period Scots pine was used on a large scale on the heather knolls, with Sitka spruce in the wet hollows. The use of mountain pine on a small scale on most exposed sites is recorded, with the introduction of Pinus contorta in 1928. Douglas fir was used in small areas of good soil in P.26, 27 and 29, and Japanese larch was used fairly extensively, usually on better ground, but to some extent on heather and bracken knolls where there was some protection from blast.

Probably as a result of the Chairman's demonstration of turf planting, demonstrated at Glenurquhart P.24 in September, 1926, trial patches of turf planting of Sitka spruce were started over 3½ acres in P.27 in Inchnacardoch, and in a note written in November, 1927, J. Cameron, Head Forester, records that in wet hollows "it is useless to plant such areas unless drained well and the turfs spread out for planting on."

In spite of this, however, there was very little turf planting done in this period, and even the drainage did not increase by a very appreciable extent.

These years saw the completion of planting of the hill areas of Inchnacardoch, with the exception of the oak-covered land round the Sanitorium. This left only the moor for planting, and the Sanitorium area.

P.30 - 34

This period completed the major planting works at

Inchnacardoch. Most of the moor was planted in P.30 - 33, using mainly Scots pine which was notched in, except in the hardest peat, where some pitting was done in advance, and the soil and peat mixed, and then the pine notched into this. Sitka spruce, where used, was notched into turves after draining these wet hollows. In P.34, the Sanitorium wood was planted with Douglas fir and Norway spruce, Douglas being pitted and Norway spruce shallow pitted with the planting mattock.

P.35 - 43

In this period, only small remaining corners alongside Forest Workers' Holdings, and small extensions to the moor plantations, were planted up, using the same method as in the last period.

P.49 - 50

A ploughing outfit was used on the moor in 1948 and 1949 for finishing the planting of the remaining 20 acres of the moor. This completed the original planting of Inchnacardoch to date.

NOTE

A disastrous fire occurred in May, 1942, burning a total of some 356 acres of P.23 (50%) and P.26 and P.29 (all). These areas were replanted by 1951. The species used for this replanting were Douglas fir, Japanese larch and Norway spruce on the best ground, pit planted with planting mattock or spade; Scots pine and Pinus contorta on the hard and exposed knolls, notched; and Sitka spruce in wet flushes after full draining and turfing, and with an admixture of Scots pine, except on the best flushes. All the spruces and almost all the pines received an application of ground mineral phosphate.

Beating Up

F.Y. 1921 - 1924

In these years, the beating up was confined to the use of the same species as originally planted, i.e., mainly Norway spruce, with a little Sitka spruce in 1923.

F.Y. 1925 - 29

The transition period noted against planting is observable in the beating up also. Unfortunately, records of plants used are sketchy for this period, but it may be noted that Scots pine was first used in beating up in 1925 in P.22 (2 acres) and there was much more Sitka spruce used in that year. Beech was interspersed through Norway spruce over 43 acres of P.20 - a very little of this still persists. By 1929, Scots pine was used in beating up over 50 acres, and it is known that Scots pine was used in this year in beating up areas of P.23 originally planted as pure Norway spruce. This beating up has provided useful lessons in the value of pine as a spruce nurse.

F.Y. 1930 - 37

This is the most important period of beating up. By 1930 it was realised that a great deal of the Norway spruce planted in the early years had been planted on totally unsuitable ground, and that the method of planting spruces generally (in notches) was inadequate, and that drainage also was insufficient.

In the Plan of Operations prepared in 1930 by Sir Henry Beresford Peirse for the period 1931 - 35, the following quotations are illuminating:-

"After acquisition, it was considered necessary to burn the whole area in order to facilitate planting. This burning, combined with the former partial burning" - (before acquisition) - "has tended to cause deterioration in the vegetation type. All the birch on the area has been felled, with the exception of a small amount on P.24 which was girdled.

There was a crop of fairly good oak and some birch of about 70 acres in the Coille Torr Dhuin, most of which has been girdled."

"Ten years have elapsed since planting was first carried out on the area, and it is now possible to determine those areas where the plantations are total or partial failures. It is proposed to take the best of the ground where stocking is not complete, and, in the light of past experience, thoroughly to beat up these areas, so as to ensure complete stocking in the future. In places, the process will amount to a replant. This beating up will consist of

(a) Planting dry slopes and knolls where spruce have failed with Scots pine by ordinary methods (addendum - and some Japanese larch on lowest slopes).

(b) Planting the better types of flats and hollows with Sitka spruce, by intensive draining and turfing, with application of slag."

These instructions were put into effect (and in fact a start had been made on these lines in 1930), although turfing on a really satisfactory scale was not methodically carried out until 1932. Semsol was substituted for slag in 1934 and 1935 only. Alders were used in P.20, P.24 and P.25 to beat up blanks caused by Honey Fungus in 1936 and 1937, but these have almost all disappeared. The alders were largely suppressed by the spruce which closed over the small blanks in which the alders were planted. The use of alders for beating up in this case was unnecessary.

In 1931, 8 acres of Japanese larch in P.20 were underplanted with Norway spruce. This also was useless work, as the Japanese larch came away and most of the Norway spruce are dead or completely suppressed.

F.Y. 1938 to date

Beating up in this period was done on a small scale, and to the extent common to all areas of dates later than 1922 and 1923.

In 1950 orders were received that Inchnacardoch was selected as one of the forests in which no beating up at all was to be done.

General

It will be noted that the beating up or reconstruction programme laid down in 1931 confined this work to "the best of the ground". This programme was completed in 1937 and (probably taking advantage of the census done in that year) the remaining areas, not considered fit for reclamation, amounting to 201 acres in P.22 and 95 acres in P.23 were written off as failures.

These areas were transferred to the Research Branch for investigation of the possibilities of devising methods of treatment which might render such areas economically plantable in the future.

It is of interest at this point to compare the acreages of species originally planted with the acreages now stocked with different species as the predominating species. The changes in areas of different species are due mainly to the following causes:-

(a) The heavy beating up, mainly with Scots pine and Sitka spruce (of areas originally planted with Norway spruce) in 1930 - 37.

(b) The replanting of P.23 (50%), P.29 and P.21 after the big fire in 1942.

(c) The discrepancy in over-all areas is due to recalculation of areas, major and minor write-offs, etc.

	S.P.	C.P.	P.C.	E.L.	H.L.	J.L.	D.F.	N.S.	S.S.	Others	Total
✱	513.5	5.5	40.5	8	9	64	191.5	1015.5	476	33.5	2357
ø	745	2.5	48.5	27	10	97	198.5	378	426	27	1959.5

✱ Acreages originally planted
ø Acreages as recorded after 1949 Census and to-date

Nursery

Immediately after acquiring this area, a start was made in making a nursery. 7 acres of land were broken in for a permanent nursery, 3 acres of old arable were made into a temporary nursery, and, for the first year, the garden at Auchterawe was used for seed beds. In 1921, the temporary nursery was extended to cover 8.6 acres, i.e. a total of 72,600 square yards of nursery. In the following years the area increased annually to a total of 162,000 square yards in 1925, to a maximum of 217,000 square yards in 1928, from which it fell to about 185,000 square yards, at which it remained fairly constant until 1950, when the least productive areas were abandoned and will be progressively abandoned.

From this nursery, the number of plants provided annually for planting has varied from about $1\frac{1}{2}$ million to 2 million.

Apart from casualties from (mainly) late spring frosts, usually combined with cold winds, against which lathe and branch covering has been employed, the main losses in this nursery were due to attacks of Neomyzaphis abietina up to 1923, and by very heavy and serious cockchafer damage, first noticed in August, 1929, and lasting to 1931, and then again becoming serious in 1934, and continuing until 1938, when sowing was reduced for this reason. Cockchafer continued to give some trouble annually thereafter, but on a much reduced scale. The policy of continuous cultivation of all fallow land in the egg-laying period, combined with late (July) sowing of rye-grass as a green crop in the most affected areas, appears to be a helpful method of treatment and continues to this date. It was started by Mr. D. Spraggan, who first made use of horse-traction, but the treatment became really effective when a mechanical cultivator was used.

It is intended to reduce the amount of nursery work at Inchnacardoch by cutting out the less productive sections of the nursery, and to transfer the work to the east.

