FORESTRY COMMISSION

BULLETIN No. 12

FOREST GARDENS

LONDON:
PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE
To be purchased directly from H.M. STATIONERY OFFICE at the following addresses:
Adastral House, Kingsway, London, W.C. 2; 120, George Street, Edinburgh;
York Street, Manchester; 1, St. Andrew's Crescent, Cardiff;
15, Donegall Square West, Belfast;
or through any Bookseller.

1931

Price 2*s.* 6*d. Net.*

70—31—12

FORESTRY COMMISSION

BULLETIN No. 12

FOREST GARDENS

LONDON:
PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE
To be purchased directly from H.M. STATIONERY OFFICE at the following addresses:
Adastral House, Kingsway, London, W.C. 2; 120, George Street, Edinburgh;
York Street, Manchester; 1, St. Andrew's Crescent, Cardiff;
15, Donegall Square West, Belfast;
or through any Bookseller.

1931

Price 2*s.* 6*d. net.*

70—31—12

FOREWORD.

THIS bulletin has been prepared by Mr. J. Macdonald, Research Officer (Scotland), partly from measurements and notes taken by him and partly from published data referred to in the text.

The five forest gardens which form the subject of this bulletin are Cockle Park, near Morpeth, Northumberland; Cirencester, Gloucestershire; Abbotswood, Forest of Dean, Gloucestershire; Alice Holt, Hampshire, and Ceiriog, Denbighshire. Each garden consists of a series of experimental plots laid out for purposes of study and for the comparison of the rate of growth of the different species of trees. The areas vary in size from 3 acres at Alice Holt, where there are only five plots, to 50 acres at Ceiriog, with more than fifty plots and groups.

The value of demonstration areas of this kind from the point of view of education in forestry has long been recognised, and it was stressed by the Departmental Committee on Forestry which reported in 1902.* At that date only the garden at Cockle Park had been planted and subsequent developments in other areas have been largely due to the recommendations of that Committee.

The Cockle Park area was established in connexion with the Agricultural Experimental Station of the Northumberland County Council. The plots were laid out by Dr. (now Sir) William Somerville, at that time Director of the Station, and planted in 1898 and 1899 for the benefit of the students of Armstrong College, Newcastle-on-Tyne. The garden contains a series of interesting plantations but unfortunately the soil conditions are not uniform, and there are well-marked variations in growth in certain plots.

The garden at Cirencester is much more satisfactory from this point of view as the conditions are as nearly as possible uniform over the area. It was planted in the seasons 1903–4 and 1904–5 under the supervision of Mr. F. C. McLellan, Lecturer in Forestry at the Royal Agricultural College, Cirencester.

The main part of the forest garden at Abbotswood, Forest of Dean, was planted by the Office of Woods between 1904 and 1909, but some plots were added subsequently.

The Alice Holt area, although small, contains one or two instructive plots. It was laid out by Dr. Somerville and Sir William Schlich for the Office of Woods and was planted in 1906.

The experimental area at Ceiriog, the largest of its kind in this country, is the property of the Denbighshire County Council and is

* *Report of the Departmental Committee upon British Forestry* (Cd. 1319), 1902.

managed by the Forestry Department of the University College, Bangor. The plots were established between 1907 and 1909 by Mr. Fraser Story, then of Bangor, and the scheme was continued under his direction until 1919 when Mr. Thomas Thomson took charge of the area.

Two other important forest gardens planted about the same time as the above are those at Bagley Wood, near Oxford, and at Avondale, County Wicklow, Ireland. The garden at Bagley Wood, which belongs to St. John's College, Oxford, was established by Sir William Schlich and planted partly in 1907 and partly in 1909. The Avondale area was planted by Mr. A. C. Forbes for the Irish Department of Agriculture between 1905 and 1907. It extends to about 100 acres, part of which was originally grassland and the remainder old woodland. It is to be hoped that at some future date reports dealing with these forest gardens will be published on similar lines to this bulletin.

In the first chapter the forest gardens of Cockle Park, Cirencester, Abbotswood, Alice Holt and Ceiriog are dealt with, the description of each being divided into two parts, viz., (1) a general description of the locality and of the various factors influencing the growth of the trees, and (2) more detailed data regarding the individual plots. In the remaining chapters the rates of growth of the various species are discussed and related as far as possible to the different locality conditions.

R. L. ROBINSON,

Vice-Chairman.

FORESTRY COMMISSION,
9, Savile Row,
London, W.1.

March, 1931.

BULLETIN No. 12

FOREST GARDENS

CONTENTS.

ILLUSTRATIONS.

FOREST GARDENS.

CHAPTER I.

DESCRIPTION OF THE FOREST GARDENS.

In the different sections of this chapter accounts are given of the various gardens in the order in which they were planted. For Abbotswood, Alice Holt and Ceiriog these descriptions refer to conditions in the summer of 1929, for Cockle Park to the spring of 1928, and for Cirencester to conditions in the summer of 1927. The accounts are accompanied by plans of the various areas and in some cases are illustrated by photographs.

The locality descriptions include notes on topography, climate, exposure, geology and soil, soil vegetation and silvicultural treatment. In the sections on soil vegetation a general account is given of the type met with over the area, and a list of the more important species is included. The local variations are dealt with in the second part under each individual plot. In describing the vegetation, the relative abundance of any species is indicated by the following symbols : (ab.) = abundant, (p.) = patchy, (sc.) = scanty.

At the beginning of each description in Part II, the age, quality class and certain growth data are supplied. These data refer to the most recent measurements. The age given is that at the time of measurement ; it is reckoned from the date of planting and thus does not represent the age of the trees from seed. Notes are then given on the soil and soil vegetation, particular attention being paid to any variations from the general type, and these are followed by a description of the crop. Use has been made of any available records in describing the past history and treatment. Recent thinnings have been defined where possible in terms of the system used by the Research Branch of the Forestry Commission, e.g. B grade, C grade, &c. A full account of these thinning grades is given in Forestry Commission Bulletin No. 10.*

* *Growth and Yield of Conifers in Great Britain*, H.M. Stationery Office, Adastral House, Kingsway, London, price 4*s*. 3*d*. post free.

COCKLE PARK.

PART I.—LOCALITY DESCRIPTION.

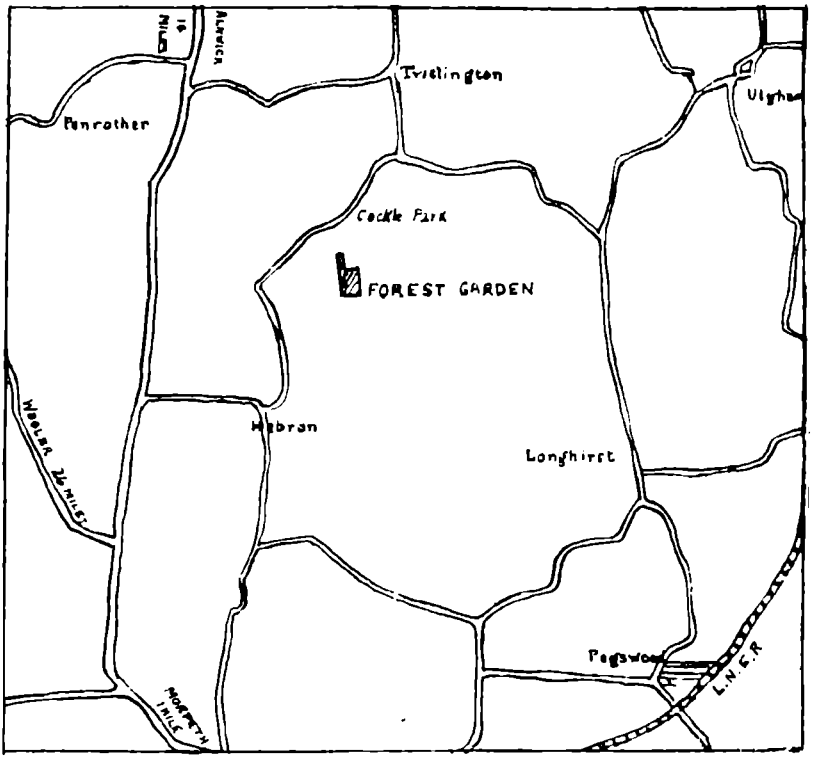
General.—The forest garden consists of ten plots, of which seven, viz., Nos. 2 to 8, are each about half an acre in extent while the others are rather smaller. The garden was laid out and Plots 1—7 planted in the spring of 1898, while the remaining plots were planted in the spring of the following year. On the western side the plots are protected by a shelter belt of Scots pine, and a small arboretum adjoins the garden at the north-east corner. The garden, together with the shelter belt and arboretum, extends to 8½ acres.

The following is a list of the plots with the species represented and the year of planting :—

		Planted.
Plot 1.	Norway spruce (*Picea excelsa*, Link.) and Ash (*Fraxinus excelsior*, Linn.)	1898
,, 2.	—Scots pine (*Pinus sylvestris*, Linn.)	1898
,, 3.	—Douglas fir (*Pseudotsuga Douglasii*, Carr.) ..	1898
,, 4.	—Sitka spruce (*Picea sitchensis*, Trautv. & Mey.)	1898
,, 5.	—Norway spruce (*Picea excelsa*, Link.)	1898
,, 6*a*.	—Beech (*Fagus sylvatica*, Linn.), Scots pine (*Pinus sylvestris*, Linn.) and European larch (*Larix europaea*, D.C.)	1898
,, 6*b*.	—Beech (*Fagus sylvatica*, Linn.) and Oak (*Quercus pedunculata*, Ehrh.)	1898
,, 7.	—European larch (*Larix europaea*, D.C.) and Japanese larch (*Larix leptolepis*, Murr.) ..	1898
,, 8.	—Norway spruce (*Picea excelsa*, Link.) and European larch (*Larix europaea*, D.C.) ..	1899
,, 9*a*.	—Japanese larch (*Larix leptolepis*, Murr.), European larch (*Larix europaea*, D.C.) and Silver fir (*Abies pectinata*, D.C.)	1899
,, 9*b*.	—Japanese larch (*Larix leptolepis*, Murr.) and Douglas fir (*Pseudotsuga Douglasii*, Carr.) ..	1906
,, 10*a*.	—Japanese larch (*Larix leptolepis*, Murr.), European larch (*Larix europaea*, D.C.) and Silver fir (*Abies pectinata*, D.C.)	1899
,, 10*b*.	—Corsican pine (*Pinus Laricio*, Poir.) and Silver fir (*Abies pectinata*, D.C.)	1906

Situation.—The forest garden is situated about a quarter of a mile to the south of Cockle Park Tower which is about 4 miles north of Morpeth (*see* small sketch map below).

Ordnance Survey Sheet—6 in.—Northumberland, 64 N.W.
" " " —1 in.—England, 4.



Topography.—The surrounding country is uniform in character. To the north, west and south-west it is generally level, though broken by eminences and undulations, and in none of these directions is there any land more than 600 feet above sea-level within 10 miles of the forest garden. Three miles to the south the land falls away into the valley of the River Wansbeck, but rises beyond it again. The North Sea is 6 miles distant to the east, and between it and Cockle Park there lies a level plain at a lower elevation. The garden is on the western side of a small valley, at an elevation of just under 300 feet.

Climate.—The climate of the north-eastern seaboard is generally considered to be harsh. The range of temperature in the neighbourhood of Cockle Park is 22°F., the mean temperature in July being 61°F. and in January 39°F.

The mean annual rainfall at Cockle Park is 29 inches. Since 1898 rainfall records have been kept at the Experimental Station and the annual rainfall for each of the years 1898-1929 is shown in the table below. The wettest month of the year is October, with an average rainfall of 3·15 inches, followed closely by August (3·09 inches) and by December (2·96 inches.). The driest months over the period have been April, February and June with average falls of 1·87 inches, 1·88 inches and 2·00 inches, respectively. The wettest year of the series was 1900 with 38·67 inches and the driest, 1905, with a rainfall of 23·29 inches.

Rainfall at Cockle Park.

Year.	Rainfall.	Year.	Rainfall.	Year.	Rainfall.	Year.	Rainfall.
1898	26·58	1906	31·07	1914	30·70	1922	27·77
1899	27·90	1907	28·46	1915	28·94	1923	27·54
1900	38·67	1908	26·10	1916	32·17	1924	33·00
1901	29·76	1909	29·48	1917	29·77	1925	31·62
1902	24·37	1910	26·83	1918	27·01	1926	30·91
1903	35·22	1911	27·38	1919	25·98	1927	32·04
1904	23·89	1912	36·29	1920	28·84	1928	26·74
1905	23·29	1913	26·01	1921	25·44	1929	23·78

A record of frosts on the grass at Cockle Park kept each year since 1894 shows that during the growing season frosts have been of frequent occurrence. The prevailing wind comes from the west and south-west, but east winds are also frequent, especially in the early part of the year.

Exposure.—The forest garden is partly sheltered from the west and south-west by the configuration of the ground and more completely by the shelter belt of Scots pine and by plantations which lie to the west and south-west. To the north and north-east the area is more exposed and the effect of this exposure is evident in Plots 9 and 10. To the east, south-east and south it is sheltered by slightly higher ground and by an older mixed plantation. The effect of the prevailing wind will increase in the western half of the garden as the trees grow out of the shelter of the protecting belt. At present the area may be described as moderately sheltered.

Geology and Soil.—The geological formation is Millstone Grit covered by boulder clay. The boulder clay thins out towards the eastern side of the forest garden and there is a corresponding variation in the soil. Over all the western half the soil is a heavy clay-loam approaching clay, generally yellow in colour near the surface and blue beneath. In the valley bottom along the eastern edge of the garden the soil is a little lighter and in places there is a good depth of loam or sandy loam underlying 8–12 inches of yellow boulder clay.

Soil Vegetation.—At the time of planting the area was covered with a heavy growth of grasses with *Juncus* in the moister places. Some years later gorse made its appearance. The vegetation is now sparse in most of the plots, but a good indication of the type is to be obtained from the adjoining wood, where it may be described as a herb-fern-moss type. The following are the chief species in the type—*Oxalis acetosella* (ab.), *Anemone nemorosa* (p.), *Primula vulgaris* (p.), *Mercurialis perennis* (p.), *Luzula sylvatica* (p.). In moist places—*Ranunculus ficaria* (ab.), *Chrysosplenium oppositifolium* (p.). Ferns—*Pteris aquilina* (ab.), *Lastraea dilatata* (p.) Mosses—*Polytrichum commune* (p.), *Mnium undulatum* (p.), *Plagiothecium undulatum* (p.), *Hypnum cupressiforme* (p.).

Silvicultural Treatment.—The trees in all the plots were planted in triangle form at 3½ ft. by 3½ ft. In Plots 6, 9 and 10 the trees were pitted; in the other plots they were notched.

The plots in the forest garden were measured and thinned in June, 1928, by the Sample Plot staff of the Forestry Commission. It was then necessary to prune the trees in Plots 1, 6A, 6B, 8, 9B and 10B, which up to that time had been untouched. The other plots had been pruned and thinned at an earlier date.

PART II.—DETAILED DESCRIPTION OF THE PLOTS.

Plot 1.—Norway Spruce and Ash.

Age—30 years.

Norway Spruce: Mean height—33½ ft. Quality Class—IV.

There is no soil vegetation. Accumulations of raw humus occur over 12–15 inches clay loam over stiff yellow clay.

When the plot was planted every fourth plant in every fourth row was an ash which thus formed only a small proportion of the crop. They are now falling behind the spruce and very few will survive. The spruce is a dense regular crop, the trees of a good type with straight stems and moderately branching. The crowns are becoming crowded.

The plot was given a light thinning (B grade). In thinning, the crop was treated as a pure spruce crop, and no particular attention was paid to the ash.

Plot 2.—Scots Pine.

Age—30 years. Mean height—30 ft. Mean ¼ girth—3¼ in. Volume per acre—1,310 cu. ft. Quality Class—II.

The following plants are coming in along the eastern edge of the plot—*Lastraea dilatata* (p.), *Primula vulgaris* (sc.), *Viola sylvatica*

(sc.), *Ajuga reptans* (sc.), *Oxalis acetosella* (sc.), *Veronica officinalis* (sc.).

The soil conditions are uniform. There is a layer of well decomposed humus over 18–24 inches heavy clay loam over a stiff impermeable blue clay.

The stocking is dense and regular, except in a small area in the centre of the plot. The height growth was moderately fast at first, but has now fallen off and the crop is almost at a standstill. The form of the trees is very poor, the stems being defective and the crowns almost invariably deformed, while the branching is heavy and the trees coarse in appearance. The trees look unhealthy and many deaths have occurred. Pine beetle (*Myelophilus piniperda*) is present and *Chermes pini* is also abundant on many of the stems. This crop is undoubtedly the worst of the series.

A light thinning (B grade) was carried out. All dead, dying and suppressed trees were removed as well as the worst of the sub-dominants.

Plot 3—Douglas Fir.

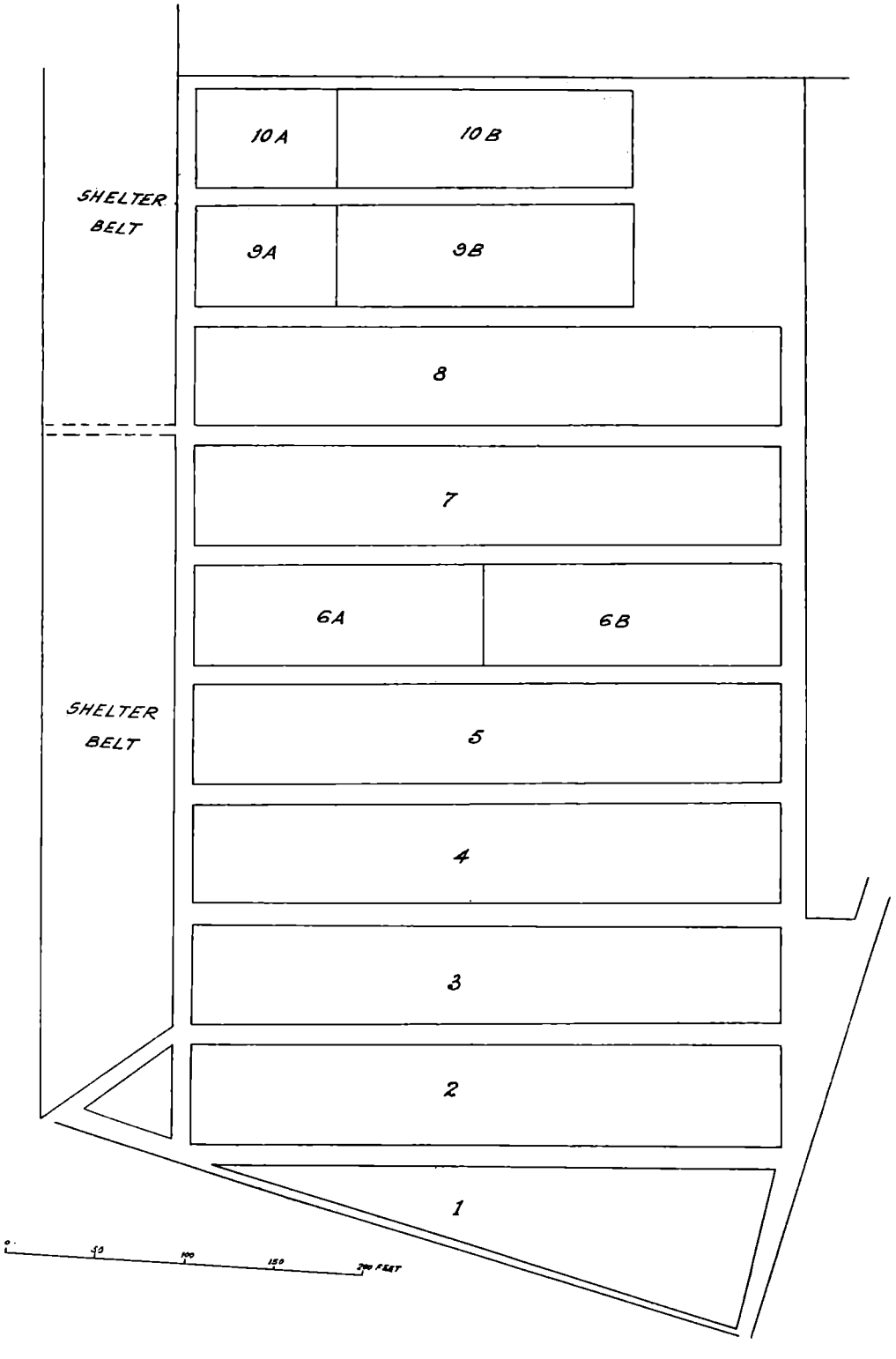
Age—30 years. Mean height—51 ft. Mean $\frac{1}{4}$ girth—5$\frac{1}{4}$ in. Volume per acre—2,040 cu. ft. Quality Class—IV.

There is no vegetation. The soil consists of a yellow clay loam and clay over a hard impermeable blue clay. At the eastern end of the plot the blue clay is at a depth of about 30 inches and the upper layers are lighter. Over the rest of the plot the underlying blue clay comes to within 12 inches of the surface. There is very little humus.

The plot was planted with Oregon Douglas fir and Colorado Douglas fir in alternate lines. Only a few of the latter now remain. The growth of the crop is uneven, due to differences in soil and exposure between the higher ground at the western end of the plot and the lower ground to the east. The height growth falls off markedly from east to west. At the eastern end of the plot the trees are large and with ample crown space. The branches are long but not too heavy. Higher up the slope in a westerly direction the trees are smaller but more uniform in size. The effect of the westerly winds has increased as the Douglas fir have now grown out of the shelter of the protecting belt of Scots pine. This is clearly seen on the trees at the western end of the plot, where the crowns are becoming bare and the shoots have that whipped appearance which is commonly associated with constant exposure. A slight attack of *Chermes cooleyi* was noticed.

This plot, previous to 1928, had already been thinned on at least two occasions. The thinning in 1928 was of the C1, or moderately heavy, grade.

COCKLE PARK.



P3647

Plot 4.—Sitka Spruce.

Age—30 years. Mean height—43 ft. Mean ¼ girth—3¾ in.
Volume per acre—2,500 cu. ft. Quality Class—IV.

There is no soil vegetation. There is a layer of partly decomposed humus 2 inches deep. Over the greater part of the plot the soil is similar to that in Plot 3. At the eastern end the soil consists of 18–24 inches clay loam over a considerable depth of loam of a lighter texture.

