FORESTRY COMMISSION

HISTORY

OF

CLOCAENOG

FOREST

N (W) CONSERVANCY

6

H I S T O R Y

of

C L O C A E N O G F O R E S T

1930 - 1952

NORTH (WALES) CONSERVANCY

HISTORY OF CLOCAENOG FOREST

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APPENDICES

HISTORY OF CLOCAENOG FOREST

CHAIRMAN'S COMMENTS

We acquired almost simultaneously, during my absence in Australia at the Third Empire Forestry Conference, two very large areas, Clocaenog in Wales and Clashindarroch in Scotland, which presented some similarities. Both were high-lying with a relatively harsh climate and much of the land was heather clad; in both also much of the soil was better than the surface vegetation indicated. Of the two, Clashindarroch was undoubtedly the more difficult afforestation subject and the difficulties there were enhanced subsequently by the extensive use of European larch which grew very well to begin with but later suffered greatly from die-back, from which there has now been quite a good recovery on all but the most frosty sites. Less reliance was placed at Clocaenog on European larch. We were in difficulties in both forests by the extensive use in the early years of spruces (mainly Sitka spruce) on heather ground.

The general result was that after 5 or 6 years' work, growth at both forests was mostly unpromising (except for European larch at Clashindarroch) and their future the cause of some anxiety to me at least. The methods of planting which we had been employing were obviously inadequate and in particular turf planting of spruces, which marked so great an advance on grassy land, did not seem to work on heather.

Then came deep ploughing with caterpillar tractors, which opened up a new approach to the whole problem. The first tentative effort at Clocaenog was in 1934 (the original furrow, turned in my presence, was still to be seen on the occasion of my last inspection in 1952).

In 1935 I had a Caterpillar outfit sent to Clocaenog and although the local opinion seemed to be that it would not work there, ploughing became general from 1936 onwards. The result has been a great improvement in the rate of establishment of plantations though it is not the whole story so far as heather areas are concerned. Gradually it has become apparent that to grow the spruces on such sites the admixture of a species which will kill off the heather is necessary. This knowledge came mainly from the Research Branch's various experimental areas but it is now an established fact. As the Clocaenog history points out, there are still a number of problems

revolving round the practical application of that knowledge to local conditions. That is where the local officer comes in and much depends on his powers of observation and analysis of accruing results.

At successive visits I have marked steady improvement of growth on Clocaenog considered as a whole and I have no doubt that it will become a satisfactory forest. Mr. Guillebaud, who inspected and reported on the land before acquisition, remarked that although exposure seemed severe the results should be mitigated as the trees grew up and sheltered each other. I think that here, as elsewhere, this is already becoming evident.

R.

July 24th, 1952.

HISTORY OF CLOCAENOG FOREST

GENERAL DESCRIPTION OF THE FOREST

Situation

Clocaenog Forest, which takes its name from the village of that name, is situated on the Denbighshire moors within the triangle formed by Ruthin, Denbigh and Pentre Voelas. The Derwydd and part of Bod Petryal blocks, 550 acres, in the extreme south of the area lie in Merionethshire. The remainder of the forest is in Denbighshire. The original acquisition of 12,000 acres formed the bulk of Lord Bagot's Pool Park estate.

The forest is made up of two blocks:-

a) The main block lies 4 miles to the west of Ruthin north of B.5105. It is bounded on the west by the Afon Brenig and Afon Alwen, and in the north by Ceunant Diffwys. It consists of 12711 acres, most of which was purchased from Lord Bagot in 1930, and planting commenced in that year.

A memorial stands on Pincyn Llys to commemorate Lord Bagot's first planting in 1830 and the Commission's first planting a 100 years later.

b) The Alwen block of 2190 acres lies on the water catchment slopes to the north-east and south-west of Alwen Reservoir, which is 3 miles north of Cerrig-y-Druidion. This area is leased from the Birkenhead Corporation.

Area and Utilisation

The total forest area is 14901 acres. Tables I and II give details of land utilisation by area.

The following approximate figures will serve to indicate former land utilisation:

Agricultural land	2,850 acres
Afforested land	650 "
Bare - mainly sheepwalk	11,400 "
	14,900 "

The farms were found throughout the area confined to no definite locality though the majority of the bigger farms were situated on the sheltered slopes of the Brenig, Alwen and Nant Ladur.

Mixed farming was practised with sheep rearing, the mainstay of the hill farmer. Cattle were kept only to supply the family with milk and butter. Cultivation consisted, in the main, of permanent leys giving hay and grazing for cattle in the summer and in the winter shelter and pasture for sheep. Some corn, chiefly oats, and root crops, turnips and swedes were grown for home use. All could have grown potatoes but few did. Cruglas farm was reputed to grow the best seed potatoes comparable with those from Scotland.

The open moorland was ranched as sheep grazing land, carrying a stocking of one sheep per acre. The best grazing was the Marial Cwyn and the Tal-y-Cefn sheepwalks. Cefn Du came next with the grazing deteriorating towards Pincyn Llys where it was almost pure gorse.

The sheepwalks were the first areas to be resumed and planted; the land coming to hand when the tenancy expired. This often meant that the land came to hand in March or November for planting in the current year. It was only in F.Y.47 that the policy of resuming land well in advance became standard practice, thus permitting large scale advance ploughing and drainage by F.Y.49.

With the loss of his sheepwalk and the good market price of milk, the farmer turned more to milk production, though sheep rearing was so ingrained that he was loath to lose his sheep altogether. Thus one finds sheep kept in the leys by the homestead, and more fields brought into cultivation for oats, barley and root crops.

Planting gradually encroached on to the less fertile and marginal land round the poorer farms, cutting them down to small holdings averaging about 12 acres, and leaving only a few larger farms in the sheltered valleys, e.g. Caer Hafod farms, Maes Tyddyn farms, Nilig, Talycefn Isaf, Hendre Uchaf, and Fachlwyd.

The open moorland was also used for grouse shooting and the original Pool Park acquisitions of 12,000 acres commanded a sporting rental of £790 and yielded bags of up to 700 brace of grouse and 300 head of other game excluding hares and rabbits. The moors were well keepered and the regular heath burning was beneficial to sheep as well as to grouse.

Since planting started grouse bags have gradually fallen as the heather has become too old and foxes and other vermin have increased due to the cessation of keepering. Game bags are now negligible and considerable expenditure has to be incurred on fox destruction.

Rabbits were never numerous except on the low ground, but hares were and still are common on the moors.

The afforested land was situated mainly on the sheltered slope of the Nant Melin-y-dwr area, lying between Clocaenog and Gyffylliog. The main species were hardwoods; oak, sycamore and ash, though Coed Pennant and Coed y Fron grew some European larch, Norway spruce and Scots pine.

TABLE I

Acquired from	By	Date	Plantations acquired acres	Plantable excl. Col. 4. acres	Nurseries acres	Agri-cultural acres	F. W. H. acres	Un-plantable excl. Col. 4. acres	Other land		TOTAL acres
									Descrip-tion	Area	
1	2	3	4	5	6	7	8	9	10	11	12
Lord Bagot	Conveyance	29. 1. 30	48	8427		1313	420	1230			11438
Lord Bagot	"	6. 6. 30		516			30				546
J. O. Griffiths	"	27. 6. 33		13							13
M. V. Wenner	"	28. 1. 35		140				4			144
J. Lee and others	"	10. 9. 38		141			35				176
Birkenhead Corporation	Deed of Variation (LEASE)	16. 1. 39		450				344			794
J. H. Wynne	Conveyance	23. 10. 44		5							5
Birkenhead Corporation	Lease	12. 4. 48		2142			26	22			2190
W. C. B. Williams	Exchange	2. 5. 51		713		38		20			771
Total Acquired			48	12547		1351	511	1620			16077
Disposed of to: R. G. Jones	Conveyance	28. 1. 31				124					124
S. J. Wilkinson	"	3, 6. 31				244					244
D. T. Jones	"	19. 7. 38		6							6
W. C. B. Williams	Lease	2. 5. 51		122		243	38	399			802
Total disposed of				128		611	38	399			1176
NET TOTAL			48	12419		740	473	1221			14901

TABLE II

(a) Woods and Plantations:	Acquired	....	28
	Formed by F.C.	....	8177
(b) Awaiting Planting:	Felled	....	62
	Bare	....	3554
(c) Nursery		....	21
(d) Agriculture	Farmed by F.C.	....	-
	Tenanted	....	406
Transferred permanently to Ministry of Agriculture.		Agricultural	2032
		Forest Workers' Holdings	39
(e) Forest Workers' Holdings		....	367
(f) Unplantable		....	174
(g) Other		....	41
		Total	14901 acres

Physiography

The forest is an undulating moorland lying mainly between the 1000 ft. and 1500 ft. contours with steep marginal slopes in the approaches to the area. The average gradient of the escarp is about 1 in 10 flattening out to about 1 in 100 on the plateau. The forest rises to a maximum of 1644 ft. on Craig Bron Banog in the south-west and falls to a minimum of 400 ft. in the Nant Melin-y-dwr in the south-east.

The chief topographical features are:-

The Marial Gwyn ridge 1500 ft. - 1703 ft. running north-east to south-west in the north-east of the forest. This ridge with Foel Frech 1483 ft. in the centre of the forest links up with Craig Bron Banog 1644 ft. to form part of the Dee/Clwyd watershed.

The river Clwyd has its source in the valley between Bron Banog and Waen Uchaf farms, and after flowing east for half a mile it turns due south leaving the forest at Bod Petryal via the "narrow bridge" on B.5105.

The Nant Llyfarddu rises on the watershed south of Foel Frech. It flows north-east to Cruglas farm turning north through Nilig to join the Oernant at Nant Uchaf to form the Afon Corris. These are the main rivers and valleys which drain into the Vale of Clwyd. West of the watershed numerous small streams drain into the Alwen and Brenig. The biggest of these rises east of Isgaerwen farm and flows south-west to join the Alwen at Tan-y-graig.

Geology and Soils

The whole forest is on the shales and grits of the Upper Silurian Series with glacial erratics.

The grain of the country runs approximately from south-west to north-east and is determined by faults rather than the strike of the rocks. The larger valleys and high moors follow this direction, the latter coinciding generally with the watersheds.

a) The geology of the Alwen block consists of the sandstones and shales of the Denbigh grit and Flag series covered in part by glacial drift and peat. Near the dam and at Pont yr Alwen the sandy flags and mudstones are readily seen.

During the construction of the reservoir more than one million cubic

yards of peat had to be removed from the bed. Mounds of peat are still evident in Compartments A.9 and A.6. where it had been dumped and Llyn Dau Ychain has been completely filled-in.

The top water level of the reservoir is 1190 ft. above O.D. The capacity is 3200 million gallons and compensation water is fixed at 2.25 m.g.d; the total resources being 11.4 m.g.d.

b) Main Block

The country lying east of the Afon Brenig and north-east of the Afon Alwen as far as Rhyd Galed, Tai Uchaf, Nilig, Pennant and Pont Petryal display a succession from the Denbigh grit series (Wenlock) to the Nilsoni zone (Ludlow). The base of the Denbigh grit series merges with the grits and sandy mudstones of the Valentian at Hendre Glan Alwen and Bryn-y-gwrgi.

Craig Bron Banog 1644 ft. and Moel Derwydd Bach 1284 ft. are formed from the lowest beds of the Denbigh grit series and consist of deep bluish grey flags and massive fine or coarse grey speckled sandstones with subordinate sandy flags or shales. These features are cut off in the east by the Pennant Pont Petryal fault. Further north exposures of bluish grey flags and mudstones are found east and west of Hafotty Newydd and at Isgaerwen. These flags are of the Cyrtograptus Lundgrenii zone (Wenlock) which succeed the Denbigh grit series flags, and are rarely exposed on the open moorland because they are insufficiently resistant to weathering to form crags.

The Marial Gwyn area appears to be formed from cleaved grey Nantglyn flags. Nantglyn flags are also exposed along the road to Nilig and in the valleys near Glan Ceirw (Compartments 41 and 42) and Nilig (Compartment 306) and by Pennant (Hiraethog).

The Denbigh grit series form bold escarps of a north-east trend, the dip lying south-east at Talycefn Uchaf (Compartment 155). Grits and flags outcrop at Ty Hen and at Ty Uchaf, and just north of it, cleaved sandy grey flags of the Denbigh grit series are well exposed. Deep ploughing on P.40 has turned up numerous fairly large slabs of flags.

The forest area lying east of the Pennant Pont Petryal fault contains beds chiefly of mudstones, flags and shales, with subordinate fine-grained sandstones and siltstones from the Wenlock to the Ludlow series.

According to Boswell, Coed Pennant is composed of the mudstones and sandstone facies of the zone of Monograptus scanicus (Ludlow) which are

siliceous and thinly bedded.

Coed-y-Fron, Parc and the area of Nant Ladur consist of the upper Nant Glyn flags or upper part of the M. Nilsoni zone (Ludlow) which continue under the M. scanicus zone of Coed Pennant and the Clocaenog district. Quarries at Pennant (Hiraethog) show Nant Glyn flags at one time extensively worked for slabs.

Cefn Du, Waen Ganol, Maestyddyn show sandy striped flags and grey mudstones of the lower M. Nilsoni zone, and Pigyn Llys the ribbon banded flags and mudstones of slab-like character of the upper M. Nilsoni zone (Ludlow).

The area of the main nursery and Glan-y-gors belong to the zone of Cyrtograptus Lundgrenii of the Wenlock series exhibiting banded slate grey flags and massive mudstones.

The terms used above are defined as:-

a) Grits - sandstones which are rough to the touch; usually coarse textured.

b) Siltstones - dominant grain size 0.002 in. - 0.0002 in. diameter

c) Mudstones - dominant grain size less than 0.005 mm. diameter. In the field they are seen to form massive beds from 2 ft. - 6 ft. or more.

d) Shales - grain size similar to siltstones or mudstones. They occur in thin beds or laminae and can be split along these bedding planes.

e) Flags - mudstones, siltstones or fine sandstones which display well defined bedding planes from $\frac{1}{2}$ in. - 6 ft. apart, and can be split along these planes.

f) Glacial drift of boulder clay superficially a rubbly incoherent grey or brown sandy material containing only local Wenlock or Ludlow rocks. Often, therefore, it cannot be distinguished from the weathering in situ of the underlying strata.

g) Denbigh grit and Flag series - coarse grit, sometimes pebbly and thick deposits of siliceous mudstones, siltstones, sandstones, shale and less commonly flags.

The composition of the rocks are of hydrated aluminium silicate with iron compounds also present. The siltstones, mudstones, sandstones and grits contain grains of quartz.

The soil, a shaley yellow clay loam, is usually of good depth. The profile of the moorland soils shows a varying depth of peat from 4 in. - 15 in. podsolisation and often the formation of an iron pan 6 in. - 8 in. below the surface of the mineral soil.

The steep slopes of the forest margins have no peat and the soil is a shaley loam.

On the moors clay beds and peat bogs may be found. Compartments 141, 225 and 229 show peat of at least 6 ft. deep. Bryn Glan-y-gors is reputed to have peat beds of up to 15 ft. deep. Pockets of clay soils exhibit poor aeration and a glei soil profile may be seen.

Vegetation

The characteristic vegetation of the moorlands is heather species. Calluna vulgaris is the most widespread and is generally dominant in associations with Vaccinium myrtillus and grasses on the drier slopes.

The very dry slopes and rocky outcrops carry dwarf gorse (Ulex galii), Erica cinerea grasses and some tufts of Calluna.

The well-drained sheltered sites carry dense bracken and grasses descending into the valleys along slopes which carry bramble, bracken, grasses, foxglove, bluebell and other species associated with old woodland.

The low-lying boggy sites on the moorland when well drained exhibit Juncus, Nardus, Calluna. Where drainage is poor the main species are Molinia, Scirpus, Eriophorum and Erica tetralix.

On the low lying flush areas of Molinia, Aira caespitosa is seen to be invading the ground indicating a more basic pH, probably the effects of drainage.

Agrostis species, chiefly Agrostis canina, invade the newly turned mineral soil, e.g. ploughed fire line traces (where also the soft grasses like Holcus lanatus are also seen) and the mineral soil on the furrows ploughed for planting.

The common moorland mosses are Sphagnum and Polytrichum. The Sphagnums are seen to form local bogs in low lying ill-drained hollows.

Meteorology

The average annual rainfall varies from 35 in. in the east to 60 in. on the moors.

Owing to the remoteness from the seas, the general elevation and all round exposure, the climate of the plateau is cold and severe. There is no shelter from the strong prevailing south-west winds and the bitter east winds in the early months of the year.

Frost and snow are frequent and snow may lie for long periods. In the severe winter of 1946/47 the forest roads were impassable for 9 weeks.

Both early and late frosts are common in certain localities e.g. frost commonly occurs along the Clwyd Valley Compartments 288, 292 well into June every year, and exceptionally late frost will be found in mid July. P.35 Compartments 202, 203, 204, 210, 211, 216, 215 a Juncus/Molinia bog is also bad for late frost.

Rainfall is recorded at the forester's house at Foel Fach and at the Alwen dam. The annual totals (in.) are as follows:-

	Foel Fach	Alwen
1936	47.61	
7	37.39	
8	41.25	
9	45.3	
1942		46.29
3		53.88
4		54.87
5		47.69
6		57.45
7	27.41	45.33
8	58.12	54.11
9	38.45	50.45
1950	44.14	60.28

The two stations show a remarkable inconsistency with each other month by month which shows how the rainfall varies locally.

Temperature records are available at Alwen dam for 1950 and '51. Spring frosts occurred in May, June and July, 1951 but only in May 1950, but in neither year were spring frosts severe in North Wales.