For maintenance of the fertility of the nursery, the use of mineral fertilisers is now prescribed by the Macaulay Institute. The fertilisers and the quantities used are in accordance with the prescriptions given. For the period 1932 to 1939 use had been made of mineral fertilisers and chemical nitrogeneous manures. The use of lupins and oats for green crop was the practice up to 1931. From 1931 onwards, the use of lupins was abandoned progressively, and the main green crop used was a mixture of oats and tares. Lupins were discarded on account of the slow germination and slow early growth. Weeds had a chance of becoming established before the lupins came up. The quantities of mineral fertilisers used in the 1932 - 1939 period were much lower than the quantities now prescribed: slag, which had been used up to that period, was forbidden on account of its possible bad effect on pH value. In the new prescriptions for mineral fertilisers, great importance has been attached to balanced quantities of the fertilisers and to the effect on pH value. Balance is, without doubt, important; the emphasis given to pH value and the exact meaning of the pH values are still somewhat difficult to understand. The nursery suffered during the war period 1939 to 1946 from scarcity of mineral fertilisers. Potash supplies were scarce right up to 1947.

In the preparation of the seed beds, Spraggan was successful in reducing the amount of hand labour formerly given to seed bed preparation and in giving careful advance back-end preparation to the seed beds. This process was assisted by the use of mechanical aids, and it was also made more easily possible on account of the reduced pressure on the nursery. To Spraggan also is due the credit for the early development of the system of lining out in narrow beds. He had adopted this type of lining for two years at least before it became general.

Line sowing was used from the early days, and in this nursery it has been retained. Use has been made of the teaching

received from the Research Branch in covering of seeds with sand and grit, and the method has been adapted to use in line sowing.

The nursery can produce good Scots pine and good Norway and Sitka spruces. It was over-worked in the early days, and full green cropping was not possible until the nurseries in the east were developed. The intention for the future is to make full use of the nursery for the rearing of spruces, although the risks of frost are appreciated. The nursery should be abandoned only when a better spruce rearing area becomes available. When the fertility of the nursery has been built up, part of the frost risks will disappear on account of the better size of one year seedlings.

Treatment of Established Plantations.

P.14

A first thinning of Douglas fir, Japanese larch and European larch was done in 1935 and 1938.

A second thinning of Japanese larch and Douglas fir was done in 1944, and at the same time the Sitka spruce was thinned where ready.

From this time onwards, some thinning was done almost every year up to the present.

From the present condition of the crop, it may be said that thinning has been fairly adequate, except in the best of the Sitka spruce, where the poor diameter and short length of crowns of many of the stems indicates that thinning was inadequate at some period. It seems probable that this inadequate thinning occurred prior to 1944, and that the drawn-up state of the crop made the only form of thinning possible to be an almost annual removal of a few of the poorest stems, so as to avoid sudden opening and the almost certain incidence of wind blow which would result.

P.20

Thinnings were started here in 1942 and 1943 and were

very light, comprising mainly the removal of dead and suppressed trees in the most advanced Sitka spruce and Norway spruce, with a timid removal of wolves in addition in Douglas fir areas. Only 16 acres were dealt with. From 1944 - 46 the main operation was the cutting back of scrub birch, interfering with the growth of conifers. From 1946 to date, a very light thinning and clearing was done where the crop was ready.

P.22, 23, 24 and 28

A small area of Japanese larch was thinned in 1938 and again, with other Japanese larch areas, in 1944 - 46. In addition, some 23 acres of Douglas fir in P.26 were lightly thinned in 1940 to 1942. From 1941 to date, the chief task has been the cutting out of scrub, except that in the later years, a start was made in thinning and, particularly, in the removal of rough Scots pine. All these areas were the areas of the reclamation or salvage operations done in the years 1930 - 37, which varied from a very heavy beat up to practically a replant of the areas originally planted with Norway spruce, and where this species had more or less failed. Where the beating up was mainly with Sitka spruce (i.e. in the flushes and hollows), the Sitka spruce has now become the main crop, although in places the draining for Sitka spruce, combined with shelter, has enabled many of the Norway spruce to come away and compete with the Sitka spruce. The thinning here sets no special problems, and either Norway spruce or Sitka spruce is accepted in the crop, depending on which is doing best and is the better tree on each particular area. Where Scots pine was the principal species in the replanting or beating up, however, the problem now set, as originally commented upon by the Chairman on his visit in 1936, is to decide where and to what extent the Norway spruce from the original planting, and the Scots pine from the beating up, shall be accepted as the crop.

The records show clearly that the Scots pine generally did well, formed canopy fairly quickly, and appeared to be

certain to suppress the Norway spruce in the first few years. The protection and drainage given then appear to have had a nursing effect on the Norway spruce, which in many places recovered and grew so well that they quickly overtook and competed with the Scots pine.

The position now is that the condition varies from a crop of Norway spruce containing a few Scots pine, usually of a coarse and poor form, to a crop of Scots pine with many suppressed and moribund Norway spruce, but with a few good stems of Norway spruce scattered through it, either singly or in groups.

While cleaning operations did include the removal of the few rough Scots pine in areas where the Norway spruce was growing well and was clearly forming the crop, no definite decision was made in the more evenly mixed areas until the start of the first real thinning of these areas in 1949 and 1950.

The decision now taken is to accept and give preference to all Norway spruce which are healthy and vigorous, wherever they occur; but to accept Scots pine as the crop in all other cases; with a rider to the effect that, if the Norway spruce is still quite healthy and forms a reasonable group below Scots pine, the thinning of the Scots pine shall be heavier than normal, so that at the next thinning it should be possible to decide whether to accept the Norway spruce as likely to succeed and make the final crop (in which case the Scots pine will be removed then) or whether the Scots pine shall be finally accepted as likely to form the crop.

P.25, 27 and 30

The main work here was cutting out birch, and girdling some oak and birch scrub, where they were interfering with the growth of the conifers, in 1942 - 1945. Along with this, completely suppressed conifer stems, mainly Douglas fir, were also cut out.

Other Areas

Very little work was done, except for cutting out birch scrub where it was interfering with the growth of the conifers. A very light thinning was made in the more advanced Scots pine, and in the small areas of Japanese larch on the moor, together with some cutting out of rough Pinus contorta and Scots pine which, having served their purpose in nursing up Norway spruce and Sitka spruce in P.31, were doing damage to that crop.

General

It was only in 1947 that a real start was made in thinning work proper, with the exception of the larches and Douglas fir, where a fair amount of light thinning had been done, and in the old Sitka spruce crops of P.14 and P.20.

In 1949, a complete examination of all established crops was made, and a realistic thinning programme laid down in a Plan of Operations. This plan also covered a programme of brashing and cleaning, so that, if these programmes are achieved, these works will be brought up to date.

Provision has also been made for attention to drainage, in the course of the above works.

In general, while it is true to say that thinning and cleaning operations had fallen into arrears, it is also true to say that the larches in general have been adequately thinned throughout, and that, as regards Douglas fir, while the time for removal of wolves was missed (during the war years), no very serious damage has occurred. In fact, the main damage resulting from delayed thinning has occurred in the areas of P.22, 23, 24 and 28 described above, where Scots pine (and Pinus contorta to a smaller extent) having served to nurse up the Norway spruce and Sitka spruce, were not removed at once when their time of usefulness was over, and their removal first became necessary to help the final crop of spruce. But even here, the damage is not so serious that we cannot look forward to obtaining a satisfactory crop in the near future.

Research - Notes compiled by Research Branch

Short Summary of Results to Date

Results at Inchnacardoch can be conveniently considered under four heads: (i) Turfing and ploughing; (ii) manuring; (iii) species and provenance; (iv) other experiments.

(i) Turfing and ploughing: Dr. Steven had become convinced that conifer roots could not function properly on the poorer, ill-drained types except when almost on the surface, and in 1924 he tried out several forms of very shallow planting to test his theory. The following year, M.L. Anderson, who succeeded him, tried a shallow turf which he inverted on to the surface of the bog; the plant being notched through this turf with its roots spread out on the original surface. The roots developed and ramified freely. He had in mind that turfs of like depth must eventually be produced by a plough of sorts. Later experiments showed that tree growth was better where two or more shallow turfs were supplied to each plant. A crude form of plough was designed and tried in 1926, but it was obvious that further progress was impossible until a suitable tractor became available. There was no direct planting on the Lon Mor until 1928, when some was carried out simply for demonstration. When it was realised that peat was much more easily cut at ten inches than at five inches below the surface, a reversion towards the old Belgian system followed, pending development of suitable machinery.