The stocking is regular and very dense. The height growth has not been fast and is much poorer in the centre of the plot than at either end. The trees are of a good type, though overcrowding has so drawn them up as to make them whippy. There are few wavy or defective stems. The crowns are small and shut in on all sides. The crop is healthy and appears to be quite free from disease.

The plot was thinned for the first time in 1922, but had become very dense by 1928 when, owing to the whippy and drawn-up condition of the stems, only a moderately heavy thinning could be carried out.

Plot 5.—Norway Spruce.

Age—30 years. Mean height—28 ft. Mean ¼ girth—2¾ in.
Volume per acre—985 cu. ft. Quality Class—IV.

There is no soil vegetation. The soil is similar to that in Plot 3 and the hard blue clay comes to within 12 inches of the surface in the middle of the plot. The middle part of the plot is almost bare of humus, but elsewhere it is 1–2 inches deep and partly decomposed.

The growth has been slow and irregular. It is best at the eastern end of the plot and poorest in the centre where the slow growth is due partly to the more adverse soil conditions and partly to interference by gorse. The gorse has now been killed, but numerous large dead stems still remain. The trees are of a good type with straight stems and ample crowns. Crown competition among the dominants is only now beginning. Part of the plot was thinned in 1922 and a second thinning (C1 grade) was made over the whole plot in 1928.

Plot 6A.—Scots Pine, European Larch and Beech.

Age—30 years.

There is no soil vegetation. The soil consists of 1–2 inches of humus, moderately well decomposed, over clay loam and yellow clay.

The species were planted in the proportions of 3 beech to 1 larch and 1 Scots pine. The conifers, to begin with, grew more rapidly and left the beech behind, but the crowns are large and defective.

The beech, especially in the gaps between the conifers, are now growing fast and are overtaking the Scots pine. The larch are large, with wide crowns and heavy branches. They have suffered to a certain extend from canker and there are several with defective tops. The Scots pine have grown fast, but are extremely coarse, with long heavy branches which are retained down almost to the base of the stems.

There are many excellent trees among the beech. Dead trees only were removed in this plot as a thinning was hardly necessary.

Plot 6B.—Oak and Beech.

Age—30 years. Mean height—36½ ft.

There is no soil vegetation. The soil consists of 1 inch humus over 18–24 inches clay loam over a stiff yellow clay.

Beech and oak were originally planted in alternate lines but the oak were killed out at an early age and the crop is now pure beech. The height growth is good and uniform over the plot. The stems are of good shape and the lower branches are dying off in a satisfactory manner. The crowns are small, but show a marked tendency to spread where they have the opportunity.

The crop had been untouched up to 1928 when the dead and dying trees were removed.

Plot 7.—Japanese Larch and European Larch.

Age—30 years.

Japanese larch: Mean height—40 ft. Mean ¼ girth—4¼ in. Volume per acre—1310 cu. ft. Quality Class—II.

The soil vegetation is patchy. The following species are represented—Meadow grasses (p.), *Viola sylvatica* (p.), *Rubus fruticosus* (p.), *Galium saxatile* (p.), *Veronica officinalis* (p.), *Oxalis acetosella* (p.), *Lastraea dilatata* (p.), *Mnium hornum* (p.), *Dicranum scoparium* (p.), *Polytrichum commune* (p.). The soil conditions vary over the plot. At the eastern end the soil consists of 1 inch well decomposed humus over 12 inches brown clay loam on a lighter loam of similar colour. Elsewhere there is ½–1 inch humus over 18 inches yellowish clay loam over an indefinite depth of yellow clay.

European larch (from Scottish and German seed) and Japanese larch were planted in alternate lines. The crop is now almost pure Japanese larch. The growth falls off gradually from the eastern to the western end of the plot. On the lower ground to the east, growth has been much better than elsewhere. The trees are taller and the stocking is less dense with the result that the stems and crowns are larger.

The best growth in the plot has not exceeded that of Quality Class II. The whole crop seems to be lacking in vigour and the height growth curves show a marked falling off in height growth in the past seven years.

The plot had been thinned on two occasions previous to 1928 when a C1 grade thinning was carried out.

Plot 8.—Norway Spruce and European Larch.

Age—29 years.

Norway spruce: Mean height—28 ft. Mean $\frac{1}{4}$ girth—$2\frac{3}{4}$ in. Volume per acre—980 cu. ft. Quality Class—IV.

European larch: Mean height—42 ft. Mean $\frac{1}{4}$ girth—$5\frac{1}{2}$ in. Volume per acre—620 cu. ft. Quality Class—III.

There is no vegetation. There is a thick layer of raw humus over 9–12 inches of clay loam over stiff yellow clay. The soil is moderately uniform over the area, but the upper layers are rather lighter at the eastern end of the plot.

The plot was formed with Norway spruce and European larch from seed of German origin. The larch formed the same proportion of the mixture as the ash in Plot 1, viz., every fourth tree in every fourth row. Owing to lack of thinning the plot grew out of control as a mixture. At the western end the spruce and larch have grown more or less at the same rate though now the larch, which are small and lacking in vigour, are being overtaken. At the eastern end the larch, which grew more rapidly than the spruce and suppressed them, are large trees with ample crowns but are badly shaped and suffer from canker. The spruce have generally straight stems, but they have a rough appearance due to the numerous branches.

The plot was pruned and thinned for the first time in 1928. The thinning was made with the object of preserving both species in the mixture.

Plot 9A.—Japanese Larch, European Larch and Silver Fir.

Age—29 years.

Japanese larch: Mean height—$33\frac{1}{2}$ ft. Quality Class—below II.

The soil vegetation is scanty. There is a sparse development of meadow grasses, *Viola sylvatica* and *Veronica officinalis*. The soil consists of $\frac{1}{2}$ inch humus, moderately well decomposed, over 12 inches clay loam passing into yellow clay over hard blue clay at a depth of 30 inches.

The Japanese larch were planted in mixture with European larch and silver fir, but it is now almost impossible to determine the original proportions of the species or the arrangement in planting.

As a result of their more rapid height growth in early youth the Japanese larch have suppressed the greater portion of the other species and are now well spaced with generally straight stems and large, heavily-branched crowns. Within recent years there has been a distinct falling off in the rate of height growth of the Japanese larch, and several of the remaining European larch are now growing faster than the Japanese. Only one silver fir survives, the others having succumbed to attacks of *Chermes* (*Dreyfusia*) *nüsslini*.

The plot was thinned for the first time in 1922. In the thinning made in 1928 most of the European larch were taken out. In its present state the plot is more or less comparable with Plots 7 and 9B.

PLOT 9B.—JAPANESE LARCH AND OREGON DOUGLAS FIR.

Age—22 years.

Japanese larch: Mean height—32½ ft. Mean ¼ girth—3 in. Volume per acre—705 cu. ft. Quality Class—II.

There is no soil vegetation. The soil consists of 1 inch well decomposed humus over 12 inches clay loam over yellow clay. The conditions are uniform over the plot.

This plot was planted in 1899 with black Italian poplar. The poplar died out gradually and were replaced in 1906 by the present mixture in which the proportion of the species used was 3 Japanese larch to 1 Douglas fir.

The plot had received no attention up to 1928 when it formed a very dense crop of Japanese larch with a few suppressed Douglas fir. As is usual with this mixture the Japanese larch outgrew and suppressed the Douglas fir at an early age.

The Japanese larch form a very even crop. The height growth is only moderate, but is uniform over the plot. The stems are generally straight (defective stems occurring mainly among the dominated classes) but are small and whippy and the crowns are narrow. At the north-eastern corner, where the plot is more exposed, there are many trees with defective tops. The branching is very light and the crop in this as in other respects contrasts strongly with that in Plot 9A.

A moderately heavy thinning (C1 grade) was carried out in 1928.

PLOT 10A.—JAPANESE LARCH, EUROPEAN LARCH AND SILVER FIR.

Japanese larch: Age—29 years. Quality Class—below II.

The soil vegetation consists of meadow grasses which are coming in along the northern edge, and a sparse growth of *Rosa canina*, *Viola sylvatica* and *Veronica officinalis*. The soil consists of scanty humus over 12–15 inches grey clay loam over yellow clay to an indefinite depth.

The mixture is the same as in Plot 9A, but this plot was treated with 16 cwt. per acre of basic slag before planting. There are, however, no records as to the effect of this treatment on the initial growth of the trees.

The crop has grown at about the same rate as that in Plot 9A, except that there are more trees with deformed stems and defective tops.

The plot is now of little value except as a protection to the others.

PLOT 10B.—CORSICAN PINE AND SILVER FIR.

Age—22 years. Mean height—22 ft.

This plot lies to the east of Plot 10A and is similar in respect of soil and exposure.

It was originally planted with black Italian poplar and silver fir, but the former failed and were replaced in 1906 by Corsican pine. Many of the silver fir have disappeared, but those which remain seem to be quite healthy. The Corsican pine have not yet formed a canopy and the growth has been irregular. The stems are straight, with symmetrical crowns which are in marked contrast to the larch in Plot 10A.

SHELTER BELT.

The plots on the western side are protected by a shelter belt of Scots pine, 20 yards in width, which had not been touched up to 1928 when the dead, dying and suppressed trees were removed.

CIRENCESTER.

PART I.—LOCALITY DESCRIPTION.

General.—This garden consists of ten plots each extending to about half an acre and separated from each other by grass rides 12 feet wide. It is surrounded on three sides by screen belts of mixed beech, larch and Scots pine which were planted in order to hide the plots from view, as the formal arrangement was considered to be unsightly. The total area of the plantations is 10½ acres, 5 acres being laid down in plots.

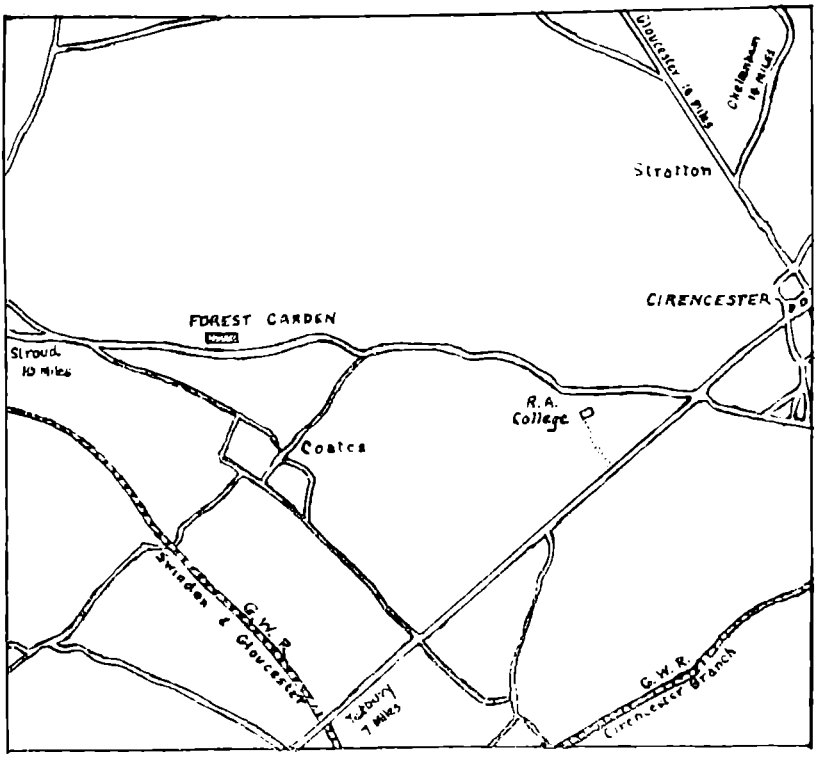
The species which have been used are given in the following list, together with the year of planting in each case.

	Planted.
Plot 1A—Norway maple (*Acer platanoides*, Linn.) and Beech (*Fagus sylvatica*, Linn.)	1904
,, 1B—Sycamore (*Acer Pseudoplatanus*, Linn.) and Beech (*Fagus sylvatica*, Linn.)	1904
,, 2A—Corsican pine (*Pinus Laricio*, Poir.) and European larch (*Larix europaea*, D.C.)	1904

		Planted.
Plot	2B—Scots pine (*Pinus sylvestris*, Linn.) and European larch (*Larix europaea*, D.C.)	1904
,,	2C—Corsican pine (*Pinus Laricio*, Poir.), Scots pine (*Pinus sylvestris*, Linn.) and Norway spruce (*Picea excelsa*, Link.)	1904
,,	2D—Scots pine (*Pinus sylvestris*, Linn.) and Norway spruce (*Picea excelsa*, Link.)	1904
,,	3A—Sitka spruce (*Picea sitchensis*, Trautv. & Mey.)	1904
,,	3B—Norway spruce (*Picea excelsa*, Link.)	1904
,,	4A—Japanese larch (*Larix leptolepis*, Murr.) ..	1904
,,	4B—European larch (*Larix europaea*, D.C.) ..	1904
,,	5A—Corsican pine (*Pinus Laricio*, Poir.)	1904
,,	5B—Scots pine (*Pinus sylvestris*, Linn.)	1904
,,	6A—Black walnut (*Juglans nigra*, Linn.)	1905
,,	6B—*Fraxinus americana*, Linn., *F. viridis*, *F. oregona*, Nutt. and Beech (*Fagus sylvatica*, Linn.)	1905
,,	6C—*Robinia Pseudacacia*, Linn.	1905
,,	6D—Sweet chestnut (*Castanea sativa*, Mill.), *Betula lutea*, Michx. and *Prunus serotina*, Ehrh. ..	1905
,,	6E—*Ulmus americana*, Linn. and *U. racemosa*, D. Thomas	1905
,,	6F—Grey alder (*Alnus incana*, Moench.)	1905
,,	7—Pedunculate oak (*Quercus pedunculata*, Ehrh.) and Sessile oak (*Quercus sessiliflora*, Salisb.)	1905
,,	8A—Nootka Sound cypress (*Cupressus nootkatensis*, Don.)	1906
,,	8B—Lawson's cypress (*Chamaecyparis Lawsoniana*, Parl.)	1906
,,	8C—Western red cedar (*Thuya plicata*, D. Don.) ..	1906
,,	9A—*Abies Nordmanniana*, Spach., under European larch and Japanese larch	1905
,,	9B—*Abies concolor*, Lindl. & Gord., under *Betula alba*, Linn.	1905
	Abies concolor, Lindl. & Gord., under *Betula papyrifera*, Marsh.	1905
,,	9C—*Abies Nordmanniana*, Spach., under *Robinia Pseudacacia*, Linn.	1905
,,	10A—Norway spruce (*Picea excelsa*, Link.) and Beech (*Fagus sylvatica*, Linn.)	1905
,,	10B—Scots pine (*Pinus sylvestris*, Linn.) and Beech (*Fagus sylvatica*, Linn.)	1905
,,	10C—Hornbeam (*Carpinus Betulus*, Linn.) and Lime (*Tilia grandifolia*, Ehrh.)	1905
,,	10D—Hornbeam (*Carpinus Betulus*, Linn.) and Lime (*Tilia cordata*, Mill.)	1905

Situation.—The forest garden is situated at Rough Hills in Earl Bathurst's Park, close to the main road from Cirencester to Stroud, three miles west of Cirencester. (*See* small sketch map below).

Ordnance Survey Sheet—6 in.—Gloucester, 51 S.W.
" " " —1 in.—England, 105.



Topography.—The surrounding country is undulating in character with a range of elevation of 400 to 600 feet, the forest garden being at an elevation of 470 feet. Farther to the west and south-west the ground rises to over 600 feet and to the north-west and north in the Cotswold Hills to over 900 feet. The garden occupies a piece of land sloping gently to the south.

Climate.—The mean annual temperature is 47° F. and low temperatures are not uncommon in the winter months. The annual rainfall is moderate, the average amounting to 38 inches. The prevailing wind is south-westerly.

Exposure.—The garden is fully sheltered to the south and west by rows and clumps of tall hardwoods. To the north and east it is scarcely so well protected, but is still well sheltered.

Geology and Soil.—The geological formation is the Limestone of the Great Oolite.

The soil is a loam, tending towards clay loam in places, with numerous rock-fragments. The underlying rock comes near the surface and the soil varies in depth from 5 to 10 inches.

Soil Vegetation.—The vegetation is of a grass-herb-moss type. The rides are covered with grasses—*Holcus mollis* (ab.), *Dactylis glomerata* (p.), *Poa* spp. (sc.), *Bromus erectus* (sc.). The herb flora is only moderately rich—*Plantago* sp., *Scabiosa* sp., *Senecio* sp., *Fragaria vesca*, *Trifolium* spp. *Prunella vulgaris*. The mosses are moderately luxuriant—*Brachythecium purum* (ab.), *Hylocomium squarrosum* (p.), *Hylocomium splendens* (p.).

Silvicultural Treatment.—Before planting, the ground was ploughed. The plants were set out in triangle form and pitted in Plots 1, 2, 4, 6, 8, and 10; in squares in Plots 3, 5, and 7 and in lines in Plot 9.

In most of the plots the planting distance was 4 ft. by 4 ft., but $3\frac{1}{2}$ ft. by $3\frac{1}{2}$ ft. was the spacing adopted in Plots 1 and 5 and in one section of Plot 7, while planting distances of 2 ft. 3 in. and 2 ft. 6 in. were employed in the other sections of Plot 7.

The preliminary treatment of Plot 8 differed from that of the other plots in that a cleaning crop of turnips was taken off before the area was planted.

Various manuring experiments were carried out just after planting in Plots 1, 3, 4 and 7, the manures used being chiefly superphosphates, kainit and nitrate of soda. The different treatments, however, have not yielded any definite results.

In May, 1919, measurements were taken in the European larch, Japanese larch, Scots pine and Corsican pine plots and a complete study of the garden was carried out in September, 1927.

PART II.—DETAILED DESCRIPTION OF THE PLOTS.

Plot 1A.—Norway Maple and Beech.

Age—24 years.

Beech: Mean height—25 ft. Mean $\frac{1}{4}$ girth—$1\frac{3}{4}$ in.

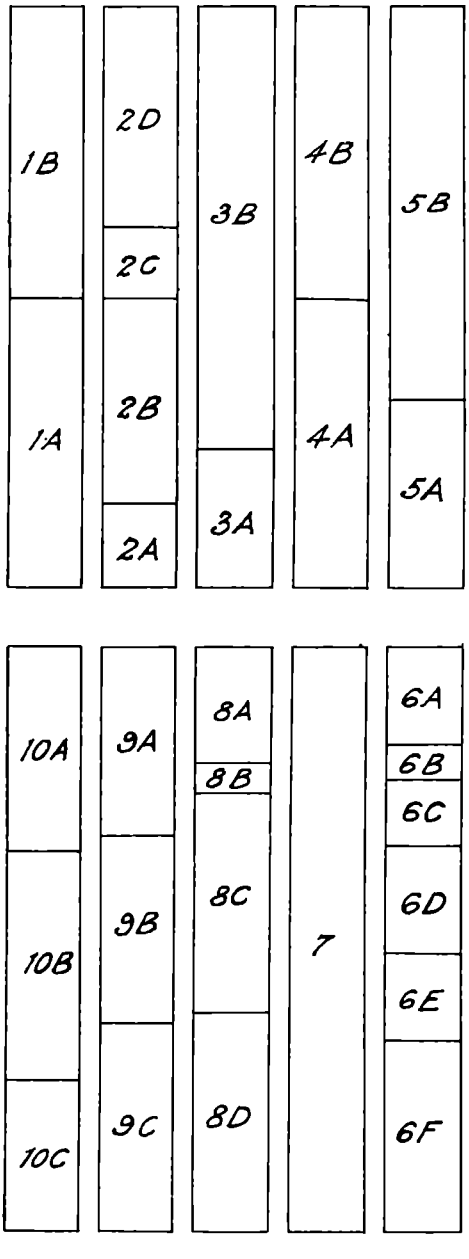
Maple: Mean height—30 ft. Mean $\frac{1}{4}$ girth—2 in.

There is no soil vegetation. The soil consists of 6 inches of moderately stony loam resting on broken oolite.

The Norway maple have outgrown the beech and are dominant over the area. A large number of the trees have crooked and forked stems, but there are many excellent poles in the crop.

The beech have grown very slowly, but the records show that the plants were damaged in transit to the area and were also injured by late spring frosts in the second year after planting.

— CIRENCESTER —



P3607

Plot 1B.—Sycamore and Beech.

Age—24 years.

Beech: Mean height—25 ft. Mean ¼ girth—1¾ in.

Sycamore: Mean height—21 ft. Mean ¼ girth—1 in.

There is no soil vegetation. The humus layer is thicker than in Plot 1A and composed principally of beech leaves, but the soil is in other respects similar.

In comparison with the beech, the sycamore have grown poorly, and it is now too late to save any but exceptional trees of this species as the beech have become dominant. The beech are of moderately good quality and a selection of good stems should be possible at a later date.

This plot forms an interesting contrast to Plot 1A where the beech were dominated by the Norway maple.

Plot 2A.—Corsican Pine and European Larch.

Age—24 years. Mean height—34 ft.

There is a sparse grass-herb-moss vegetation with an occasional plant of *Epipactis latifolia*. The humus layer is moderately decomposed and the soil is similar to that in Plot 1.

The species were planted in alternate lines. The Corsican pine have failed, leaving the larch dominant and almost pure. The larch have suffered severely from canker but are now recovering. A thinning (C1 grade) was carried out in 1927 with the object of favouring the larch. Most of the trees removed were pine.

Plot 2B.—Scots Pine and European Larch.

Age—24 years.

Scots pine: Mean height—32½ ft. Mean ¼ girth—3¼ in. Volume per acre—222 cu. ft. Quality Class—I.

European larch: Mean height—35½ ft. Mean ¼ girth—3¾ in. Volume per acre—734 cu. ft. Quality Class—II.

Some *Rubus fruticosus* is appearing, but otherwise the vegetation and soil are as in Plot 2A.

The species were planted in alternate lines and the Scots pine have been suppressed over most of the area. The larch are now dominant. Like the larch in Plot 2A they have suffered from canker, but are now recovering. A thinning (C1 grade) was carried out in 1927 when the pine and numerous defective larch were removed.

PLOT 2C.—NORWAY SPRUCE, SCOTS PINE AND CORSICAN PINE.

Age—24 years. Mean height—24 ft.

There is no herbage, but a few mosses are coming in. The humus is up to 2 inches thick and moderately decomposed.