The prevailing wind is south west but although most of the moorland is fully exposed the effects of exposure on tree growth are less than expected, probably due to the greater distance from the west coast than most of the North Welsh forests.

Risks

a) Fire

The risk of a fire starting is not severe for North Wales but the risk of a very severe fire resulting is greater than normal owing to the large unbroken stretches of inflammable vegetation and forest.

The fire risk from grass and heather burning is greatly reduced now that all the heather moor has been planted up and also the "Heather and Grass Burning Regulations (England and Wales)1949" prohibits burning except under licence between 31st March and the 1st November. All tenants are warned to give notice of burning.

There is always the usual risk from the public - visitors, ramblers, cyclists - who use the many roads and paths which cross the forest area. Visitors are to be found at any time from 10 a.m. - 10 p.m. in the summer months. Favourite picnic spots are B.5105, Compartments 240 and 243, Bod Petryal area and Talycefn crossroads.

Appendix B gives a record of fires at Clocaenog forest from which it might be assumed that the fire risk is not great, but this is not the case and it is believed that the forest has been extremely fortunate in its forest fire record. Now that most of the moorland has been planted and more has grown out of the fire stage and there are few effective natural fire breaks, the danger must be regarded as considerable.

b) Trespass and Theft

There is risk of theft of Norway spruce for Christmas trees. In 1948 and 1949, 100-200 trees were stolen in each year, and 150 trees in 1950 together with 100 lbs. of holly in that year.

Patrolling of the forest is carried out in December.

c) Mammals

(i) Rabbits are scarce on the moors. They are found mostly in the eastern blocks which lie surrounded by agricultural land. Rabbits appear to be on the increase in the Coed Tre'r Parc and Coed-y-Pentre areas.

(ii) Hares are the chief pest on the moors. No severe damage has been reported in recent years.

(iii) Voles. On 17.1.49 it was reported that there were signs of voles being very numerous over much of the forest, including the old experimental plot in the nursery.

(iv) No grey squirrels or deer.

d) Birds

(i) Black game are on the increase in the Bron Banog area of later years but no damage has been recorded.

(ii) Wood pigeons by perching on the leaders of Norway spruce and Sitka spruce sometimes snap them off. Those trees with

lammas shoots being especially susceptible.

e) Insects

(i) Compartment 440, P.46 was replanted immediately after felling as a result it was severely attacked by Hylobius abietis, but elsewhere this beetle has caused no appreciable damage.

(ii) Pine sawfly. In July, 1939 pine sawfly were reported on Pinus contorta in Gasnach. Again in 1950 on Pinus contorta in the Research plots Compartment 91. These attacks were local and no extensive damage was caused.

(iii) Chafer. The Waen nursery showed attack by chafer on Sitka spruce 2+2 lines on 27.4.44 and again on 29.11.44. No further attacks have been recorded.

(iv) Larch shoot moth - a local attack was found in Compartment 240 hybrid larch P.37 on 5.9.46.

(v) Neomyzaphis abietina. In 1948 there was widespread attack of Sitka spruce by Neomyzaphis. Bont Petryal Sitka spruce showed a bad attack on 4.6.49. Compartment 244 P.37 Sitka spruce were a sickly lot, checked in heather ground, and these showed a more pronounced attack by the insect. P.41 Compartments 278 and 251 also showed a concentrated attack, but generally the insects activities were diffused over the forest area, showing up on the sickly trees where they were suppressed or in frost hollows.

The trees began to recover in 1949/50 and shook off the attack. The mixture of Japanese larch and Sitka spruce in Compartment 129 P.30 also exhibited a severe attack on 5.9.46. The Japanese larch becoming the more vigorous, suppressed the Sitka spruce.

f) Fungi

(i) In 1950 in Sitka spruce seedbeds the lower leaves and stems were covered by a fungus growth matted with soil and chippings. The fungus was a species of Telcophora. The seedbeds were very densely stocked and the conditions excessively wet. No damage was caused and the plants showed no ill effects.

(ii) Abies procera Compartment 464, P.40, planted in an old hardwood area amongst ash regeneration and coppice have been attacked by Armillaria mellea, but Sitka spruce have been surprisingly free.

(iii) In 1949 20% of the stems of P.31 European larch in Coed Pennant and Coed-y-Fron were suffering from larch canker.

g) Climatic

(i) Wind. Compartment 436 P.00 Norway spruce, ½ acre plot suffered from heavy windblow in 1936. There had been a heavy fall of snow which had clung to the trees. A gale got up and caused the damage, but the primary cause was neglected drainage in a naturally wet site which gave rise to a spring.

Compartment 91 P.34 Pinus contorta Research plots - a number of stems were wind thrown in 1938. The risk of windthrow is likely to increase in future years as the trees gain height, particularly on the wet sites.

Cefn Du P.48 showed mechanical damage caused to Scots pine by rocking of the plant against sharp shale. The Scots pine were planted on the furrow, rain has washed away the soil leaving shaly pieces of stone against the stems.

(ii) Exposure. It is remarkable that in spite of the high elevation of the moorland areas, the effects of exposure are not extreme, and even Scots pine can be grown on moderately exposed sites without severe browning and many of the more exacting species have been grown at high elevations experimentally.

(iii) Snow. In spite of heavy falls there has been no extensive snow damage but the use of Scots pine other than as a screen, is not advised on a large scale.

(iv) Frost. The ice storm of 1940 did very little damage but most of the plantations were then too young to be susceptible to the worst type of injury so frequently to be seen

in North Wales.

Winter cold has had little effect and the disastrous results of the 1947 winter, so much in evidence in the forests of Cardiganshire, were little in evidence.

Spring frosting is severe in hollows at high elevation but Norway spruce comes away well eventually although Sitka spruce has suffered severely in places.

Roads

a) County Roads

The map shows the roads in and around the forest as they now exist.

The trunk and county roads serve the forest well on all sides with one third class road up the middle. These roads are generally tarmac, but some of the minor ones suffer from steep but short gradients besides being narrow and sharply curved. They are serviceable for present traffic, but alterations will be necessary when long poles have to be extracted. It is hoped to have cattle grids installed on a county road at Cae'r Hafod and near Ffridd Arw to eliminate the double line of fencing that would otherwise be required between these two points. Negotiations are proceeding for the installation of two other grids at Hafotty Hendre and in Compartment 240, close to the main Ruthin - Cerrig-y-Druidion road (B.5105); these grids will not save much fencing but will give considerably increased protection to the plantations.

b) Forest Roads

A start was made on forest roads in 1949 when the Galion grader cleared a quarter of a mile of ground during a fortnight's fine weather. This is serviceable in dry weather.

In 1950, the Galion grader graded 7.4 miles of track at a costed rate of £70 per mile. These tracks will gradually improve with wear and are passable in dry weather but will not stand up to very heavy traffic. When plant is available it should be easy to stone these tracks to take all traffic in all weathers and

and maintain them by mechanical plant at low cost.

A start was also made with a permanent road, F/19, which will become the link between the main and Alwen blocks. In 1951 the grader re-graded 3 miles of track restoring the ditches and raising the load-carrying capacity of the tracks. A number of culverts were installed and the drainage system improved generally.

F/19 was nearly cleared, but road work had to be stopped for two months while the labour was switched to planting during the short season available that year.

This year F/19 has been finished off, except for surfacing, but it is passable for Forestry Commission vehicles. A road to a holding has also been put in order and dozers are working on the formation of the roads in the central block to provide tracks for fire fighting vehicles, and to act as fire breaks in this dangerous area.

Costs

The 6.7 miles of unmetalled track have cost £626, giving a rate of £94 per mile. The permanent road cost £1,973 for .9 miles, at a rate of £2,200 per mile, which is a fair rate for manual labour. The expenditure was unavoidable as the road was wanted when plant was not available.

The easiest roads were tackled first and have proved their worth within their limitations. They can be improved with the needs of the forest and as plant becomes available. Dozers have been brought in to work on the central portions where the fire danger is high and the ground is also bad. It is intended to doze out the road formations and leave them to settle and consolidate till traffic warrants improvement.

Labour

When the forest started in 1930 labour was comparatively easy to get, following on from the depression years and with a very young forest there was no great need for a large labour force.

During the war and after, there was a great shortage of labour particularly in 1945. In that year and until 1947 twelve to eighteen men were transported daily from Denbigh. Gradually, however, men began returning from industry and the Services and to settle in the district.

This was made possible by the Rural District Council housing scheme. By building in the surrounding villages the Council assisted in settling labour in the area. The following gives a list of the new houses built since 1945:

Village	Total houses built	Houses for Forest Workers	Houses for Agricultural Workers
Clawddnewydd	2(+2 in 1930)	2	-
Clocaenog	12	3	5
Bont Uchel	8	-	4
Gyffylliog	8	3	4
Derwen	6	1	3
Llanfihangel G.M.	8	2	?
Cerrig-y-Druidion	6	1	?
	50(+2 in 1930)	12	16+?

Forest Workers are also eligible for application for houses set aside for Agricultural Workers should the quota for forest workers be filled.

There is now a total labour strength of 78, of whom 25 are holders and 4 are boys. There is one girl clerk. The present position is that though there is no excess of labour there is a good nucleus of 7 Grade I and 25 Grade II men. More men could be employed if available especially on road work. In F.Y.47 recourse had to be made to German and Italian P.O.W. labour. These were employed on draining, preparation of ground and planting. They were very 'green' and close supervision was required.

In 1948 and 1950 during a rush of work in the nursery, 8 displaced persons labourers from the Denbighshire Agricultural Executive Committee were used for lifting plants in the nursery and in 1948 Land Army girls were used for weeding. Other than for these rush jobs the forest was able to manage on its labour strength. This has largely been possible to date owing to the fact that the spruces of P.30, 31, 32, which would normally be due for thinning from F.Y.49 onwards, were not ready for thinning either because the Sitka spruce/Norway spruce line mixture thinned itself or the growth was not as rapid as was expected to close the canopy.

SILVICULTURE

Preparation of ground prior to planting.

a) Moorland areas. For P.31 area doubt was expressed as to whether heather should be burnt or not prior to planting. It was agreed by the Chairman on the Commissioner's tour of 19.4.31 that heather would be burnt.

Prior to 1936, therefore, work on preparation of ground consisted of burning off the tall, strongly growing heather and gorse, and planting was done with a mattock. Wet or frosty ground was turfed and planted with spruces. Pines were sometimes planted on turfs in admixture with spruces on heather peat or on thin heather peat knolls. Turfs were not cut for other species. Main drains were also cut, and if possible these drains with cut-offs were put in a year or two in advance. The planting area was fenced against rabbits and stock. Other methods were carried out in small trial plots, e.g. cultivation of $\frac{1}{8}$ acre by digging over soil two spits deep to simulate deep ploughing was carried out on the P.34 Nilig area, Compartment 59. Again in P.35 Nilig a small area was prepared for planting using a Fordson and Ransome single-furrow plough.

After P.36 preparing the ground work consisted in burning off the rank heather growth and ploughing where possible. All peaty ground and bogs with a vegetation of heather, Molinia, Nardus, Juncus and Scirpus were ploughed. Rocky ground and generally the better bracken ground on the steeper slopes were not ploughed. Draining and fencing as for areas prior to P.36.

b) Old woodland sites. The old woodland areas of Coed-y-Fron, Pennant, Wyllt, Cooper, Tre'r parc, Pentre etc. were cleared of coppice growth of hazel, ash, willow, birch and bramble where the trees were not too large. Otherwise large stems of ill-shaped oaks, ashes and beeches were ringed and planting done through the area. Fencing and, where necessary, draining were also pre-requisites for these sites.

In 1948 the Fron Fari area was cleared of coppice and scrub hardwoods of ash, oak, sycamore and sold for firewood. This was only done because of the good firewood market, otherwise the operation would have been too expensive. As it was, the firewood paid for the cost of clearing, and a site ready for planting was obtained.

Choice of Species

In the first inspection tour of the forest on the 25th and 26th August, 1929, it was stated that "the choice of species would be generally Japanese larch with Sitka spruce in bogs and Scots pine

on rocky knolls possibly Corsican pine in the eastern part where also possibly European larch and Douglas fir and possibly some hardwood areas".

This was more or less confirmed by the Technical Commissioner's Tour in October 1929, which states that "the forest as a whole appears definitely a Japanese larch, Sitka spruce, Norway spruce area with some European larch in the more favourable situations". Following on from this decision, in P.30 the lower sheltered slopes of Coed-y-Fron, Coed Pennant and Hafotty Wen, which carried bracken and grasses, were planted with European larch and Japanese larch, and the higher more exposed ridges with Nardus, Calluna and mosses with some Juncus and Molinia were planted with spruces. Norway spruce occupied the low ground and sheltered wet hollows - chiefly Molinia areas - and a Norway spruce/Sitka spruce single row mixture on the higher ground. The rocky heather tops, e.g. Compartment 119 were planted with Scots pine but Corsican pine was not used owing to its failure at Lake Vyrnwy.

In P.31 the same choice of species was adopted. Norway spruce/Sitka spruce single row mixture was the chief species mixture planted. With Japanese larch and European larch again on the old woodland sites of Coed-y-Fron and Coed Pennant. In Gasnach a Norway spruce/Scots pine mixture was planted on patches of tight peat carrying very short Calluna growth.

In P.32 Norway spruce and Sitka spruce were planted in pure blocks rather than alternate line mixtures. The Sitka spruce generally on the high ground carrying Calluna and the Norway spruce in the hollows where Molinia and Juncus predominated. A mixture of Scots pine/Sitka spruce was planted on Gasnach on tight, very short heather, a poor type of ground which was very exposed. Sitka spruce was also planted in a bracken/Calluna mixture on Gasnach with European larch confined to grass, bracken, gorse areas.

The choice of species on heather remained unchanged until P.47 when Sitka spruce/Scots pine 2/1 mixture was planted on Talycefn and Nilig areas on pure tight Calluna ground which had been ploughed.

In P.48 planting of a 2 row, 2 row mixture of Sitka spruce and Scots pine became standard practice on the ploughable heather ground. While pure Sitka spruce was used in the exposed bracken, heather and grass areas Norway spruce was confined to the low lying, rushy ground which was free from heather. Japanese larch was planted on sheltered bracken slopes, Scots pine on rocky knolls and Pinus contorta on the really bad sites, i.e.

very exposed rocky ridges and boggy frost hollows. Small plots of Lawson cypress and Tsuga have been tried.

European larch was not extensively planted after P.38. In Compartment 464 P.49 an experimental plot of European larch was laid down in a matrix of nurse species, e.g. Douglas fir, Norway spruce, Scots pine to compare its rate of growth, resistance to canker and general health, with a control plot of pure European larch of the same identity.

Choice of species for amenity planting in the early thirties was Tsuga, Abies procera, Abies grandis and Thuya, which were planted in single rows along rides and roadsides. In the amenity block of Bont Uchel P.44, beech, cherry and sycamore were used in a coppicing hardwood area of oak, ash and sycamore.

Amenity planting is now arranged in small groups or strips of irregular outline along roadsides, the species chosen being mainly beech, copper beech, birch and red oak.

The choice for fire belts was birch until P.45 after which following on from the Chairman's instruction of 20.4.46 Japanese larch planting for fire belts became standard practice, with a few birch groups in the wet, peaty sites unsuitable for Japanese larch.

Planting

a) Spacing. The planting distance on ploughed ground for all species was normally 5 ft. x 5 ft. but in the early war years some wider ploughing was done for economy and speed and planting was closed up along the furrows to allow the same number of trees per acre. On unploughed ground the pines and Norway spruce were planted at $4\frac{1}{2}$ ft. x $4\frac{1}{2}$ ft., Sitka spruce and Japanese larch and amenity species at 5 ft. x 5 ft.

The Research Branch carried out experiments on planting distances of 5 ft.- 10 ft. in Tre'r parc with European larch (P.35) and also with Norway spruce (P.35) Compartment 214, and Sitka spruce in Compartments 175 and 212 (P.35).

b) Type of plant used. Sitka spruce, a 2+1 transplant of 6 in.- 9 in. was used for turf or plough planting and a 2+2 9 in.- 12 in. for surface planting. From time to time batches of seedlings had to be planted,

e.g.

P.32	Gasnach	2+0
P.34	Nilig	3+0
P.50D		2+0

Norway spruce, mostly a 2+2 6 in.- 9 in. plant was used; Japanese larch, a 1+1 transplant 9 in.- 12 in. high.

In the days before the war the main supplying nurseries, in addition to Clocaenog, were Delamere, Cannock and Mortimer. After the war plant supply was chiefly within the N(W) Conservancy. Clocaenog was able to produce the bulk of its Sitka spruce and Norway spruce and part of its Japanese larch requirements from the home nursery from F.Y.48. Scots pine was usually imported from Scotland.

c) Methods of planting. Direct planting of Sitka spruce (in bracken) Japanese larch and the pines was done with mattocks; the L notch was the method used.

On turves the spruces were dibbled through; a hole being made in the turf with a sharpened piece of wood about 1 in. in diameter, the plant threaded through, the roots spread out under the turf, the turf lowered to the ground and the plant firmed in with the heel of the boot.

On ploughed ground planting was done with the semi-circular spade. The average man could put in 800 plants a day and the best men about 1,000 plants.

Much of the pre-war planting was done on double-furrow ploughing, the plants inserted in the centre of the second furrow. Planting is now done on single-furrow ploughing on the side of the furrow slice.

An experimental plot was planted in April 1950 for the Chairman where 2 ft. turves carrying Sitka spruce and Norway spruce 3 ft. to 4 ft. high were dug out from the plantation and planted in two half acre plots of mountain pine 10 ft.- 12 ft. high, the Sitka spruce and Norway spruce turves being spaced in the gaps in the pine plot about 9 ft. apart.

d) Annual rate of planting.