At the end of the War (1945) a really suitable draining plough (the Cuthbertson) and an adequately shod caterpillar tractor provided with a winch, were brought to the Lon Mor. Tree growth to date in the ridges it provided has been amazingly good.

(ii) Manuring: No worthwhile growth at all was ever secured in the absence of a phosphatic dressing. Tests commenced in 1925 when basic slag was used in experiment 12

under shallow turfs. Within three years it was very easy to see the remarkable stimulus which had been given. By 1928 it was so obvious that growth was hopeless in the absence of phosphate, that it became the rule to apply two ounces of basic slag at the roots of each plant in experiments other than special manuring ones. A 1928 experiment was the first to show that there might be more suitable forms of phosphate than basic slag, and a few years afterwards it became the rule to apply North African ground mineral phosphate because it gave superior and more consistent results than slag. Numerous experiments designed to compare different ways of applying phosphate showed that the cheapest method, i.e. top dressing immediately after planting, was good enough.

Potassium, produced some small beneficial results, but it is doubtful if the improvement was worthwhile. Nitrogen in the form of sulphate of ammonia was generally harmful. Dr. A.B. Stewart attempted to supply a complete fertilizer which would give nitrogen and potash in slowly available forms in addition to phosphate. The results have been interesting, but it is doubtful if the addition of nitrogen and potash is justified.

(iii) Species and provenance: Sitka spruce, the main indicator species in the experiments has proved to be difficult to raise, both on the poor peats and on the drier heather clad slopes. The remarkably good start that the species has made on the latest deep single furrow ploughing at Lon Mor has, however, raised hopes again. With such preparation and with the aid of Pinus contorta and Scots pine as nurse species it may yet be encouraged to become a useful timber producer.

Norway spruce was used in some of the earlier experiments where it appeared to be a little slower than the Sitka. It is remarkable to note how much better both types of spruce look in the Inchnacardoch area since the extraordinary frost in the spring of 1947 practically killed out the heather. The most

promising spruce has been Picea omorika although unfortunately it has only been used in one 1928 trial and in some post war plantings.

Pinus contorta is outstanding among the pines. When planted extensively or where given some protection against roe deer the species continues to grow more rapidly than any other on the poorest peats. The faster grower is the coastal type with its dense foliage, but the best plantation on the Lon Mor is of an inland type (Mt. Ida, B.C.) which has straight slender boles and short lightly needled branches. The coastal type has made a remarkably fine shelter belt in experiment 18.P.26 and has obviously got a great future in the Highlands of Scotland. On account of heavy blackgame attacks Scots pine had an extremely bad start in the older Inchnacardoch experiments, but where given good drainage, turfing and manuring it is now making very satisfactory growth and may yet compare favourably with Pinus contorta. Mountain pine has made normal growth, but, of course, will never provide any timber; since Pinus contorta can be made to grow on the poorest types, very little reason for growing mountain pine is left.

Hybrid larch has done extremely well when given adequate turfing and manuring, but results both with this and the Japanese species have been variable. However, there are reasons to believe that the origins of both have to be very carefully examined. European larch has been useless on the peat types. Among other species Tsuga heterophylla is probably the most promising, but Douglas fir is worth further trial and so are some of the Abies. Although at one time the grey alder and Oregon alder established themselves well and made fast growth no hardwood now shows any promise on the poorer peat types, but note should be made that no hardwoods have been tried in the most recent single furrow ploughings.

Only Scots pine has been dealt with to any extent in the provenance trials. It is still early to say much about

relative rates of growth, but it is clear that relatively local Scottish races do better than races from either the far north or the far south of Europe.

(iv) Other experiments: Most Inchnacardoch experiments deal with peat. There is, however, a (1928) shallow ploughing experiment on a fairly dry heather site which was covered with a thin layer of raw humus. Of the four species planted on it, Sitka spruce failed to grow, Japanese larch has grown taller than the remaining species, but the Pinus contorta still leads the Scots pine by a considerable margin. No manure was added.

A group of high elevation experiments are of interest; the best species has proved to be Pinus contorta. Two beating-up experiments showed, as elsewhere, the folly of beating up fast growing sites more than a year after the initial planting. Early season of planting experiments, in the forest, simply showed that provided the weather was reasonable one could plant in every month of the year. Three years after planting Sitka spruce on a dry Calluna-Erica cinerea slope, pines were planted between the rows of spruce in half of the plots when the spruce were going into severe check. The pine grew rapidly on this site and the experiment has become noteworthy on account of the successful nursing by the pine which were later removed in groups as required.

J.A.B. MACDONALD.

2.10.51.

Research - Observations by Conservator

A history of research work and experiments, written by the Research Branch, is included in the history, but an attempt is made here to discuss the more important aspects of the work in so far as the evidence from these experiments has been so impressive that the methods have been or can be safely adopted as standard practice in planting up difficult areas at

Inchnacardoch and similar ground in other forests. Brief mention is also made of results which are less definite, but where experience so far merits consideration for adoption on at least a field trial scale, at Inchnacardoch or on similar areas.

Briefly then, the work which has yielded such proofs can be classified under three main heads:

1. Turfing (leading on to ploughing)
2. Manurial treatments
3. Choice of Species

The experimental work has been taken up on a deep peat area (peat generally of depths over 2 ft.) - the Lon Mor, and on shallower peats (peat varying from a few inches to 2 ft.) with a few deeper flushes or flats - above P.22 and P.28. In my comments, the statements made may be taken as applying to both types, except where otherwise stated.

(1) Turfing and Ploughing

The first turfing experiments were with thick or Belgian turfs (e.g. Experiment 6 of P.23) and these were followed by experiments with shallow turf (e.g. Experiment 12 P.25) which proved better than the Belgian type. Both types of turfing led to drain formation, and in an Experiment 69 of P.28, the draining and turfing was accomplished with the aid of a horse-drawn plough. This experiment was made on the shallow tough turf over kettle moraine on the moor area, where a horse could work, and this was the first pointer to the possible use of a plough for this purpose, at Inchnacardoch.

In Experiments 117 and 118, P.35 and P.36, an experiment was made which envisaged the future possibilities of mechanical ploughing on deeper peat (where a horse could not work) by simulated complete ploughing, the work actually being done by hand. The first attempts with caterpillar tractor and heavy plough were made on the Lon Mor (Experiments 128-132, P.46), and this was later followed by comparisons of such ploughing done as

complete ploughing (with drains formed later where required) with single furrow ploughing at 5 ft. intervals. These experiments covered varying peat conditions, and the results were very impressive, and deductions made from these experiments are tentatively recorded as follows:-

(1) Draining and turfing is essential on difficult peat areas, and this is best achieved by tractor drawn ploughs where possible. The best type of equipment at present available and tested for such work in such areas is the very broad tracked caterpillar type tractor, with a Cuthbertson single furrow plough.

(2) In deep rich peat and deep poorer peat, in shallow flushes, single furrow ploughing is entirely adequate to start a tree crop.

(3) In shallow peat overlying drift, of the poor flush type, single furrow ploughing is adequate. There is some evidence that complete ploughing may have advantages, but it is very doubtful if these are worth the extra costs involved.

(4) In general slope conditions with peat up to 2 ft. deep, the remarks are the same as in (3) above.

(5) On knolls with peat up to 2 ft. deep, single furrow ploughing is adequate. The advantages of complete ploughing, for which there is some evidence, are not generally attainable, as rock and boulders below the shallow peat render this method almost impossible of achievement, even if worth while.

Evidence to date does not show that complete ploughing has sufficient clear advantages over a single furrow ploughing at 5 ft. intervals to warrant its adoption on a large scale at present.