The plot was originally a mixture of Corsican pine and Norway spruce, but there were numerous failures in the Corsican pine and these were beaten up with Scots pine in the third season after planting. The spruce are dominant and form an almost pure crop, but such Corsican pine as remain are generally in the upper canopy. The spruce crowns are healthy and well developed and the branching is light.

PLOT 2D.—SCOTS PINE AND NORWAY SPRUCE.

Age—24 years.

Scots pine: Mean height—32 ft. Mean $\frac{1}{4}$ girth—$3\frac{1}{2}$ in. Volume per acre—795 cu. ft. Quality Class—I.

Norway spruce: Mean height—28 ft. Mean $\frac{1}{4}$ girth—$2\frac{3}{4}$ in. Volume per acre—392 cu. ft. Quality Class—III.

There is no soil vegetation with the exception of a few mosses. The humus is up to 2 inches in thickness and moderately decomposed.

The pine are dominant over the area, but among them are many defective stems and crowns, a result of attacks by the pine shoot moth (*Tortrix buoliana*). There are more spruce at the western end of the plot than elsewhere. They are of quite a good type with light branching and where the trees are in the upper canopy they have well shaped crowns. A thinning (C1 grade) was carried out in 1927. In this thinning it was chiefly the Scots pine which were removed, but it was then too late to secure an even mixture.

PLOT 3A.—SITKA SPRUCE.

Age—24 years. Mean height—$19\frac{1}{2}$ ft. Quality Class—below IV.

There is no herbage except patches of invading mosses, principally *Brachythecium purum*. The humus is a thin layer less than 1 inch thick and moderately decomposed. The soil consists of 7 inches brown loam tending to clay loam, with small oolitic fragments, on broken oolite.

During the first ten years of its existence the crop developed slowly and irregularly. The height growth at the present time is still uneven, but on the whole it is vigorous, dominant trees putting on 2 feet per annum. The canopy is not yet everywhere complete and the lower branches are just beginning to die.

PLOT 3B.—NORWAY SPRUCE.

Age—24 years. Mean height—20 ft. Mean ¼ girth—2 in. Quality Class—IV.

The vegetation consists of mosses with an occasional plant of *Epipactis latifolia*. The following mosses occur—*Thuidium tamariscinum, Eurynchium* spp., *Brachythecium purum* and *Hylocomium splendens*.

The humus is shallow and moderately well decomposed. The soil is as in Plot 3A.

The crop is irregular in height and the growth falls off in the middle of the plot. Growth was slow in early life and although now more vigorous is less so than that of the Sitka spruce in Plot 3A. No thinning is required at present as the canopy has not yet closed

PLOT 4A.—JAPANESE LARCH.

Age—24 years. Mean height—32½ ft. Mean ¼ girth—3½ in. Volume per acre—1,186 cu. ft. Quality Class—II.

There is a grass-moss herbage, consisting of scanty *Holcus mollis* and the following mosses which are fairly abundant—*Brachythecium purum, Hylocomium squarrosum, Hylocomium triquetrum*.

The humus is moderately deep, but is dry and not well decomposed. This plot was planted in two sections, that at the western end being one year younger. The general development of the trees has been poor, particularly in the section first planted. The crowns of many trees are already flat and moribund and the stems are not quite straight. The rate of growth began to fall off seriously about the fifteenth year. There has been no damage by larch canker.

PLOT 4B.—EUROPEAN LARCH.

Age—24 years. Mean height—34 ft. Mean ¼ girth—3¼ in. Volume per acre—1367 cu. ft. Quality Class—III.

The herbage is of the same type as in Plot 4A, but is much more luxuriant and *Rubus fruticosus* is dominant in places. The humus is moderately deep and well decomposed and is derived principally from the ground vegetation. The soil is as in Plot 4A.

Larch canker has been severe and has killed many trees. As the crop is rather open, a light thinning (B grade) was considered sufficient in 1927.

PLOT 5A.—CORSICAN PINE.

Age—24 years. Mean height—31 ft. Mean ¼ girth—4 in. Volume per acre—1,290 cu. ft. Quality Class—I.

The vegetation is of the usual grass-moss type with a few herbs and some *Rubus fruticosus*. The humus is moderately deep, up to

2 inches, and fairly well decomposed, but accumulations of raw humus occur round the butts of the trees. The soil is as in Plot 4.

Some difficulty was experienced in establishing this plot. It was planted in November, 1903, and in the first season after planting 80 per cent. of the plants died. The blanks were filled up in April 1905 with smaller plants, but again 50 per cent. died out. In September, 1906, it was again beaten up with plants 12–18 inches high, each plant being treated with basic slag. This treatment proved successful.

This crop is patchy and irregular. The trees vary considerably in size, but generally have straight stems and well formed crowns.

A moderately heavy thinning (C1 grade) was carried out in 1927.

Plot 5B.—Scots Pine.

Age—24 years. Mean height—32 ft. Mean $\frac{1}{4}$ girth—$3\frac{1}{2}$ in. Volume per acre—1,010 cu. ft. Quality Class—I.

The vegetation is similar to that in Plot 5A, but *Rubus* is rather more abundant. Humus and soil conditions are also similar.

The stocking is fairly complete, but the crop is unhealthy and numerous deaths are taking place. The stems are straight with moderately heavy branches, but many of the tops are deformed. This is due probably to attacks by *Tortrix buoliana* which were noted in 1905 and 1906 and again in 1919.

A thinning (B grade) was carried out in 1927, but the plot appears to have been thinned at least once previous to that date.

Plot 6A.—Black Walnut.

The soil in Plots 6A-6F consists of 12 inches brown loam tending to clay loam with oolitic fragments on broken oolite. Plot 6A has been a failure and out of the 223 trees planted very few remain. The failure appears to be due principally to frost, though rabbit damage may have been a contributory cause.

Plot 6B.—American Ash (*Fraxinus americana*, *F. viridis* and *F. oregona*) and Beech.

The various species of ash have been outgrown by the beech, which are healthy and vigorous. *F. viridis* have been suppressed and killed; *F. oregona* have been almost completely suppressed, but *F. americana* have retained a place in the upper canopy. The stems of the last-named are very much misshapen.

Plot 6C.—*Robinia Pseudacacia*.

The stems are of poor quality, but the height growth has been satisfactory. The crop is rather open and there is a dense growth of weeds.

PLOT 6D.

This section consists of sweet chestnut mixed with American yellow birch (*Betula lutea*) and *Prunus serotina*.

The chestnut has been almost a complete failure, the remaining stems being very poor. The *Prunus serotina* are branchy and badly shaped trees but they appear to be healthy. The *Betula lutea* have all disappeared.

PLOT 6E.—*ULMUS AMERICANA* AND *ULMUS RACEMOSA*.

Age—23 years. Mean height—31½ ft.

The stocking is complete and the trees have moderately straight stems and good crowns.

PLOT 6F.—GREY ALDER.

Age—23 years. Mean height—36½ ft.

This is a vigorous and successful plantation. The stocking is dense, but the stems are straight and the crowns satisfactory. There is an abundant development of suckers.

PLOT 7—OAK (SESSILE AND PEDUNCULATE).

Age—23 years.

The soil is similar to that in Plot 6 but is only 10 inches in depth. This plot was laid out in four sections, three of these being planted with sessile oak and the fourth with pedunculate oak. The sessile oak have made a poor growth and failures have been numerous. The growth of the pedunculate oak, on the other hand, has been excellent and the trees are of a good type. The mean height of the pedunculate oak is 26 ft.

PLOT 8A.—NOOTKA SOUND CYPRESS.

Age—22 years. Mean height—6 ft.

The trees are healthy but have grown slowly and there are considerable variations in growth in the plot.

PLOT 8B.—LAWSON'S CYPRESS.

Age—22 years.

This section was planted with two different lots of plants, those in the eastern half having come from a German source and those in the western half from France. The two lots differ

considerably in habit and foliage. The trees are of the usual type and show the characteristic forking near ground level. A canopy is commencing to form.

The mean height of the German plants is 15 ft.
The mean height of the French plants is 19 ft.

Plot 8c.—*Thuya Plicata.*

Age—22 years. Mean height—13½ ft.

This crop is healthy, but has developed slowly and irregularly and the canopy is not yet complete. There are several forked stems.

Plot 9a.—*Abies Nordmanniana* under European and Japanese Larches.

Silver fir: Age—19 years. Mean height—8 ft.

The larches (equal numbers of the two species) were planted in the autumn of 1904 and the silver fir introduced in 1908. The larches have made satisfactory growth and form a dense canopy over the silver fir, which though heavily shaded are quite healthy.

Plot 9b.—*Abies Concolor* under *Betula Alba* and *Betula Papyrifera.*

Silver fir: Age—21 years.

This area was set out in two sections in one of which the common birch were used as a nurse and in the other the paper birch. The nurses were planted in the autumn of 1904 and the silver firs introduced in 1906.

In section (a) the common birch (*B. alba*) appear to have been cut back once already, but stray coppice shoots are again threatening and whipping the *Abies*, the mean height of which is 8 ft.

In section (b) the paper birch (*B. papyrifera*) have not coppiced so vigorously and the silver fir have grown correspondingly better, the latter having now a mean height of 12 ft.

Plot 9c.—*Abies Nordmanniana* under *Robinia Pseudacacia.*

Silver fir: Age—21 years. Mean height—12 ft.

This section was planted at the same time as 9b.

Many of the *Robinia* have now been removed and the remainder are injuring the silver firs. The latter are healthy, vigorous trees.

PLOT 10A.—NORWAY SPRUCE AND BEECH.

Norway spruce: Age—23 years. Mean height—27 ft. Mean $\frac{1}{4}$ girth—$3\frac{1}{4}$ in. Volume per acre—723 cu. ft. Quality Class—III.

There is no soil vegetation except patches of mosses, mainly *Brachythecium purum*. The humus is a thin, well decomposed layer, less than 1 inch thick.

The species were planted in alternate lines. The spruce are now almost everywhere dominant with straight, lightly-branched stems and well-formed crowns. A heavy thinning (C2 grade) was marked among the spruce in 1927 in order to relieve the beech which were being overtopped.

PLOT 10B.—SCOTS PINE AND BEECH.

Scots Pine: Age—23 years. Mean height,—31 ft. Mean $\frac{1}{4}$ girth—$3\frac{3}{4}$ ins. Volume per acre—751 cu. ft. Quality Class—I.

There is no surface herbage. The humus is moderately deep and well decomposed.

The Scots pine are vigorous but coarse trees and many of the stems are crooked, the result probably of attack by *Tortrix buoliana*. The beech are not so badly suppressed as in Plot 10A but are generally in the lower canopy. In order to encourage the beech a heavy thinning (C2 grade) was marked among the pine in 1927.

PLOT 10C.—HORNBEAM AND LONG-LEAVED LIME,

AND

PLOT 10D.—HORNBEAM AND SMALL-LEAVED LIME.

Age—23 years.

These sections are mixtures of lime and hornbeam in alternate rows. The lime are dominant in each section and have made satisfactory growth. The hornbeam are partially suppressed.

LITERATURE.

1. ROYAL AGRICULTURAL COLLEGE, CIRENCESTER. *Students' Guide to Forest Garden, Oakley Park Woods, etc.*, 1907.

2. LE SUEUR, A. D. C. "Rough Hills Experimental Plots, Royal Agricultural College, Cirencester"; *Quarterly Journal of Forestry, R.E.A.S.*, Vol. 23, 1929.

ABBOTSWOOD.

PART I.—LOCALITY DESCRIPTION.

General.—The forest garden in Abbotswood, Forest of Dean, consists of four different series of experimental plantations established between 1904 and 1919. The most important is No. 1 which comprises 21 plots planted between 1904 and 1909 to illustrate the growth of various tree species both in pure crop and in mixture. The other series are younger. The second series planted between 1915 and 1918 is devoted mainly to European and Japanese larches, special attention having been paid to comparative tests of plants from seed of different origins. The third series consists of 9 plots, established to study the development of Sitka spruce in pure plantations and in various mixtures. The fourth series includes a number of small plots formed in 1915–16 with plants raised from seed collected in Western China by E. H. Wilson's expedition in 1910. The total area of the four series is about 43 acres.

The following is a list of the several series and plots with the species represented and the dates of planting.

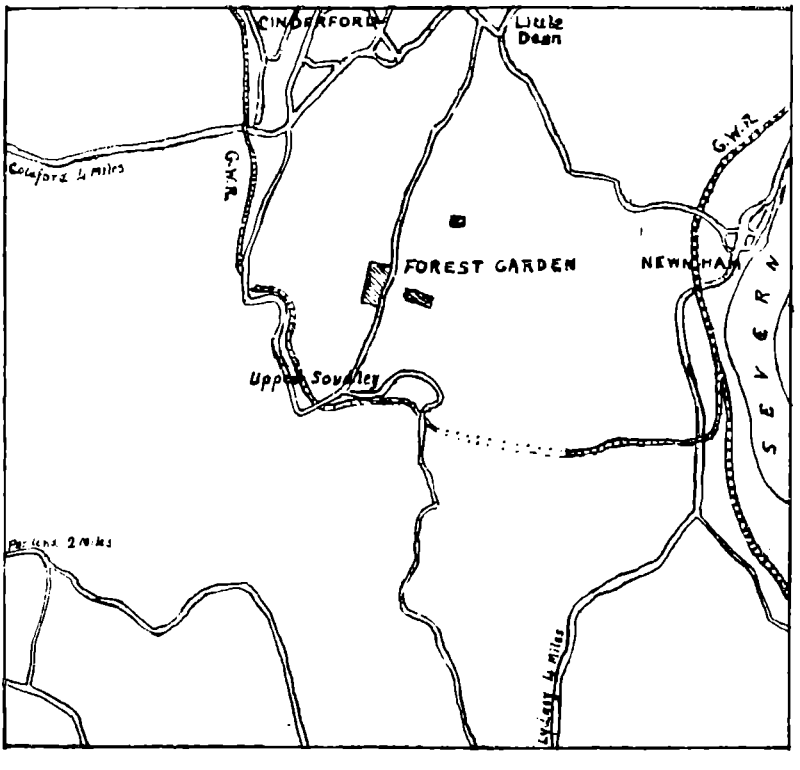
SERIES 1.	*Planted.*
Plot 1.—Norway spruce (*Picea excelsa*, Link.)	1905
,, 2.—Colorado Douglas fir (*Pseudotsuga glauca* Mayr.)	1905
,, 3.—Oregon Douglas fir (*Pseudotsuga Douglasii*, Carr.)	1905
,, 4.—Scots pine (*Pinus sylvestris*, Linn.)	1905
,, 5.—Norway spruce (*Picea excelsa*, Link.)	1905
,, 6.—Sweet chestnut (*Castanea sativa*, Mill.).. ..	1905
,, 7.—Pedunculate oak (*Quercus pedunculata*, Ehrh.)	1905
,, 8.—Norway spruce (*Picea excelsa*, Link.)	1905
,, 9.—European larch (*Larix europaea*, D.C.) and Norway spruce (*Picea excelsa*, Link.) ..	1906
,, 10.—European larch (*Larix europaea*, D.C.) and Douglas fir (*Pseudotsuga Douglasii*, Carr.) ..	1906
,, 11.—Scots pine (*Pinus sylvestris*, Linn.) and Douglas fir (*Pseudotsuga Douglasii*, Carr.) ..	1906
,, 12.—Lawson's cypress (*Chamaecyparis Lawsoniana*, Parl.)	1906
,, 13.—Scots pine (*Pinus sylvestris*, Linn.) and Norway spruce (*Picea excelsa*, Link.)	1906
,, 14.—Norway spruce (*Picea excelsa*, Link.) and Colorado Douglas fir (*Pseudotsuga glauca*, Mayr.)	1906
,, 15.—Lawson's cypress (*Chamaecyparis Lawsoniana*, Parl.) and Scots pine (*Pinus sylvestris*, Linn.)	1908

SERIES 1—*continued.*	*Planted.*
Plots 16–17.—Scots pine (*Pinus sylvestris*, Linn.) ..	1908
Plot 18.—Oregon Douglas fir (*Pseudotsuga Douglasii*, Carr.)	1908
,, 19.—*Robinia Pseudacacia*, Linn.	1909
,, 20.—Colorado Douglas fir (*Pseudotsuga glauca*, Mayr.)	1909
,, 65.—Corsican pine (*Pinus Laricio*, Poir.)	1906
SERIES 2.	
Plot 21.—European larch (*Larix europaea*, D.C.) and Beech (*Fagus sylvatica*, Linn.)	1916
Plots 22–35.—European larch (*Larix europaea*, D.C.) ..	1916
,, 36–41.—Japanese larch (*Larix leptolepis*, Murr.) ..	1916
Plot 42.—Deodar (*Cedrus deodara*, Loud.)	1916
Plots 44–49.—European larch (*Larix europaea*, D.C.) in mixture with Beech (*Fagus sylvatica*, Linn.) and Chestnut (*Castanea sativa*, Mill.) ..	1917
,, 50 and 52.—Hybrid larch (*Larix eurolepis*, A. Henry)	1918
SERIES 3.	
Plot 53.—Sitka spruce (*Picea sitchensis*, Trautv. & Mey.)	1919
Plots 54–55.—Sitka spruce (*Picea sitchensis*, Trautv. & Mey.) and Douglas fir (*Pseudotsuga Douglasii*, Carr.)	1918
Plot 56.—Sitka spruce (*Picea sitchensis*, Trautv. & Mey.)	1918
Plots 57–58.—Sitka spruce (*Picea sitchensis*, Trautv. & Mey.) and Beech (*Fagus sylvatica*, Linn.) ..	1918
Plots 59–60.—Sitka spruce (*Picea sitchensis*, Trautv. & Mey.) and Western Red Cedar (*Thuya plicata*, D. Don.)	1918
Plot 61.—Sitka spruce (*Picea sitchensis*, Trautv. & Mey.)	1918
SERIES 4.	
Plot 101.—*Picea asperata*, Mast.	1916
,, 102.—*Picea retroflexa*, Mast.	1916
,, 103.—*Picea montigena*, Mast.	1916
,, 104.—*Picea asperata*, var. *ponderosa*, Rehd & Wils.	1916
,, 105.—*Picea asperata*, Mast.	1916
,, 106.—*Picea asperata*, Mast.	1916
,, 107.—*Picea purpurea*, Mast.	1916
,, 108.—*Picea asperata*, Mast.	1916
,, 109.—*Picea heterolepis*, Rehd. & Wils.	1916
,, 110.—*Picea ascendens*, Patschke	1916
,, 111.—*Picea asperata*, Mast.	1916
,, 112.—*Picea Sargentiana*, Rehd. & Wils.	1916
,, 113.—*Picea purpurea*, Mast.	1916

SERIES 4—*continued.*	*Planted.*
Plot 114.—*Abies recurvata*, Mast.	1916
,, 115.—*Abies Faxoniana*, Rehd. & Wils.	1916
,, 116.—*Abies recurvata*, Mast.	1916
,, 117.—*Abies Faberi*, Craib = *A. Delavayi*, Franchet	1916
,, 118.—*Abies Faxoniana*, Rehd. & Wils.	1916
,, 119.—*Abies squamata*, Mast.	1916
,, 120.—*Abies Faxoniana*, Rehd. & Wils.	1916
,, 121.—*Pinus sinensis*, Lamb.	1916
,, 122.—*Pinus sinensis*, Lamb	1916
,, 123.—*Fraxinus platypoda*, Oliver	1916
,, 124.—*Betula utilis* var. *Prattii*, Burkill	1916
,, 125.—*Betula japonica* var. *mandshurica*, Wintel ..	1916

Situation.—Abbotswood is situated near the eastern boundary of the Forest of Dean, 3½ miles in a direct line to the north-east of Parkend. By road it is 3 miles south of Cinderford and 4 miles to the north of Blakeney on the Gloucester–Chepstow road. The nearest railway station is Upper Soudley on the Newnham–Cinderford branch of the Great Western Railway. This station is half a mile to the south. (*See* small sketch map below).

Ordnance Survey Sheet —6 in.—Gloucestershire, 39 N.E.
,, ,, ,, —1 in. England, 103.



Series 1 and 2 are contiguous, but Series 3 and 4 lie a quarter of a mile to the east and half a mile to the north-east respectively.

Topography.—The forest garden is situated on the slopes of a valley which runs in a north and south direction from Sutton to Upper Soudley. The valley bottom which is occupied by a number of ponds connected by a stream lies at an altitude of about 250 feet. On either side, to the east and to the west, the ground rises to over 650 feet. To the west, the slope is moderate, but on the eastern side it is steep and uniform. The main part of the forest garden lies on the western slope, with an easterly to south-easterly aspect. The plots in Series 1 occupy a gently sloping piece of ground lying at an elevation of about 350 feet. Those in Series 2 extend almost to the summit of the slope on the western side of the valley and cover a range of elevation of 400 to 625 feet. The plots in Series 3 and 4 are situated on the opposite side of the valley and have a westerly aspect.

The plots of Sitka spruce in Series 3 extend from near the valley bottom at 300 feet to an elevation of 525 feet on the hillside. The plots of Chinese exotics in Series 4 lie between 500 and 640 feet above sea level.

Climate.—The climate generally is mild, the mean annual temperature being in the neighbourhood of 50° F. The prevailing wind is south-westerly.

The winters are generally open and the spells of severe weather which occur do not as a rule last long. Late frosts occur frequently in spring and early summer and do some damage to forest growth. The average annual rainfall over the Forest of Dean is 36 inches.

Exposure.—The plots in Series 1 are fairly uniform in respect of shelter. They are sheltered on all sides except to the north-east and the south-east where they are subject to valley winds. Gales from the south-east have already caused some damage in Plots 9, 10 and 65. The plots in Series 2 are in this respect more varied and the exposure ranges from the fully sheltered plots of Japanese larch and deodar on the lower ground to the more severely exposed plots of European larch on the higher part of the slope. The plots of Sitka spruce on the other side of the valley are slightly exposed to the south-west and the effect of the exposure will increase as the trees grow taller. The plots of Chinese exotics occupy a situation which is more exposed as they lie open to the north-west and south-west. At present the young plantations are fully sheltered by the surrounding growth, but as they grow older they will become increasingly subject to exposure.

Geology and Soil.—The geological formation is the Old Red Sandstone.