The following table gives the annual rate of planting:-

Area in Acres

P. year	Area	P. year	Area	P. year	Area
30	311.5	40	437.0	50	599.7
31	641.4	41	304.75	51	596.2
32	465.0	42	181.0	52	
33	377.0	43	113.5		
34	397.1	44	44.5		
35	446.0	45	Nil		
36	436.2	46	99.5		
37	366.0	47	437.6		
38	500.0	48	385.0		
39	447.0	49	649.4		

e) Manuring

The manure used in the plantations was basic slag, 2 oz. application at the time of planting. Basic slag was not extensively used as the ground when ploughed generally showed good mineral soil and texture. Applications were made to the spruces on very poor, peaty soils devoid of much mineral matter, or on sour boggy and peaty ground carrying heather, Scirpus, cross-leaved heath etc.

Manuring was mainly done in the Research plots of Marial Gwyn and Talycefn, where experiments were carried out with basic slag and semsol on Japanese larch and Sitka spruce seedlings and transplants, and basic slag on Pinus contorta transplants. The Research plots in Compartment 158 P.33 Sitka spruce were treated with basic slag and they showed by F.Y.47 earlier establishment and better growth than the surrounding Norway spruce and Sitka spruce.

In Compartments 60 and 61 P.34 on pure Calluna ground slag was inserted under the turves after planting the Sitka spruce. The soil was stiff blue clay overlain by a varying depth, up to 15 in. of Calluna peat. The plantation is very uneven in growth, gappy and not at all promising. In Compartment 79 P.40 the Sitka spruce used for beating up the Sitka spruce/Norway spruce mixture were treated with 1 oz. basic slag.

The Talycefn bog (Compartment 225) Sitka spruce and Pinus contorta were treated with basic slag when planted (P.49). The

ground was very boggy with deep peat and a vegetation of Erica tetralix, Eriophorum, Scirpus and bog asphodel. The take was good and the plantation looks promising. This is probably due to the deep Cuthbertson draining and ploughing.

9 acres of Sitka spruce 2 yr. seedlings were treated with 2 oz. per plant of Fisons No.8 (Compartment 352 P.50). The fertilizer was laid in two bands on each side of the plant. No appreciable visual difference was recorded in F.Y.51. The ground was ploughed with a R.L.R. plough. The soil was a heavy clay, shaly in parts, with a vegetation of Calluna and some wisps of bracken.

f) Success or otherwise of establishment.

It can generally be said that far better establishment has been obtained from transplants than from seedlings. The percentage deaths have been much lower with transplants, and the subsequent growth and competition with weeds more satisfactory.

Throughout the inspection reports attention has been drawn from time to time to the failures in planting seedlings and the success of transplants, e.g. Divisional Officer's tour of 26th January 1938, "The use of too small plants and still more so of seedlings appears to be a very false economy which has sometimes been forced on the forest by circumstances".

Attention was drawn in April 1931 to the fact that seedlings planted deeper than normal looked more healthy, especially in areas where frost lift had occurred.

The advent of ploughing saw a general reduction in failures following planting coupled with earlier establishment and more regular crops.

Ploughing

Preparation of the ground prior to planting consisted in burning off the tall heather and gorse. Compartment boundaries are marked by turning out two single furrows half a chain apart.

Ploughing for planting started by trial plots in the P.35 area of Nilig using a Fordson and single-furrow Ransome plough. This was seen by the Chairman in 1935 and good results were reported. Instructions were then

given that "one of the Commission's tractors and a plough should come to Clocaenog and deal with the large areas of dry light peat over good soil which wants stirring up". By November 1935 a 28 h.p. Caterpillar tractor and double-furrow Oliver plough arrived.

The first ploughing started in F.Y.36 for P.36 ground in the Maestyddyn and Wenner blocks. The method adopted was for the tractor to circle the hill wherever possible in decreasing circles throwing the furrow downhill. This was done to eliminate dead time which was needed to turn on straight runs. The ground was peaty and very stony with a vegetation of Calluna on the high ground and Molinia/Juncus on the low ground. Pan was found on the drier areas. Visible boulders were marked with pegs and the plough drawbar was coupled with a wooden pin to obviate damage to the share if an obstacle was met. This was later replaced by an automatic release.

The furrow slice sometimes fell back when the plough bumped over stones. An assistant was employed to follow the plough and cut the furrow slice before it fell back. Two furrows were ploughed. The first generally did not lie well and the second lay at a slant with one edge on the first. The rate of ploughing worked out to about $1\frac{3}{4}$ acres per day in winter and 2 acres per day in summer. Ploughing fire lines averaged 27 chains per day. In P.36 and P.37 100 acres and 246 acres respectively were ploughed.

At this time a Ransome deep furrow-trac and a Unitrac Major plough were also tried, but the double-furrow Oliver proved the more satisfactory. The Caterpillar could plough up a 1 in 4 gradient for short lengths and it gave very reliable service. The double-furrow Oliver ploughing was shallow, from 4 in.- 6 in. The furrows were spaced at 5 ft. intervals. Planting was done with a semi-circular spade in the centre of the 2nd furrow slice.

In F.Y.40 the Timber Supply Department withdrew the tractors for a time. Recourse was then made to the Denbighshire Agricultural Executive Committee and a contractor in Llanrwst - Kerry Brothers. Kerry Bros. used a caterpillar and a double furrow Oliver plough and agreed to do the ploughing for 25/- per acre. The Denbighshire Agricultural Executive Committee assisted with a Fordson and Ransome single-furrow.

The double-furrow Oliver continued to be used until F.Y.47 when it did its last ploughing on the Carreg Berfedd P.47 area. The first R.L.R. ploughing was done in the Talycefn area Compartments 155 and 156 where heavy

breakages occurred owing to boulders. Ploughing was to a depth of 9 in. The first single-furrow Cuthbertson ploughing was done in P.47 Talycefn bog (Compartments 160 and 161) where ploughing was done to a depth of 18 in. The first double-furrow Cuthbertson ploughing was carried out on the Alwen P.51 and Compartment 411 P.52 (Pincyn Llys) areas. Other ploughs used were the Begg and Ransome solotrac and duotrac.

The R.L.R. ploughed all the drier stony ground carrying heather/ Vaccinium and grasses. This meant that most of the ridges and high ground were ploughed with a R.L.R. plough. The tractors used with this plough were the D.4, Fowler FD3, and Fordson County. Ploughing depth averaged 10 in. Very good work was given by this plough on very difficult ground e.g. Cruglas, which often resulted in heavy breakages. Almost all the P.48, P.49, P.50 and P.51 heather moor was ploughed with the R.L.R.

The Ransome solotrac was used on bracken/Calluna ground by the Waen nursery which was to be planted with Sitka spruce. Only small areas were ploughed to a depth of 6 in. - 8 in. by this implement on typical R.L.R. ground where there was no danger from boulders. The main use to which the solotrac and duotrac was put was the ploughing of fire lines. In this they ploughed all types of ground except very bad bogs and they did a very satisfactory job.

The Begg with the Caterpillar D2 was used on definitely wet sites. It was able to plough Sphagnum/bogs in Alwen and ground at Nant Uchaf, which could not be tackled by the double-furrow Cuthbertson and D4. It was also used in conjunction with the double-furrow Cuthbertson at Alwen to plough the headlands and odd corners which could not be negotiated by the larger plough. The Begg is an excellent plough for marshy ground with rushes, Juncus and mosses. With its wide wheel track giving a low centre of gravity it is easily handled on sloping ground. It can turn a 10 in. furrow or a 3 in. furrow for skim ploughing if required. The 26 in. tracks of the D2 enable the ploughing of really soft quaking ground to be done.

The single-furrow Cuthbertson was used in Compartments 262 and 263 (P.50) and Compartments 225 and 229 (P.49) where there was deep peat and a vegetation of Sphagnum, Erica tetralix and Eriophorum. Excellent drains 18 in. to 20 in. deep were laid down with this plough.

The rate of ploughing was with the R.L.R. $2\frac{1}{2}$-3 acres per day on the

easier going and long runs of the Cefn Du - Pincyn Llys area (P.50 and 51). The P.49 Cruglas area was very difficult, the ground being steep and very rocky. The rate here was about 1½ acres per day. Given reasonable going the R.L.R. with the D4 or FD3 will average 2 acres a day.

The double-furrow Cuthbertson ploughed on an average 5 acres a day at an average labour cost of 7/6d per acre. The going was not easy and often one way ploughing had to be done. On easier going 6 acres per day could be ploughed quite comfortably. The areas ploughed were soft clays, and wet peaty ground with a vegetation of heather, Juncus, grasses and mosses. Ploughing on the drier soil where the plough is not very efficient owing to its flat bottomed share, the depth went down to 4 in. On the boggy ground which was suited to the plough 12 in. or more was the depth ploughed.

The tractors used were the Caterpillars D4 and D2, the International TD6, the Fowler FD3, Fordson County and the Fordson half-track. The half-track was not very successful, especially on gradients, and the County was not robust enough for continued R.L.R. ploughing. The Caterpillars and Fowler proved the best all round tractors for the job. Ploughing throughout is done at 5 ft. spacing, leaving an unploughed space at every 2 chains for access and extraction.

Contour ploughing was tried at Alwen (P.50). It was found that this method unduly complicated draining. Ploughing is generally done in straight lines running obliquely across the contour where the ground is steep, or otherwise ploughing straight lines up and down the slope.

Planting is done with a semi-circular spade on the side of the furrow slice. The plant used, where possible, is a sturdy transplant averaging 9 in. in height. It can be said that all species definitely benefited in growth and take when planted on ploughed ground. There were fewer deaths and, therefore, less beating up and greater height growth and no weeding was needed, except in dense bracken areas, until the third year in grasses and rushes.

Japanese larch was not usually planted on ploughed ground but where it had been planted, growth was vigorous, the plants, however, rocked in the wind and exhibited saber growth. Sitka spruce in Scots pine/Sitka spruce mixture also rocked and assumed a floppy growth.

An example of delayed planting on ploughed ground was seen in Compartments 302, 303, 321-323 (P.46). The area was ploughed F.Y.42, but owing to the war and the food production drive, planting was not permitted until F.Y.46. The resultant plantation was very disappointing in height growth and was not comparable in vigour, height and even growth with the adjacent P.48 area.

Prior to F.Y.38 Compartments 89, 91 and 92 were thought to be doubtful plantable ground at an elevation of 1400 ft. - 1450 ft. but after draining and ploughing the area was classified as plantable and planted in P.42. Again Compartments 225, 229, 158, 173 were classified unplantable prior to F.Y.38 but deep ploughing and draining has enabled the area to be planted in P.49.

Ploughing has, therefore, assisted greatly in the quicker establishment of plantations, reduced the costs of establishment and made possible the planting of hitherto unplantable boggy and sour ground.

Beating Up

The following table shows the areas beaten up each year:-

Beating up in thousands of Plants

F.Y.	P. Year 50	49	48	47	46	44	43	42	41	40	39	38	37	36	35	34	33	32	31	30	Totals
51	198.1	16	3	6	2	1				6.5				2				5			233.6
50		176.5	3.5	10	2			6		9	3		8	3		3		8	8		236
49			110	190	6														6		132
48					26		8				5		2	7		1					239
47					17.5			.23		2	2	15									59.5
46						1	11	3		13	5	4.5	3	1	5			1	3		50.5
45						3	10	9	1	9	8	7.5	4		3.5	1.5		3	6.5	5	71
44							2	11	7.5	30	10.6	12.5	8	3	2.5		1.5	2	8.3	1.7	100.6
43								39	27	4	8	21	3	11	9		5	7.5	5		139.5
42									7.6	5.3	18.1	28.45	18	10.55	11		8.8	11	16.35	2.85	138
41										32.95	2.05	4.25	5.7	3.2		48.75					96.9
40											44	22	11	23	2	13	21	32	37		205
39												72	16	28	7	1	7	14	17	7	169
38													10	5	7	7	9	71	22		131
37														51	12	55	42	51	12	4	227
36															1	42		30			73
35																68	108	77	12	9	274
34																	82	39	44	26	191
33																		149	44	41	234
32																			37	41	78

Beating up for two years after planting was done with the same original specied planted.

From F.Y.48 onwards it became standard practice (vide Commissioner's visit 25.8.48) to beat up checked spruce in heather areas with pines, using Scots pine on the drier sites and Pinus contorta in the wet hollows and frosty sites.

In F.Y.48 an instruction dated 31.10.47 laid down that Japanese larch was generally to be used for delayed beating up on firm, well drained ground suitable for that species. Generally Pinus contorta has been used to beat up bad frost hollows since F.Y.46. The P.30, P.31 Gasnach European larch was beaten up with Pinus contorta in P.37 and also five years after planting the checked spruces on heather were beaten up with Scots pine and Pinus contorta using beech on the grassy knolls and hollows of better ground. The beech never came to anything and were eventually suppressed by the larch and spruces. Beating up got behind in P.38 owing to the severe weather and the shortages of Sitka spruce plants in the past.

Beating up with pines of backward spruce areas, particularly Norway spruce in dense heather, is still being done where the checked gaps are large and the soil is dry. The pines are coming away well and are outgrowing the Norway spruce. It is expected that the pines will eventually nurse the spruces through the heather competition and exposure. Japanese larch is used for late beating up on heather/bracken/Vaccinium ground.

Large beat ups were essential for a good and effective take. Where planting into the natural surface was practical the surface was broken up and where possible a sturdy 12 in. plant was used. Where the ground was peaty and poor in minerals with heather and Scirpus (e.g. Compartments 97 and 225) the beat up plants were slagged.

16 acres of a Sitka spruce/Norway spruce mixture were ploughed and re-planted in P.44 with Sitka spruce/Scots pine 3/1 mixture as the area was very backward (Compartments 308 and 313 P.31). By F.Y.51 this plot showed great improvement with an even growth and average height of 3 ft.- 4 ft. The plot looks promising.

Weeding

On ploughed ground generally no weeding is required in the first two years on heather, grass and gorse types, especially if the heather has been burnt off before ploughing. Where the vegetation is bracken and the land

ploughed, weeding may not be needed in the first year if the bracken is not very vigorous, e.g. P.51c Compartments 373, 379 Sitka spruce. If the bracken is vigorous a weeding will be required in the first year, e.g. P.51 Compartment 338 - perhaps once in the growing season will suffice.

In about the third year in ploughed and turfed ground, especially where it is lowlying and wet, grass and rushes soon invade the turned up mineral soil and afford serious competition to the spruces. Weeding must then be done sometimes twice in a favourable growing season for a year, and exceptionally a further year. By this time the plants have usually topped the grasses and rushes.

In unploughed ground where there is vigorous bracken growth, weeding must be done at least twice in the growing season. Such ground has usually been planted with Japanese larch so weeding need only be done for three years after planting

Gorse comes in again in the 4th or 5th year after cutting. A further cutting then sees the plants - usually pines - out of serious danger from the gorse.

The main weed species in the Japanese larch and pure Sitka spruce areas is bracken. On the Sitka spruce/Scots pine areas it is chiefly Calluna, but here also the bents (chiefly Agrostis canina) invade the mineral soil turned up on the furrow slice and may form a very dense growth which can smother the young plant if there is a fall of snow in winter.

On the lowlying, wet places planted mainly with Norway spruce and Sitka spruce and ploughed by the Begg or Cuthbertson, the chief species are rushes and grasses, e.g. P.49 Bron Banog block. Eriophorum, Scirpus, Erica tetralix, on P.49 Compartments 225, 229, etc., and Molinia on P.35 Derwydd block, P.30 P.31 Hafotty Wen and P.40 Compartment 141.

The pure pines planted on the rocky knolls come away very satisfactorily and are seldom troubled by the Calluna.

The nature of the damage caused by the weeds varies with the tree species. In delayed bracken weeding Japanese larch is entirely cut away from the light and develops a succulent etiolated leader, which is susceptible to early frosts. The plant is suppressed and unable to put on any growth. If the bracken is not cut away before the winter it withers and falls on the plant bending it over. A fall of snow can then snap the stem

or smother the plant. Molinia, grasses and rushes smother Norway spruce and Sitka spruce. Heather checks the spruces and the larches are checked in gorse, Japanese larch to a less degree than European larch.

The weeds of the hardwood areas of the east of the forest were mainly bramble, bracken, willow herb, and coppice growth of hazel, willow and birch. Japanese larch or European larch were the species planted on these sites. Weeding for 2 or 3 years generally saw the larches free from the coppice. At higher elevation and exposure, especially in gorse, European larch required a longer period of weeding.

The effect of weeding on the plantations was to relieve competition and afford the plant ample light and air. It also served to weaken the growth of weeds like bracken and to reduce root competition. The plants were, therefore, assisted in getting away quicker to establishment than would have otherwise been the case.

Mixtures

In the first plantings of P.30 and P.31a Norway spruce/Sitka spruce 1/1 mixture was used on the high exposed ground of heather, grasses, Juncus, Nardus and mosses. But after P.31 Norway spruce and Sitka spruce were not planted in mixture again. This mixture has not produced an even crop and establishment was long delayed. Pure spruce planting of the same age would have probably been thinned in F.Y.48 onwards, but thinning of this mixture is not expected to be done for the first time until F.Y.53. Generally the Sitka spruce proved the more vigorous and suppressed the Norway spruce, the plantation thus thinning itself, but occasionally the two species have grown satisfactorily together. Alternate lines of Norway spruce were totally lost and the Sitka spruce developed coarse branches. The pure planting of these spruces in groups or blocks would have produced probably more even plantations and beneficial competition.