(2) Manurial Treatment

The first experiment to test the advantages of application of artificial manures was Experiment 12, P.25. It soon became clear, and has been generally accepted that the application of phosphatic manures was a sine qua non for all the poor and doubtful types of peat conditions, and that its application was advisable even in the better flush conditions which are classified meantime as relatively rich in nutriment, viz., Molinia flushes; Calluna-Molinia flushes; and Molinia and Myrica flushes. The first experiments used basic slag as the phosphatic manure; then Semsol was tried, and finally ground mineral phosphate, the latter having become the standard, having been proved as good if not better than any other source of phosphate. Experience with the use of ground mineral phosphate indicates that the application of this manure has a beneficial though somewhat delayed effect in stimulating growth when applied to Scots pine and spruces which have been planted by notching direct into the peat, and also that its application does stimulate the growth of almost all species, even when it is applied many years after the original planting and after these plants have been in check for several years. It has been used successfully to bring plants (which have gone into check after original good growth) out of check again, and also to bring plants out of check, which have been in check for many years, and from the time they were originally planted.

As regards other manures tried, there has been some evidence to show that the addition of manures to provide a source of potassium and nitrogen may have been of some slight benefit to the health and vigour of the plants used in some cases, but this evidence has been so slight and conflicting that there is no case for general adoption of this practice.

(3) Choice of Species

The combined lessons derived from the research teaching at Inchnacardoch and our own experience there show that our knowledge is incomplete even for the species which are regarded generally as our chief planting species where we require to use those in poor planting conditions. These chief species are:- Scots pine, Pinus contorta, mountain pine, Sitka spruce, Norway spruce, Serbian spruce, European larch, Japanese larch, hybrid larch, Douglas fir.

On the better growing conditions - i.e. alluvial flats, loch-side terraces, concave slopes covered with "wash", short hill slopes below outcrops of mica schist, burnsides with deep wash cover on the banks, outwash terraces with deep sandy cover, rich flushes - the choice of species conforms to generally accepted teaching. Mistakes in choice of species in the richer conditions are not common, and if mistakes are made, the consequences are not so serious as with poorer conditions. These poorer conditions are - poor flush conditions on deep peat; poor flush conditions on shallow peat; and poor Calluna moor conditions, when the wash layer below the peat is thin or non-existent. The research results have been our guide in these poor conditions.

It has been fully realised from 1929 and onwards that the introduction of soil improving species into all coniferous crops is desirable. On the richer conditions the introduction of broad-leaved species is fairly easy and there is a range of possible choices. On the poor conditions, there has been no real success of any of the species tried.

In the experimental work, mainly Sitka spruce and Japanese larch were used in most of the early experiments, as these species were thought to be the most sensitive indicators for the various treatments. Experiment 19, P.26, was the first occasion when Scots pine was used to any extent as a possible species for planting in such conditions, and Pinus contorta was similarly

introduced for this purpose for the first time, in Experiment 52, P.28 (although it had been used in Experiment 18, P.26, in a composite shelter-belt trial of various pines, mainly Pinus contorta, Scots pine and mountain pine). From these experiments, I think the conclusions to be drawn and the further experiments required can be summed up briefly as follows:-

(a) On deep basin peats, such as occur in the Lon Mor, the ploughing and manurial treatments show that Sitka spruce, Scots pine and Pinus contorta all start well, and that there are good hopes of our ability to establish crops of these species. The use of Scots pine in such places has been limited and more experience is required for this species. Pinus contorta starts off most vigorously and, except in the richest flushes, it is doubtful whether Sitka spruce could compete with it or would indeed persist in mixture with it, unless given assistance by thinning out the Pinus contorta. More experience is required in this respect also, but it is probable that, by careful manipulation in thinnings, a crop of Sitka spruce could be finally established, and that the yield might be better, in terms of volume and price, than a crop of Pinus contorta. It is, however, fairly sure that a useful crop of Pinus contorta can be established in such conditions, and that it is safe to plant such areas with a Pinus contorta/Sitka spruce mixture, while further trials of Scots pine in such conditions are urgently required, and have now been provided.

(b) On good deep flushes with pure or very plentiful Molinia, the success of Sitka spruce is very probable, and in the best of these it may safely be planted pure. Where there is any doubt, however, it should be planted in mixture with a pine, especially towards the margins, where the proportion of pine should be increased.

(c) In good but shallower flushes, the proportion of pine to Sitka spruce should be half and half.

(d) In the poorest flushes, the pine used with the Sitka spruce should be Pinus contorta.

NOTE

The research plots appear to show that pines in mixture with Sitka spruce do exercise a beneficial influence on the growth and health of the spruce, but especially so in rich conditions, and this influence appears to increase the closer the plants are together, e.g., it is most marked in the Anderson Group planting Experiment 86 and 93 of P.30 and 31. More information is required on the best method of arriving at the mixture, the best proportion and the planting distances, and on a further important question, viz., should the mixture be made at the time of first planting, or by the later introduction of one of the species?

(e) On deeper peat slopes (14 in. and up) and on better type peat covered knolls, the evidence to date shows that the chief species to be used should be Pinus contorta and Scots pine. Experiments have shown that these two pines can be successfully grown in mixture in these conditions. As experience grows, it may be possible to be more precise as to the limitations of these two species, and as to the exact method of obtaining, and the proportions of each to be used in, this mixture. At present it can only be said that the evidence observable to date indicates that the poorer the conditions are, the more the Pinus contorta should predominate. On the toughest and shallowest peat slopes and knolls, pure Pinus contorta should be planted, or no planting done at all on the worst parts.

Japanese larch is as yet in an uncertain position for use on the poorer slopes and on knolls where there is a thick peat cover, but of poor quality. It is, however, successful on knolls with a shallow peat cover, especially where some shelter is assured.

Japanese larch should not be planted on exposed knolls with bad peat conditions.

APPENDIX I

Notes from Inspection Reports - 1932 - 1946

Date	Inspecting Officers
30. 6.32	Mr. O.J. Sangar.
18.10.33	Chairman; Mr. J. Fraser, Divisional Officer.
18. 7.34	Mr. O.J. Sangar.
12. 7.36	Chairman; Mr. J. Fraser, Divisional Officer.
18.10.38	Chairman; Mr. J. Fraser, Divisional Officer.
4. 6.41	Chairman; Mr. A.H. Gosling, Asst. Commissioner.
11. 8.42	Chairman; Mr. A.H. Gosling, Asst. Commissioner; Mr. D. Spraggan, A/Divisional Officer.
21. 8.46	Chairman; Rt.Hon. Hugh Dalton; Mr. J. Fraser, Conservator (N).

Mr. Sangar's first visit in 1932 comprises a detailed description of conditions of the crops in the areas planted to that time, with special reference to those areas originally planted with almost pure Norway spruce which had gone into check, and which had been specially treated with a "reclamation" beating up, starting in 1930.

The main points of interest are that, even at this early date, he noted that where draining, turfing and slagging had accompanied the introduction of Sitka spruce in the beating up, much of the original Norway spruce also appeared to have benefited and to have put on good growth and to have come out of check.

Also, that the Scots pine introduced was generally doing very well and that here, too, the original Norway spruce interplanted with Scots pine appeared to be coming out of check and to be more healthy than on neighbouring patches of similar soil conditions where Scots pine had not been introduced.

He also commented that the crops on all the lower slopes and in the birch-cleared areas were doing well and were established, or nearly so, up to P.28.

The Chairman on his visit in 1933 commented on the fact that the reclamation work in P.22 and P.23 "has been done on well

considered lines. There will remain an area on higher ground which it will not be worth while treating" and that this would require to be written off.

He also stated:- "I was struck with the growth of Oregon alder on the poor ground, though the preparation work has been heavy and costly."

(Note:- All alders used at Inchnacardoch started well, but almost every plant was later killed out. This occurred mainly due to the severe frost of 1946/47, but in some cases they have been killed out by suppression by the conifer crop).

The Chairman made a slight criticism of the use of Scots pine on ground more suitable for spruce, in one or two places; and also pointed out that, where rowan and birch were coming in freely (more particularly in P.23) these might be retained as part of the crop with a consequent saving of plants and costs, but that these species must be "rumped" where they threatened the conifers. Mr. Fraser notes that where repair work (i.e. replanting or beating up) had been done, there were several instances where the draining and slagging work done had resulted in the recovery of some of the original plants, which were now growing up well with the new (beat up) plants.

Severe damage by black game to Scots pine was noted.

The Chairman expressed his willingness to consider the formation of experimental planting above P.28 on the lines of simulated mechanical ploughing.