The soil conditions in the plots of Series 1 are fairly uniform. The soil consists of a brownish loam, tending to clay loam in places, varying in depth from 2 to 3 feet. It contains few stones or rock

fragments. A number of boulders mostly of conglomerate are scattered over this area. In the area occupied by the plots of Series 2 the soil conditions are variable. Generally the soil increases in depth from the top to the bottom of the slope. In the European larch plots (21–30) which occupy the highest ground, the rock comes close to the surface and the soil is in places no deeper than 6 inches. There are, in addition, many large boulders with soil occurring in pockets amongst them. On going downhill, one finds that the soil increases in depth until it approximates to that in the area first described.

The soil in the plots of Series 3 and 4 is similar but rather shallower, being generally less than 2 feet deep.

Soil vegetation.—The soil vegetation is abundant. Over most of the open spaces it consists of *Rubus fruticosus* (ab.), *Pteris aquilina* (ab.). Grasses—*Holcus, Aira flexuosa, Agrostis, Cynosurus, Poa* (p.), *Digitalis* (p.), *Veronica* spp. (p.), *Teucrium Scorodonia* (p.), and other herbs. Mosses (p.)—*Hyclocomium* spp., *Dicranum scoparium, Hypnum* spp., *Plagiothecium undulatum.*

Silvicultural Treatment.—Very complete records have been kept of the work carried out in this forest garden, and in the following pages a brief account of the various cultural operations will be found.

PART II.—DETAILED DESCRIPTION OF THE PLOTS.

SERIES 1.

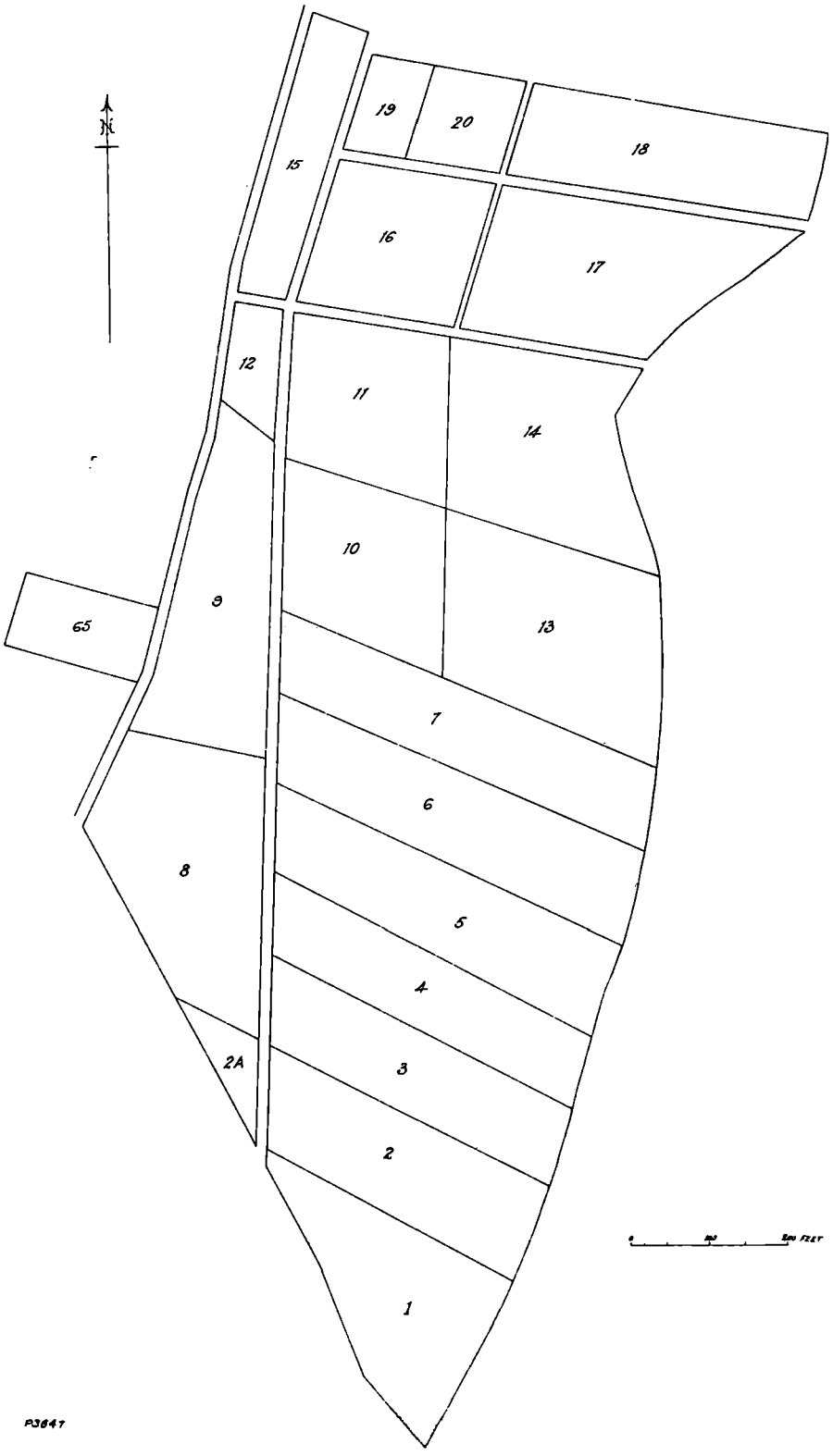
Plot 1—Norway Spruce.

Age—23 years. Mean height—28 ft. Mean $\frac{1}{4}$ girth—$2\frac{7}{8}$ in. Volume per acre—975 cu. ft. Quality Class—III.

There is no soil vegetation. The soil consists of $\frac{1}{2}$ in. moderately well decomposed humus over a brownish loam (with few stones) more than 3 ft. in depth.

Part of this area was laid out in nursery lines, the surplus plants being removed later and used to stock other plots in the garden. The planting distance was 3 ft. by 3 ft. The growth at first was very slow, a heavy growth of grass interfering with the young plants, while later self-sown birch and larch invaded the area and did some damage to the crop. These species were removed in 1918. The stocking is now dense but irregular. Height growth is improving and is uniform over the area. Several stems have been damaged by honeysuckle, but the majority are straight and carry good crowns. As a result of the slow growth branches are numerous and the stems are rough in appearance. The plot was thinned for the first time in 1927 and received a second thinning

ABBOTSWOOD
SERIES 1



P3647

in January, 1928, when a permanent sample plot was laid down. On that occasion a moderately heavy thinning (C grade) was carried out.

Plot 2.—Colorado Douglas Fir.

Age—23 years. Mean height—24 ft. Mean ¼ girth—3 in.

The soil vegetation has now been almost completely killed out. There remain *Rubus fruticosus* (sc.) and *Pteris aquilina* (sc.). The soil is similar to that in Plot 1.

As in Plot 1 part of the area was laid out in nursery lines originally. Two-year seedlings were used, planted 3 ft. by 3 ft. The plot was badly damaged by a severe frost in May, 1907, and rank weed growth caused additional losses, but the remaining plants began to grow in the shelter of birch which had invaded the area. The birch were removed in 1918 and the blanks filled up with 4-year-old seedlings. Several weedings have been necessary since that year, but the crop has now become established and a canopy is beginning to form in places. The height growth is now satisfactory, the leading shoots on the largest trees being more than a foot in length. *Rhabdocline Pseudotsugae* is present on the needles of some of the trees, but it is doing very little damage.

Plot 3.—Oregon Douglas Fir.

Age—23 years. Mean height—40 ft. Mean ¼ girth—4¼ in. Volume per acre—1,800 cu. ft. Quality Class—IV.

The soil vegetation is scanty—*Sambucus nigra* (sc.), *Veronica officinalis* (sc.), *Stellaria media* (sc.), *Rubus fruticosus* (sc.). Under gaps in the canopy the vegetation is more abundant and the following additional species are found—*Digitalis purpurea* (ab.), *Geranium Robertianium* (p.), *Circaea lutetiana* (p.), *Galium saxatile* (p.), *Rumex acetosella* (p.), *Viola sylvatica* (p.), *Holcus lanatus* (p.). The humus is well decomposed, but variable in depth and nowhere abundant. The soil is similar to that in Plot 1.

The crop, planted 3 ft. by 3 ft., developed irregularly and there were many failures, but by 1913 a canopy had begun to form. During the war years considerable damage was done by snow and the gaps which were caused still persist. In 1919 a thinning was made and the trees pruned to a height of 5 ft. A second thinning was carried out 5 years later. The crop is now irregular. During the last few years it has suffered from heavy infestations of *Chermes cooleyi* the presence of which was noted for the first time in 1924. These attacks, which have had the effect of checking the height growth to a marked degree, appear now to be diminishing in intensity and the height growth is again improving. The trees are

not of the best type. There are many wavy stems and the branches are long and heavy. The largest trees have wide spreading crowns, but the crowns of the smaller trees are poorly developed.

A light thinning (B grade) was carried out in 1928.

Plot 4.—Scots Pine.

Age—23 years. Mean height—37 ft. Mean ¼ girth—4 in. Volume per acre—1,600 cu. ft. Quality Class—I.

The soil vegetation is abundant. The following species are represented—*Sambucus nigra* (p.), *Rubus fruticosus* (ab.), *Pteris aquilina* (ab.), *Digitalis purpurea* (p.), *Epilobium angustifolium* (p.), *Oxalis acetosella* (p.), *Rumex acetosella* (sc.), *Polytrichum commune* (sc.). The humus is moderately well decomposed, but is of no great depth except round the butts of the trees where it tends to accumulate. The soil is as in Plot 1.

The planting distance was 3 ft. by 3 ft. Growth from the beginning was fast and the crop by 1913 had formed a dense thicket and killed out the ground vegetation. Some damage had been caused by *Tortrix buoliana* and there was further damage by snow between 1913 and 1918. The first thinning was made in 1920, when the dead and dying trees were removed, and further thinnings were carried out in 1924 and 1928. The crop is now dense and regular and the growth continues to be exceptionally fast. The stems are slender and drawn up and the branching is coarse and heavy.

Plot 5.—Norway Spruce.

Age—23 years. Mean height—31 ft. Mean ¼ girth—3 in. Volume per acre—1,225 cu. ft. Quality Class—II.

There is no soil vegetation except for a few fronds of *Pteris aquilina*. There is a layer of undecomposed humus and 1 inch of well decomposed humus. The soil is similar to that in Plots 1–4.

The trees in this plot, planted 3 ft. by 3 ft., grew rather faster to begin with than those in Plot 1 and formed a more regular crop. They had reached the thicket stage by 1913. The removal of self-sown larch and birch in 1918 left the crop rather irregular for a time, but the gaps have now closed and the stocking is dense and moderately regular. The trees are similar to those in Plot 1 but are slightly better in quality.

The first thinning was carried out in 1927 when all dead, dying and suppressed trees were removed. Another light thinning was made in the following year.

PLOT 6.—SWEET CHESTNUT.

Age—23 years. Mean height—41½ ft. Mean ¼ girth—4 in. Volume per acre—1,435 cu. ft.

The soil vegetation is abundant and the following are among the species represented—*Scilla nutans* (ab.), *Rubus fruticosus* (ab.), *Oxalis acetosella* (ab.), *Pteris aquilina* (p. to ab.), *Sambucus nigra* (p.), *Galium saxatile* (p.), *Rumex acetosella* (p.), *Holcus lanatus* (p.), *Mnium hornum* (p.), *Polytrichum commune* (p.).

There is a thin layer of broadleaved humus over 24-30 inches brown loam. At the western end of the plot numerous boulders of conglomerate are scattered over the surface of the soil. The plot was formed with 4-year-old plants dug out of natural regeneration, with the object of testing the value of such plants. The planting distance was 3 ft. by 3 ft. At the beginning the crop did badly and in 1913 was considered to be hopeless and of no further value. By 1919, however, a canopy had formed and since that time growth has been rapid and regular. A first thinning was made in 1924 and a second in 1928, when particular attention was paid to the removal of defective dominants and co-dominants. This plantation, in spite of the poor start which it made, is now one of the most successful in the garden. Height growth during the past ten years has been fast and it is continuing unabated. There are numerous curved stems, but the great majority are of a good type ; they are long and well drawn up and are cleaning themselves satisfactorily. The crowns are small and there is intense competition among the trees in the canopy.

PLOT 7.—PEDUNCULATE OAK.

Age—23 years. Mean height—32 ft. Mean ¼ girth—3 in. Volume per acre—660 cu. ft.

The vegetation is abundant—*Scilla nutans* (ab.), *Pteris aquilina* (ab.), *Oxalis acetosella* (ab.), *Sambucus nigra* (p.), *Galium saxatile* (p.), *Holcus lanatus* (p.), *Aira flexuosa* (p.), *Rumex acetosella* (sc.), *Scrophularia nodosa* (sc.), *Polytrichum commune* (p.), *Mnium hornum* (p.).

The soil consists of a thin layer of well decomposed oak-leaf humus over 24–30 in. brown loam.

This plot was planted with 4-year-old seedlings dug from natural regeneration with the object, as in Plot 6, of testing the value of such plants, and the planting distance was the same. The plot did badly at the commencement and in 1913 was looked upon as a failure. By 1919 it had improved, but had not formed a canopy and was open and irregular. Five years later the canopy was not quite complete although the growth had improved. This improvement has continued and there is now a

complete canopy which in places is dense. The trees as a result of the open stocking are heavily branched and their crowns are spreading and have many low forks. A thinning was carried out in 1928 in which some of the worse dominants and co-dominants were removed along with the dead, dying and suppressed trees.

Plot 8.—Norway Spruce.

Age—23 years. Mean height—32 ft. Quality Class—II.

Under the gaps in the canopy the following plants are found—*Pteris aquilina* (ab.), *Sambucus nigra* (p.), *Polytrichum commune* (p.), *Eurynchium striatum* (p.). The humus generally is from 1 to 1½ inches in depth and moderately well decomposed. The soil is similar to that in Plots 3—5.

The young plants were put out in a rank grass vegetation and a large number died, with the result that it was necessary to replant practically the whole of the area. This was done in February, 1906, and larger plants were used. In part of the plot the young plants were set out in groups of three. The crop grew slowly to begin with and was much interfered with by birch, the removal of which in 1918 and 1924 left it irregular and open in places. The plot received its first thinning in 1927 when the dead, dying and suppressed trees were removed. Another light thinning was carried out in 1928. The crop is still irregular, but is growing satisfactorily.

Plot 9.—European Larch and Norway Spruce.

Age 22 years.

European larch: Mean height—43 ft. Mean ¼ girth—4¾ in. Volume per acre—955 cu. ft. Quality class—II.

The soil vegetation is scanty and consists of the following species—*Pteris aquilina* (sc.), *Digatalis purpurea* (sc.), *Oxalis acetosella* (sc.), *Galium saxatile* (sc.), *Sambucus nigra* (sc.), *Agrostis alba* (sc.), *Hypnum purum* (sc.), *Eurynchium striatum* (sc.).

The humus is about 1 inch deep and is well decomposed. The soil is a brown loam tending to clay loam to a depth of 24-30 inches.

The plantation was formed with 2 + 1 transplants, the species being planted in alternate lines 4 ft. by 4 ft. Many plants were lost during the summers of 1906, 1907 and 1908, but no damage was done by the long drought of 1911. By 1913 the larch were well ahead of the spruce, but no canopy had formed; by 1919, however, the larch had formed a dense canopy over the spruce which were then being suppressed. By 1924 the suppression of the spruce had advanced a stage further and a thinning which was carried out in that year came too late to save the spruce. By

1928 the spruce had become completely suppressed, in many cases beyond hope of recovery. They are small, with thin foliage and an unhealthy appearance. The larch vary in quality. Many of the larger trees are leaning over to the north-west and are coarse and cankered, but there are, on the other hand, many trees with straight stems and symmetrical crowns. The height growth has been fast and is uniform over the plot. A heavy thinning was made among the larch in 1928.

PLOT 10.—EUROPEAN LARCH AND OREGON DOUGLAS FIR.

Age—22 years.

European larch : Mean height—44 ft. Mean $\frac{1}{4}$ girth—$4\frac{1}{4}$ in. Volume per acre—895 cu. ft. Quality Class—II.

Douglas fir : Mean height—40 ft. Mean $\frac{1}{4}$ girth—4 in. Volume per acre—725 cu. ft. Quality Class—IV.

The vegetation is scanty—*Sambucus nigra* (sc.), *Oxalis acetosella* (sc.), *Rubus fruticosus* (sc.), *Galium saxatile* (sc.), *Luzula sylvatica* (sc.), *Lastraea dilatata* (sc.), *Mnium hornum* (sc.), *Eurynchium praelongum* (sc.).

The humus is moderately deep and well decomposed. The soil consists of 24–30 inches loam tending to clay loam with numerous rock fragments. Over the area there are numerous boulders of conglomerate.

The species were planted in alternate lines 4 ft. by 4 ft., the Douglas fir being 2 + 1 transplants. More than a quarter of the Douglas fir died in their first year and the gaps were filled up in January, 1907. In 1913, the larch were well ahead of the Douglas fir. Both species were healthy and growing well, although the thicket stage had not then been reached. In 1918 a first thinning was carried out and the trees pruned up to 6 ft. At that time both species were showing a similar rate of growth, but on an average the larch were taller and larger than the Douglas fir. *Chermes cooleyi* was observed on the Douglas fir in 1924 and some canker on the larch. In 1928 a second thinning was carried out with a view to the preservation of an even mixture and in that thinning it was necessary to favour the Douglas fir, many of which were being whipped by the surrounding larch.

The larch are long, rather whippy trees with small crowns. The stems are generally straight, but there is a considerable percentage of wavy and slightly defective stems. The Douglas fir are also whippy and there is a risk of their bending over as the crowns expand after thinning. As regards height growth the Douglas fir appear now to be growing slightly the faster.

PLOT 11.—SCOTS PINE AND OREGON DOUGLAS FIR.

Age—22 years.
Scots pine: Mean height—38 ft. Quality Class—I.
Douglas fir: Mean height—40½ ft. Quality Class—IV.

There is no vegetation except under the gaps in the canopy where the following species occur—*Digitalis purpurea* (p.), *Galium saxatile* (p.), *Rumex acetosella* (sc.), *Viola sylvatica* (sc.), *Lastraea* sp. (sc.)

The soil varies from place to place. Along the western edge of the plot it is a loam with few stones tending to clay loam to an indefinite depth; in the eastern half of the plot the soil has the same character but occurs in pockets among boulders of conglomerate. In places the soil is moist.

Alternate lines of Scots pine and Douglas fir, 2 + 1 transplants, were planted 4 ft. by 4 ft. Almost 20 per cent. of the Scots pine and 25 per cent. of the Douglas fir died during the first year and were replaced in January, 1907. In 1913 the crop was healthy and had shown satisfactory growth, but no canopy had formed; by 1918, however, the canopy was dense and a first thinning became necessary. A second thinning was carried out in 1922 and a third light thinning in 1928. The Scots pine in this plot, though now falling behind, have maintained their position extremely well in competition with the Douglas fir, particularly in the eastern half of the plot where the soil is poorer and the Douglas fir have not done so well. The pine are of very poor quality with defective stems and crowns, and coarse, heavy branches. The Douglas fir differ much in quality. Some of the smaller stems are of a good type and have light branching, but the larger stems are, without exception, coarse and heavily branched. Wind and snow have caused two unfortunate gaps where the soil is wet.

PLOT 12.—LAWSON'S CYPRESS.

Age—22 years. Mean height—35 ft. Mean ¼ girth—3⅜ in. Volume per acre—1,806 cu. ft.

There is no vegetation. The humus is not abundant and the soil is as in Plot 11. Before planting it was described as rather wet; it appears to have dried considerably since that time.

The plot was planted with 2-year seedlings in nursery lines 4 ft. apart, but the surplus plants were taken up in March, 1908, leaving the remaining trees at approximately 4 ft. by 3 ft. The crop grew satisfactorily, but a complete canopy did not form until 1919. A light thinning was carried out in 1927, and all the low forks were removed; a second light thinning was made in 1928. The crop is now dense and uniform, and making good growth. The trees have straight stems and ample crowns. There are now very few forked trees, as most of the forking took place near the ground in the manner characteristic of this species.

Plot 13.—Scots Pine and Norway Spruce.

Age—22 years.

Scots pine. Mean height—35½ ft. Quality Class—I.

There is no soil vegetation. The ground in this plot is irregular and the soil conditions vary, though within narrow limits. Generally there is 1 in. humus over ½ in. well decomposed humus over a brown loam, tending in places to clay loam to a depth of 24–36 in. The plot was formed with Norway spruce and Scots pine planted in alternate lines 4 ft. by 4 ft., 2 + 1 transplants being used. The failures were filled up in the year after planting. During the first few years growth was rapid, and in 1913 the Scots pine had leading shoots up to 3 ft. in length. Both the spruce and the pine were attacked by *Armillaria mellea*, which caused numerous deaths, and the pine also suffered from attacks by *Tortrix buoliana*. By 1919 there was a dense canopy, and the spruce were being suppressed by the pine ; a large number of suppressed spruce were cut out in the thinning in 1924. The crop is now unsatisfactory. The Scots pine are dominant and are almost without exception defective. The stems are large and coarse with long, heavy branches, and many are crooked, the result no doubt of the attacks by the *Tortrix*. Only a few spruce have maintained a place in the canopy, but such as remain are showing excellent growth. The majority are completely suppressed, as in Plot 8. A second thinning was carried out in 1928, in which the most promising spruce were favoured.

Plot 14.—Norway Spruce and Colorado Douglas Fir.

Age—22 years.

Norway spruce: Mean height—37 ft. Mean ¼ girth—4¼ in. Volume per acre—1,590 cu. ft. Quality Class—II.

There is no soil vegetation except for a few fronds of *Pteris aquilina*. The humus is deep, but only partly decomposed. The soil is similar to that in Plots 11 and 13, but there is a wet patch near the north-eastern corner of the plot.

The spruce and Douglas fir were planted in alternate lines 4 ft. by 4 ft., the plants employed being 2 + 1 transplants, and there were comparatively few failures. The crop grew slowly to begin with, but a canopy was formed by 1919. At that time the Douglas fir had fallen behind the spruce, but although partially suppressed, they were still healthy. During the subsequent years, however, the Douglas fir became completely suppressed and almost all the survivors were removed in the thinning of 1928. The spruce have thus been left in pure crop with a comparatively open stocking, which will afford some comparison with the more densely stocked plots already described. The growth is now fast and uniform. The stems are straight and the crowns are large and well developed.

PLOT 15.—LAWSON'S CYPRESS AND SCOTS PINE.