In Compartments 129 and 407 (P.30) a Japanese larch/Sitka spruce mixture was planted on bracken grass slopes. In the shelter of ridges or local hollows the Japanese larch was the more vigorous growing and in Compartment 129 it had suppressed the Sitka spruce. A serious Aphis attack in F.Y.46 and perhaps earlier had also greatly reduced the vitality of the Sitka spruce. In severe exposure the Sitka spruce had completely ousted the Japanese larch, which had tattered crowns and very poor stems.

Up to the present time it appears that neither of the above two mixtures have proved satisfactory on the soils and exposure on which they have been planted at Clocaenog. In P.37, P.38 and P.39 a Sitka spruce/Scots pine 3/1 mixture on ploughing was planted on exposed peaty ground carrying a growth of stunted, tight heather.

In P.47 the Sitka spruce/Scots pine mixture was changed to 2 rows of spruce to one of pine and in P.48 the planting of Sitka spruce/Scots pine, 2 rows of spruce to 2 of pine, on ploughable pure dry Calluna ground became standard practice. An acre plot of a 1 row - 1 row mixture of Tsuga and Pinus contorta was planted in Compartment 338 P.50.

All mixtures were planted contemporaneously. In Compartment 91, Experiment 9, P.33, a Pinus contorta plot was underplanted by the Research Department with Sitka spruce in P.36 by lines and groups, and the Sitka spruce was treated with 2 oz. basic slag.

The Sitka spruce took well and by F.Y.46 were vigorous and promising - doing better where the Pinus contorta was shortest. In subsequent years the Sitka spruce were checked by shading. Thinning and branch trimming was done to the Pinus contorta but the growth was too vigorous for the Sitka spruce, and they only began to thrive in small groups where there was no crown competition from the Pinus contorta. The inference to be drawn from this mixture is that the Sitka spruce were introduced too late under vigorous-growing Pinus contorta, which benefited the spruce by killing some of the heather allowing the Sitka spruce to get away, but the failure to thin the contorta drastically, resulted in the suppression of the Sitka spruce.

It is too early to assess the final effects of the Scots pine nurses in the spruce/Scots pine mixtures, especially in the later 2/2 Sitka spruce/ Scots pine mixtures. Large areas of this mixture were planted in P.48 Nilig and Cefn Du; P.49 Bron Banog and Cruglas and P.51 Cefn Du. So far, the plantations look very promising. The growth is even and there has been a good take without any large groups of suppressed spruces. Particularly even growth can be seen in P.40 Isgaerwen 2/1 Sitka spruce/Scots pine and P.47 Nilig 2/2 mixture, notwithstanding the planting in the latter by P.O.W.labour.

The earliest plantings of a Norway spruce/Scots pine mixture (i.e.3/1) on heather gorse show that the Scots pine grow very much faster than the Norway spruce. The Scots pine averaged 15 ft. and the Norway spruce

ranged from 4 ft.- 8 ft. though some reached the height of the Scots pine. The centre row of the Norway spruce was the tallest, while the Scots pine threw out long, coarse, lateral branches which interferred with, and suppressed or damaged, the leaders of the two outer rows of the Norway spruce.

In the beginning of F.Y.49 some of the side branches of the pine were cut back to free the Norway spruce. This operation was stopped on 2.2.49 and it was decided to await developments as some of the outer rows of Norway spruce may hold their own against the Scots pine. It now appears on this fairly sheltered northerly slope on dense heather and gorse that the Scots pine are too fast growing for the Norway spruce and are ruining more of the outer rows than they are nursing. The shelter from the Scots pine is very effective, but other than in the Scots pine rows the vegetation has not been effectively suppressed - gorse growth is strong.

In Compartment 351 the 3/1 Sitka spruce/Scots pine is the more promising. The vegetation is heather, gorse on a northerly aspect at about 1300 ft., and rather more exposed than the Norway spruce/Scots pine mixture.

The Scots pine, perhaps due to the exposure, are not so tall, averaging about 10 ft. and are bushy and form admirable shelter. The Sitka spruce are generally the same height as the Scots pine with a fairly even growth and healthy colour. All plants have moved and show a consistent leader growth of about 8 in. per year over the past three years.

In comparison with the pure Sitka spruce P.36 in the adjoining compartment of 350, the Sitka spruce in admixture with Scots pine in Compartment 357 is much superior. The pure Sitka spruce in Compartment 350 is still suffering from check and frosting, yet the marginal trees adjoining a block of pure Scots pine are decidedly better. Some Sitka spruce of the three Sitka spruce to one Scots pine single row mixture in Compartment 357 in dense gorse, are not so fast growing but are not checked and look healthy.

In the spruce/Scots pine mixtures, therefore, it may be tentatively suggested at this time that on strong heather and gorse mixture, and on dense Calluna the Sitka spruce/Scots pine is the better mixture as the outer row of Sitka spruce competes with the Scots pine, and is more vigorous growing and is able to fight its way above the Scots pine better than the Norway spruce. Both spruces, however, show improvement and promise in mixture with the nurse than pure on these exposed moorland sites.

A similar result is seen in Compartment 357 P.38. The Sitka spruce/ Scots pine 3/1 mixture on dense heather looks far more promising and vigorous than pure Sitka spruce or Norway spruce or Norway spruce mixed with introduced Scots pine.

Some 16 acres in Compartment 207 P.42 were originally planted with pure Scots pine on steep rocky heather ground, which was very exposed to the south and south-west but later in F.Y.42 every third row of Scots pine was taken up and planted with Sitka spruce giving a Scots pine/Sitka spruce 2/1 mixture. the Scots pine average 8 ft. and are twice the height of the Sitka spruce and look like swamping them. The Sitka spruce look well and are not suppressed.

Underplanting was done in P.51 in Compartment 436 (Pennant). The overwood is P.00 European larch and the underplants pure Tsuga and Sitka spruce. The Sitka spruce in a two chain belt along the exposed west margin, and the Tsuga on the more sheltered bracken ground.

Rates of Growth

Scots pine - No plots of Scots pine have yet reached the thinning stage. The planting of this species has been mainly as a nurse in mixture with spruce and in small pure plots on dry, rocky ground or in gorse. It was also used to beat up badly checked spruce on tight Calluna.

Generally the growth of Scots pine is regular and there are no instances of severe check in height growth on the types of ground on which it has been planted. In exposure there is less height and a more bushy habit. In Compartment 94 (P.39) Scots pine of 6 ft.- 8 ft. in height show the effects of blast and wind break in F.Y.49. As a nurse crop, so far, Scots pine has topped the spruces and offers admirable shelter.

The following table gives an idea of the growth rate of Scots pine:-

Cpt. No.	P. Year	Age	Geology and Soil Vegetation	Altitude - Aspect Slope Exposure	Mn. Height of Dominants B.H.Q.G.	Mn. Annual Height Increment	Current Annual Ht. Increment last 3 yrs.	Remarks
56	34	17	Ludlow, Nantglyn flags Shaly clay freely drained. Dense calluna	1150 ft. South Moderate Very exposed.	19' $3\frac{1}{4}$"	1.1'	12"	Pure stand
351	37	14	Ludlow beds Lower M. nilsonii zone Very shaly loam, thin peat rather dry. Dense calluna and gorse.	1300 ft. North Moderate fairly sheltered	14'	1'	12"	In mixture with Sitka spruce and Norway spruce 3/1.
242 243 282	39	12	Wenlock shales. Clay loam. Calluna/ bracken/grass.	1130 ft. General- north flat. Fairly exposed.	16'	1.3'	12"	Pure and in mixture with Sitka spruce.
65	40	11	Wenlock shale. C. Lundgrenii zone. Heavy clay, freely drained by plough- ing. Dense calluna.	1500 ft. South Very exposed.	10'	11.8"	12"	In mixture with Sitka spruce 1/2

35

On shaly, clay loam with dense Calluna in moderate exposure Scots pine pure and in mixture with Sitka spruce exhibits the following heights:-

P.42	C.87	7 ft.	mixture	1/2	with	S.S.	even crop	
P.43	C's. 205 & 206	5 ft. - 6 ft.	"	1/2	"	S.S.		
P.44	C.308	3 ft. 6 in.	"	"	"	"		
P.47	Nilig area	3 ft. 6 in. - 4 ft.	"	"	"	"	even crop	
P.48	Cefn Du	2 ft. - 3 ft.	"	2/2	"	"	"	"

Some of the Scots pine at Bont Petryal is very fine, both in size and in form, considering the elevation, and natural regeneration is quite good.

European larch

The oldest plantations are two European larch plots planted in 1900 by Lord Bagot:

1. Isgaerwen plantation, 6 acres.
2. Pennant Keeper's Cottage, ½ acre Norway spruce and 12.5 acres European larch of which 9.2 acres were underplanted in F.Y.51.

	Isgaerwen	Pennant
Species	European larch 6 acres	European larch 12.5 acres. Norway spruce 0.5 acres.
Age	51	51
Geology and Soil	Wenlock shale. C. Lundgrenii zone. Shaly clay loam well drained.	Ludlow beds. M. scanicus zone. Sandy loam in European larch portion. Clay in Norway spruce area, boggy.
Vegetation	Soft grasses. Agrostis. rare patches of Calluna and mosses.	Holcus, Agrostis, Oxalis, Galium, Hylocomium, bracken. Norway spruce - rushes, grasses.
Altitude	1444 ft.	1100 ft.
Aspect	South	East
Slope	Moderate	Fairly steep in parts.
Exposure	Very exposed	Sheltered
Estimate of Stocking	150 trees per acre	250 trees per acre.
Mean Heights of Dominants	40 ft.	European larch 43 ft. Norway spruce 64 ft.
B.H.Q.G.	11 in.	E.L. 7 in. N.S. 17 in.
Mean Annual Ht. Increment	9.4 in.	" 10 in. " 1.3 ft.
Form	Crowns show the effect of exposure usually forked at 25 ft. Moderate lean of stem. Good stem form, little taper and free from canker.	Crowns small and whippy showing effects of neglected thinning. Stems in gaps show better crown development. Stem form fair, more taper and less lean than Isgaerwen. Increment borer shows diameter increment has depreciated in the last 5 years. Some checked stems.

The following table shows typical growth rates of European larch

Cpt. No.	P. Year	Age	Geology and Soil Vegetation	Altitude Aspect Slope Exposure	Mn. Height of Dominants B.H.Q.G.	Mn. Annual Height Increment	Current Annual Ht. Increment Est. last 3 yrs	Remarks
438	31	20	Ludlow beds M. scanicus zone. Shaly, sandy loam. Well drained. Bkn./grass/bramble	800 ft. East Moderate Sheltered	24' 4½"	1.2	9"	20% cankered stems
453	35	16	ditto	1000 ft. South east 1 in 15 fairly sheltered	28' 3¼"	1.8	11"	150 cu. ft./ acre in F.Y. 51

The growth of European larch does not appear promising on the high ground of Coed Pennant (P.30) and Coed Fron (P.31) where it is 10ft. - 12ft. and looks unhealthy, particularly where there is dwarf gorse. About 15% of the stems are cankered.

The European larch of Fron Wyllt (P.37 and P.38) has been heavily beaten up with Japanese larch in the early days and is now almost a pure Japanese larch plantation. The European larch in Compartment 456 (P.37) at 900 ft. shows a poor growth rate of 5 in. per annum and unhealthy looking plants. The European larch in Compartment 455 (P.36) Coed Cooper are more promising and of a good form.

Japanese larch

P.36 Japanese larch are the youngest plantations which have become established and which have been thinned.

Typical growth rates of Japanese larch are given in the following table. It will be seen that the mean annual height increment for this species is $1\frac{1}{2}$ ft. Stem form, however, shows variation. On moist bracken grass ground the stem develops a corkscrew form, and on the poorer and drier ground (marked by a less luxuriant growth of bracken and by some Vaccinium) the stem is straighter. In moderate exposure though the stems lean they do not exhibit the corkscrew tops to such a marked degree as in completely sheltered sites. Plantations look much better after the first thinning.

On ploughed ground, e.g. P.48 Compartment 262, Japanese larch exhibits a very rapid rate of growth reaching 5 ft. 6 in. in F.Y.51, i.e. a 22 in. mean annual height increment. This site is on a sheltered northerly slope at 1150 ft. carrying dense bracken. It has been found that Japanese larch easily rocks and subsequently develops a bad bow at the base if planted on top of a plough furrow.

Cpt.	P. Year	Age	Geology and Soil Vegetation	Altitude Aspect Slope Exposure	Mn. Ht. of Dominants ft. and B.H.Q.G.	Mn. Annual Height Increment	C. Ann. Ht. Increment last 3 yrs. Estimation	Remarks
433	31	17	Ludlow beds. M. scanicus zone. Sandy loam, shaly freely drained. Bracken/ grasses/gorse rare.	900 ft. East Moderate Sheltered	28' 3¾"	1.6'		Thinned FY.48 107 cu.ft/ac.
305	32	19	Ludlow beds. Freely drained, shaly yellow clay loam. Bracken/ grass.	1180 ft. East 1 in 20 Very exposed	28' 3¾"	1.5'		First thinned F.Y.51. 320 cu.ft/ac.
290	33	15	Denbigh Grit series. Shaly, clay loam. Bracken/grass	1000 ft. S.E. 1 in 10 Sheltered	22¾' 3¾"	1.5'		Thinned F.Y.48
281	33	15	ditto	1030 ft. South Steep fairly exposed.	25' 3¾"	1.7'		Thinned first time F.Y.48 251 cu.ft/ac.
280	33	18	Denbigh Grit series. Shaly loam. Bracken/grass	1100 ft. S.E. 1 in 10 Exposed	29' 4"	1.6'		First thinned F.Y.51. 210 cu.ft/ac.
236	33	18	Denbigh Grit series. Shaly, clay loam freely drained. Bracken/grass.	1300 ft.	26' 3¾"	1.4'		FY.51 (thinned) 270 cu.ft per acre.
249	33	18	Denbigh Grit series. Freely drained. Bracken/grass.	1250 ft. South 1 in 25 Exposed	26' 4"	1.4'		260 cu.ft/ac. in F.Y.51 1st thinning.
250	33	18	ditto	1250 ft. S.S.E. 1 in 20 Exposed	28' 4½"	1.6'		240 cu.ft/ac. in F.Y.51.
43	34	14	Nantglyn flags. Shaly, sandy loam. Well drained. Bracken/grass.	1000 ft. S.E. Steep Sheltered	28' 4"	2'		1st thinned F.Y.48, 190 cu.ft/acre
285	36	15	Wenlock Shales C. lundgrenii zone Freely drained. Shaly yellow clay loam.	1000 ft. West 1 in 8 fairly exposed	22' 3¼"	1.5'		270 cu.ft/ac. in F.Y.51. 1st thinning.

Hybrid larch

The following table shows the growth of a single plot of hybrid larch of 1.5 acs. Considering the exposure, stem form and crown development are good.

240	37	14	Denbigh Grit Series. Wenlock shaly clay loam freely drained. Bracken/grass/ Calluna.	1140 ft. South 1 in 15 Very exposed	30' 3½"	2.1'	24"	Thinned F.Y.51 220 cu.ft/ac.

Norway spruce

The oldest Norway spruce is a ½ acre plot in Compartment 436, Pennant, P.00 already described under European larch.

The Norway spruce areas on the open moorland are slower growing and no plantations are ready for thinning yet. The early Norway spruce/Sitka spruce 1/1 mixtures of P.30 and 31 have thinned themselves, the Norway spruce having been suppressed. Subdominant Norway spruce in such mixtures generally average 19 ft. x 2½ in. B.H.Q.G., while the Sitka spruce are 24 ft. x 4¾ in. in the areas where canopy has closed.

Great variety in the rate of height growth is exhibited by Norway spruce throughout the forest area and indeed within the same compartment, where patches may be found with Norway spruce barely 2 ft.- 3 ft. in dense heather, while nearby Norway spruce of the same age may be 12 ft. - 16 ft. on the same type of soil and vegetation. Such instances may be seen on Wenner P.36, P.37 and Bod Petryal, P.39. Typical growth rates of Norway spruce:-

1) On lowlying, good type of bog and flush with Molinia, Juncus vegetation, e.g. P.35 Compartment 216 etc.

2) On sheltered well drained clay loam, grass and rush, almost hardwood type of ground, e.g. P.31 Compartment 439.

3) On dense Calluna gorse P.37 Compartment 351.

are given in the table overleaf:-

Cpt.	P. Year	Age	Geology and Soil Vegetation	Altitude Aspect Slope Exposure	Mn. Ht. of Dominants B.H.Q.G.	Mean Annual Height Increment	Current An. Ht. Increment last 3 yrs Estimation	Remarks
216	35	16	Denbigh Grit Series. Heavy clay, rather wet and low lying. Juncus, Molinia, some Aira caespitosa, wisps of bracken on slopes.	1220 ft. Tending West Flat Sheltered	16' 3"	1'	14"	Uneven ht. growth, canopy not closed.
439	31	20	Ludlow, M. scanicus zone. Shaly clay loam, freely drained. Grass, some bracken.	660 ft. East Moderate Sheltered	22' 4"	1.1'	10"	Canopy closed, fairly even growth. To be thinned F.Y. 52.
351	37	14	Ludlow beds. Lower M. Nilsonii zone. Very shaly loam, thin peat, rather dry. Dense Calluna and gorse.	1300 ft. North Moderate Fairly sheltered.	5'	5"	8"	In 2/1 mixture with Scots Pine.

Sitka spruce

No Sitka areas have yet reached the thinning stage. The early Sitka spruce/Norway spruce 1/1 mixtures P.30 and P.31 have thinned themselves. The Sitka have been more vigorous and have totally suppressed the Norway spruce; however, these plantations do not have an even aged canopy. Checked gaps of 4 ft.- 6 ft. height may be found mixed with established groups, e.g. Hafotty Wen P.30, P.31 and P.32 areas.