Mr. Sangar, on his next visit in 1934, comments on the progress of the "reclamation" work as follows:- "The earlier spruce areas on dry sites are now interplanted with Scots pine which show considerable promise. Work has proceeded systematically in the repair of the lower elevation wet areas by draining, slagging and beating up with Sitka spruce. The results of this latter work are so far satisfactory, but in many cases there, so far there is still lacking definite evidence of the likelihood of second check or as to probable ultimate production. On the

higher land, the Scots pine on dry slopes are developing well, as are intensively treated Sitka spruce, Japanese larch and Pinus contorta of 1930 and 1931. The earlier high elevation spruce areas have not been touched, except where clearly suitable for interplanting with Scots pine, or in the case of selected wet areas which have been further drained to await developments."

The Chairman on his visit in 1936 noted the necessity for removal of rough birch interfering with the growth of the conifers in P.24. In regard to the "reconstruction" work, he noted that the original backward Norway spruce areas had been interplanted with Scots pine. Where this Scots pine had closed canopy and was of good quality, it would be necessary at once to make the choice of which species was to form the crop.

Cleaning and thinning of Douglas fir, Japanese larch and European larch in the area of the original P.14 acquired plantation was seen and the Chairman recommended that this work be continued in frequent gradual thinnings. Attention was especially directed to the need to break up groups.

The Chairman, on his visit in 1938, again inspected the "repair work" in P.22 and 23, and noted with particular interest the recovery of the original Norway spruce plants, making good growth under the Scots pine which was interplanted through them in or about 1930. The Chairman expressed the view that "most of the spruce would be suppressed by the pines, but it showed the advantage of mixing spruce and pines on this type of ground."

The Chairman agreed that on the upper areas of poor Scirpus peat, where the spruces were all dead or in check, this type of ground should be written off. He stated that small patches might be taken up each year with draining, mounding and slagging, and with special emphasis on "cut-off" drains at the foot of slopes.

Drier slopes could be planted with a 50% mixture of Scots pine and Sitka spruce, with some draining.

In the experimental plots, the success of Anderson's Group

planting was noted, but it appeared that the groups were too far apart.

(Note:- This no longer appears to be the case.)

Japanese larch on wet flushes appeared to be doing quite well, but the selection nevertheless appeared unsuitable.

A small plot of Pinus contorta in P.22 was noted by the Chairman, who asked for an early brashing and thinning to be done.

The Chairman, in his visit of 1941, visited the experimental areas and commented particularly on the growth of the Anderson Groups above P.22. "Here, each group consisted of 13 plants at 2 ft. apart, and there were 80 groups to the acre. Species used were Sitka spruce in mixture with Scots pine, Pinus contorta and alder, and also Scots pine and Pinus contorta in mixture. Of these mixtures, the Sitka spruce with Scots pine or Pinus contorta were most successful, and with the Sitka spruce in the centre of pine groups, the spruce generally had taken the lead having benefited from growing in mixture with the pine.

There was a discussion of the advantages and disadvantages of the group system. Chief advantages are:-

(A) Quick formation of forest soil conditions within the groups.

(B) Saving in number of plants required to plant an acre.

The disadvantages are:-

(A) Great difficulty in planting.

(B) Supervision and management more difficult and doubtful production of final crop of good quality trees.

At this point the Chairman expressed his opinion that in establishing forest crops on difficult soil types, a more intensive study should be made of the ecological factors involved.

The aim was, of course, to establish the climax forest type for any particular soil as soon as possible.

In the past this had generally been attempted without taking into consideration the natural succession which would normally lead up to the climax type and as a result considerable difficulty was generally experienced. This was due to the fact that the species which is required to form the final forest crop is generally of a more delicate nature than the species which form the intermediate stages in the succession leading up to the climax type.

It was now recognised that on certain soil types natural birch rapidly established itself after enclosure and it was much easier to get a crop of spruce on this ground after the birch had come in than if this had been attempted beforehand. In the same way on ground of a harder and more difficult type but which could be assessed as that which would carry a climax crop of spruce this could often be more easily established if planted in mixture with pine which species would naturally have formed one of the stages in the succession leading up to the climax forest type. The Chairman thought that by a more intensive study of successions for different soil types and by the judicious use of mixtures, it would be possible to speed up the process of succession and the ultimate establishment of the climax forest crop. In P.22 area a considerable part of the original planting had been done with Norway spruce and this having gone into check was later beaten up with Scots pine. Part of this area was inspected and the Norway spruce has now come out of check but will in most cases be unable to compete with the Scots pine which has made rapid growth. It was agreed that a certain amount of cutting back of the pine could be done to free good groups of spruce or to favour a spruce growing near a badly shaped pine.

An interesting experimental area was seen where the original crop of Sitka spruce having checked was beaten up with pine, the result being a very fine pine plantation, but the spruce had come out of check and were in places even overtaking the pine so

that a problem in future treatment had arisen. It was agreed that in view of the very good pine it was not desirable to favour the spruce in the thinnings except where it could be retained without damage to the main crop. It was however desirable to attempt to get a mixture of spruce with the pine in the final crop.

A good plot of Pinus contorta was seen which had been pruned and was not requiring a light thinning.

In P.23 areas some good plantations of Japanese larch were seen and these were all requiring to be thinned, especially to remove rough trees liable to damage the crop."

The Chairman, in his visit in 1942, primarily inspected the area burnt in the big fire of May, 1942. He also visited the experimental area above P.28 where Scots pine, mountain pine and Pinus contorta were interplanted in 1926 in an area originally planted with Sitka spruce in 1923 and 1924, for the purpose of discovering the effect of planting pines in areas of backward Sitka spruce.

It was noted that the introduction of Scots pine in these plots had given exceptionally good results, and thinning had taken place in 1941 to produce groups of Scots pine and Sitka spruce in each plot.

In the Pinus contorta plot, only a few Sitka spruce remained, and these only near the edge. In the mountain pine plot, the Sitka spruce were coming on slowly. The Chairman expressed his satisfaction at the effect of the Scots pine on the Sitka spruce, of which many were now overtopping the pine.

The Chairman, on his visit of 1946, with the Rt.Hon. Hugh Dalton, visited the experimental areas.

The important comments made were that in Experiment 95, P.32, and in general, the Scots pine appeared to be almost as good in height and health as the Pinus contorta and in his view much more use should be made of Scots pine (in place of Pinus

contorta) in experiments where a pine was to be used in mixture with Sitka spruce.

The results of ploughing with the Cuthbertson plough were noted as very satisfactory. One section was ploughed shallow, on which the Chairman commented that now that we had a machine capable of turning out deep drains which require little or no clearing, why do we use this machine to turn out shallow drains which will require deepening in a few years.

APPENDIX II.

SUPERVISION - INCHNACARDOCH FOREST

Divisional Officers

1. 8.19 - March 1931	Mr. F. Scott
20. 3.31 - 1940	Mr. James Fraser
1940 - 29.12.42	Mr. D.S. Spraggan
30.12.42 - Nov. 1945	Mr. Andrew Watt

Conservator

29.10.45 - continuing	Mr. James Fraser

District Officers

13.12.19 - Sept. 1928	Mr. George Home
Sept. 1928 - 22.9.29	Mr. J.W. Mackay
23. 9.29 - 7.12.36	Mr. H.C. Beresford-Peirse
7. 1.37 - 15. 7.49	Mr. D.S. Spraggan
15. 7.49 - continuing	Mr. R.O. Drummond

Foresters

1920 - 30. 5.31	Mr. John Cameron	Head Forester
1931 - 30. 9.34	Mr. W. Anderson	Grade I Forester
1.10.34 - 31. 1.49	Mr. W. Anderson	Head Forester
10. 1.49 - 30. 9.49	Mr. D. MacDonald	Grade I Forester
1.10.49 - continuing	Mr. D. MacDonald	Head Forester