Age—20 years.

Lawson's cypress: Mean height—30 ft.

Scots pine: Mean height—29 ft.

The soil vegetation is patchy and consists of *Pteris aquilina* (p.) and *Rubus fruticosus* (p.), also *Holcus lanatus* (p.) and other grasses, which are coming in from the rides. There is 1 inch partly decomposed humus over 24 inches loam, tending to clay loam. The cypress were 2 + 2 transplants and the Scots pine 2 + 3 transplants; the latter were bad plants, and many failed and were replaced by good 2-year seedlings in 1909. The two species were planted in alternate lines 4 ft. by 4 ft. The cypress grew in quite a satisfactory manner and left the Scots pine far behind for the first ten years. Afterwards, the rates of growth became more nearly equal, but the Scots pine are now falling behind once more. The survival of so many Scots pine is due to the habit of the Lawson's cypress, which keeps a pyramidal shape and does not throw out long side branches.

PLOTS 16 AND 17.—SCOTS PINE.

Age—20 years. Mean height: Plot 16—29 ft.; Plot 17—30 ft. Quality Class—I.

The vegetation is patchy—*Rubus fruticosus* (p.), *Pteris aquilina* (p.), *Galium saxatile* (p.), *Digitalis purpurea* (sc.).

There is about 1 inch well decomposed humus over 24–30 inches loam, tending to clay loam. These plots were planted with 2 + 3 transplants, bad plants being purposely selected in order to follow out their development with different planting distances—4ft. by 4 ft. in Plot 16 and 5 ft. by 5 ft. in Plot 17. Unfortunately, a large number of plants in each plot failed after the dry summer of 1908, and the blanks had to be filled up with good 2-year seedling plants in the following spring. Growth to commence with was moderately fast, and by 1919 a dense canopy had formed in both plots. A first thinning was carried out in 1927, and a second light thinning in the following year. There is now little difference between the plots, both being thoroughly unsatisfactory. The stocking is irregular and the trees are of bad shape, almost all being faulty in some respect. Many of the stems are wavy and crooked, the branching is heavy and coarse, and the crowns are generally defective. The wider planting in Plot 17 has led to the development of longer branches, but there is no other difference.

PLOT 18.—OREGON DOUGLAS FIR.

Age — 20 years. Mean height — 35 ft. Mean $\frac{1}{4}$ girth — $3\frac{3}{4}$ in.
Volume per acre—1,460 cu. ft. Quality Class—IV.

There is no soil vegetation. The humus is 1–$1\frac{1}{2}$ inches in depth and moderately well decomposed. The soil is a loam and clay loam 24-36 inches in depth.

This plot was planted with 2 + 3 transplants and, as in Plots 16 and 17, bad plants were selected. As in those plots, a large number of failures occurred during the first year and replacements were carried out in the spring of 1909 with good 2-year seedlings. The crop has thus developed from a mixture of older bad plants and younger good plants. The planting distance was 5 ft. by 5 ft. Growth has been slow and irregular and in 1919 a canopy had not completely formed. The growth after that date was rather better and a first thinning became necessary in 1927 when dead, dying and suppressed trees were removed. The plot was pruned in 1928. The plantation is now interesting when compared with Plot 3. In spite of the fact that bad plants were used at its formation, the percentage of bad trees is now lower in this plot than in Plot 3 and the number of good stems higher. The bad trees generally occur in patches and are rather larger than the others, indicating that they are probably survivors of the original planting. The branches are rather longer than in Plot 3, but do not appear to be heavier. There are one or two small gaps where damage was done by snow during the war years. These are now closing over.

PLOT 19.—*ROBINIA PSEUDACACIA.*

Age—19 years. Mean height—20 ft.

The soil vegetation is abundant—*Rubus fruticosus* (ab.), *Pteris aquilina* (ab.), grasses (ab.). The soil is as in Plot 16.

The plot has been a failure. At an early stage it was invaded by birch which did much damage to the remaining *Robinia*, and although the birch were cut out in 1918 they have sprung up again and now constitute the major part of the crop. The surviving *Robinia* are badly shaped.

PLOT 20.—COLORADO DOUGLAS FIR.

Age—20 years. Mean height—20 ft.

The vegetation is still moderately abundant, but is now being gradually killed out. It consists of *Rubus fruticosus* and *Pteris aquilina.*

This plot was formed with 2 + 4 transplants at a planting distance of 4 ft. by 4 ft., the object being to establish a plot with a

spacing wider than in Plot 2. Growth at the commencement was slow and the plot was left untouched until 1918 when the self-sown birch which had come into the area were removed. The height growth now appears to be improving, but is still irregular. The canopy is beginning to close, but the lower branches are still alive. Although lacking in vigour the crop appears to be healthy and there is no sign of disease.

Plot 65.—Corsican Pine.

Age—22 years. Mean height—32 ft. Mean $\frac{1}{4}$ girth—$3\frac{1}{2}$ in. Volume per acre—1,385 cu. ft. Quality class—I.

The soil vegetation is scanty—*Pteris aquilina* (sc.), *Galium saxatile* (sc.). There is 1 inch partly decomposed humus over 30-36 inches loam with some fragments of sandstone.

This plot was planted as a rough nursery with 2-year seedlings in lines 4 ft. apart. In 1908 the lines were thinned out to supply Corsican pine requirements elsewhere and the remaining plants were left in the lines at approximately 2 ft. apart. Previous to 1921 no records of this plot were kept, but since then it has been treated as one of the experimental plots. It was thinned in 1921 for the first time and for the second time in 1928. Unfortunately, it was severely damaged by gales in the winter of 1928-29. Growth has been rapid and regular. A few of the stems are curved at the base, but the majority are straight with normal branching. The crowns are small.

SERIES 2.

This series comprises thirty plots which are situated above the plots in Series 1 and extend over a fairly wide range of soil and exposure conditions. Plots 21-35 consist of European larch. Plot 21 was planted with beech in mixture with the larch while Plots 22-35 were planted pure. Plots 36-41 were formed with Japanese larch plants raised from seed from three different localities in Japan and there are two plots from each origin, one grown pure and one planted in mixture with beech. Plots 44-49 illustrate European larch in different mixtures with beech and chestnut. Plots 50 and 52 are hybrid larch, pure and in mixture with beech respectively.

Plot 21.—European Larch and Beech.

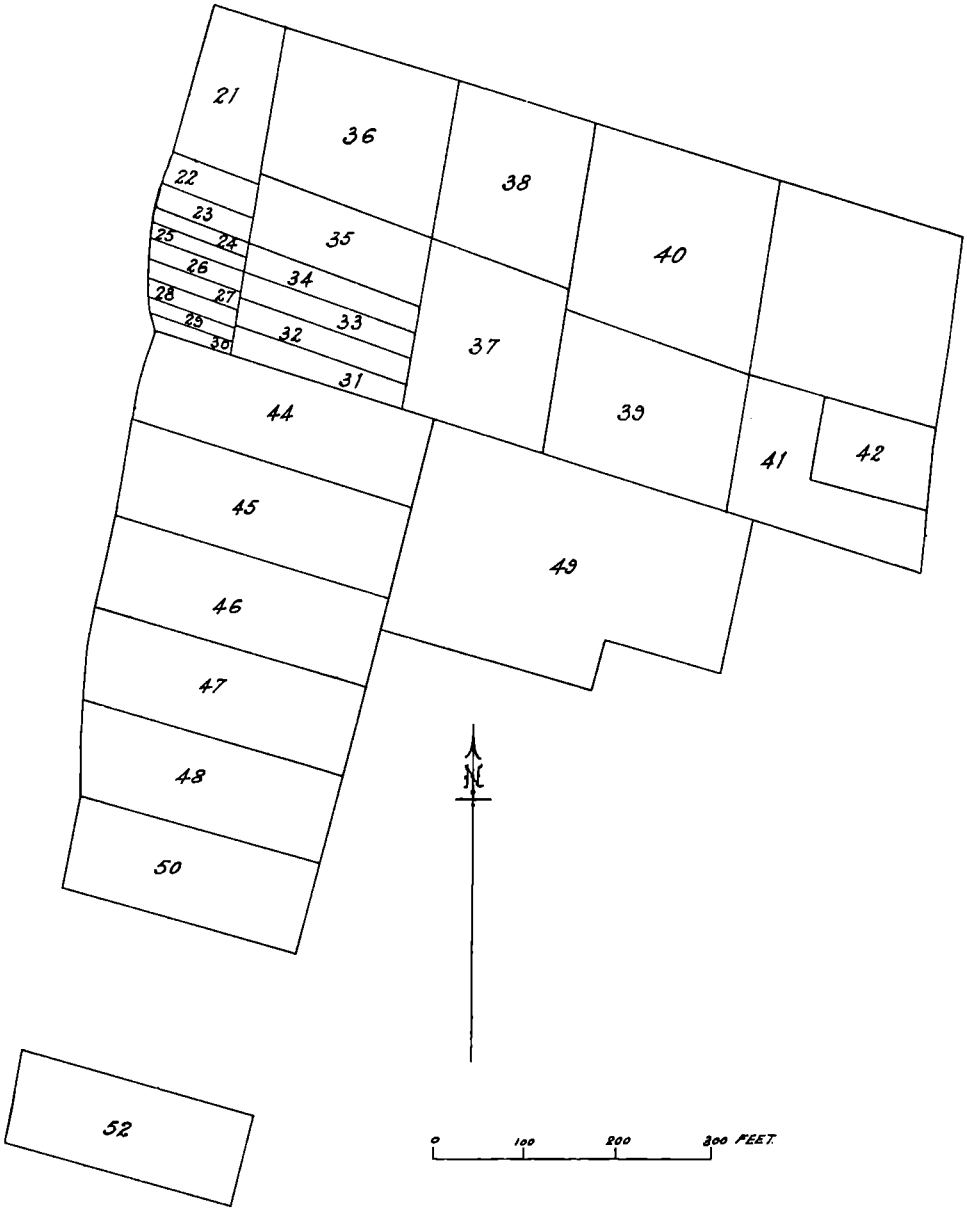
Age—14 years.

European larch : Mean height—27 ft.

Beech : Mean height—$16\frac{1}{2}$ ft.

The vegetation is abundant—*Pteris aquilina* (ab.), *Rubus fruticosus* (p.), grasses (p.) ; *Veronica* sp. (p.), *Digitalis purpurea* (p.), *Oxalis acetosella* (p.), *Scilla nutans* (p.).

ABBOTSWOOD
SERIES 2.



P3647

This plot was laid out in order to compare the development of this mixture with that of the pure larch in Plots 22-35. It was planted in 1915-16, one line being pure larch and the next line alternate larch and beech. The larch were 2 + 2 transplants and the beech 3-year seedlings. The planting distance was 5 ft. by 5 ft. and the plants were pitted.

Many of the beech have disappeared. The larch crop is irregular and there is a large area in the centre of the plot where the growth is poor. Elsewhere the trees have grown moderately well. The stems are of good size but wavy, and the branching is heavy. The variations in growth appear to be due in some measure to variations in the soil. The poorest growth occurs in a boulder-strewn area where the soil is shallow.

Plots 22–35.—European Larch.

These plots were planted in 1915-16 with 2 + 1 transplants obtained from Bangor where they were raised from seed of different origins. They were planted in pits at 5 ft. by 5 ft. Plots 22-34 are very small and consist each of only a few lines of trees. Plot 35 is larger and extends to about a third of an acre. The soil and vegetation are as in Plot 21.

It will be seen that the outstanding feature of this experiment is the poor growth of the larch raised from Hungarian and Silesian seed and the good growth obtained with plants of Welsh and Irish origin. The plants from Welsh seed have grown rather faster than those of Irish origin.

Plot 22.

Age—14 years. Mean height—25 ft.

The plants in this plot were raised from seed obtained at Proskau, Silesia. The crop is unsatisfactory, the stems being crooked and the crowns poor and heavily branched.

Plot 23.

Age—14 years. Mean height—24 ft.

The trees in this plot are of Hungarian origin. The plot has been almost a complete failure. The stems are bent over in all directions and appear from an early stage to have suffered in this way. Canker is not so severe as in some of the other plots.

Plot 24.

Age—14 years. Mean height—22½ ft.

The plants here are also from Hungarian seed.

The stocking is a little more regular than in Plot 23, but the crop is poor. The stems are crooked and heavily branched and the crowns are bad.

PLOT 25.

Age—14 years. Mean height—23 ft.

The seed was obtained from Vaynol Estate, near Bangor.
This crop is similar to that in Plot 24, but a little better.

PLOT 26.

Age—14 years. Mean height—27 ft.

The plants were raised from seed collected at Murthly, Perthshire.
This crop is better than those already described. There have been very few failures. The stems are straight and the crowns of good shape. There is some canker.

PLOT 27.

Age—14 years. Mean height—28 ft.

The plants were raised from seed collected at Gorddinog Estate, near Bangor. The crop is open in places and the stocking is irregular, but the trees are of a much better type than those in Plots 22–25. The stems are straight, but rather heavily branched.

PLOT 28.

Age—14 years. Mean height—30 ft.

The plants in this plot are from the same source as those in Plot 27. This is quite a satisfactory crop. There have been few failures and the stocking is dense. The stems are straight with light branching and well shaped crowns.

PLOT 29.

Age—14 years. Mean height—25 ft.

The plants in this plot were raised from seed collected at Pentir, North Wales. The stocking is irregular and there have been several failures. The stems are generally straight and the crowns moderately good. There is some canker.

PLOT 30.

Age—14 years. Mean height—27 ft.

The seed was collected at Denbigh.
This is a satisfactory crop with few failures. The trees are of a good type with straight stems and good crowns. There is very little canker.

PLOT 31.

Age—14 years. Mean height—25 ft.

The plants were raised from seed from Kerry, Ireland.
The crop is now rather open, but the trees are of a fairly good type.

PLOT 32.

Age—14 years. Mean height—25 ft.

The seed from which the plants in this plot were raised was obtained from Tipperary, Ireland.

The trees are not so uniform in size as in Plot 31, some trees being much larger than others, otherwise the two plots are similar.

PLOT 33.

Age—14 years. Mean height—25 ft.

The plants in this plot were raised from seed collected at Camolin, County Wexford, Ireland.

The crop is similar to that in Plot 32.

PLOT 34.

Age—14 years. Mean height—26½ ft.

The seed from which the plants in this plot were raised was collected at Baunreagh, Ireland.

The growth in this plot has been rather better although it is irregular. The trees are of quite a good type, but there is much variation in the size of the stems.

PLOT 35.

Age—14 years. Mean height—31 ft.

The origin of the plants in this plot is unfortunately unknown.

The trees differ markedly from those in the other plots of the series in that the branchlets are distinctly pendulous. Growth in the initial stages was faster than in any of the other plots and is still satisfactory. The stems are heavy and straight, and the plot is probably the best of the series.

PLOTS 36–41.—JAPANESE LARCH.

The plants used in this set of plots were obtained as 2 + 1 transplants from Bangor where they were raised from seed collected in three different localities in Japan. The places of origin were Mt. Asama, Ontake and Mt. Yatzugatake.* Two plots were allocated to plants from each source, one plot of each pair being a pure crop of Japanese larch and the other a mixture of one line of pure larch

* These localities are in a mountain area in the Province of Shinano, about 100 miles west north-west of Tokio. The distinguishing features of the three localities are :—

Asama	Elevation, 3,000 ,, ..	An afforestation area.
Ontake	Elevation, 3,000 ,, ..	Natural forest.
Yatzugatake.. ..	Elevation, 6,500 feet. ..	Natural forest.

The soil is a good friable sandy loam over volcanic rocks.

and one line alternate larch and beech. The beech used were 3 + 1 transplants. The plants were set out in pits at 5 ft. by 5 ft.

In each of the plots which contained beech, the latter species has been almost entirely killed out by the Japanese larch. The proportion of beech in the mixture does not appear to have been large enough to ensure the maintenance of a mixed crop.

The vegetation in the plots is scanty and consists of patches of *Rubus fruticosus, Hedera Helix, Lastraea Filix-mas, Pteris aquilina, Oxalis acetosella, Sambucus nigra.*

From the description given below it would appear that no definite conclusions can be drawn from these plots. There is no marked difference among the rates of growth nor among the types of tree produced. There is an indication, however, that the seed from Mt. Yatzugatake has tended to produce a coarser type of tree.

PLOT 36. (Mt. Asama).

Age—14 years. Mean height—31 ft.

This crop is irregular and gappy. The stems are coarse with long and heavy branches but on the whole are straight. There is some crowding in the canopy in places, but generally over the plot the crowns have still ample room. Growth improves towards the bottom of the plot where the soil is deeper. The beech have almost all been killed out.

PLOT 37. (Mt. Asama).

Age—14 years. Mean height—31 ft.

There were no beech in this plot.

This is a dense crop which is distinctly better than Plot 36 ; there are one or two irregularly stocked patches over heaps of boulders. The stems of the dominant trees are generally straight with moderately heavy branching, but among the co-dominants and sub-dominants there are numerous defective trees.

PLOT 38. (Ontake).

Age—14 years. Mean height—31½ ft.

This plot had an admixture of beech which has now disappeared. The crop is more even than that in Plot 36 and is generally satisfactory. The good trees are of an excellent type but there are many coarse and deformed dominants.

PLOT 39. (Ontake).

Age—14 years. Mean height—33 ft.

This plot had no admixture of beech.

The crop is dense with a moderately regular stocking. The stems are heavy and there are many coarse and defective trees.

PLOT 40. (Mt. Yatzugatake).

Age—14 years. Mean height—32½ ft.

The beech have almost all disappeared.

The crop is dense and regular. The trees are of good size, but there are many wavy and forked stems and defective tops. The branching is heavy.

PLOT 41. (Mt. Yatzugatake).

Age—14 years. Mean height—30 ft.

No beech were planted but a certain number of plants of that species appear to have come in later and are growing moderately well.

The larch form an even crop, but are smaller than those in Plots 39–40. The stems are generally straight and the branches though long are not too heavy.

PLOT 42.—DEODAR.

Age—14 years. Mean height—14 ft.

The seed from which the plants in this plot were raised was collected in the Himalayas and sown at Tintern in 1913. The seedlings were transplanted in 1914-15 to a nursery in the Forest of Dean and planted out in this plot in the following season.

The crop is now irregular, many of the trees having died, the result probably of attacks by *Armillaria mellea*. A canopy has not yet formed and the trees bear living branches almost to the ground. The growth has been slow, but is now becoming faster.

PLOTS 44–48.—EUROPEAN LARCH, WITH BEECH AND SWEET CHESTNUT.

These plots consist of mixtures of European larch with chestnut and with chestnut and beech, the object being to test these mixtures. The plants used were larch 1 + 1 transplants, chestnut 2 + 2 transplants and beech 1 + 3 transplants. The planting distance was 5 ft. by 5 ft. and the plants were pitted. In two of the plots the chestnut was sown in pits to test whether sowing would give better results than the planting that was carried out elsewhere. The plots were established in 1916-17.

PLOT 44.—EUROPEAN LARCH AND SWEET CHESTNUT.

Age—13 years.

European larch : Mean height—25 ft.

Chestnut : Mean height—25 ft.

Both species were planted, one line being pure larch and the next, alternate larch and chestnut.

PLOT 45.—EUROPEAN LARCH AND SWEET CHESTNUT (NOW BEECH).

Age—13 years.
European larch : Mean height—24½ ft.
Beech : Mean height—20½ ft.

The arrangement was as in Plot 44, but in this plot the chestnut were sown in pits. The pits were 12 inches in diameter and 9 inches deep, and four seeds were sown in each pit in May. The sowings were a failure and the gaps were filled with beech dug from natural regeneration.

PLOT 46.—EUROPEAN LARCH, SWEET CHESTNUT AND BEECH.

Age—13 years.
European larch : Mean height—26 ft.
Chestnut : Mean height—27 ft.
Beech : Mean height—20 ft.

This plot consists of alternate lines of larch and hardwoods, one line being pure larch and the next, alternate beech and chestnut. All the trees were planted.

PLOT 47.—EUROPEAN LARCH AND SWEET CHESTNUT.

Age—13 years.
European larch : Mean height—24½ ft.
Chestnut : Mean height—24 ft.

This plot consists of alternate lines of larch and sweet chestnut, all planted.

PLOT 48.—EUROPEAN LARCH AND SWEET CHESTNUT (NOW BEECH).

Age—13 years.
European larch : Mean height—29 ft.
Beech : Mean height—20 ft.

The arrangement was the same as in Plot 47, but the chestnut were sown. The sowings were a failure and the blanks were filled up with large beech plants taken from natural regeneration in the forest.

PLOT 49—EUROPEAN LARCH AND BEECH.

Age 13 years.
European larch : Mean height—27 ft.
Beech : Mean height—20 ft.

This plot was laid out as a control in the ordinary arrangement for larch and beech mixtures—one line pure larch, one line alternate larch and beech.

These plots have not been pruned nor opened up and consequently no careful examination can as yet be carried out. Certain conclusions may, however, be drawn. The first is, that European larch under the conditions in the forest garden cannot hold their own against sweet chestnut when the mixture consists of alternate lines of each species. This is clearly seen in Plots 46 and 47 where the larch are being suppressed but where the chestnut form only 25 per cent. of the mixture, as in Plot 44, the larch are at present not so seriously threatened. In the plots where beech occur in alternate lines with the larch, the larch are still holding their own, but are being gradually overtaken and will probably be suppressed in the end. When the beech form only 25 per cent. of the mixture, as in Plot 49. they are not likely to threaten the larch seriously.

Plots 50 and 52.—Hybrid Larch.

Age—12 years.

Plot 50: Mean height—28 ft.

Plot 52: Mean height—31 ft.

The hybrid larch plants were obtained as 1-year seedlings from Scotland but the origin of the seed is unknown. They were lined out for one year before being planted in 1917-18. The planting distance was 5 ft. by 5 ft. and the plants were pitted. In Plot 50 the hybrid larch were planted pure, and in Plot 52 there was a 25 per cent. admixture of beech.

In Plot 50 there is now a moderately dense canopy, but the stocking is not quite regular. The stems are generally straight and the crowns satisfactory. The branches are long but light.

In Plot 52 the beech are quite suppressed. The growth of the larch is much better at the bottom of the slope, but is satisfactory all over. The canopy is not quite complete, but is rapidly closing. There are one or two wavy stems, but the majority are of excellent shape.

SERIES 3.

Sitka Spruce.