Though the Sitka spruce plantations are not as uneven as the Norway spruce on the dense heather moor, yet they do exhibit a great range of height growth for the same age over the forest area. It was noted that in the last three years the growing seasons have been most favourable to the growth of the spruces, and Sitka spruce, in particular, over the whole forest has put on a shoot length of 12 in. or more. Very few checked areas remain; both Sitka spruce and Norway spruce are beginning to move rapidly. Growth rates are given in the table overleaf.

Cpt.	P. Year	Age	Geology and Soil Vegetation	Altitude Aspect Slope Exposure	Mn. Height of Dominants B.H.Q.G.	Mean Annual Height Increment	Current Annual Ht. Increment last 3 yrs Estimation	Remarks
126	30	21	Denbigh Grits. Clay freely drained. Molinia, grasses.	1250 ft. West Moderate to Steep Exposed	24' 4¾"	1.1'	14"	In 1/1 mixture with Norway spruce Groups with closed canopy. To thin F.Y.52.
97	31	20	ditto	1300 ft. West Flat Exposed	25' 4"	1.3'	15"	Very uneven canopy. Figures for group which are brashed and ready for thinning.
158	33	19	Denbigh Grits. Shaly clay; Calluna, A. caespitosa, Juncus, Molinia, Scirpus, boggy.	1330 ft. N.W. Moderate Exposed	14' 2¾"	8.8"		
60 61	34	18	Nantglyn Flags. Heavy blue clay. Variable depth of peat 4 in. - 15 in. evidence of pan. Dense Calluna.	1450 ft. S.W. Moderate Very exposed.	from 2' to 15'x2"	1.3" to 10"		Planted with seedlings owing to shortage of Sitka spruce. Slag applied under turves. Very variable growth - not promising.
241 243	39	12	Denbigh Grits. Shaly loam, thin peat. Calluna, bracken/grass.	1130 ft. Inclined to N. Flat Exposed	10' 1¾"	10"	12"	
351	37	14	Ludlow. Lower M. Nilsonii zone. Very shaly loam, rather dry and thin peat. Dense Calluna gorse.	1300 ft. North Moderate Fairly sheltered.	12' 1¾"	10.3"	12"	In 3/1 mixture with Scots pine.
65	40	11	Wenlock Shale. C. lundgrenii zone. Heavy clay loam, freely drained. Dense Calluna.	1500 ft. South Moderate Exposed.	8'	8.7"	10"	In 2/1 mixture with Scots pine.

Generally on ploughed clay loam soils in dense Calluna with some Agrostis in mixture with Scots pine nurses, Sitka spruce exhibits the following typical height growths:-

P.41	Compartment	325	5'-7'	
P.42	"	87	5'	Very uneven crop.
P.43	"	205,206	3'-4'	Very rocky and exposed.
P.44	"	308	3'	3'6" in best parts. Heavy blue clay.
P.46	"	302	3'6"	Uneven crop. No Scots pine nurses. Crop just coming through dense Calluna.
P.47	Nilig block	...	3'6"	Many 4 ft. stems. Good even crop, healthy and vigorous.
P.48	Cefn Du	...	3'	More Agrostis coming in. Soil shaly loam. Good even crop, vigorous.

Tsuga heterophylla

Compartments 438 and 439 (P.31) have two rows of Tsuga each side of the road as amenity planting. The geology is Ludlow beds of the Monograptus scanicus zone with a shaly, sandy loam soil carrying bramble, bracken, grasses on a steep well sheltered easterly slope at 700 ft. The average Tsuga are 36 ft. x $4\frac{3}{4}$ in. B.H.Q.G. and look very well, both in crown and stem form.

Pinus contorta

Pinus contorta has been chiefly used for beating up badly checked spruce areas in dense Calluna. Small plots have been planted on rocky exposed ground, and in wet frost hollows.

Pinus contorta has always come away well and has shown vigorous growth under difficult conditions. The form is very variable, bushy, coarse branched types and slender, open branched forms are to be found. The conical crown is well maintained.

A complete survey of Pinus contorta was carried out 22.2.51 and fuller details on type form and growth can be found in this report. Pinus contorta throughout its range of planting at Clocaenog has shown vigorous growth. It maintains its conical form and generally shows superior height growth, in the young stages at any rate, to Sitka spruce, European larch and Scots pine. It can keep pace with Japanese larch or remain co-dominant even as a beat up.

Some indications of growth rates are given in the following table:-

Cpt.	P. Year	Age	Geology and Soils Vegetation	Altitude Aspect Slope Exposure	Mn. Height of Dominants B.H.Q.G.	Mn. Annual Height Increment	C.A.Ht. Increment over last 3 yrs. Est.	Remarks
307	32 onwards	19 & less	Ludlow beds. Clay loam. Heather/Bracken/Grass	1150 ft. West Steep Very exposed	25' $5\frac{1}{2}$"	1.3'	12"	Beat up in European larch, coarse branched.
317	32	19	- do -	1190 ft. South Moderate Very exposed	18' $4\frac{1}{2}$"	11"	11"	$\frac{1}{2}$ acre plot
216 217	43	8	Denbigh Grits. Shaly clay, thin peat, some rocks. Calluna, grass.	1250 ft. North Gentle Sheltered	12' to 7'.	1.5' to 10.5"	11"	Beat up in Norway spruce P.39 where Norway spruce is 5 ft.- 12 ft.
72	40	11	Denbigh Grits. Rocky, shaly clay. Dense Calluna, Molinia grasses.	1350 ft. West Steep Very exposed	8'	8.7"	8"	Pure $1\frac{1}{4}$ acre plot. Good even growth and tree form.

Birch

Birch has been planted as fire breaks in half chain strips along road sides. The results have generally been disappointing, with poor height growth in dense heather.

The tree develops a bushy, stunted habit, reaching a height of 6 ft. or 7 ft. in 10 years on heather ground, and 12 ft. in 12 years on moist grass, rush ground along stream banks.

Past Treatment of Established Plantations

Japanese larch plantations since F.Y.46 and P.31 and P.32 European larch in the sheltered eastern parts of the forest are the established plantations to date. There are small scattered strips and groups of P.30 and P.31 Norway spruce/Sitka spruce 1/1 mixture and Compartment 439 Norway spruce P.31 which have been brashed and will be ready for thinning by F.Y.53.

Brashing

The following table gives the areas of larch and spruce brashed since F.Y.44.

The cost of brashing in F.Y.50 worked out at £6 per acre for Sitka spruce and £4 15s. per acre for larch on piece work. The spruce was complete and the larch 50% brashed. (Day wage for Grade II was 96/-). Sitka spruce (P.30 and P.31 Hafotty Wen area) on exposed south-west sites and mixed 1/1 with Norway spruce developed coarse branches. The Sitka spruce must have been checked or had a very slow rate of growth for some years until they were 6 ft. or so high, which meant short internodes and a large number of very close spaced coarse branches making brashing difficult.

Brashing was done throughout with a short-handled, curved pruning saw having 6 teeth to the inch for spruces, and sticks for the larches.

F.Y.	Spruces acres	Larches acres	Racks sq. chs.	Remarks
44	26.75	-	242	
45	-	25	85	
46				no record
47	46	77	619	
48				no record
49	164		1375	
50	92	134	1113	
51	68.77	130	76	

No pruning has been carried out other than on scattered stream side poplars planted along Melin Dwr.

Cleaning

Cleaning has been confined to the old woodland areas of Coed-y-Fron, Pennant, Fron Wyllt, Cooper, Tre'r parc etc. The weed growth has been coppice of hazel, birch, alder and willow along the streams, and some ash. The aim has been only to clear the coppice where it interferes with the crowns of the forest crop and retaining ground cover in gaps and the under storey. However, this has not always been realised by the labour, and Coed Cooper (P.36) was unnecessarily heavily cleaned in F.Y.50.

The coppice growth in Fron Wyllt P.37-39 larch is now very much weaker in growth as the crop is entering the thicket stage.

Thinning

Thinning proper first started in F.Y.48. From F.Y.45 to F.Y.47 cuttings consisted in removing a few score poles for conversion to stakes, posts and stays for local use when needed. Most of these fellings came from relieving amenity belts from suppression by Japanese larch and European larch in P.30, P.31 areas of the old woodlands and from windblown stems.

The following is a list of such cuttings:

F.Y.	Cpt.	P. Year	Species	Quantity
45	408	30	J.L.	132 score poles
46	436)	00	E.L.)	
	440)		)	453 trees
	408	31	J.L.)	
47	436)	00	E.L.)	
	440)		)	
	432	30	E.L.)	158 trees
	433	31	J.L.)	
	79	00	E.L.)	

The following table gives the areas and outturns since F.Y.48.

P. Year	Thinnings 1st	Thinnings 2nd etc.	Species	No. of Trees	Cubic feet	Cu. ft. per ac.	Poles per ac.
FY.48							
30	16.5	-	E.L.	5631	2326	141	341
		16.5	J.L.	2776	2140	130	168
31	17.5	-	E.L.	4975	3251	188	284
	11.5	-	J.L.	3541	1081	94	308
33	9.0	-	J.L.	2458	1522	169	273
34	14.25	-	J.L.	3203	3081	216	224
35	2.0	-	J.L.	590	489	244	295
FY.48	70.75	16.5	-	23174	13890		
FY.49							
30	6	-	E.L.	1687	1723	287	281
		1.2	J.L.	203	456	380	170
31	-	10	J.L.	1204	1705	170	120
35	9.5	-	J.L.	2860	2277	240	301
34	11.5	-	J.L.	3373	4100	357	294
35	12.5	-	J.L.	3583	2791	223	287
38	1	-	J.L.	127	105	105	127
41	2	-	J.L.	376	251	125	138
44	7	-	Oak) Syc.) Elm)	45	687	98	6
FY.49	49.5	11.2	-	13458	14095		
FY.50							
30	0.5	-	J.L.	187	119	238	374
31	2	-	E.L.	453	379	189	226
33	16	-	J.L.	6248	4123	258	390
	-	4	J.L.	690	706	176	172
34	9	-	J.L.	2872	3062	340	318
35	0.5	-	J.L.	210	100	200	420
37	0.5	-	H.L.	158	92	184	316
FY.50	28.5	4	-	10818	8581		
FY.51							
31	-	2	E.L.	223	297	148	111
32	2.3	-	J.L.	789	653	284	343
33	8	-	J.L.	3063	3220	402	383
	-	1.5	J.L.	344	313	209	230
	1	-	P.C.	677	219	219	677
34	2	-	J.L.	874	314	157	437
35	5.5	-	J.L.	1655	1338	243	301
	5.5	-	E.L.	2368	952	173	430
36	1	-	H.L.	207	126	126	207
		-	N.S.	130	39	-	-
	33	-	J.L.	11231	7603	230	340
37	4	-	J.L.	1457	1249	312	364
38	0.5	-	EL/JL	195	91	182	380
FY.51	62.8	3.5	-	23213	16414		

The thinning interval for young plantations in their first thinnings has been 3 years for Japanese larch and European larch. The spruces have not been thinned yet, but it appears that Sitka spruce will probably require a 4 year and Norway spruce a 5 year interval.

The output has been chiefly from first thinnings of Japanese larch. These were the worst corkscrew and bowed stems of the P.33 Brynhyfryd, Derwydd areas and P.36 Compartments 286, 287.

Careful grading was required and conversion of this type of produce was most difficult and entailed a high percentage of waste. For the very crooked Japanese larch sale for rustic poles was one outlet, but Japanese larch is not as popular as European larch for this and many of these poles were only fit for firewood.

Conversion to the smaller pit prop sizes (2 ft. $2\frac{1}{2}$ ft. 3 ft.) was done with the straighter stems and from the butt ends. A large quantity of stakes and rails were obtained from the middle of the pole. The stakes were used mainly for forest fencing and sold to local farmers.

There was still a lot of waste from the crooked tops, mid lengths and curved butts, which were too short for pit props. These were sawn for firewood and found a ready market in times of coal shortage, but Japanese larch makes a very poor fuel and not greatly sought for this purpose.

This then was the state of affairs until F.Y.51 - the forest trying to find a market for its poor first thinnings of Japanese larch and finding it a very difficult business. In F.Y.51 Gordons of Chester developed and installed a multiple gang saw-bench in their Queensferry Sawmill. This saw-bench was especially constructed to take small lengths of thinnings for conversion by high speed multiple saws into lath sizes which found a ready market for crates, boxes etc. The waste from the "squaring" was sold for press board manufacture and the sawdust for fuel. There was virtually no waste. Gordons were ready to absorb all conifer thinnings within a radius of 70-80 miles of Queensferry.

Conversion and outturns at Clocaenog now fitted in with what Gordons would buy. This market has been a boon for Japanese larch first thinnings, as Gordons will take short lengths down to 20 in. and it is possible to use the bowed butts for this purpose. This means that there is now very little waste of butt ends for firewood and a longer mid length for stakes. The

main produce now is stakes, with Gordons absorbing the short lengths. The second thinnings of Japanese larch just beginning to come in do not offer the same difficulties in marketing.

RESEARCH NOTE BY THE RESEARCH BRANCH

Twentyeight experiments have been laid down in Clocaenog Forest by the Research Branch between the years 1932 and 1951 all concerned with the establishment of forest on high elevation Calluna moorland of the type of which the forest is largely composed.

Experimental Sites. The experiments are mostly in three separate blocks at the following areas:-

1. Shooting Box Area. (Compartments 37, 62 and 63). Nine experiments: Nos. 6, 7, 8 and 13, P.33; 14, P.34; 20, P.37; 22 and 23, P.42; and 23A, P.44.

   This consists of a large block situated on the south-eastern slope of Marial Gwyn (height 1703 ft.) at an elevation of 1420 ft. to 1480 ft. which is considerably greater than the average elevation of the forest as a whole. The site has a south-easterly aspect and is fully exposed in all directions except the west.

   The vegetation is mainly pure Calluna, with Vaccinium in scattered patches. Gorse and Juncus may be locally abundant. Grasses, chiefly Deschampsia and Festuca, are scattered over the area and are also locally abundant. In some parts the heather is over two feet high while in others it is less than a foot indicating the variability in the nature of the ground.

2. Tae'n-y-Waen (or Sheepwalk) Area. (Compartments 91 and 17) Twelve experiments: Nos. 9, 10, 11 and 12, P.33: 16, 17 and 18, P.34; 19, P.35; 24, P.46; 25, 26 and 27, P.39.

   This large block of experiments is on the southern slope of Foel Frech (height 1483 ft.) at an elevation of 1380 ft. to 1425 ft. The site is gently sloping with a south-easterly aspect, the exposure being severe to the south-west especially in the upper part of the area. It is fully exposed to the east.

   The vegetation is mainly Calluna with patches of Eriophorum and a few Juncus sites in hollows.

3. Tae'n-y-Waen Bog (or Sheepwash) Area. (Compartment 158) Four experiments: Nos. 1, 2, 3 and 4 all P.32.

   This small scattered group of experiments is situated on the

northern slope of Craig Bron Banog (height 1644 ft.) at an approximate elevation of 1250 ft. to 1280 ft. It is lower than the two previous sites and is sheltered on the south and south-east, but is exposed to the south-west and north-east. It has a north-westerly aspect. The whole area is subject to severe frosts.

The vegetation varies from pure Calluna to Calluna - Molinia, often with Scirpus, on the lower ground. Patches of a Juncus - Molinia type are common, while grasses, sedges and Vaccinium occur scattered, sometimes locally abundant. Eriophorum is found near the bog.

The peat layer varies in type, according to ground vegetation, from Molinia peat of good depth at the lower levels to fibrous Calluna peat, which may be only shallow, on the slopes.

The low ground has been extensively drained.

Other Areas

In addition to the foregoing the following experiments are to be found at other sites in the forest:

Foel Frech: A single experiment (No.15, P.34), which is a trial of species for shelterbelt planting, was laid down near the summit of Foel Frech in a very exposed position at an elevation of 1450 ft.

Cefn Du (Pincyn Llys): Two experiments (Experiments 28 and 29, P.51) were laid down at Pincyn Llys under conditions of severe exposure at an elevation of about 1350 ft. The vegetation is dense Calluna.

Experiment 28 is a trial of nine coniferous species, both with and without a nurse crop of Pinus contorta, all with a 2 oz. dressing of NPK fertilizer, on ploughed ground. The object of this experiment is to see how far it is possible to extend the planting range of some of the more exacting species to upland Calluna sites. Planting losses have been low except in the case of Lawson cypress which totalled 43 per cent.

Experiment 29 is a provenance trial with four origins of Corsican pine from Italy, Corsica, Spain and East Anglia.

Nant Llyfarddu: Poplar trials were laid down in 1950 and 1951 to test thirteen varieties of poplar on a moist site at a high elevation (see below)

Summary of Experimental Results

To keep in line with the development of modern techniques in the afforestation of Calluna moorland planting on ploughed furrows replaced the orthodox turf planting, or notching direct into the natural surface, in most of the experimental work carried out since the year 1942. Experiments Nos. 22, 23, P.42, 23A, P.44. 24, P.46 and 28, P.51 were all laid out on normally ploughed ground.

It is apparent from measurements made in Experiment 23 P.42, which is partly on turves and partly on double-furrow ploughing, that early growth is far better on the ploughed section in all three species (Sitka spruce, Scots pine and Pinus contorta).

The chief results of the experimental work carried out at Clocaenog Forest may be summarised, according to object of experiment, as follows (the measurements given are those for the assessment made in July and August 1951) :-

1. Trials of Species

Shooting Box Area :

Expt. No. 13, P.33 - Tsuga heterophylla
" " 20, P.37 - Thuja plicata, Thuja occidentalis, Chamaecyparis nootkatensis; Abies pectinata, Pyrus intermedia, Pyrus aucuparia.
" " 22, P.42 - Tsuga heterophylla, beech, sycamore with Scots pine as a nurse.
" " 23, P.42 - Sitka spruce, Scots pine, Pinus contorta (pine/spruce mixtures).
" " 23A P.44 - Sitka spruce and Scots pine (pine/spruce mixture).