Assistant Foresters

1921 - 9. 8.25	Mr. J. Gunn	Foreman
10. 8.25 - Dec. 1931	Mr. J. Gunn	Grade II Forester
7.12.29 - 30. 9.38	Mr. H. Pennet	Foreman
1.10.38 - 29. 9.39	Mr. H. Pennet	Grade II Forester
30. 6.43 - 31.12.46	Mr. T. Fraser	Ganger
1. 1.47 - continuing	Mr. T. Fraser	Foreman
1. 9.47 - 6. 6.48	Mr. D.D.C. Robertson	Foreman
20. 5.48 - 30. 9.48	Mr. C.O. McIntosh	Foreman
1.10.48 - 19. 4.49	Mr. C.O. McIntosh	Grade II Forester
21. 4.49 - 31. 5.49	Mr. D.R. Smith	Foreman
1. 6.49 - 13. 8.50	Mr. D.R. Smith	Grade II Forester
15. 8.49 - continuing	Mr. W.R.C. Beattie	Foreman

APPENDIX III

REPORT OF VISIT OF COMMISSIONERS TO INCHNACARDOCH OCTOBER 6th 1930

Sir John Stirling Maxwell and Mr. Robinson arrived at Inchnacardoch Nursery at 10.30 where they were met by H.Beresford-Peirse, Cameron and Grant, the Experimental Forester. They went by motor to Auchterawe and then walked up to the Lon Mor by the path through P.27 and P.24. They inspected a considerable number of the experiments and Grant explained the different types of treatment that had been tried. Sir John made the criticism that many of them were of a nature so far removed from practical forestry as to lessen their value, but he was particularly struck by the response of Sitka spruce to slag treatment on the worst types of ground, particularly where turfs had been spread over most of the ground, which had a definite change for the good in the vegetation, Molinia coming in strongly in place of Scirpus. At about 1.30 Sir John and Cameron returned direct to Auchterawe, made a short visit to that nursery and then went on to the Golf Course Nursery. Mr. Robinson with Mr. Beresford Peirse and Grant went across the top of P.24 and P.30 into P.22 as Mr. Robinson was particularly anxious to see the condition of spruces which had been in check since they were first planted. While going through the old scrub ground of P.20, Mr. Robinson said he thought European larch might have been planted on a good deal of the ground, though he agreed that it should grow an excellent crop of Norway spruce. In P.22 although very few plants could be said to be out of check, the majority were still living, and Mr. Robinson considered that further treatment should be tried even on the worst types of Scirpus ground, perhaps 10 acres being done each year. He suggested intensive draining might help to bring on the existing plants, or still more might be done by lifting the plants with the turfs in which they were growing, placing them on the surface and applying a dressing

of slag. He was insistent that there was no hurry in treating the areas of checked spruce but they should be watched and care should be taken that in myrtle ground healthy plants were not being suppressed by the myrtle. Mr. Beresford Peirse explained the proposed plan of beating up in P.22 and other early plantations - namely to deal with about 70 acres yearly of which about 10 needed intensive draining and turfing and over the rest pines and Japanese larches would be planted wherever the spruces had failed. Mr. Robinson seemed to approve of this programme. He went down through P.22 to the road passing the Scots pine which was planted in 1925 and he remarked upon their good growth and healthy condition. He was also much struck by the excellent appearance of Japanese larch in P.28 and P.23 and he considered it was a tree that could have been much more extensively used on the lower slopes of Inchnacardoch. Mr. Robinson joined Sir John again at the Golf Course Nursery and they left at 3.15 by car for Spean Bridge to catch a train back to Corrour.

(Sgd.) H.B. PEIRSE.

6.10.30.

APPENDIX IV

Growth of Various Species at Inchnacardoch

Measurements made in February, 1951, of the largest trees of various species show the following results: in each case, several of the largest trees of each species were measured, and the results averaged as shown:-

Species	Age	Greatest Height (Total) ft.	Greatest Q.G. B.H. O.B. ins.	Average Total Height ft.	Average Q.G. B.H. O.B. ins.	Remarks	Compartment No.
Scots pine	28	40	6¼	36	5½		78, 79
Mountain pine	28	20	3½	19	2¾		78
Douglas fir	36	78	13	71	11	Age uncertain.	1, 2
Pinus contorta	22	50	7¼	44	6½		55
Serbian spruce	25	36	5	33	5		131
Abies nobilis	23	50	9¾	43	7½		124
Abies grandis	18	45	10½	45	9½		147
Lawson's cypress	23	38	8½	-	-		124
Tsuga heterophylla	18	35	7½	-	-		147
Japanese larch	36	78	12¾	68	10¾	Age uncertain	9, 8
Hybrid larch	30	75	12½	61	8¼	"	10
European larch	30	49	5	48	4½	"	10
Sitka spruce	36	79	10½	74	9½		7
Norway spruce	30	57	6½	51	5½		7

(Sgd.) R. O. Drummond

District Officer, Fort Augustus

26.2.51

(APPENDIX V)

RAINFALL RECORD 1939-1950

Month	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	Average Rainfall
January	4.73	.82	.49	3.74	4.80	8.13	4.26	6.92	3.42	4.20	10.20	5.22	4.74
February	7.69	1.54	4.19	2.23	6.67	3.63	7.87	5.05	.04	6.64	9.01	6.48	5.09
March	4.83	2.70	2.01	1.34	5.68	2.23	5.71	2.89	1.72	5.04	2.90	2.92	3.33
April	2.81	4.13	2.21	1.49	5.59	3.02	1.59	1.69	10.14	4.12	5.81	6.19	4.07
May	1.64	1.45	2.25	2.36	3.14	4.18	3.93	1.32	2.17	2.48	2.54	1.36	2.40
June	1.63	1.28	.97	2.45	5.19	4.74	4.18	3.81	4.01	3.42	1.19	3.42	3.02
July	5.14	7.01	3.53	2.60	1.53	2.36	1.43	6.75	3.34	4.14	1.26	2.78	3.50
August	1.09	2.14	5.23	5.15	5.31	2.97	1.89	2.75	.02	7.39	5.05	3.57	3.55
September	1.55	2.56	1.90	6.33	3.50	3.54	4.43	3.78	5.99	5.07	2.16	8.40	4.10
October	1.56	4.61	4.60	8.62	8.61	4.43	2,87	.44	1.90	4.72	5.79	6.27	4.53
November	7.64	8.38	6.12	1.75	3.80	6.59	.63	3.65	8.54	6.11	4.64	5.10	5.24
December	2.36	6.80	6.41	7.97	4.09	6.00	4.58	4.51	2.62	6.98	6.82	3.21	5.20
Totals	42.67	43.42	39.91	46.03	57.91	51.82	43.37	43.56	43.91	60.31	57.37	54.92	48.77
Number of Frost free days	316	312	289	295	337	331	298	277	301	273	289	261	

APPENDIX VI.

HISTORY OF THE EXPERIMENTS AT INCHNACARDOCH.

1921/24

The first registered experiment in this forest (1.P.21) was laid down by Dr. H.M. Steven to determine the effect of heather burning on the growth of subsequently planted Norway spruce. Today with single furrow ploughing few reasons against burning remain. In the following year, trials of method and season of planting, and of types of plants were started. These experiments and others eventually showed that pitting was little better than much less costly notching, that planting could be done throughout the year, and that transplants were more hardy than seedlings, but most of all they emphasised the need for some better method of dealing with wet peaty land.

Actually the third year, 1923, produced the first attempt to deal with poor, peat clad areas by employing Belgian turf-planting (Experiment 6 P.23). Unfortunately no phosphate was applied and growth was consequently poor. It was in this year that Steven produced his "Root Form on Peat" report which indicated the futility of placing roots into wet anaerobic conditions. In 1924 he laid down an experiment to test methods whereby the roots of the trees would be brought very near to the surface of the peat. The methods were not very successful. When Dr. M.L. Anderson succeeded Steven in 1925 the "Lon Mor" (Big Waste) consisting of a series of level bogs up to 12 ft. deep, separated by rock ridges and moraines capped with shallow peat, and surrounded by slopes of shallow peat, was selected for experiments. George Home, the resident District Officer at the time, offered to carry all the trees that ever grew on Lon Mor down to Fort Augustus on his back. He died before the war, but the job would certainly have taxed his strength had he lived.