This series of plots lies on the eastern side of the valley, facing the plots in Series 1 and 2. It was planted in 1917-18, the previous crop of birch, oak and alder having been cut and cleared away in the spring of 1917.

The plots, of which there are nine, are situated on a steep but regular slope with a range of elevation of from 300 to 525 ft. The soil varies in depth over the area, but is nowhere less than a foot deep. It consists of a rich reddish brown loam tending to clay loam with numerous fragments of broken and rotted rock.

The soil vegetation is abundant. It consists mainly of *Rubus fruticosus, Pteris aquilina, Lonicera Periclymenum, Scilla nutans, Digitalis purpurea, Epilobium angustifolium* and other herbs, *Hylocomium* spp. and other mosses.

The plots consist of Sitka spruce grown in variously arranged mixtures with Douglas fir, beech and *Thuya plicata*, and there are also three pure plots of Sitka spruce. With Douglas fir the Sitka spruce has been tried in an alternate line mixture in Plot 55, and in a chess-board arrangement (alternate squares of 25 plants of each species) in Plot 54, and the same arrangements were repeated with the *Thuya* in Plots 60 and 59 respectively. In Plot 57, beech was introduced in groups of nine trees throughout the spruce, and in Plot 58 it formed 25 per cent. of the mixture in the usual way—one line pure Sitka spruce and one line alternate Sitka spruce and beech.

The growth of the Sitka spruce falls off markedly on the higher ground and the conditions are not sufficiently uniform to enable any definite conclusions to be drawn as to the comparative merits of the different mixtures.

The planting distance was 5 ft. by 5 ft. in all plots except No. 53, where it was 4 ft. by 4 ft. The plants used were as follows :— Sitka spruce (except in Plot 53) 2 + 2, Douglas fir 2 + 2, beech 2 + 2, *Thuya* 2 + 2 + 1. The plants were pitted. Weeding was necessary in some cases for four years after planting.

Plot 53.—Sitka Spruce.

Age—11 years. Mean height—16 ft.

This plot is a year younger than the others of the series as it was planted in 1918–19 in place of *Abies grandis*, which had been planted a year earlier but failed. The planting distance for this plot of Sitka spruce was 4 ft. by 4 ft., and the plants used were 3 + 1 transplants.

It now forms an irregular crop, but of satisfactory growth. There are some wavy stems, although the majority are straight and of good form.

Plot 54.—Sitka Spruce and Douglas Fir.

(Chessboard arrangement.)

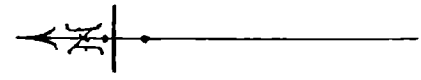
Age—12 years.

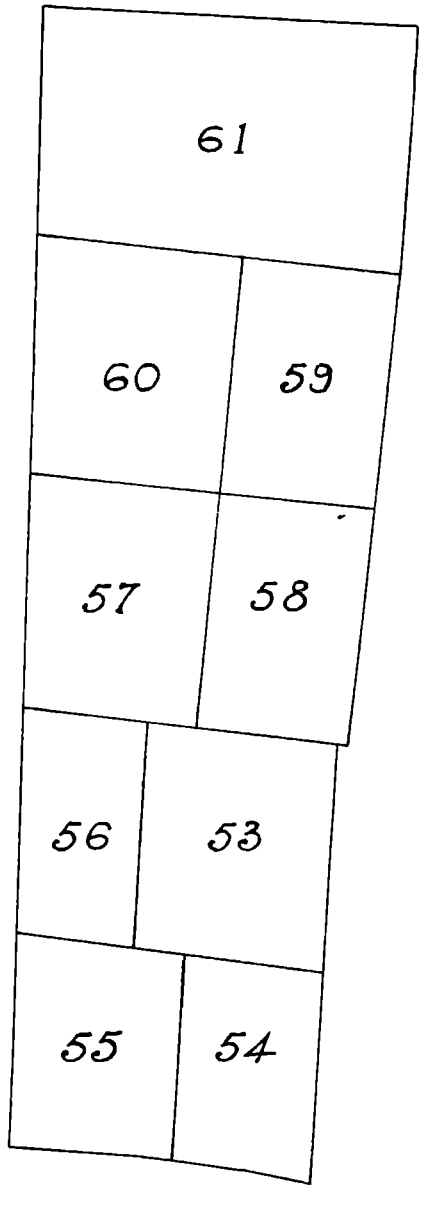
Sitka spruce : Mean height—16½ ft.

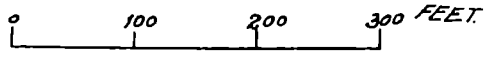
Douglas fir : Mean height—20 ft.

— ABBOTSWOOD —

SERIES 3.







The growth over this plot has been irregular. The Douglas fir appear to have grown faster to begin with than the Sitka spruce, but the latter are now overtaking them. The falling off in the rate of growth of the Douglas fir is due largely to attacks by *Chermes cooleyi*. The chessboard arrangement of small alternate blocks seems likely to prevent the undue dominance of either species and to make certain of a mixture in the final crop.

PLOT 55.—SITKA SPRUCE AND DOUGLAS FIR.

(In alternate lines.)

Age—12 years.

Sitka spruce : Mean height—16 ft.

Douglas fir : Mean height—19½ ft.

The Sitka spruce in this plot are being seriously threatened by the Douglas fir, which are already dominant in one corner. Elsewhere the check in the rate of growth of the Douglas fir has allowed the Sitka spruce to recover slightly, and they are now pushing their leaders through between the lines of the other species.

In a mixture of alternate lines of two species there is a much greater danger of one of these species being completely suppressed than there is in a mixture such as that in Plot 54.

PLOT 56.—SITKA SPRUCE.

Age—12 years. Mean height—16½ ft.

This plot is similar to Plot 53. The height growth is a little better, but the crop shows the same irregularity.

PLOT 57.—SITKA SPRUCE AND BEECH.

(Beech in small groups).

Age—12 years.

Sitka spruce : Mean height—16 ft.

Beech : Mean height—13 ft.

PLOT 58.—SITKA SPRUCE AND BEECH (25 per cent. beech).

Age—12 years.

Sitka spruce : Mean height—15 ft.

Beech : Mean height—13½ ft.

In the above two plots the beech are growing vigorously and holding their own with the Sitka spruce. Canopy has not yet begun to form. The Sitka spruce show a very irregular growth and there have been several failures.

PLOT 59.—SITKA SPRUCE AND *THUYA PLICATA*

(Chessboard arrangement.)

Age—12 years.
Sitka spruce: Mean height—15 ft.
Thuya plicata: Mean height—15 ft.

PLOT 60.—SITKA SPRUCE AND *THUYA PLICATA.*

(Alternate lines.)

Age—12 years.
Sitka spruce: Mean height—14½ ft.
Thuya plicata: Mean height—14 ft.

The *Thuya* in these plots have grown, up to the present time, at about the same rate as the Sitka spruce, but the growth of the latter species is now improving.

PLOT 61.—SITKA SPRUCE.

Age—12 years. Mean height—14½ ft.

This plot is dense, but has developed irregularly. Growth which has been slower than in some of the other plots is now improving.

SERIES 4.

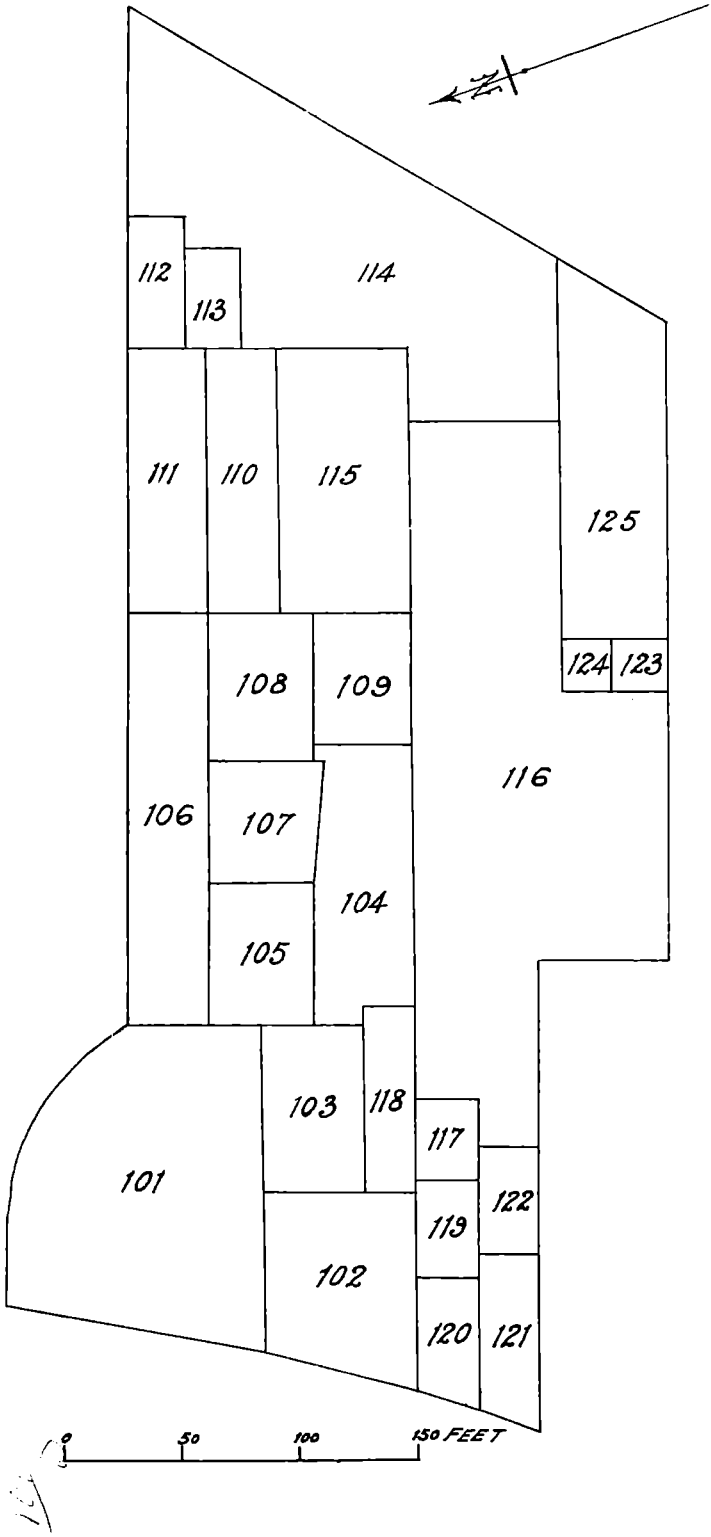
This series comprises 25 small plots of exotic trees raised from seed collected by E. H. Wilson's expedition to Western China in 1910. The seed was sown in a nursery in the Forest of Dean in the spring of 1911, and the seedlings transplanted in the nursery in 1913. The transplants were put out in these plots in the season 1915–16. The species of *Picea, Abies* and *Pinus* were planted at 4 ft. by 4 ft., and those of *Betula* and *Fraxinus* at 5 ft. by 5 ft.

At the present time there is a dense weed growth mainly of bracken and bramble, but in places also of birch and willow through which the plants are struggling. It is difficult in some cases to locate the exact boundaries of the plots on account of this weed growth, but most of the species are quite clearly distinguishable. Specimens from the different plots have recently been sent to Kew for examination; when, as a result of this examination, plants have been referred to species other than those to which they were originally thought to belong, the new names have been placed in brackets after the original names.

The following table gives particulars of the plots:—

— ABBOTSWOOD —

SERIES 4.



Plot No.	Species.	Age.	Mean Height.	Remarks.
		Years.	Feet.	
101	*Picea asperata* ..	14	7	Slow growth but few failures. Leading shoots 6–8 in. long.
102	*Picea retroflexa* (*Picea asperata*).	14	4½	Growth slower than in Plot 101.
103	*Picea montigena* (*Picea asperata*).	14	6½	Similar to Plot 101.
104	*Picea asperata* var. *ponderosa* (*Picea asperata* var. *notabilis*, Rehd. & Wils.).	14	8½	Slightly more vigorous than *Picea asperata*. Leading shoots up to 15 in. long.
105	*Picea asperata* ..	14	8	—
106	*Picea asperata* ..	14	7½	—
107	*Picea purpurea* (*Picea likiangensis*, Pritzel, var. *purpurea*).	14	7	Many failures. Crop irregular.
108	*Picea asperata* ..	14	6	—
109	*Picea heterolepis* ..	14	7	Many failures. Growth irregular.
110	*Picea ascendens* (*Picea asperata* var. *notabilis*).	14	7½	—
111	*Picea asperata* ..	14	7	—
112	*Picea Sargentiana* (*Picea asperata*).	14	6½	—
113	*Picea purpurea* (*Picea likiangensis* var. *purpurea*).	14	8	—
114	*Abies recurvata* ..	14	11½	Many failures. Growth irregular. Tallest trees 15 ft. high with leading shoots of 12 in.
115	*Abies Faxoniana* ..	14	13	Irregular crop. Tallest trees 15–18 feet.
116	*Abies recurvata* ..	14	10	—
117	*Abies Faberi* ..	14	8½	—
118	*Abies Faxoniana* ..	14	11	—
119	*Abies squamata* ..	14	10½	Inferior to *A. recurvata and A. Faxoniana.*
120	*Abies Faxoniana* ..	14	12	—
121	*Pinus sinensis* ..	14	13½	Only one tree left.
122	*Pinus Wilsonii* (*Pinus sinensis*).	14	12	Five badly shaped trees are all that remain.
123	*Fraxinus platypoda*	14	11	Few trees survive.
124	*Betula utilis* var. *Prattii*	14	8½	An unsatisfactory crop.
125	*Betula japonica* var. *mandshurica*.	14	8	Similar to 124.

ALICE HOLT.

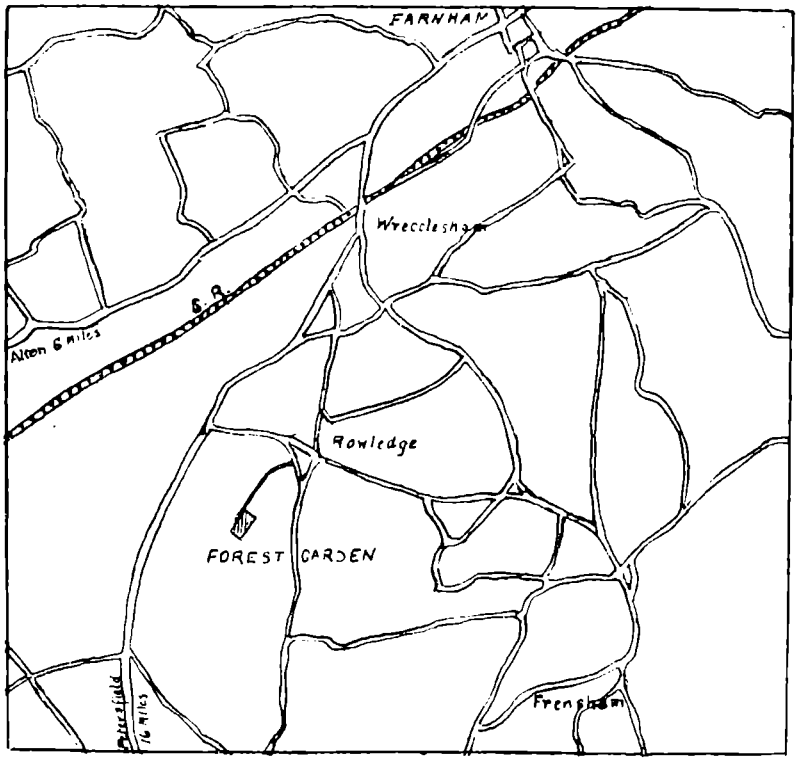
PART I.—LOCALITY DESCRIPTION.

General.—The plots constituting this garden were planted in 1906. Each plot extends to rather more than half an acre, and the whole garden occupies a site of about three acres. The plots contain the following species :—

Plot 1—Japanese larch (*Larix leptolepis*, Murr.).
,, 2—Western red cedar (*Thuya plicata*, D. Don.).
,, 3—Weymouth pine (*Pinus Strobus*, Linn.).
,, 4—Colorado Douglas fir (*Pseudotsuga glauca*, Mayr.).
,, 5—Oregon Douglas fir (*Pseudotsuga Douglasii*, Carr.).
Sub-plot A—Sitka spruce (*Picea sitchensis*, Trautv. and Mey.).
,, B—Corsican pine (*Pinus Laricio*, Poir.).
,, C—European larch (*Larix europaea*, D.C.) and Scots pine (*Pinus sylvestris*, Linn.).

Situation.—The area is situated in Glenbervie Inclosure, Alice Holt Forest, and lies about half a mile to the south-west of Rowledge, the nearest village, and 2½ miles to the south-west of Farnham. The nearest railway station, which lies about two miles to the west, is Bentley, on the Farnham and Alton branch of the Southern Railway. The garden is just within the county boundary of Hampshire. (*See* small sketch map below.)

Ordnance Survey Sheet,—6 in.—Hants, 28 S.E.
,, ,, ,, —1 in.—England, 125.



Topography.—The surrounding country is undulating, the range of elevation being from 200 to 600 feet. The highest point in Alice Holt Forest is found in the Lodge Inclosure, 1½ miles to the west of the garden. The height at that point is 418 feet. Thence, the ground falls gradually to the south and south-east, generally to the valley of the River Wey, about three miles to the south-east. Eight miles to the south-west the land rises to over 600 feet in the chalk hills of Alton, which afford a measure of protection from winds from that quarter.

The forest garden is situated at an elevation of just over 300 feet, on an area which slopes gently to the south and south-east. Immediately to the north and north-west there lies, at a slightly higher elevation, a tract of level ground extending beyond the Farnham–Portsmouth road; to the east the ground rises in the direction of Rowledge. Immediately to the south-east, south and south-west there is a gradual fall.

Climate.—The climate is slightly more extreme than that of the other gardens, but is in general equable. The mean annual temperature is about 50° F., the summer temperatures being high; severe winters are, however, not unknown. Late spring frosts are frequently a source of danger to tree growth. The rainfall is moderate and amounts to about 30 inches per annum. Usually the driest month of the year is April, and the wettest, October. The prevailing wind is south-westerly.

Exposure.—The garden is sheltered by the configuration of the ground to the east, north-east, north, north-west and west, and by forest growth on all sides except the south-east and may thus be described as fully sheltered.

Geology and Soil.—The soil consists of a stiff blue and yellow clay characteristic of the Gault formation, but there is an admixture of flints and other elements.

Soil Vegetation.—The vegetation is typical of an oak wood on heavy soil, and consists of under-shrubs and abundant herbs. Ferns are moderately well represented, but grasses and mosses are scanty. The following are among the principal species—*Rubus fruticosus* (ab), *Lonicera Periclymenum* (ab.), *Rosa canina* (p.), *Viola sylvatica* (p.), *Primula vulgaris* (p.), *Teucrium Scorodonia* (p.), *Potentilla Tormentilla* (p.), *Lychnis dioica* (p.), *Pteris aquilina* (p.), *Lastraea dilatata* (p.).

Seedlings of Japanese larch and Douglas fir are found sparingly round the plots in the garden. Seedlings of oak, yew and hawthorn are frequent and those of beech occasional.

Silvicultural Treatment.—The species were planted pure at 4 ft. by 4 ft., and the necessary beating up was carried out in 1907–8 and 1908–9.

Permanent sample plots were laid down in Plots 1, 2 and 3 in January, 1927, and an additional plot was established in Plot 5 in May of that year. Up to that time Plots 2, 3, 4 and 5 had been untouched, but Plot 1, Japanese larch, had been thinned on two occasions. Plots 2 and 3 were pruned and thinned for the first time in January, 1927, and Plot 5 in May, 1927. Plot 4, Colorado Douglas fir, has not yet been dealt with.

PART II.—DETAILED DESCRIPTION OF THE PLOTS.

PLOT 1.—JAPANESE LARCH.

Age—21 years. Mean height—36½ ft. Mean ¼ girth—3⅜ in. Volume per acre—760 cu. ft. Quality Class—II.

The soil vegetation is abundant—*Rubus fruticosus* (ab.), *Rosa canina* (p.), *Ilex Aquifolium* (p.), *Lonicera Periclymenum* (p.), *Teucrium Scorodonia* (p.), *Viola sylvatica* (p.), *Hypericum pulchrum* (p.), *Veronica officinalis* (p.), *Pteris aquilina* (sc.), *Crataegus Oxyacantha* (sc.), *Salix* spp. (sc.), *Rhamnus Frangula* (sc.), *Holcus mollis* (sc.), *Poa* spp. (sc.). The humus is a thin layer ¼–½ inch deep, and well decomposed. The soil consists of 4 inches grey clay loam with some flints over a stiff yellow clay to an indefinite depth.

This plot is more exposed to the east and south-east than any of the others. The height growth has been only moderately fast, but it is uniform over the plot with the exception of a patch at the north-west, where the growth is poorer. The stocking has been dense and the trees in consequence have slender stems and small crowns ; the girths are small for the age and the volume production low. There is a considerable percentage of defective stems, but these belong mainly to the lower stem classes, the dominants being mostly of good shape.