Tai'n-y-Waen (Sheepwalk) Area :

Expt. No. 10, P.33 - Sitka spruce, Pinus mugo, Pinus contorta birch, common alder and grey alder.

" " 24, P.46 - Sitka spruce, Norway spruce, Scots pine (pine/spruce mixtures).

Tai'n-y-Waen Bog (Sheepwash) Area :

Expt. No. 2, P.32 - Sitka spruce and the nurse species pubescent birch, grey alder and common alder.

" No. 4, P.32 - Sitka spruce and the nurse species Pinus mugo, Pinus contorta, Scots pine, Corsican pine and grey alder.

Foel Frech :

Expt. No. 15, P.34 - Sitka spruce, Pinus mugo, Pinus contorta, and Pyrus aucuparia.

Cefn Du (Pincyn Llys) :

Expt. No.28, P.51 - Abies concolor, Abies grandis, Abies procera, Picea sitchensis, Picea engelmanni, Picea omorika, Chamaecyparis lawsoniana, Thuja plicata and Tsuga heterophylla; on ploughed ground.

In addition to the above Japanese larch has also been extensively used in experiments dealing with drainage, manures, the effect of age of heather and age and type of plant.

Pinus contorta

Of all the species tried this has so far proved the most rapid growing and vigorous species on all types of ground. It is frost hardy, very accommodating as regards soil and is little affected by extremes of exposure providing it has adequate drainage. In the most exposed experimental plots (No.15, P.34) situated near the summit of Foel Frech at an elevation of 1450 ft. Pinus contorta had, in 1951, an average height of 9.9 ft. compared with 7.2 ft. for Sitka spruce. Under less severely exposed conditions height growth may average well over a foot per year, as in the provenance experiment at Tai'n-y-Waen (No.16, P.34), where the tallest plot showed a mean height of 23.5 ft. in eighteen years.

Scots pine

Scots pine has proved satisfactory on the whole but shows a slower rate of growth than Pinus contorta, though faster than Sitka spruce in the early years. It is therefore more liable to suffocation by the dense Calluna vegetation. This species is frost hardy and will withstand a high degree of exposure and has grown best on well drained sites. Comparative growth rates in the best plots in Experiment 23, P.42 in the Shooting Box Area are, expressed in mean height, in inches : Sitka spruce 57, Pinus contorta 97, and Scots pine 62. Scots pine is one of the most suitable species tried as a nurse for Sitka spruce (see under Nursing Experiments), while as a suppressor of heather it is better than Pinus contorta though not as effective as Pinus mugo. This species is, however, liable to serious attack and defoliation by the fungus Lophodermium and should therefore be used with caution.

Sitka spruce

Sitka spruce has grown well at Clocaenog even under conditions of severe

exposure but is very subject to variations in site quality and to damage by frost and Neomyzaphis.

The main difficulty with this species on the upland peat sites has been that of establishment, since having once got a start it grows strongly and rapidly. Its best growth is seen on Juncus or Molinia ground as, for example, in Experiment 10, P.33 (Juncus section) where it averaged 14 ft. compared with 10 ft. in pure Calluna in fourteen years' growth. Though mainly vigorous its growth rate is depressed by exposure, as in Experiment 15, P.34 where the rate of growth is only 7.2 ft. in eighteen years.

The growth of Sitka spruce is seriously checked by frost in bad situations and also on some tight peat soils. It has, however, shown a good response to a dressing of 2 ozs of basic slag applied at planting and also to intensive draining. Planting on ploughed ground appears to have a stimulating effect on its early growth compared with planting on turves or in the natural surface.

Norway spruce

This species does not figure in any of the experimental work until P.46 when it was used in Experiment 24 in a trial of Scots pine/spruce mixtures. Planting losses amounted to 18 per cent compared with 1 per cent for Sitka spruce. At the 1951 assessment comparative mean heights were - Norway spruce 22 in. Sitka spruce 54 in. and Scots pine 52 in.

Mountain pine

This species has grown well with few losses and has proved itself able to withstand extremes of exposure as well as Pinus contorta and Sitka spruce. It is one of the slowest growing conifers tried at Clocaenog and its dense spreading habit renders it of value as a suppressor of heather. Its chief uses would therefore be as a nurse for a more valuable species such as Sitka spruce and also on very stony, exposed sites.

A particularly well shaped, upright variety of this species is to be found in Experiment 4 in the Tai'n-y-Waen Bog Area.

At the request of the Chairman a nursing trial was laid out in P.50 in one of the mountain pine plots in Experiment 10. This consisted of inter-planting it with Sitka and Norway spruce of about 4 ft. in height taken from adjacent Conservancy plantations.

Corsican pine

Corsican pine (var. calabrica, ex Sila Forest, Calabria, Italy) has been tried in Experiment 4, P.32 (nurse species for Sitka spruce) but has not proved successful. After repeated beating up in 1933 and 1934 the plants continued to die, losses in 1946 amounting to 55 per cent. In height growth, too, it has proved inferior to Scots, contorta and mountain pines and Sitka spruce, having averaged only 10.7 ft. in 18 years compared with 16.5 ft. for Sitka spruce on the same site.

Japanese larch

This species has given quite good results in the Shooting Box and Sheepwalk Areas where it was tried in various experiments. It appears to withstand severe conditions of exposure providing soil conditions are suitable, but will only develop a good form under less extreme conditions. For this reason its economic use in Calluna upland afforestation is limited to the more sheltered sites. The best plots of this species at the Shooting Box Area averaged 17 ft. in height in fourteen years.

Tsuga heterophylla

This species has been tried in two experiments (Experiments 13, P.33 and 22, P.42) in the Shooting Box Area and on both sites suffered from a prolonged early check and heavy losses through drought in the first few years. In the early years most of the plants had a weak, sickly appearance and did not begin to grow strongly until eight to ten years of age. Subsequent growth in Experiment 13 has been fairly vigorous considering the exposed nature of the site. The latest available assessment data gives the following results:-

	Mean Ht. (in.)	
	Slag	No Slag
Experiment 13, P.33 (assessed July, 1946)	73.7	62.7
" 22, P.42 (assessed August, 1951)	-	34.0

This species shows a moderate response to slag.

As a result of its success at the Shooting Box Area this species has been given a further trial at Cefn Du in the recently established species experiment (Expt.28, P.51). The trials at Beddgelert have, however, shown it to be subject to wind damage at about 20 ft. in height under exposed conditions.

Other Conifers

Other coniferous species have given somewhat varied results in Experiment 20 P.37. Thuja plicata and Thuja occidentalis after a rather slow start with a death rate of less than 2 per cent. have gradually become adapted to the site. The former has a mean height of 82 in. and the latter 62 in. being of a very bushy form.

Chamaecyparis nootkatensis made a very bad start, 41 per cent of the plants dying in the first year, but has since shown a steady improvement. In 1951 the plants were sturdy and healthy with a mean height of 65 in. and a mean shoot growth of 5.6 in.

Abies alba has proved rather disappointing on the upland Calluna sites, especially on burnt over ground where it has suffered heavy losses and severe check. In dense, unburnt heather in a fairly exposed position it has however attained a mean height of 64 in. and so far is quite vigorous and healthy.

Hardwood species

The establishment of hardwoods has been a difficult problem on exposed upland Calluna sites and various trials have been laid down in the experimental areas to test the value of certain species for shelter belt planting.

Of the hardwoods tried Pyrus intermedia has proved the best so far and has produced an abundance of healthy foliage with sturdy stems and branches. The best specimens have put on a height growth of 13 ft. in fifteen years the mean overall height of three plots being 7.9 ft., the best growth occurring in the most sheltered.

Although generally vigorous, many crowns show wind damage. In the best sections heather suppression has commenced and there is already a considerable leaf litter.

Pyrus aucuparia (rowan) has not fulfilled its early promise (Experiment 20, P.37, Experiment 15, P.34) having fallen into a decline at about the fifth year. Many have died back and the remainder have developed a narrow, spindly form with sparse, sickly foliage. In Experiment 15 in the most exposed position the mean height of this species is only 4.9 ft. compared with 7.2 ft. for Sitka spruce and 9.9 ft. for Pinus contorta. Under less exposed conditions in Experiment 20 it shows a mean height of 7.9 ft.

Birch has behaved in a similar manner to rowan except that it has

attained a larger size before beginning to die back. This species appears unable to withstand the exposure and is unsuitable as a nurse or shelter tree in this area. In a less exposed position in Experiment 2, P.32 some individuals have reached a height of over 13 ft. but the majority are flat-crowned and badly wind-blown. More intensive drainage has failed to effect any marked improvement in the growth of this species.

Both common and grey alder have been tried but have failed on Calluna ground and are therefore unsuited to the locality. They have grown well, however, in more sheltered positions on a Juncus vegetation.

Trials of Manures

The manurial experiments carried out at Clocaenog have all been concerned with testing the effect of basic slag and a proprietary fertilizer 'Semsol'. 'Semsol' is an equal mixture of superphosphate and rock mineral phosphate consisting of 45 per cent total phosphates, of which 5 per cent are soluble and 15½ per cent insoluble phosphoric acid. The basic slag used varied from 19 to 24 per cent total phosphate content. Application of the manures was at the rate of 1 or 2 ozs. per plant sprinkled around the base of the plant or, in the case of turf planting, spread underneath the turf.

Experiments dealing with manurial treatments are the following:

Tai'n-y-Waen Bog (Sheepwash) Area :

Experiment No.3, P.32 - Sitka spruce, turf planted, with 1 oz. and 2 oz. of slag and control.

Tai'n-y-Waen (Sheepwalk) Area :

Experiment No.12, P.33 - Sitka spruce and Japanese larch with 2 oz. basic slag, 2 oz. 'Semsol' and control, in screefed patches in natural surface.

Shooting Box Area :

Experiment No.14, P.34 - a repetition of Experiment 12, P.33.

The manurial experiments have given significant results in that basic slag has had a marked beneficial effect on tree growth compared with 'Semsol' and the controls. The growth results obtained with 'Semsol' were little better than where no manure was applied while it is believed to have been the cause of very heavy losses among the larch in Experiment 12 in the first year, totalling 73 per cent. This experience is similar to that encountered at Allerston, Wareham and Harwood Dale in 1933, the effect probably being accentuated by the very dry weather.

The Effects of Basic Slag

It is interesting that though slagging appears to have had no effect on the number of failures in the first year, manured plants seem to develop a vitality which enables them better to withstand subsequent adverse conditions.

The benefits derived from the application of basic slag at planting, as observed in the Clocaenog experiments on exposed peat areas, are most marked on the poorer ground types. They consist chiefly in quicker establishment with more vigorous early growth and a consequent reduction in beating-up and weeding costs. The result is better stocked and more uniform plantations at the pole stage

Species tried at Clocaenog show a variation in the degree of response to the application of basic slag, which, broadly, may be expressed as follows:-

Good response : Sitka spruce, grey alder, common alder, birch, rowan.

Moderate response : Tsuga heterophylla, Japanese larch.

Little or no response : Pinus contorta, mountain pine.

Different Methods of Planting

Two experiments dealing with different methods of planting on a thin peat 2 to 4 inches in thickness (Experiment 11, P.33 and Experiment 18,P.34) have been carried out in the Tai'n-ŷ-Waen (Sheepwalk) Area, both using Pinus contorta.

In Experiment 11, which was a trial of turf and mound planting and normal inverted turf planting produced quicker initial growth than by replacing the turf in its hole after breaking up the soil, or by planting direc into the natural surface.

Of the three planting methods tried in Experiment 18 the most successful was that in which a turf was cut and inverted in the hole from which it came and the plant notched in. This method resulted in more rapid and uniform growth in the early years than dibble planting into a thin inverted turf or notching direct into the natural surface. In 1939 the mean heights of the three treatments were 40, 34 and 27 in. respectively.

The conclusions to be deduced from these two experiments are that on a thin peat from which a good solid turf cannot be cut the most satisfactory method is notch planting in the turf inverted in the hole from which it came.

Disturbance of the soil in the hole did not show improved results but, on the contrary, is thought to have had a harmful effect by rendering the plants more liable to drought damage. Combined turf and mound planting, though having given good results, is very expensive and much more difficult to carry out. Planting in thin unsatisfactory turves laid on the natural surface has resulted in heavy losses during periods of drought in the first year after planting. Planting on ploughed furrows has, however, to a great extent, superseded turf planting on peat areas at the present day except on the most difficult ground.

Age and Type of Plant

Two experiments have been carried out to compare the growth of seedlings and transplants, using Sitka spruce and Japanese larch, one in the Shooting Box Area (Experiment 6, P.33) and one in the Tai'n-y-Waen (Sheepwalk) Area (Experiment 17, P.34), planted in turves in both cases. Sitka spruce. In Experiment 17, in which both species were used, the losses at planting among the spruce were much heavier among the seedlings than the transplants, being 40 per cent as compared with 10%.

The results of these experiments indicate that in general losses in the first few years are considerably less among transplants than seedlings, giving a better stocked and more uniform plantation. Transplants also show a marked improvement in height growth compared with seedlings, the average heights for Sitka spruce at the end of ten years being 7 ft. and 4 ft. and for Japanese larch at the end of six years 41 in. and 29 in. respectively.

This experiment was unfortunately spoiled through a combination of adverse circumstances, the chief being the very poor quality of the larch transplants, unsatisfactory turves and severe drought during and after the P.33 planting. The extensive beating-up which these conditions necessitated largely nullified any accurate comparisons of the treatments.

Intensity of Drainage

Three experiments to compare the effect of different intensities of drainage on tree growth have been carried out at Clocaenog. The experiments were all laid down in single blocks, without replication, at the Shooting Box Area (Experiment 8, P.33, Japanese larch and at the Tai'n-y-Waen (Sheepwalk) Area (Experiment 9, P.33, Pinus contorta; Experiment 19, P.35, Sitka

spruce). The plants were put in on turves at 4½ ft. spacing with drains cut at intervals of 9, 15, 18 and 21 ft. compared with an undrained control.

The drainage experiments have not produced any outstanding results. It was shown, however, that the more intensive drainage slightly raised the average height of the crop, and gave rise to a greater degree of uniformity as it approached the pole stage. The best comparison of growth effect is seen in Experiment 8, where the mean heights of the Japanese larch in the seventh year were: drains at 9 ft. spacing - 78 in. 18 ft. spacing - 62 in. no drains 55 in.

In Experiments 9 and 19 the effect of the different treatments was much less marked. None of the sites of these drainage experiments would, however, be considered wet by ordinary conservancy standards.

Heather Burning

One experiment (Experiment 1, P.32) was laid down, using Sitka spruce as the indicator species, to compare losses and growth when the heather is burnt off before turfing and planting, and when the heather is left unburnt. The site selected for this experiment was in the Tai'n-y-Waen Bog (Sheepwash) Area, and carried a natural cover of tall, dense Calluna, on a peat soil, at the outset of the trial. The burning was carried out with the 'Hauch' burner.

The true effect of the treatments applied to this experiment have unfortunately been somewhat masked by neglect of weeding (caused by shortage of labour) in the early years which weighed rather heavily in favour of the burning treatment. This is reflected in the heavier losses in the unburnt portion which, in 1939 amounted to 60 per cent as compared with 31 per cent where the heather was burnt. The height growth in the unburnt treatments was slightly better than in the burnt treatments in 1946, averaging 9.4 ft. compared with 8.2 ft.

Taking all the circumstances into account it may be stated that the heather burning reduced the losses on establishment and the initial weeding costs but resulted in a slightly depressed rate of growth.

Planting in different ages of Heather

An experiment was laid down in 1933 in the Shooting Box Area (Experiment 7) to compare the growth of the three species Japanese larch, Sitka

spruce and Pinus contorta, turf planted, in three different ages of heather : (a) short, young heather, recently burnt in February 1932; (b) medium sized heather, up to 12 in. high and uniform; (c) tall, old heather, open and with long thick stems.

The results of this experiment indicate that the plants benefited in the early years in proportion to the degree of shelter provided by the different sizes of the heather in which they were planted. A comparison of growth rates at the end of the third season gave the following results (mean heights in inches) :

	Tall Heather	Medium	Short
Japanese larch	21.2	18.9	15.5
Sitka spruce	11.3	10.1	9.5
Pinus contorta	15.3	11.5	12.4

Differences in growth rates which have persisted until the present day appear to be due chiefly to variations in site quality. The plants growing in the tall heather plots are still taller than those in both the other two treatments which show similar rates of growth, having outgrown the earlier differences. The mean heights of the three treatments for Sitka spruce in 1946 were : 15.5, 8.4 and 8.9 ft. respectively.

Losses in the first year after planting were considerably less in the short burnt-over section than in the two unburnt sections in the case of both Sitka spruce and Japanese larch. This is considered to be due to the greater risks of suppression by the taller, denser vegetation. The data for these losses are as follows (percentages) :

	Tall heather	Medium	Short
Sitka spruce	20.0	19.2	7.4
Japanese larch	43.5	50.0	31.7
Pinus contorta	30.5	18.2	28.5

Losses of Sitka spruce were similarly reduced by the heather burning treatment in Experiment 1, P.32.

Nurses for Sitka spruce - Trials of coniferous and broad-leaved species

Trials of various species have been carried out at Clocaenog for use in mixture with Sitka spruce with the aim of promoting its growth and preventing it from going into check on exposed ground. Four experiments have been laid down with this object in view, as follows:-

Tai'n-y-Waen Bog (Sheepwash) Area :

Experiment 2, P.32 - pubescent birch, common alder, grey alder, Sitka spruce; on turves.