The outstanding feature in 1925 was Dr. Anderson's use of a new method which he termed the 'shallow turf' method. This entailed inverting turfs, of about 15 in. square and 5 in. deep, by the side of the ditch from which they were cut. Planting was through them in such a way that the roots of the plants lay in the sandwich of vegetation provided by the bog surface and inverted turf. A subsidiary experiment compared planting through these turfs by means of the semi-circular spade and by means of the much simpler and cheaper side-notch which later became very popular. Local shelter was afforded to certain trees by wooden frames but it was subsequently found that although this did have a minor effect, it was not nearly so essential as an application of phosphate. It was Experiment 12 P.25 which finally proved just how essential a dressing of phosphate is for spruce on this type of land. An experiment to study the effect of decomposition of turfs for one, two or three years was commenced, and there were several new age and type of plant experiments. Results were vitiated by the lack of available phosphate in the soil which was the major limited factor to tree growth. In May of 1925 Mr. J.A.B. Macdonald was appointed first Research foreman in Scotland and stationed at Inchnacardoch.

Among the eight experiments laid down in 1926 two were on good ground and six on peat lands. The experiments on good ground were an age and type of spruce trial and a spacing experiment. On the peat overlying a rock and moraine ridge to the west side of the Lon Mor a narrow belt was planted with pines, rowan and birch. Coastal Pinus contorta which has since proved to be the outstanding shelter belt species for poor, peaty and exposed ground was included in this experiment. Mountain pine, although very much smaller than the Pinus contorta has also done well in this belt as a dense near-to-ground-level tree on the windward side. Rowan and birch failed. Alternate sections of the belt were

manured with phosphate at the end of the third year and before long showed that even pines responded remarkably well to applications of phosphate on really bad peat. In 1926 potash was employed as kainit in another experiment for the first time, but the method or quantity proved harmful; later on, however, small positive effects were produced using sulphate of potash. A peat nursery was started to discover whether the raising of conifers in this media would make them more adaptable for planting out on peat in subsequent years. Results were negative.

It is interesting to find that in this fourth year of the Inchnacardoch experiments, the mistake made in choosing spruce for dry Erica cinerea slopes had become so obvious that Dr. Anderson introduced pines between the rows of Sitka spruce in the hope of nursing them. This experiment (16) now shows that even on the unsuitable spruce site measures can be taken to raise quite a satisfactory spruce crop; but a lot of attention is required in thinning. Black game were very troublesome at the Lon Mor throughout the 1920's and many experiments had to be completely caged for protection.

1927.

Among twenty-two experiments laid down in 1927 number 36, which was a simple comparison of different species on peat, is now of great interest. The tallest species on this poor Scirpus/Sphagnum bog are hybrid larch, omorika spruce and and Western hemlock. The commoner spruces are relatively poor. Much the best growth in the experiment is on ground which was slagged twice, but in the control (unmanured) section Tsuga and omorika spruce stand out. This particular trial contained all the conifers available at the time except the pines which were later introduced into Experiment 18. That Norway and Sitka spruce were poor starters on peat types had been realised, and some rather unusual efforts were

made to obtain a better spruce growth as in Experiment 22 (planting of pines and spruces on the same turf), 26 (treatment of backward Sitka spruce by lifting) and 31 (trial of spruces specially grown in pots). One or two small experiments were attempted to find better ways of providing surface rooting than shallow turfing but none were satisfactory. New manuring experiments included various magnesium salts which produced small but positive results with the sulphate. At the request of Sir Hugh Murray, a visiting Commissioner, direct notching into the peat was tried for the first time at Lon Mor; and demonstrated its futility. A trial of direct sowing on peat turfs was made and a high elevation nursery (at about 1100 ft.) was started to find the effect, of treating conifer nursery stock 'rough' in their youth; this was later found to be harmful. Off the peat, three of four extensions of nursery experiments were planted out testing effects of density of sowing and grading in the nursery.

1928/29.

Experiment 55 P.28 compared draining and turfing processes carried out in the year of planting, one year in advance and two years in advance of planting. The important conclusion from this trial was that it is not only useless but slightly harmful to drain and turf a year or more in advance of planting, especially if heavy turfs of the Belgian type are used. The idea of giving the plant roots the most favourable possible start by placing them at ground level right away was responsible more than anything else for the fact that the Belgian type of turf was not employed at Lon Mor until 1928, but when it became realised that peat turf was more easily undercut at ten inches than at five inches below the surface a swing towards the Belgian system followed. The largest number of experiments established in any one year was in 1928; initial success from earlier turf planting and slagging trials were becoming apparent. Dr. Anderson had

moved to Ireland and J.A.B. Macdonald was left much on his own in the North.

Experiment 43 P.28 compared several new phosphatic manures with basic slag and showed that ground mineral phosphate was also very beneficial, also that a mixture of this with superphosphate had an even more stimulating effect on tree growth. In later years a proprietary mixture of this sort (which was called Semsol) was found to be rather dangerous especially in a drought. The same applies to superphosphate which was also tried. Although it often caused high losses the surviving plants grew extremely well.

Dr. G.K. Fraser of the Macaulay Institute, isolated a square chain of peat by digging a deep ditch to the underlying 'hard' on all four sides. Practically no improvement in the vegetation type has been recorded after twenty-two years and there has been only negligible shrinkage of the peat. The rainfall of the region is apparently sufficient to maintain the bog unless more intensive draining is provided. A second square chain isolated in the same way, but from this area the surface part was removed, the underlying peat dug over, well manured, cropped with potatoes and oats for a couple of years, and thereafter planted with Sitka spruce and Japanese larch which have made relatively rapid growth.

The Belgian method of draining and turfing was compared with Anderson's single shallow turfing system and with a group turf system in Experiment 49 P.28. Interesting points about the experiment are: (i) the good start of the plants on the Belgian turfs; (ii) their subsequent check apparently when the turf became 'amalgamated' with the bog and when the plant had exhausted the phosphate provided but had not yet spread out roots on to the surface of the bog; (iii) the remarkable invasion of Molinia on the large area of upturned

turf provided by the group shallow turf method and the rapid start of the plants. Today these group turfed areas only have formed a complete canopy.

A one acre block of Pinus contorta planted in Experiment 52 has for many years been in complete canopy, and is still growing in height at the rate of about one foot per annum. The experiment was laid down primarily to compare (a) relatively close drains (twelve feet) given regular cleaning and deepening, and with (b) drains eighteen feet apart and given little or no subsequent attention. So far there is little difference between the two treatments. This experimental block has proved a blessing to visitors in stormy weather and is frequently used as a shelter for lunch.

A certain number of the older experiments on peat which had been planted by direct methods and had checked were taken in hand this year and compared turf planting (with and without slag). In addition to phosphate effect, turf planting succeeded well. An interesting minor experiment entailed the careful lifting of very badly checked spruce and lining the plants in the nursery; they very rapidly recovered. Another experiment, number 72, tried out very heavy surface dressings of basic slag on a checked area of spruce. This eventually had remarkable effects.

1929/39.

During the ten years preceding World War II, the most notable feature was the laying down of a number of trial plantations embodying the lessons of previous experiments. In 1930 Dr. Anderson's ten acre field trial of experimental methods on a typical blanket bog hillside was established in P.22 where original direct planting, mainly of spruce, had failed. The experiment (86) employed Anderson's group system of planting groups of thirteen plants closely spaced together with 18 ft. between group centres. The supposedly more "difficult" species were sheltered by stronger species

planted round the outside of the group. An efficient system of girdle drains trapped the surface water and supplied many of the necessary turfs. Different tree species or mixtures of species were arranged to occupy each of the main vegetation types within the area and, but for one species, Oregon alder, the choice was good. Pinus contorta helped to nurse Scots pine on the very poorest Scirpus heather knoll types, and in the same way Scots pine certainly nursed Sitka spruce on the semi-flushes.

Mr. James Macdonald became Research Officer (Scotland) in 1931 and repeated the trial plantation more or less in Experiment 93 that year, but he wisely included ordinary square planting in addition to the Anderson groups. This plantation has also made excellent growth.