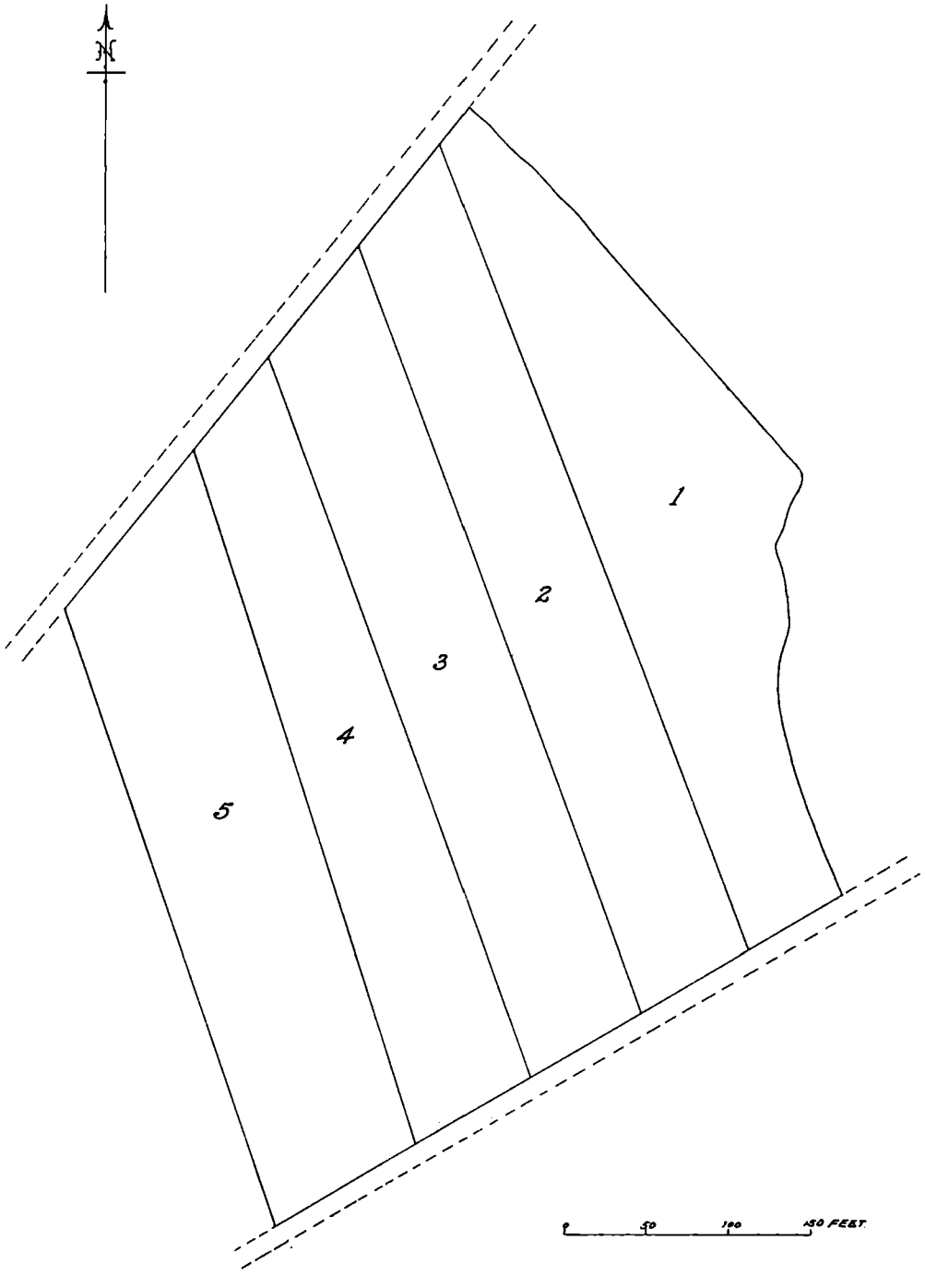
When the permanent sample plot was established, a heavy thinning (C2 grade) was carried out. This had the effect of removing most of the defective stems and of giving the remaining good stems ample room for development.

PLOT 2.—*THUYA PLICATA*.

Age—21 years. Mean height—30 ft. Mean ¼ girth—3⅝ in. Volume per acre—1,225 cu. ft.

The soil vegetation is scanty—*Pteris aquilina* (sc.), *Lonicera Periclymenum* (sc.), *Rubus fruticosus* (sc.), seedlings of beech (*Fagus sylvatica*). The soil consists of 1 inch humus over 10 inches grey clay with numerous flints over a stiff blue and yellow clay to an indefinite depth.

ALICE HOLT



P3647

The crop is irregular as is not infrequent with this species at this stage of its development. The irregularity is greatest at the southern and south-eastern sides where the *Thuya* have been overtopped by some Scots pine and Corsican pine which were introduced in " beating up." Elsewhere, the canopy is complete but irregular. Height growth varies over the plot, the best growth occurring towards the northern end where the crop is denser. The stems are straight and well shaped and have suffered less from honeysuckle (*Lonicera*) than those of the Weymouth pine and Douglas fir. The crowns are large and deep and not yet subject to any severe competition amongst themselves. The branches are light and are dead up to about 10 feet from the ground.

The plot received a light thinning (B grade) in 1927.

Plot 3.—Weymouth Pine.

Age—21 years. Mean height—31 ft. Mean $\frac{1}{4}$ girth—$3\frac{5}{8}$ in. Volume per acre—1,450 cu. ft.

The soil vegetation is scanty—*Pteris aquilina* (sc.), *Rubus fruticosus* (sc.), *Lonicera Periclymenum* (sc.). The soil consists of 1 inch humus over 12 inches grey clay with some flints over a blue and yellow clay to an indefinite depth.

The stocking is regular and moderately dense. Height growth is uniform and the various canopy classes well differentiated. The stems generally are straight with long internodes and definite whorls of heavy branches. There are several wavy stems and many which have suffered from honeysuckle. The crowns are not too well developed; several are defective and many forked. The bark is still smooth except near the ground where it is beginning to fissure. The pine blister rust (*Cronartium ribicola*) had made its appearance in 1927 and seemed to be spreading, but more recent observations have shown that the progress of the disease has been checked. The honey fungus, *Armillaria mellea*, has done some damage in killing off several trees at the southern end of the plot.

The plot received a heavy thinning (C2 grade) in 1927.

Plot 4.—Colorado Douglas Fir.

Age—21 years. Mean height—21 ft.

The soil vegetation is still moderately abundant, but is being killed out—*Rubus fruticosus* (ab.), *Pteris aquilina* (ab.), *Lonicera Periclymenum* (ab.), *Viola sylvatica* (p.), *Crataegus Oxyacantha* (p.), Mosses (p.), *Thuidium tamarascinum*, *Dicranum scoparium*.

The soil is as in Plot 3.

Growth has been slow and the canopy, though now forming, has not yet closed. The height growth is uniform over the area

but there are great variations in the heights of individual trees. The stems generally are straight, although several have been badly distorted by honeysuckle. The branches are long and fairly heavy and are in almost all cases alive down to the ground. In the spring of 1927 the crop was found to be suffering from a severe attack of *Rhabdocline Pseudotsugae* which was causing almost complete defoliation.

PLOT 5.—OREGON DOUGLAS FIR.

Age—21 years. Mean height—32 ft. Mean ¼ girth—3½ in. Volume per acre—1,205 cu. ft. Quality Class—less than IV.

The soil consists of a thin layer of raw humus over 24–30 in. stiff grey clay loam with a few stones over yellow clay with some flints to an indefinite depth.

The stocking is dense and regular except at the southern end of the plot where two large gaps have been caused by wind. The height growth has been exceedingly slow and is poorer at the northern end of the plot. The stems are straight, but many have been damaged by honeysuckle. The crowns of the dominants are large with long heavy branches. This, together with the comparatively short length of the internodes gives the crop a coarse appearance. In the cold clay soil the root development has been poor and many of the larger trees appear to be unstable. *Chermes cooleyi* has done some damage. The occurrence of *Rhabdocline* on the needles of some suppressed trees in contact with the infected Colorado Douglas fir of Plot 4 is a feature of considerable interest. A permanent sample plot was laid down in this plantation in May, 1927. This was thinned to a C1 grade only as it was considered to be inadvisable to thin more heavily on account of the poor root-hold of most of the trees. A small area at the northern end of the plot was given a crown thinning by way of comparison.

Immediately adjoining the garden there are other small blocks of conifers of the same age, a brief description of which may be of interest.

SUB-PLOT A.—SITKA SPRUCE.

Age—21 years. Mean height—32½ ft. Mean ¼ girth—3 in. Volume per acre—1,385 cu. ft. Quality Class—IV.

The plot is situated in Forest Compartment 52 on the opposite (north-east) side of the main ride to the plots described above and nearly on a level with the Oregon Douglas fir (Plot 5).

There is no soil vegetation. The soil consists of a thin layer of needles and humus on 6 in. grey loam on 6 in. yellow loam passing into yellow clay loam and clay with some flints.

The trees were planted at 4 ft. apart and no thinning had been carried out up to the time of measurement. Suppressed trees were numerous, about 1,200 trees per acre being marked in a light thinning, while over 2,000 per acre still remain. The stand as a whole has shown very irregular development but within the past five to ten years the crop has evened up in a remarkable manner; apart from a few relatively small patches of backward growth the stand is now fairly uniform. Analysis of dominant trees showed that these had not checked badly in growth, the trees attaining a height of 5 ft. in 6 years and 10 ft. in 9 years, thereafter growth has been at a rate of 24–30 in. per annum. The stems are well shaped and the branches light.

Sub-Plot B.—Corsican Pine.

Age—21 years. Mean height—34 ft. Mean ¼ girth—4¼ in. Volume per acre—1,630 cu. ft. Quality Class—I.

The plot is situated in Forest Compartment 52 immediately to the north-east of the Sitka spruce, Sub-plot A, and to the north-west of Plots 2, 3 and 4 in the forest garden.

The soil vegetation is patchy there being considerable areas bare, or almost bare, of undergrowth—*Rubus fruticosus* (p.), *Teucrium Scorodonia* (Sc.), *Viola sylvatica* (Sc.), *Veronica officinalis* (Sc.), *Pteris aquilina* (p.), *Lastraea dilatata* (p.), Mosses (p.), *Thuidium tamariscinum.*

The soil consists of 1 in. of needles and humus passing abruptly into a layer of variable depth (2–12 in.) of grey loam on 6 in. of yellow clay loam over yellow clay with numerous stones.

The stocking is somewhat irregular with alternation of dense and more open groups of trees. There are a few European larch scattered through the crop but these are mostly shorter and much smaller in girth than the pine. The highest growth has been uniform and rapid, averaging 20 in. per annum after the first five years. The stems are straight but the larger trees are very coarsely branched while some of the smaller stems have markedly adpressed crowns.

Sub-Plot C.—European Larch and Scots Pine.

Age—21 years.

European larch: Mean height—36½ ft. Mean ¼ girth—3¼ in. Volume per acre—750 cu. ft.

Scots pine: Mean height—32 ft. Mean ¼ girth—3¼ in. Volume per acre—390 cu. ft.

The plot is situated in Forest Compartment 53 adjoining and to the south-west of Plot 5, Oregon Douglas fir, described above.

The soil vegetation is moderately abundant—*Rubus fruticosus* (ab.), *Teucrium Scorodonia* (p.), *Lonicera Periclymenum* (p.), *Lapsana communis* (sc.), *Primula veris* (p.), Mosses (p), *Thuidium tamariscinum.*

The soil consists of 1 in. humus over a variable depth of yellowish loam (12–30 in.) on stiff yellow clay.

The crop was planted at 4 ft by 4 ft. and was thinned in 1927 just prior to the measurement of the plot. The two species have maintained a fairly uniform rate of growth but the larch appears now to be taking the lead. The larch stems are rather badly cankered; there is still a good deal of resin flowing but most of the cankers appear to be occluding. The form of the stems is only moderate and the crowns are small as a result of overcrowding. The Scots pine have grown fast and show a good girth development but the stems are inclined to be coarse and many have defective tops.

CEIRIOG.

PART I.—LOCALITY DESCRIPTION.

General.—The area extends to 50 acres and is divided into 31 plots, each extending to 1¼ acres, and a number of smaller areas on which groups, mostly of less common species, have been planted. A shelter belt of mixed conifers and hardwoods extends along the southern and western margins of the area. Planting commenced in the spring of 1907 and all the plots had been completed by the spring of 1910. Some of the groups were planted in 1913 and 1914.

The following is a list of the plots and groups with the species represented :—

		Planted.
Plot	1.—Sycamore (*Acer Pseudoplatanus*, Linn.), Oak (*Quercus pedunculata*, Ehrh.) and Beech (*Fagus sylvatica*, Linn.)	1907
,,	2.—Ash (*Fraxinus excelsior*, Linn.) and Beech (*Fagus sylvatica*, Linn.)	1907
,,	3.—European larch (*Larix europaea*, D.C.) and beech (*Fagus sylvatica*, Linn.)	1907
,,	4.—Douglas fir (*Pseudotsuga Douglasii*, Carr.) ..	1907
,,	5.—Sitka spruce (*Picea sitchensis*, Trautv. & Mey.) and Norway spruce (*Picea excelsa*, Link.) ..	1907
,,	6.—European larch (*Larix europaea*, D.C.).. ..	1907
,,	7.—European larch (*Larix europaea*, D.C.) and sycamore (*Acer Pseudoplatanus*, Linn.) ..	1907
,,	8.—European larch (*Larix europaea*, D.C.) and Douglas fir (*Pseudotsuga Douglasii*, Carr.)..	1908
,,	9.—Japanese larch (*Larix leptolepis*, Murr.) and Douglas fir (*Pseudotsuga Douglasii*, Carr.)..	1908

Planted.

Plot 10.—Corsican pine (*Pinus Laricio*, Poir.), Japanese larch (*Larix leptolepis*, Murr.) and Sitka spruce (*Picea sitchensis*, Trautv. & Mey.) .. 1907
,, 11.—Scots pine (*Pinus sylvestris*, Linn.), Japanese larch (*Larix leptolepis*, Murr.) and Norway spruce (*Picea excelsa*, Link.).. 1907
,, 12.—Norway spruce (*Picea excelsa*, Link.) and Silver fir (*Abies pectinata* D.C.) 1907
,, 13.—Scots pine (*Pinus sylvestris*, Linn.) and European larch (*Larix europaea*, D.C.) 1908
,, 14.—European larch (*Larix europaea*, D.C.) and Norway spruce (*Picea excelsa*, Link.) .. 1908
,, 15.—Japanese larch (*Larix leptolepis*, Murr.) .. 1908
Plots 16–20.—Scots pine (*Pinus sylvestris*, Linn.), European larch (*Larix europaea*, D.C.) and Norway spruce (*Picea excelsa*, Link.).. 1908
Plot 21.—Douglas fir (*Pseudotsuga Douglasii*, Carr.), European larch, (*Larix europaea*, D.C.), Norway spruce (*Picea excelsa*, Link.) and *Thuya plicata* 1909
Plots 22 & 23.—European larch (*Larix europaea*, D.C.), Silver fir (*Abies pectinata*, D.C.) and Scots pine (*Pinus sylvestris*, Linn.) 1908
Plots 24 & 25.—European larch (*Larix europaea*, D.C.) .. 1908
Plot 26.—Norway spruce (*Picea excelsa*, Link.) 1908
,, 27.—Corsican pine (*Pinus Laricio*, Poir.) 1908 & 1909
,, 28.—Scots pine (*Pinus sylvestris*, Linn.) 1908
,, 29.—Norway spruce (*Picea excelsa*, Link.) 1908
,, 30.—Western red cedar (*Thuya plicata*, D. Don.) .. 1909
,, 31.—Douglas fir (*Pseudotsuga Douglasii*, Carr.) .. 1909

Group 32.—Japanese larch (*Larix leptolepis*, Murr.) and *Abies grandis*, Lindl. 1907
,, 33.—American larch (*Larix americana*, Michx.) (1908) and Western hemlock spruce (*Tsuga heterophylla*, Sarg.) (1914)
,, 34.—Siberian larch (*Larix sibirica*, Ledeb.) .. 1908
,, 37.—Fraser River Douglas fir (*Pseudotuga Douglasii*, var. *caesia*. Schwerin.).. .. 1909
,, 38.—Scots pine (*Pinus sylvestris*, Linn.) 1910
,, 39.—*Abies grandis*, Lindl. 1910
,, 40.—*Abies concolor*, Lindl. & Gord. 1910
,, 41.—Japanese larch (*Larix leptolepis*, Murr.) .. 1910
,, 42.—Serbian spruce (*Picea Omorica*, Bolle) .. 1910
,, 43.—Lawson's cypress (*Chamaecyparis Lawsoniana*, Parl.) 1910

Planted.

Group 44.—Douglas fir (*Pseudotsuga Douglasii*, Carr.) and Sitka spruce (*Picea sitchensis*, Trautv. & Mey.) 1910

,, 45.—Douglas fir (*Pseudotsuga Douglasii*, Carr.) and *Thuya plicata*, D. Don. 1910

,, 46.—Western American larch (*Larix occidentalis*, Nutt.) 1913

,, 47.—Oregon Douglas fir (*Pseudotsuga Douglasii*, Carr.) 1909

,, 48.—Colorado Douglas fir (*Pseudotsuga glauca*, Mayr.) 1909

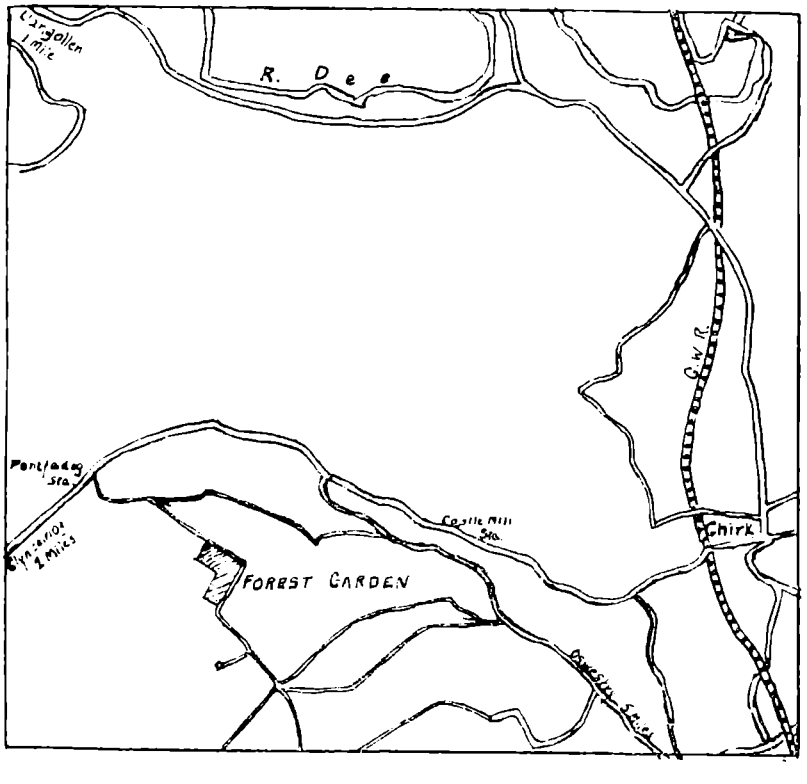
,, 49.—Himalayan spruce (*Picea morinda*, Link.) .. 1914

,, 50.—Norway spruce (*Picea excelsa*, Link.) .. 1914

,, 51.—*Abies nobilis*, Lindl. 1910

Situation.—The forest garden lies on the southern side of the Ceiriog valley and is about three miles distant from the village of Chirk. From Pontfadog and Castlemill stations on the Glyn Valley railway it is 1½ miles and 2 miles distant respectively. It is 9½ miles by road north-west of Oswestry. (*See* small sketch map below.)

Ordnance Survey Sheet—6 in.—Denbighshire, 39 S.E.
,, ,, ,, —1 in.—England, 51.



Topography.—The forest garden lies some 600–700 feet above the level of the River Ceiriog, at an elevation of 1,000–1,250 feet, occupying a steeply sloping piece of land just below the summit of a hill 1,330 feet in height. The aspect generally is to the north-east, but part of the area has a northerly and part a south-easterly aspect, as the ground falls away on either side from the main central ride of the garden.

The surrounding country to the west and south-west is hilly, heights of 2,500 feet being found within 15 miles to the south-west; to the north-west and north there is a country of a similar type but with lower elevations. A few miles to the east, the land falls away into the plain of North Shropshire and Cheshire.

Climate.—The climate is favourable to tree growth. It is generally mild with winter temperatures rather higher than those in the south and south-east of England, but with lower temperatures in summer. The mean annual temperature is about 49° F. Late spring frosts cause considerable damage at times. The rainfall is moderate, from 40 to 45 inches per annum and the prevailing wind is south-westerly.

Exposure.—The garden may be described as fully exposed but the effects of exposure vary much from place to place in consequence of the local topography.

The most seriously exposed portion is that at the south-west corner which is subject to constant winds from that quarter blowing down the Ceiriog valley. All the plots to the west of the central ride are more or less affected in this manner, but chiefly Plots 5–7, 10, 11, 16 and 17. Plots 22–29 are still protected by the shelter belt on the south-western side, although the larch in Plot 24 are growing out of this shelter, and the belt along the western border does not protect the higher-lying plots.

In addition to general exposure to the north and north-east, the plots on the eastern side of the central ride lie open to winds from the east, north-east and south-east.

Geology and Soil.—The geological formation is Silurian (Lower Ludlow Shales) and the rock is a moderately soft shale. The soil is moderately deep and consists of a brownish loam which is fairly uniform over the area.

Soil Vegetation.—Before planting, the vegetation consisted of a rough pasture with a strong growth of gorse (*Ulex europaeus*) and bracken (*Pteris aquilina*). The surrounding land is still of this type, but has been heavily grazed. The following species are found—*Ulex europaeus* (ab.), *Pteris aquilina* (ab.), Grasses (ab.).

Mosses (p.)—*Hyloconium squarrosum, Plagiothecium denticulatum—Galium saxatile* (p.) *Carduus* sp. (p) *Veronica officinalis* (p.), *Ranunculus repens* (p.), *Digitalis purpurea* (p.).

Silvicultural Treatment.—The planting distance in all the plots (1–31) was 4 ft. by 4 ft. with one or two exceptions, which are noted in the subsequent section. The planting distance in the groups (32–51) was 6 ft. by 6 ft. When mixtures were planted, equal numbers of the various component species were used. In planting, grass and other weeds were removed from a patch of soil about 15 inches square and the soil thoroughly stirred with a mattock. The plant was then inserted with a trowel. Other methods as mentioned below were tried in some of the plots. Losses after planting were low and the crops established themselves uniformly.

Up to 1914, annual measurements of heights were taken in each plot, and this work was resumed in 1918. Measurements are now taken each second year. A certain number of the plots have been pruned and thinned, and these operations are being continued and extended.

PART II.—DETAILED DESCRIPTION OF THE PLOTS.

Plot 1.—Oak, Beech and Sycamore.

Age—23 years.

Sycamore : Mean height—23½ ft.