" 4, P.32 - mountain pine, Pinus contorta, Scots pine, Corsican pine, grey alder, Sitka spruce; on turves; group planting.

Shooting Box Area :

Experiment 23, P.42 - Scots pine, Pinus contorta, Sitka spruce; on ploughed ground.

" 23A, P.42 - Sitka spruce in groups of 9 in a matrix of Scots pine; on ploughed ground.

Tai'n-y-Waen (Sheepwalk) Area

Experiment 24, P.46 - Sitka spruce, Norway spruce, Scots pine; on ploughed ground.

" 25, P.39 - Sitka spruce introduced into Pinus contorta of Experiment 9, P.33.

" 26, P.39 - Sitka spruce introduced into Pinus contorta of Experiment 11, P.33.

" 27, P.39 - Sitka spruce introduced into Pinus contorta of Experiment 18, P.34.

These trials have shown that no hardwood species has yet proved suitable for planting on a forestry scale at Clocaenog, chiefly on account of their failure to withstand the exposure. The only good growth is to be found in sheltered situations on Juncus vegetation. Birch and alder are therefore of no value as nurses for Sitka spruce on the exposed peats.

Of the several species of pine tried as nurses only Corsican pine has failed to grow satisfactorily. In Experiment 4 it is seen that Scots pine/spruce mixture has given good results whereas Pinus contorta owing to its more rapid early growth tends to suppress the spruce, particularly on the poorer ground. Mountain pine has given good results for the spruce and, like Scots pine, has caused early suppression of the vegetation.

Interplanting of Advance Nurse Species. In 1939 experiments were carried out at the request of the Chairman (Experiments 25, 26, 27) to test the effect of introducing Sitka spruce into established plantations of Pinus contorta. The old experiments dealing with intensities of drainage (Experiment 9, P.33) and methods of planting (Experiments 11, P.33; 18, P.34) were used, the average height of the tallest plots at this time being 35 to 40 in. The results up to the present time indicate that the spruce have benefited considerably from the nursing effect of the Pinus contorta

but chiefly where the latter were smallest. Elsewhere the rapid growth of the Pinus contorta has necessitated rather drastic and expensive trimming and thinning operations. It seems evident that better results would have been achieved by introducing the spruce several years earlier, as many of the plants are too far behind to be nursed up.

The progress of this trial is illustrated by the 1946 assessment data for Experiment 26 when the Pinus contorta were 13.4 ft. and the Sitka spruce 3.5 ft. in height. The mean height of un-nursed Sitka spruce at the same age in adjacent plots in Experiment 10, P.33 was 2.3 ft. In July 1951 the Pinus contorta averaged 17.4 ft. and the nursed Sitka spruce 6.0 ft.

A further nursing trial was carried out at the request of the Chairman in 1950 to test the possibility of introducing large plants of Sitka and Norway spruce into an established crop of mountain pine. The site chosen for this trial was Experiment 10, P.33 the spruce being approximately 4 ft. high and transferred from nearby compartments (Compartments 60, 61 P.34 (Sitka spruce); Compartment 219, P.37 (Norway spruce)), with a large turf around the base. The spacing was 9 ft. by 9 ft. The spruce are now well established but the general impression is that they are going to have a hard struggle to avoid suppression by the mountain pine which are two or three times taller.

Provenance Studies

Pinus contorta

An experiment (Experiment 16) to test the value of seven seed lots of Pinus contorta of different origins was laid down in the Tai'n-y-Waen (Sheepwalk) Area in 1934. The collection included four lots from inland regions of British Columbia at medium elevations, one lot from Alaska and two lots from the coastal belt of the U.S.A. at elevations of below 500 ft.

The growth and appearance of the two coastal lots (ident. No.34/39 U.S. Coast; ident. No.34/40 Olympic Peninsula, Washington) are very good and they are in general, superior to the inland origins on this site. Many plots have suffered injury by windblow.

A study of form shows that the coastal lots are more heavily branched, having a greater number of branches per whorl, thicker branches and also a slightly greater crown spread. Their needles are, however, shorter and stiffer than those of the inland origins. The mean data for comparable plots, measured in 1951, is as follows :-

Race	Height (ft.)	Branches per whorl at B.H.	Branch girth (ins.)	Crown spread (ft.)	Needle length (m.m.s)
P.37 - 34/39, U.S. Coast, 50 - 100 ft.	17.7	5.8	2.8	9.0	49.2
" - 34/40, Olympic Peninsula Washington, 300 - 500 ft.	20.6	5.8	2.3	8.0	44.2
P.34 - 31/26, Mt. Ida, B.C.	20.5	- brashed -		8.0	61.7
" - 31/49, E. of Kamloops, B.C. over 1310 ft.	21.4	4.4	2.1	7.6	63.0

Among the inland origins the Kamloops race is very promising. The more heavily branched coastal lots have proved very effective in suppressing the dense vegetation.

Corsican pine

A provenance trial (Experiment 29) using four origins of Corsican pine was laid down on Cefn Du (Pincyn Llys section) in 1951. The plants were raised from seed lots collected in Italy, Corsica, Spain and East Anglia and were planted in screefed patches in the natural surface.

There is little to be said at present about this experiment except that losses at planting were heaviest in the case of the Spanish lot (38 per cent) and lowest for the Italian lot (8 per cent). Losses for the East Anglian and Corsican lots were 23 and 25 per cent respectively.

Poplar Trials

Trials were laid down at Nant Llyfarddu in 1950 and in 1951 on a moist grass moorland site to the west of Cruglas Farm. The ground is at an elevation of 1100 ft., moderately sheltered and with a north-north-easterly aspect. The soil is peat of variable depth which in places exceeds 4 ft.

The object of these trials was to test the value of several varieties of poplar for planting on moist sites at high elevations.

The following varieties were planted :-

Planted in 1950 :

Populus gelrica H.A.
" laevigata
" tremula x tremuloides
" serotina V.B.
" robusta P.H.
" androscoggin
" 214A

Planted in 1951 :

Populus trichocarpa	C.F.
"	72A
"	gelrica V.B.
"	berolinensis
"	O.P.60
"	214A
"	78B

All that can be said of these trials at the present stage is that losses at planting and growth rates have not differed appreciably from those experienced on other less severely testing sites. The plots have been beaten up three times since planting and in May 1952 were practically fully stocked.

Summary

1. Trials of Species

The most rapid growing and vigorous species so far tried at Clocaenog is Pinus contorta. This species is frost hardy, very accommodating as regards soil, and is little affected by extremes of exposure providing it has adequate drainage.

Scots pine has grown at a very satisfactory rate under moderately exposed conditions. Owing to its slow growth it is more liable to suffocation by dense vegetation in the early years, and sometimes suffers serious injury by the fungus Lophodermium.

Mountain pine, though slow growing, is steady and vigorous and appears able to withstand the severest degree of exposure. Its spreading, heavy branching habit renders it of value as a suppressor of vegetation. This species has a possible use as a nurse for Sitka spruce.

Corsican pine has so far proved disappointing on account of the high percentage of failures and is not considered suited to the soils and climate of the locality.

Sitka spruce grows very well on the peat soils even under conditions of severe exposure, but is more sensitive to variations in ground quality than the pines. It tends to go into prolonged check on badly drained or stony ground and on tight shallow peats overlying a pan formation. This species responds to the application of basic slag and to intensive drainage. It has done poorly on frosty sites.

Japanese larch withstands the extreme exposure well providing soil conditions are suitable. It does not, however, produce straight stems

and would not appear to be an economic timber tree. Limited use might be made of this species in less exposed situations, and for fire belts.

Other coniferous species which now show promise after a very slow start are:- Tsuga heterophylla, Thuja plicata, Thuja occidentalis, and Chamaecyparis nootkatensis.

The only hardwood species which has so far shown promise of growing well on the upland peats is Pyrus intermedia. Rowan, birch, common alder and grey alder have all suffered chronic die-back of the crowns and sometimes very heavy losses. They are not suited to the soils and exposed climate of the area.

2. Trials of Manures

Experiments show that 'Semsol' (an equal mixture of superphosphate and ground mineral phosphate, consisting of 45% total phosphates) is of little value as a fertilizer on peat and may cause heavy losses of plants under drought conditions. Basic slag, applied at planting at the rate of 2 ozs. per plant, has had a marked beneficial effect on the growth of Sitka spruce, Japanese larch, Tsuga heterophylla, alder, birch and rowan. Mountain pine and Pinus contorta show little or no response. Slagging has resulted in a stimulation of early growth, and a reduction in losses and in costs of weeding and beating-up.

3. Different Methods of Planting

On a thin peat, 2 in. to 4 in. thick, from which a good solid turf cannot be cut, the most satisfactory method of planting is notching in the turf inverted in the hole from which it was cut. This is better than normal inverted turf planting or planting direct in the natural surface and also cheaper than combined turf and mound planting.

4. Age and Type of Plant

Experiments with transplants and seedlings of Japanese larch and Sitka spruce indicate that in general transplants show a higher survival rate, faster growth in the early stages and produced a more uniformly stocked plantation.

5. Intensity of Drainage

It is found that the more intensive drainage slightly raises the average height of the crop and results in a greater degree of uniformity

at the pole stage.

6. Heather Burning

Burning of the heather before planting Sitka spruce reduced the losses on establishment and the initial weeding costs but resulted in a slightly depressed rate of growth.

7. Planting in Different Ages and Sizes of heather

Plots of Sitka spruce, Japanese larch and Pinus contorta planted in old tall heather grew faster than plots planted in shorter heather, due probably to the increased shelter provided. Losses of Sitka spruce and Japanese larch in the first year were less among short, recently burnt heather than among medium sized and tall heather of a greater age.

8. Nurse Species for Sitka spruce

The hardwood species birch and alder, are of no value as nurses as they have failed to adapt themselves to the soils and climate. Among conifers Scots and mountain pines are valuable heather suppressors and do not damage the spruce. Pinus contorta is more difficult to manage on account of its faster rate of growth and it also has a lighter branching habit.

Interplanting of 5 and 6 year old Pinus contorta with Sitka spruce was only partially successful as many of the nurse trees were too far advanced. The experiment would have been more successful had it been carried out several years earlier.

9. Provenance Studies

Trials with seven origins of Pinus contorta under exposed conditions show that two origins from the U.S. coast are more vigorous than four inland forms from British Columbia and one from Alaska.

10. Poplar Trials

Trials of thirteen varieties of poplar were laid down in 1950 and 1951 on a moist high elevation site on a peat soil. At the end of two years losses and growth rates had not differed appreciably from those experienced on other less severely testing sites.

Sample Plot W.73 - Shooting Box Experimental Area

Previously an old drainage experiment (Experiment 8, P.33) sample plot W.73, national grid ref. 23/467767 was established in 1951 for details upon growth and yield of Japanese larch grown on this very exposed site.

The plot occurs high up on Denbigh moor at 1400 ft. on a gentle 3° slope with a south west aspect. It is not sheltered by plantations or hills although there is some fine young Tsuga heterophylla adjacent to it with a height of 10 ft.- 15 ft.

The soil is podsolic with the top four inches of duff humus followed by a leached layer which varies in depth from between 2 in. - 6 in. Below this is an orange brown pan which can be broken by tree roots and is not wholly impervious to water. The subsoil is a good clay loam with particles of sandstone rock becoming more frequent with depth until the bed rock of the Silurian sandstone is reached at 24 in.

Previously the land was used for grouse shooting and carried a vegetation of :-

Calluna vulgaris
Vaccinium myrtillus
Galium saxatile
Brachythecium purum
Hypnum cupressiforme

These plants are now dying out under the larch crop and occupy only 20 per cent of their former surface area.

The trees were planted in P.33 and in 1951 the crop received its first thinning which was a silvicultural D grade, 665 stems with a total volume of 236 hoppus feet under bark being removed per acre. The remaining crop of 954 stems per acre have a volume of 615 hoppus feet under bark.

Crown percentage averages 48½ and the best stems have been pruned to a height of 12 ft.

Stem form is bad and all the stems have a tendency to lean away from the west.

Details of measurements taken in 1951 are given in the following table:

(*47683) WT.[redacted]/464 3.000 2/53 A.& E.W.LTD. GP.650

SAMPLE PLOT FORM No. 9

Plot No. [redacted] Area 2·15 acres Species J.L. Quality Class III

Site Clocaenog Forest, Denbigh 33/467767 Thinning Grade 'D'

Q.G.

RECORD OF PERIODICAL MEASUREMENTS PER ACRE

Year of measurement	Age of crop yrs.	Main Crop: Number of trees per ac. after thinning	Main Crop: Height — Average of 100 largest trees ft.	Main Crop: Height — Av. of crop ft.	Main Crop: Form Factor	Main Crop: True Girth at 4′ 3″ ins.	Main Crop: Basal area per ac. after thinning Q.G. sq. ft.	Main Crop: Vol. per ac. (under bark) Q.G. cu. ft.	Main Crop: Cr'wn % / Bark %	Intermediate Yield from Thinnings: Number of trees	Intermediate Yield from Thinnings: Av. Ht. ft.	Intermediate Yield from Thinnings: True Girth at 4′ 3″ ins.	Intermediate Yield from Thinnings: Basal area per acre Q.G. sq. ft.	Intermediate Yield from Thinnings: Vol. per ac. (under bark) Q.G. cu. ft.	Total Crop Yield to Date: Basal area Q.G. sq. ft.	Total Crop Yield to Date: Vol. (under bark) Q.G. cu. ft.	Entered & checked by	Periodic Mean Annual Main Crop Increment: Basal Area Q.G. sq. ft.	Periodic Mean Annual Main Crop Increment: Vol. (U.B.) Q.G. cu. ft.
6/51	18	954	24½	23½	.368	13	71.9	615	48½ / 15½	665	20½	11	34.9	236	106.8	851			
									70										

Conclusions

i) Preparation of Ground

a) Tall heather must be burnt off prior to ploughing, for the furrows to lie satisfactorily.

b) Advanced draining is a big asset, especially in very wet areas. Deep main drains and cut-offs should be put in the previous summer is possible, to enable ploughing to be done in the following year without having to waste time on de-bogging operations.

c) Ploughing and advanced draining doubtful planting land has made these sites fit for planting. Ploughing has also made possible a higher planting line on exposed moorlands.

ii) Choice of Species

a) European larch has not proved promising on all sites on which it has been planted. These have been on the sheltered well-drained old woodlands where good results could be expected. It is severely checked in gorse.

b) Douglas fir should have been tried to see how it would have done on sheltered bracken ground. Instances of Douglas fir planting in the locality indicate that probably better results would have been obtained than has been shown by European larch.

c) Japanese larch is a very good all round tree with a wide range of sites on which it will grow. It does not like exposure. It grows too fast and develops saber growth on ploughed ground. It does well on bracken/Vaccinium sheltered slopes, but tends to corkscrew tops on more fertile and moist grass/bracken ground, though not to such a marked degree if in moderate exposure. It will not stand much dwarf gorse competition but more than European larch. Japanese larch is very useful for fire breaks, soon closing canopy and smothering out the vegetation.

d) Norway spruce does not like dense Calluna or Calluna/gorse and will remain in check for many years. It does well on sheltered flushes and bogs of Molinia, Juncus, Nardus and is much better on frosty sites than Sitka spruce.

e) Sitka spruce/Scots pine mixture is better than pure Sitka spruce on dense Calluna on exposed peaty ground. As yet, the best form

of mixture, i.e. 3/1, 2/1 or 2/2 has not been demonstrated.

f) Pinus contorta deserves more attention. The evidence points to the hardiness and ease of establishment of Pinus contorta and suggests a more widespread use on really inhospitable sites as a pioneer species.

g) Birch is generally disappointing for fire belt planting but is successful on Juncus flushes.

iii) Planting

a) Type of plant used. Transplants have proved to be more satisfactory than seedlings. They give a higher percentage survival, lower beating up figure, are quicker in coming away and need less weeding than seedlings. For spruces a 2+1 or a 1+2 is generally the best plant, and a 1+2 for larches and pines.

b) Manuring - The addition of basic slag, 2 oz. per plant, on very poor ground marked by deep peat and a vegetation of Erica tetralix, Calluna, Eriophorum, seemed to assist in getting a better take, but whether the effects will be lasting remains to be seen.

c) Success in establishment is surer and quicker on ploughed ground with transplants.

iv) Ploughing

Planting on ploughed ground is better than on turf for spruces and is cheaper. Japanese larch should not be planted on ploughed ground because of saber growth.

v) Beating up

Japanese larch can be used for delayed beating up of the spruces on suitable firm ground. Checked gaps of spruces in Calluna can be satisfactorily planted through with Scots pine or Pinus contorta, and Pinus contorta is useful for beating up in frost hollows.

vi) Weeding

Bracken weeding must not be delayed for Japanese larch and Scots pine.

vii) Mixtures

In Norway spruce/Sitka spruce alternate mixture row/the mixture usually thins itself, suppressing all Norway spruce; though delaying

thinning, this gives no early returns. In Scots pine/spruce mixtures there is some evidence to show that the Scots pine nurses benefit the spruces, but it is too early to assess the full effects. Sitka spruce/Scots pine is a better mixture than Norway spruce/Scots pine on dense Calluna.

Conservator's comments

The original acquisition was, and still is, the largest ever made in North Wales. Much of the ground was considered doubtfully plantable owing to vegetation and soil conditions and to exposure. Many experimental plots were established and these and the early plantations showed that exposure was not very great or adverse factors as bad as had been expected, and that with suitable preparatory methods and treatment, trees of many species would grow tolerably well under what appeared to be very adverse conditions. Ploughing soon overcame our early problems and Sitka spruce although generally slow growing on the moors, has become firmly established as our main timber tree. There are problems as yet unsolved or incompletely solved. Canopy has not yet closed over an extensive acreage of the poorest ploughed ground, and there are areas where growth has fallen back as heather has re-invaded the ground and the subsequent development of these crops is not certain.