In 1933, by which time J.A.B. Macdonald had become Research Officer (Scotland), a large scale trial of Japanese larch was laid down between the two experimental plantations last described. The method was straightforward square planting on turfs after a thorough draining of the ground. Japanese larch was chosen because of the excellent results which it and hybrid larch were showing in some of the 1928 experiments at Inchnacardoch, Achnashellach and Glenrigh. This trial plantation has not been a success. Trial plantations on high and yet unplanted land above Lon Mor were laid down by Research Branch in 1932 at the request of Mr. Scott who was then Divisional Officer (North). These plots, with what was then believed to be the best method and species for each ground type have grown well. Trial plantation 75 at Lon Mor was of an earlier date and like 86 was planted by the Anderson group method; in it use was made of mountain pine which shows up rather pathetically against the strong contorta in Experiment 18 and 52 alongside. Among the purely manuring trials carried out during the 1929-39 period were advance

applications (in nursery and field) of quantities of basic slag; types of commercial phosphatic manure; effect of mixed manures, i.e. complete fertilisers; top dressing experiments; and also a few trials of compost (in the hope of introducing suitable mycorrhiza), and of so-called active peat soils from areas where plantations were already growing vigorously on peat.

A special study of the tough peat knolls was made and attempts were made to find better ways of planting them. Methods for dealing with the knolls ranged from notching as a control to turfing and complete turning over of the surface peat by a method which came to be known as mock ploughing.

A series of experiments carried out on the dry morainic lower slopes and on the heath known as Blar an Righ included ploughing trials. The best growth has been made in the earliest ploughing experiment (69 P.28) by Japanese larch and Pinus contorta. Scots pine follows but Sitka spruce failed badly. Further south on the heath (78-82 P.31) the ground was much more peaty and growth has been slow. On the same heath a large collection of Scots pine races (92 P.31) has been built up since 1931, but attempts to grow races of alder and birch on peat types met with little success.

As in many other forests, some beating up experiments were conducted in Inchnacardoch (in 1934) in order to study the fate of trees put in as beat-ups one, two, or three years after initial planting. In order to be certain of a perfectly fair basis for the experiment permission had to be received from Conservator (North) to cut out gaps in perfectly healthy and uniform plantations. The experiments were completely successful and gave invaluable evidence as to the futility of late beating up even in gaps as large as the space occupied originally by four trees.

A flushing experiment did improve the ground but the method is hardly practicable for large scale application.

In conjunction with the Macaulay Institute planting was done into each of the well defined soil horizons on the podsol of the heath at Inchnacardoch. This looked most odd at the time and has given quite unexpected results.

Apart from the experiments mentioned, large numbers of preliminary trials were carried out at Inchnacardoch; as a rule these were actually well replicated experiments but with specially small units usually containing only five plants and were therefore only of use during the initial establishment stage.

1940/50.

Few experiments were carried out during the war, though in 1942 there was a preliminary manurial trial using native rock phosphate from Fiunary forest, and in 1945 a direct sowing trial. 1946, however, saw a new start with six important experiments. They employed all the latest methods of ground preparation including the Cuthbertson draining plough and the wide tracked caterpillar type tractor fitted with a winch. This equipment made it possible to plough tough peat slopes and quaking bogs alike. For the first time use was made of specially raised conifer stock grown either in heathland nurseries or in old established nurseries where the soil had been partially sterilised. Spring 1947 was remarkable for the prolonged and severe frost which killed out the heather over much of the forest and the fact that spruce growth improved from that year is almost certainly correlated.

In the same year Experiment 135 (the first competitive trial) was laid down. Within it, by order of the Chairman, four officers including himself each selected the species and planting arrangement that he personally thought would do best. The planting was carried out on an area which had been single furrow ploughed within a western extension of the Lon Mor. Growth has been unusually good. No forest experiments

of importance have been carried out at Inchnacardoch since that year, but one small trial laid down in 1950 is worth mentioning. This is a planting of Japanese larch partly in the lee of the pine shelter belt (18 P.26) which has by now become most effective. The Japanese larch recently planted extends beyond the line of shelter so that a comparison of growth on both sheltered and unsheltered ground should be possible later on.

Inchnacardoch

Panorama of upper half P's 26 (on left of fence) and 20/21. Showing vigorous S.P. of P.26 on dry calluna also groups and clumps of established P.20/21 N.S. and otherwise complete check.

(Mr. Sangar's photo No. 32/25 - see page 2 of History).

(15) Group Planting Inchnacardoch 86.P.30 in 1938

An early view of Anderson's group planting. The area had been directly planted with spruces in 1922 and had failed. Groups with Sitka spruce in the centre and Scots pine round the outside may be seen on the right and centre foreground. On the extreme left foreground an Oregon alder/Sitka spruce group appears. These mixtures occupy semi-flush conditions. On the knoll slopes behind, some groups can be seen with Scots pine in the centre surrounded by Pinus contorta. In the background there is some ordinary planting of Scots pine on a dry calluna bank.
(Inchnacardoch 18B).

Group planting - Inchnacardoch 86. P.30 in 1949

Group planting of the most suitable species on peat and poor Calluna ground. A single group of Scots pine (9 plants) and Sitka spruce (4 plants). Manurial treatment 2 ozs. slag per plant.

High Elevation Planting Inchnacardoch 25A.P.27 in 1949.

Photograph shows the groups within this experiment now 21 years old. A group of upright mountain pine is in the left foreground. The edge of a Sitka spruce group can be seen on the right, and a pinus contorta group in the centre. The gap in the foreground was where Pyrus aira failed. (D.621).

(14). Group planting Inchnacardoch 86.P.30 in 1949

A.contorta/Scots pine group on a tough peat covered knoll. (D.616)

Pinus contorta/Sitka spruce mixture - Inchnacardoch 1951.
75% Pinus contorta and 25% Sitka spruce. P.46, planted on single furrow ploughing and manured with ground mineral phosphates.

INCHNACARDOCH FOREST

1
Panorama of upper half P's 26 (on left of fence) and 20/21. Showing vigorous S.P. of P.26 on dry Calluna also groups and clumps of established P.20/21 N.S. and otherwise complete check.
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2
Group planting Inchnacardoch 86.P.30 in 1938
An early view of Anderson's group planting. The area had been directly planted with spruces in 1922 and had failed. Groups with Sitka spruce in the centre and Scots pine round the outside may be seen on the right and centre foreground. On the extreme keft foreground on Oregon alder/Sitka spruce group appears. These mixtures occupy semi-flush conditions. On the knoll slopes behind, some groups can be seen with Scots pine in the centre surrounded by Pinus contorta. In the background there is some ordinary planting of Scots pine on a dry Calluna bank. (Inchnacardoch 18B).

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Group planting Inchnacardoch 86.P.30 in 1949
Group planting of the most suitable species on peat and poor Calluna ground. A single group of Scots pine (9 plants) and Sitka spruce (4 plants). Manurial treatment 2 ozs. Slag per plant.

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High Elevation Planting Inchnacardoch 25A.P.27 in 1949.
Photograph shows the groups within this experiment now 21 years old. A group of upright mountain pine is in the left foreground. The edge of a Sitka spruce group can be seen on the right and a pinus contorta group in the centre. The gap in the foreground was where Pyrus aira failed. (D.621).

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Group planting Inchnacardoch 86.P.30 in 1949
A.contorta/Scots pine group on a tough peat covered knoll. (D.616)

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Pinus contorta/Sitka spruce mixture – Inchnacardoch 1951.
75% Pinus contorta and 25% Sitka spruce. P.46, planted on single furrow ploughing and manured with ground mineral phosphates.

INCHNACARDOCH FOREST

SCALE

feet 1000 500 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 feet

FASNAKYLE 132 K.V.

MORISTON 132 K.V.

Meall na Ruadhaig

COMPARTMENTS NOS. 99 & 110 - TOTAL AREA 218·0 ACRES.
WRITTEN OFF 1958 - TRANSFERRED TO RESEARCH BRANCH.

Grey Drift hollows and pockets

Schist

Boundary of Readvance Moraine

Auchterawe Wood

Approx. boundary of Granite and Schist

Lòn Mòr

Gf

Foliated Granite or Granite Gneiss

Cattle Tor Dhuin

Creag Tor Dhuin

Oukwark Sand and Gravel

Kettle Moraine

CALEDONIAN CANAL

INVERGARRY & FORT AUGUSTUS RAILWAY

LOCH NESS

FORT AUGUSTUS

Pier

St Benedict's Abbey

Inchnacardoch

To Invermoriston

LIMIT OF AREA BURNT 1/6/46. REPLANTED AS SHOWN

SOUTH LIMIT OF AREA BURNT 1/6/46. REPLANTED AS SHOWN