The use of pine nurses shows promise, but we do not, as yet, know exactly how and where they should be used.

The driest parts of the heather moorlands have only recently been planted and these areas may prove too dry for the satisfactory growth of Sitka spruce. Such ground is more typically a pine site, but stands of Scots pine and Corsican pine elsewhere in North Wales give no grounds for expecting better results from these species. Pinus contorta has been very successful but information is lacking as to its ultimate production.

APPENDIX I

Notes from Inspection Reports

25 & 26 August 1929. Assistant Commissioner

Choice of species.

Generally Japanese larch with Sitka spruce in bogs and Scots pine on rocky knolls; possibly Corsican pine in east part where also possibly European larch and Douglas fir and possibly some hardwood areas.

October 1929. Technical Commissioner

Choice of species on Juncus articulatus type with 6 in.- 18 in. peat on clay and dense Polytrichum and varying proportion Sphagnum, Calluna and occasionally Erica was considered excellent Sitka spruce ground after draining and mounding. Burning previous to planting very desirable to reduce physical difficulties and cost of this operation. Species approved for Coed-y-Fron - Norway spruce on more exposed and wet areas (Sitka spruce as an alternative), Japanese larch on the dense bracken ground, some European larch in sheltered slope in north-east. Spruce on the grass moor type to be turf planted. Open heather moor north of Coed-y-Fron - Experiment must determine choice of alternatives Japanese larch, Japanese larch/Sitka spruce, Norway spruce/Pinus contorta, Sitka spruce/Pinus contorta also Norway spruce or Sitka spruce with Scots pine nurses. Probably Japanese larch/Sitka spruce will prove best and possibly pure Japanese larch where bracken is encroaching on heather.

The forest as a whole appears definitely a Japanese larch, Sitka spruce Norway spruce area, with some European larch in the more favourable situations.

25/8/48. Commissioner (Mr. W. L. Taylor)

The following, in order, were the most successful - Scots pine, Norway spruce, Sitka spruce. There might be a future for Corsican pine on the drier sites, and it was agreed to be a pity that more Douglas fir had not been planted on the sheltered margin slopes instead of European larch .

Japanese larch was a useful pioneer crop on old coppice or weedy sites and a useful proportion of the crop were of good form.

Pinus contorta was not considered valuable enough to plant on any but the worst sites which could not be ploughed.

17/3/49. State Forests Officer

Japanese larch would be used more freely on dry heather/bracken/ Vaccinium ground for planting and for late beating up.

19/4/31. Commissioners' Tour

Plantations

Chairman said that the pine planted at the top of Hafotty Wen was a mistake.

20/4/31. Commissioners' Tour

P.30 Pennant. 'Although the Norway spruce and Sitka spruce look sickly now, Mr. Robinson is confident that it is only temporary and that they will come away one by one. The larch which looked poorly after planting looked a great deal better now and should do well with another good growing season.'

16/3/33. Divisional Officer

Talycefn and Hendre Uchaf P.31 and P.32 seedlings unsuccessful on upper bad area.

31/7/33. Commissioners' Tour

Doubt was expressed on the planting of Scots pine at 1300 ft. in exposure. Compartment 126 P.30 Norway spruce/Sitka spruce 1/1 mattock planted, doing well. Coed Pennant P.30 European larch was doing excellently on the slopes "as was the Japanese larch of a year later a little higher up". The Norway spruce and Sitka spruce which run along the top of the ridge were not really so good to all appearances, but the Chairman pointed out how they were looking well in the declines and where there was shelter afforded by the rising western ridge, and that the rest would come on gradually as the shelter from the other trees increased.

Coed-y-Fron P.31 European larch were small and not so good on higher ground, lower down the plants were excellent. Gasnach P.31 and 32. Spruces do not show much sign of growing yet, it was considered merely a matter of patience, since although the exposure is considerable the soil conditions are not unfavourable, and have improved with drainage.

22/3/35. Divisional Officer

Lodge Isaf P.33 west block - it was decided that Japanese larch was a mistake and similar areas in future will be considered for Norway spruce.

April 1935. Chairman

Sitka spruce is better than Norway spruce in heather, particularly where the dry, gravelly soil is found with a very tight peat over it.

Gasnach P.32 - thought to be showing improvement; Chairman considered that Sitka spruce would have been better than Japanese larch, but that the latter ought to come on all right now. If it is at all possible to plough or otherwise stir up the soil on the heathery parts, great benefit will result. As a rule there is excellent soil below.

6/6/35. Divisional Officer

Late planting of Sitka spruce better than early - Sitka spruce do better if planted out soon after lifting and not kept heeled in long.

9/10/36. Assistant Commissioner.

P.36 Lodge Uchaf Compartments 239, 240 etc.- Sitka spruce looking better than Norway spruce on ploughed ground. Gasnach P.31-32, Compartments 304 - 317. Trees still not all growing satisfactorily. Japanese larch unsuited to so exposed an area, and such poor soil conditions as on the tops, and European larch is obviously not at home on much of the ground. Even pine and spruces are not growing as they should.

January 1937. Divisional Officer.

The usual species for the forest are Norway spruce on all bogs, grass flats and moist slopes, with Sitka spruce on all high, exposed land and on pure heather areas. Some Japanese larch on bracken slopes. Scots pine on dry, rocky outcrops. A very high proportion of the plantable areas of the forest is spruce ground. Neglected grass weeding causes losses by suppression and from frost in hollows and flats. Compartment 211 showed the advantage of using large, strong transplants in dense vegetation, and frost hollows - better growth, less failures and cheaper establishment than seedlings.

October 1937. Chairman.

On bad Erica - Juncus squarrosus land, Sitka spruce does not get away very quickly even on plough, and a 50% mixture of Sitka spruce/Scots pine is advised where pan is present.

Nant Uchaf Compartments 59-61 P.34. Sitka spruce doing unexpectedly well on turfs on deep Calluna peat. This sort of ground, if planted at all, should be ploughed in future.

11/7/38. Advisory Committee. Chairman.

P.36 plough planting Norway spruce and Sitka spruce showed complete absence of check in Compartments 240 and 244. The general conclusions arrived at were that conditions of soil and exposure are not as bad as they appear, but that ploughing is greatly superior to other forms of planting so far tried.

20/4/46. Chairman. Lord Chancellor.

P.31 Norway spruce/Scots pine Compartments 104 and 101. Norway spruce holding its own against the Sitka spruce having equal growth and better form. The Sitka spruce having suffered heavy leader damage. Talycefn experiments showed striking results of Sitka spruce doing better in long heather than in the short and medium heather. Birch was too slow growing to be of value as a roadside fire break and Japanese larch to be used in future. P.30 Compartment 432 European larch doing well and compared favourably with adjoining Japanese larch P.31. However, plenty of canker in evidence and Director pointed out that neglected weeding was a contributory cause.

9/46. Director

Compartment 240 P.37 Hybrid larch showed signs of attack by larch shoot moth. Gasnach P.31 European larch in Compartment 306 windswept and extremely poor. Extensive beating up with pine had resulted in a complex crop of poor quality and treatment could only be done on such a windswept site with a view to providing a shelter crop for the next plantation. The gorse areas corresponded with poor tree growth. Compartment 308 P.44 ploughed area Sitka spruce/Scots pine was getting away in advance of the adjoining P.31 areas which had been turfed.

31/10/47. State Forests Officer.

Japanese larch to be used on an experimental scale to beat up backward areas of all species on firm, well drained ground.

12/3/48. State Forests Officer

Gasnach P.31 European larch remarkably free of disease, and it was suggested that this was associated with the windswept aspect and unbrashed state. The latter fact was most evident when comparison was made with the

cankered, brashed trees on the lower edge of the plantation. Birch should not be planted on exposed heather ground.

25/8/48. Commissioner (Mr. W. L. Taylor)

Bryn Hyfryd P.33B, Compartments 290-291. Improved appearance of Japanese larch after first thinning. Tain-y-waen bog Experiment 3, P.32 Compartment 158 - Outstanding growth of turfed, slagged plot compared to surrounding turfed but unslagged P.33 Norway spruce. The result indicated that Norway spruce was unsuitable for poorer soils at this forest, unless on ploughed ground. Continue to beat up checked spruce patches with pine - Scots pine on drier sites, Pinus contorta on damp. These should be planted through the spruce to nurse them up and no attempt made to pull up the spruce.

2/2/49. Conservator

Lopping of pine in pine/spruce mixture to be avoided if possible. It is costly and only a temporary remedy. In most cases the complete removal of any offending pine is more economic and sometimes this can be deferred until pitwood size has been reached. It is not expected that every spruce should get through.

11/4/49. State Forests Officer

Alwen. Area nearly all ploughable. Main block P.36, 37. It is clear that ploughing of stony ground with a vegetation of dwarf gorse or bell heather or both does not provide the answer so far as Sitka spruce is concerned, although Scots pine is satisfactory. There is evidence that such areas should be planted with pines. Japanese larch may succeed in the bell heather but not in dwarf gorse. Long-eared owl's nest found in Compartment 350, probably the first record for this forest.

4/6/49. Sir Wm. Taylor

Plantations round Cefn Banog developing well on the whole, but some P.38 Norway spruce is badly checked in heather ground, introduction of more pine desirable. Norway spruce in Bont Petryal falt is looking better this year after a spring free from frost, but Sitka spruce badly attacked by Aphis. Foel Fasnach improving. Nilig, Isgaerwen, Hendre Uchaf plantations developing well; some check in P.34 heather ground and checked patches in other older plantations before ploughing was carried out. Ploughed plantations are far more uniform.

21/4/50. Chairman

Poor growth, sickly appearance of P.33 Sitka spruce Compartment 288 comparing unfavourably with much of the Norway spruce on similar sites. P.46 (ploughed F.Y.42) Cruglas Sitka spruce was seen to be growing at last. Delay in planting after ploughing gave poor results.

Gasnach P.31 improving after many years of doubt as to its future treatment. Health and vigour of Sitka spruce in mixture with pine was noticed on several occasions. The forest is developing well, and there are indications that the soil is generally of a good type for afforestation, particularly after ploughing. Tree growth is sometimes surprisingly good on the earliest heather sites which had not been ploughed, and considerably better results could be expected since the advent of ploughing.

In spruce/pine mixture the Scots pine should be in the row instead of double alternate Sitka spruce, Scots pine rows. Pinus contorta is too vigorous for mixing with spruces. Mountain pine may well prove to be the best nurse for spruce on heather sites. Its spreading form smothers the heather rapidly, and its growth interferes less with the spruce than any other pine.

Norway spruce should be kept off severely exposed margins and dense heather sites. More Norway spruce should be planted where possible to keep a balance with Sitka spruce.

Birch as a fire break was too slow to be of value against ground fires, but may be useful against the spread of crown fires in later years. It does not like any heather ground.

30/3/51. State Forests Officer

Alwen P.51, showed better soil conditions after ploughing than was anticipated.

31/7/33. Commissioners' Tour

Drainage. P.30 area. Comment was made on the rapid introduction of the finer and better grasses resultant on the drainage.

P.31 Hendre Uchaf Compartment 97 seedling area. The area was favourably commented upon. The Chairman mentioned the vast improvement resultant from drainage and that at one time he had doubts as to the suitability for planting on the site.

18/5/50. State Forests Officer

Visit of Bangor Forestry Students. Professor Mobbs commented on the bog in Compartment 225 P.49 (Talycefn). The very marked improvement both in vegetation and in the degree of drying out was noticeable after drainage.

APPENDIX II

Supervision

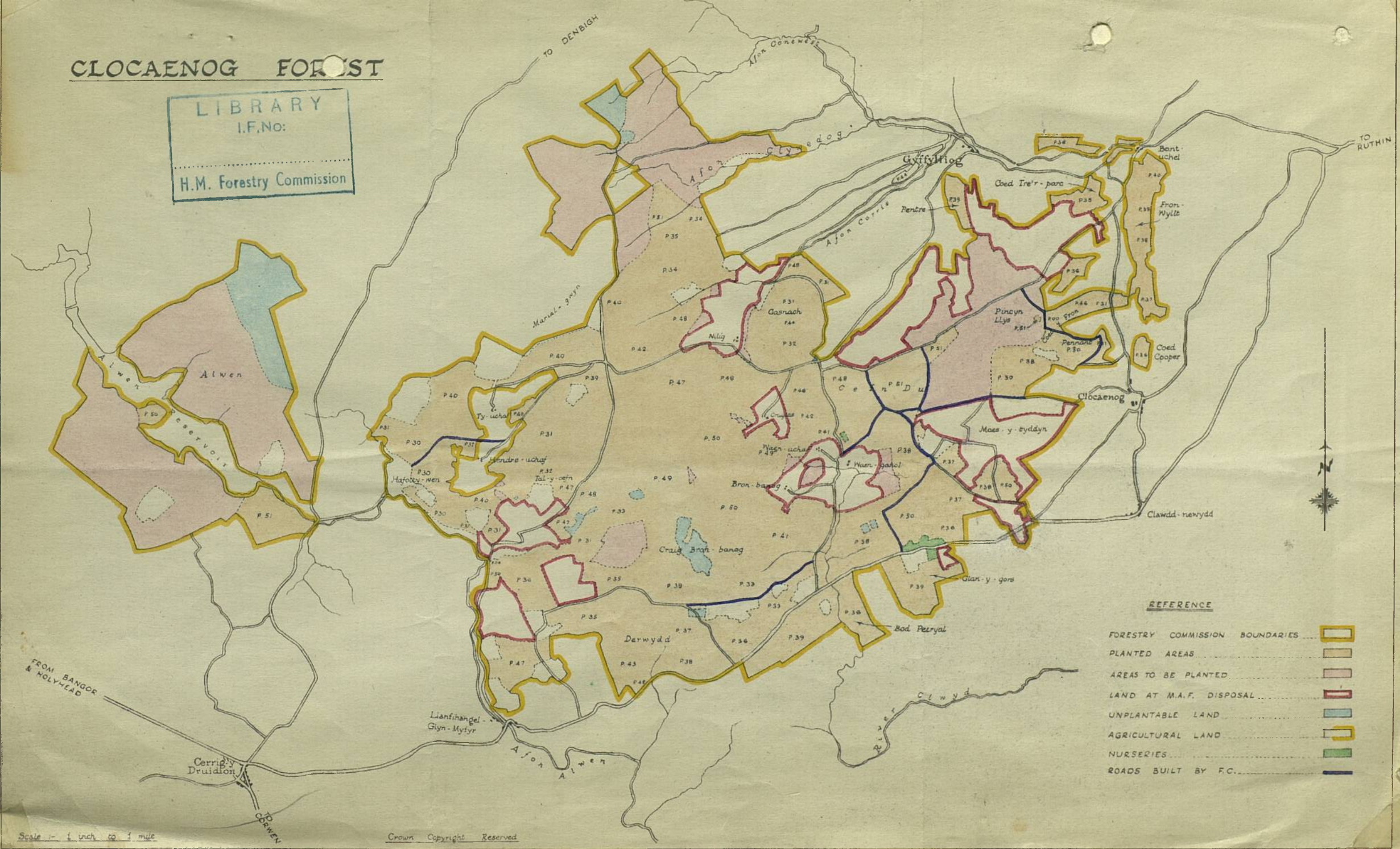
Conservators	Divisional Officers	State Forest Officers	District Officers	Foresters
	O. J. Sangar 1930-31		R. H. Smith 1930-36	J. W. Anderson 1930-39
	A. P. Long 1931-37		F. C. Best 1936-39	N. Smith 1939-41
	A. H. Popert 1937-39		J. L. Shaw 1939-46	H. J. Wallington 1941-43
	C. E. L. Fairchild 1939-41		J. R. Hampson 1946-49	A. I. Davies 1943-
	R. H. Smith 1941-46		W. A. Lindsay-Smith 1949-51	
R. H. Smith 1946-47		W. A. Cadman 1947-51	J. A. Spencer 1951-	
F. C. Best 1947-				

APPENDIX III

Record of Fires at Clocaenog

Block or Cpt.	Area	P.year	Date	Remarks
Public F.P. C.463	-	U.P.	15.4.38	Cause unknown
Nant Uchaf C.7, 8, 10	14 acs	35	8.6.39	Cause unknown. Started 12.30 out 15.45 hrs.
C.456	15 acs	37	2.8.40	Cause unknown
C.109	700 sq.yds	32	7.8.44	Cause unknown. Started 17.30 out 1800 hrs.
C.433	250 sq.yds	38	23.3.45	Started by E.Davies, Pentre, on his land. Started 1830 hrs out 1850 hrs.
F.W.H.23	Haybarn	-	2.8.45	Cause unknown
Bdy. C.480	-	-	10.3.48	Fire started by P.Rowlands, Garwfynydd, burning gorse on Cpt. boundary. No damage done. Started 1430 out 1445 hrs.
C.338	2½ acs	38	18.5.48	Cause unknown. Started 1855 out 20.30 hrs.
Roadside 288	-	-	22.5.48	Fire started on roadside near C.288. No damage done. Cause unknown. Started 22.40 out 22.42 hrs.

CLOCAENOG FOREST



REFERENCE

- FORESTRY COMMISSION BOUNDARIES
- PLANTED AREAS
- AREAS TO BE PLANTED
- LAND AT M.A.F. DISPOSAL
- UNPLANTABLE LAND
- AGRICULTURAL LAND
- NURSERIES
- ROADS BUILT BY F.C.

Scale :- 1 inch to 1 mile