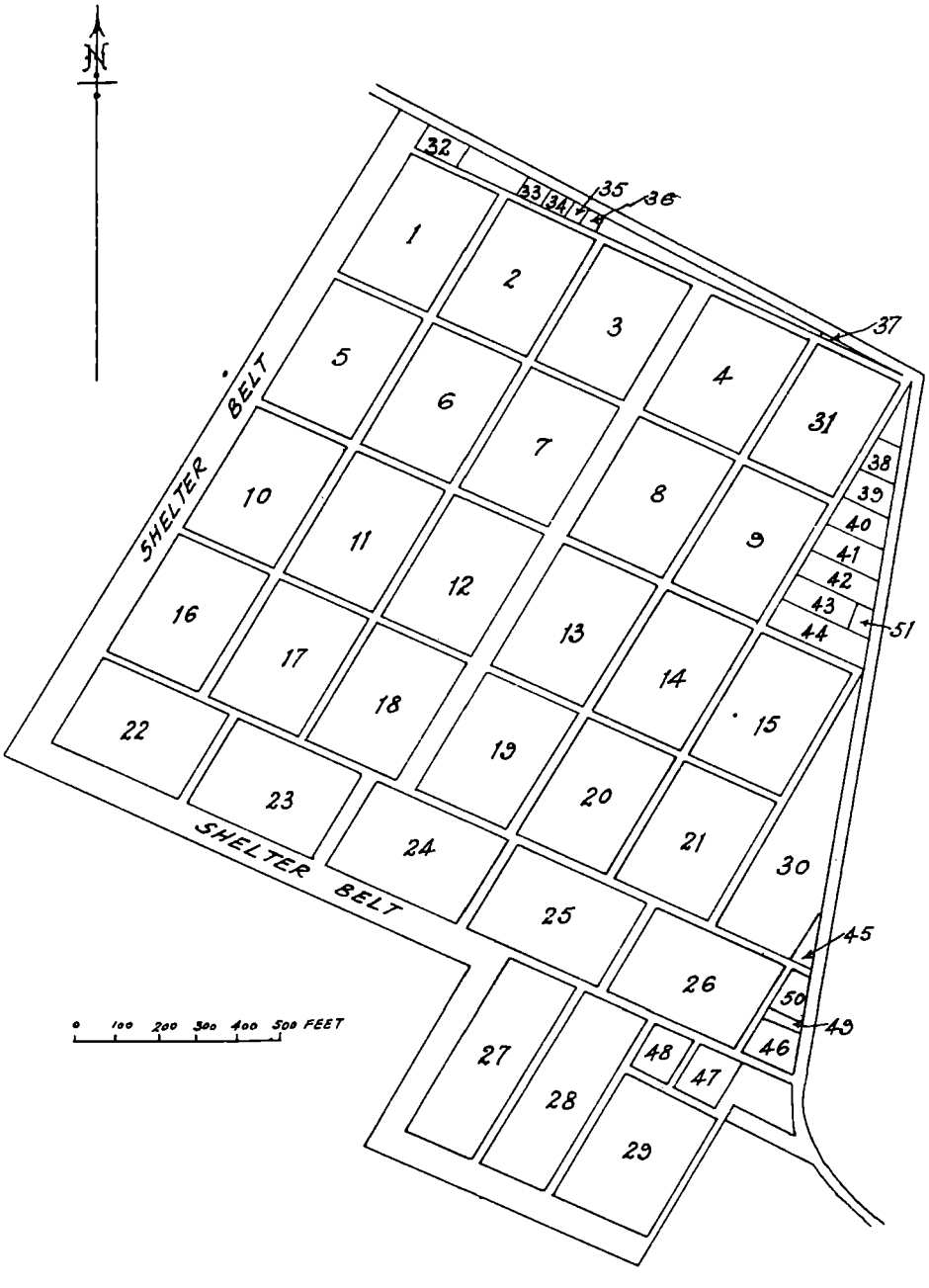
Oak : Mean height—22½ ft.

Beech : Mean height—22½ ft.

The soil vegetation is scanty—some *Pteris aquilina* and *Catharinea undulata*. There is little humus, but deeper pockets occur in places. The soil is a moderately open loam with fragments of shale to a depth of about 20 inches.

The plot was formed with alternate plants of each species, the plants used being 2 + 2 sycamore, 3 + 2 oak and 2 + 1 beech. Height growth at the beginning was slow, but is now improving, especially with the beech and sycamore. Many of the oak have been suppressed, but several which have survived are of good size. The beech suffered at one time from attacks by rabbits and many gaps were caused thereby, but no damage appears to have been done recently. Where the beech have been killed out in this way the sycamore are dominant, but elsewhere the beech are rather the dominating species. The stems are cleaning themselves in a satisfactory manner.

CEIRIOG



P3647

PLOT 2.—ASH AND BEECH.

Age—23 years.

Ash : Mean height—26 ft.

The vegetation is moderately abundant—*Pteris aquilina* (p.), Grasses (p.), *Veronica officinalis* (p.), *Viola sylvatica* (p.), *Rubus fruticosus* (sc.), Mosses (ab.), *Catharinea undulata* (p.), *Brachythecium purum* (p.), *Hylocomium squarrosum* (p.).

The plants used were 2 + 3 transplants of ash and 1 + 3 transplants of beech.

The beech were interplanted with the ash in order to maintain the fertility of the soil, but, unfortunately, they have been attacked by rabbits and killed out over a large part of the plot. A number of beech have survived at the northern end of the plot and are beginning to outgrow and dominate the ash there. The ash made very poor growth after planting, due to the large plants employed, but are now growing faster. The trees are of poor quality. The death of the beech left them spaced too widely for the development of the best type of tree ; the side branches are long and heavy, there are many low forks, and green epicormic shoots are abundant on the stems. The height growth of the ash appears to be best where the beech remain in mixture.

PLOT 3.—EUROPEAN LARCH AND BEECH.

Age—23 years.

European larch : Mean height—30½ ft. Quality Class—III.

The soil vegetation is scanty—*Sambucus nigra* (sc.), *Pteris aquilina* (p.), *Catharinea undulata* (sc.), *Thuidium tamariscinum* (sc.). There is a layer of moderately well decomposed humus over a soil similar to that in Plot 1.

The larch and beech were both 2 + 1 transplants.

The beech in this plot were also planted in order to conserve the fertility of the soil, but they have been largely killed out by rabbits, and the larch are now practically a pure crop. The larch form a dense stand with small crowns and long, slender, drawn-up stems. The bark is distinctly reddish in colour. There is some larch canker, but this has done comparatively little damage. The tops of many of the larch are showing signs of exposure. There has been a slight attack by *Argyresthia*.

PLOT 4.—OREGON DOUGLAS FIR.

Age—23 years. Mean height—34½ ft. Volume per acre—2,586 cu. ft. Quality Class—below IV.

There is no soil vegetation. The soil consists of ½-1 in. humus over 12-18 inches loam with fragments of shale over broken rock.

2 + 1 transplants of Douglas fir were used in planting.

This has been a highly successful plot and is now dense and regular. The height growth is uniform over the plot except that there is a slight falling off towards the southern end. The trees are of an excellent type. The stems are straight, except for a slight curvature at the butt, due to exposure to wind after planting, and the branching is light. Along the northern and western edges of the plot the effect of exposure is now visible, and the crowns of the more exposed trees are quite bare on the side next the wind. The exposure, however, does not appear as yet to have checked the height growth. The crop is suffering from a severe attack of *Chermes cooleyi*. Some typical *Phomopsis* cankers are to be seen along the edges of the plot, where injuries have been caused in pruning.

Plot 5.—Sitka Spruce and Norway Spruce.

Age—23 years.

Sitka spruce: Mean height—32 ft. Quality Class—below IV.

There is no soil vegetation. There are 1½–2 inches raw humus over ½ inch well decomposed humus over soil similar to that in Plot 1. The species were planted alternately, the plants used being 2 + 1 + 1 transplants of Sitka spruce and 2 + 2 transplants of Norway spruce. The height growth falls off markedly towards the southern end of the plot where the trees are only half the height of those at the north. At that end the canopy has not yet closed, and the Norway spruce has not yet been suppressed, whereas on the lower ground to the north the crop is dense, the canopy unbroken and the Norway spruce completely suppressed. The Sitka spruce are large and shapely trees with straight stems and good crowns. The branches are long but light. The mixture is fast turning into a crop of pure Sitka spruce.

Plot 6.—European Larch.

Age—23 years. Quality Class—IV.

The soil vegetation is abundant—*Pteris aquilina* (ab.), Grasses (ab.), *Galium saxatile* (ab.), *Digitalis purpurea* (p.), *Urtica dioica* (p.), *Viola sylvatica* (p.), *Veronica officinalis* (p.), *Rubus fruticosus* (sc.), *Sambucus nigra* (sc.).

The humus is only ½ inch in depth and the soil is shallower than in Plot 1.

2 + 1 transplants of larch were used at planting.

This has been a disappointing crop. The site is more exposed than that of any of the plots described above, and many of the trees are suffering badly from exposure. The trees generally are leaning away from the west and their tops are badly whipped,

with one-sided and bent-over crowns. Canker has also done much damage. Numerous deaths have taken place, with the result that the crop has now become gappy and irregular in stocking. The plants used in this plot were raised from Continental seed.

Plot 7.—European Larch and Sycamore.

Age—23 years.

European larch : Mean height—30 ft. Quality Class—IV.

Sycamore : Mean height—28 ft.

There is no soil vegetation except for patches of *Lastraea spinulosa.*

The humus varies in depth, accumulating in pockets, but is generally ½ inch deep. It is mainly of the broadleaved type.

This is a companion plot to Plot 3, sycamore having been used here in place of beech; owing, however, to the disappearance of the beech in Plot 3 a comparison is no longer possible. The plants used were 2 + 1 transplants of European larch and 2 + 2 transplants of sycamore. The exposure to the west is severe, and this is reflected in the growth of the larch, the tops of which are defective, many being bent over and curved away from the wind. Damage has also been caused by the taller sycamore, which have whipped many of the larch crowns severely. The stems of the larch are wavy and cankered, and the crop appears to be lacking in vigour. The sycamore, on the other hand, though dominated by the larch for some years, are now growing strongly. They form a satisfactory crop; the stems are straight, and the crowns sufficient, but the branching is heavy, and there are several low forks. If left unchecked, the sycamore in this plot will undoubtedly suppress the larch over the greater part of the area in a few years' time.

Plot 8.—European Larch and Oregon Douglas Fir.

Age—22 years.

European larch : Mean height—31 ft. Quality Class—III.

Douglas fir : Mean height—34½ ft. Quality Class—below IV.

There is no soil vegetation. There is 1 inch raw humus on ½ inch well decomposed humus. The soil is similar to that in Plot 4 but shallower, especially towards the southern end of the plot.

The plants used were 2 + 2 European larch transplants, and 2 + 1 + 1 transplants of Douglas fir.

This is an interesting mixture. For about 15 years after planting the larch showed rather better growth than the Douglas fir, but recently the latter have been growing faster and the crop will probably end as a pure stand of Douglas fir. The Douglas fir have

already suppressed the larch at the north-west corner of the plot, but elsewhere the crowns of the larch are still free. The height growth of both species, but especially of the larch, falls off markedly towards the southern end of the plot. This decrease is associated with shallower soil and increasing exposure. The larch stems are only of moderate quality. The Douglas fir are almost free from attack by *Chermes*, and are satisfactory as regards stem and branch development. Many of the crowns, however, have been badly whipped.

PLOT 9.—JAPANESE LARCH AND OREGON DOUGLAS FIR.

Age—22 years.

Japanese larch : Mean height—40 ft. Quality Class—II.

Douglas fir : Mean height—34½ ft. Quality Class—below IV.

There is no soil vegetation. There are accumulations of humus, partly decomposed, up to 2 inches deep, and the soil is as in Plot 4.

The plot was planted with 1 + 1 transplants of Japanese larch and 2 + 2 Douglas fir.

The crop is dense and the trees are long and drawn up. As is usual with this mixture the Douglas fir were suppressed at an early age, but several of them have succeeded in retaining a place in the canopy, although they are not numerous enough to form a crop by themselves. The Japanese larch crop contains only a small proportion of crooked and defective stems and, though in need of thinning, is quite satisfactory. Almost all the trees show a distinct curvature at the butt away from the direction of the prevailing wind.

This plot makes an interesting comparison with Plot 8.

PLOT 10.—CORSICAN PINE, JAPANESE LARCH AND SITKA SPRUCE.

Age—23 years.

Japanese larch : Mean height—30 ft. Quality Class—II.

There is no soil vegetation. The soil consists of 1 inch raw humus over 12 inches loam with fragments of shale.

This plot is fully exposed to the west and partially exposed to the south-west.

The species were planted alternately, and the following plants were used :—Japanese larch, 1 + 1 transplants ; Corsican pine, 2 + 2 transplants ; Sitka spruce, 2 + 1 transplants. The Japanese larch suppressed the other species at an early stage, and the Corsican pine are now almost all dead, while the Sitka spruce are completely suppressed except along the edges of the plot. The Japanese larch form a complete crop with a dense canopy. The trees are not, however, of a good type, as the severe exposure has produced bent and wavy stems and defective tops.

PLOT 11.—JAPANESE LARCH, SCOTS PINE AND NORWAY SPRUCE.

Age—23 years.

Japanese larch : Mean height—38 ft. Quality Class—II.

There is no soil vegetation. The soil is as in Plot 10. The plants used were 1 + 1 Japanese larch transplants, 2 + 1 + 1 Scots pine transplants and 2 + 2 transplants of Norway spruce.

This plot may serve as a comparison with Plot 10 where, instead of Scots pine and Norway spruce, Corsican pine and Sitka spruce were mixed with the Japanese larch. The result in each plot has been the same. Both Scots pine and Corsican pine have been almost all killed out by the Japanese larch, though there is evidence that the Scots pine survived longer, while Norway as well as Sitka spruce have been completely suppressed. In their suppression, the Norway spruce look much healthier than the Sitka, and show the greater tolerance of shade. The Japanese larch form a complete crop. The height growth falls off slightly towards the southern end of the plot. The stems are curved at the butt, but are otherwise straight, and the crowns are better than in Plot 10 as a result of the shelter provided by that plot.

PLOT 12.—NORWAY SPRUCE AND SILVER FIR.

Norway spruce : Age—23 years. Mean height—23 ft. Quality Class—IV.

There is no soil vegetation, but *Ulex* and *Rubus* have only recently been killed. The humus is 1–2 inches in depth and partly decomposed.

Norway spruce and silver fir were planted alternately, the plants used being 2 + 1 Norway spruce transplants and 2 + 2 + 1 silver fir. In consequence of a severe attack of the silver fir chermes—*Dreyfusia nüsslini*—the silver fir have almost all disappeared, and the spruce thus remain in pure crop. Growth has been slow and the canopy has not quite closed over all the area, but leading shoots now average 12 inches in length. The stems are straight, but are coarse as a result of the slow growth and heavy branch development in early life.

PLOT 13.—EUROPEAN LARCH AND SCOTS PINE.

Age—22 years.

European larch : Quality Class—IV.

Scots pine : Quality Class—III

European larch 2 + 1 transplants and Scots pine 2 + 1 + 1 transplants were planted alternately. Growth has been slow, but

the larch have kept ahead of the pine from the beginning and have completely suppressed them in places. Generally, however, the pine still retain a place in the canopy. The stems of the pine are not of the best type, the branching is heavy and the crowns are being damaged by the larch.

The larch are showing the effects of exposure along the western edge of the plot where the crowns are becoming one-sided and bare.

Plot 14.—European Larch and Norway Spruce.

Age—22 years.

European larch: Quality Class—IV.

There is no soil vegetation.

The species were planted alternately, 2 + 1 transplants being used, and the larch have completely suppressed the spruce over the whole area.

The larch form a uniform crop. The height growth varies a little from place to place, but there is no marked falling off in any one direction. The stems are all curved slightly at the butt away from the south-west and many are wavy and defective. A few trees have been blown over and several co-dominants have been bent over and caught in the tops of dominant trees.

The spruce, though suppressed, are quite healthy and may recover when the larch are thinned.

Plot 15.—Japanese Larch.

Age—22 years. Mean height—39 ft. Quality Class—II.

There is no soil vegetation. The humus is from 1-2 inches deep, and is partly decomposed. The soil consists of 18 inches loam with fragments of shale on broken rock.

This plot has been thinned in two sections. In the eastern half the thinning was heavier, badly shaped dominants and sub-dominants being removed as well as whips and suppressed trees, whereas in the western half only the suppressed trees and whips were taken.

The crop is dense and the stems long and slender with small crowns, but the more heavily thinned section of the plot has now much the better appearance.

Plots 16-20.—Scots Pine, European Larch and Norway Spruce.

Age—22 years.

Mean height of Plot 17—Scots pine, 20½ ft.; European larch, 27 ft.; Norway spruce, 24½ ft.

This series of plots was laid out to illustrate the effect of different treatments upon the growth of these three species in mixture. The plots were established as follows:—

Plot No.	Planting distance.	Plants used.	Method of planting.	Treatment.
16	4 ft. × 4 ft.	2 yr., 2 yr.	" Holing "	Heavy thinning.
17	6 ft. × 6 ft.	2 yr., 2 yr.	" Holing "	Normal thinning.
18	4 ft. × 4 ft.	2 yr., 2 yr.	" Notching "	Normal thinning.
19	4 ft. × 4 ft.	2 yr., 2 yr.	" Holing "	Normal thinning.
20	3 ft. × 3 ft.	2-yr. seedlings	" Vertical Notching "	Normal thinning.

The plots are fairly uniform in situation. Exposure is most severe in Plot 16 and decreases through the different plots to Plot 20 which is the best sheltered. The southern edge of each plot is the most exposed portion. In Plots 16, 17 and 18, the soil is shallower in the southern half, but in Plots 19 and 20 the soil conditions appear to be uniform all over.

Alternate plants of each species were set out in lines in each plot and 2 + 2 transplants were used in all plots, except Plot 20 where 2-yr. seedlings were employed. It is possible to compare in this series the effects of (*a*) different methods of planting, and (*b*) different planting distances on the development of this mixture.

" Notching " in Plot 18 was carried out in the usual manner with a spade and the " vertical notching " in Plot 20 with a heavy-wedge-shaped implement of iron. The " holing " in the other plots consisted of removing weed growth from a patch about 15 in. square, stirring the soil with a mattock and inserting the plant by means of a trowel. As regards the method of planting, notching led to much heavier losses but the method appears to have had little effect on the subsequent growth of the trees.

The effect of the different planting distances is more marked. The wide planting (6 ft. × 6 ft.) in Plot 17 has resulted in a much coarser crop while the close planting (3 ft. × 3 ft.) in Plot 20 has resulted in the suppression of both the Scots pine and the Norway spruce. In all the plots the larch grew faster to begin with than either of the other species, but owing to the wider planting distances was unable to form a canopy over them, whereas with the closer planting in Plot 20 it was able to close over and suppress them. It should at the same time be stated that the larch in Plot 20 are not so severely affected by exposure as in the other plots where their growth is now falling off.

Plot 16, for which heavy thinning has been prescribed, was thinned in 1921 when about a third of the trees were removed. There is a considerable difference between the growth of the three

species at the northern end of the plot and their growth on the higher ground to the south. On the lower ground the larch have grown much faster than the other species and have dominated them. The Scots pine are in a backward state, but the spruce are now beginning to grow faster though still far behind the larch. To the south the larch have suffered from the exposure and have been overtaken both by the pine and by the spruce.

The same features are evident in Plots 17, 18 and 19. The larch makes much better growth in the more sheltered places, but in exposed situations falls off early in height growth, and is overtaken by the Norway spruce. The Scots pine is generally close behind the spruce.

The best growth of spruce is to be found in Plot 19.

Plot 20 is an irregular crop in which the Scots pine and spruce have been completely suppressed except along the southern edge of the plot. The growth of the larch is not so good as in Plot 19, and is much poorer at the southern end of the plot where the exposure increases.

PLOT 21.—OREGON DOUGLAS FIR, EUROPEAN LARCH, NORWAY SPRUCE AND *THUYA PLICATA*.

Age—21 years.

Douglas fir: Quality Class—IV.

European larch: Quality Class—III.

There is no soil vegetation. The humus is ½-1 inch deep and well decomposed. The soil is as in Plot 15.

The plot was formed with alternate trees of each species. The spruce and *Thuya* have been completely suppressed and killed out except along the edges of the plot where a few survive. The crop is now composed of a mixture of Douglas fir and European larch with Douglas fir as the dominant species. The larch have small crowns and badly shaped and cankered stems. The Douglas fir are large, rough, heavily branched trees mostly with bad tops.

PLOTS 22 AND 23.—EUROPEAN LARCH, SCOTS PINE AND SILVER FIR.

Age—22 years.

Plot 23. European larch: Mean height—25½ ft. Quality Class—IV.
Silver fir: Mean height—12 ft.
Scots pine: Mean height—21½ ft.

These plots are situated at the highest point of the forest garden and are considerably exposed though protected by the shelter belt to the south and west.

The growth has been slow and is rather better in Plot 23. The silver fir have suffered badly from the *Chermes*, which has caused

many deaths, and more recently from rabbits which are still carrying out their attacks. One or two silver firs in Plot 23 have grown up into the canopy, but the majority are completely suppressed. The European larch are taller in Plot 23 where they are still ahead of the Scots pine, but in Plot 22 they are less vigorous and are being overtaken by the pine which is withstanding the exposure better. Many of the larch are badly shaped and suffering from canker. The Scots pine have straight stems and good crowns but the branching is coarse and heavy.

Plots 24 and 25.—European Larch.

Plot 24. Age—22 years. Mean height—28 ft. Quality Class—III.
Plot 25. Age—22 years. Mean height—27 ft. Quality Class—III.

These plots illustrate the development of European larch raised from seed of different origins, Plot 24 having been formed with plants raised from seed obtained from the Atholl estates in Perthshire and Plot 25 with plants from German seed.

The vegetation in both plots is abundant—*Holcus lanatus* and other grasses (ab.), *Urtica dioica* (ab.) to (p.), *Rubus Idaeus* (p.), *Galium saxatile* (p.), *Rubus fruticosus* (p.), *Veronica officinalis*, *Veronica chamaedrys* (p.), *Scrophularia nodosa* (p.), *Digitalis purpurea*, (sc.), *Epilobium angustifolium* (sc.).

Plot 24 has proved to be very much the better, and now forms a dense regular crop with slender stems and small crowns. It is comparatively free from canker. Plot 25, on the other hand, where the plants were weak originally, has been an almost complete failure, the stems are crooked and bent. Larch canker has been extremely severe, and has been responsible for the death of many trees, the disappearance of which has resulted in large gaps.

This plot and Plot 6 are distinctly inferior to Plot 24, and indicate that, for the conditions in this area, the plants of foreign origin are not so well suited as the plants from Scotland.

Plot 26.—Norway Spruce.

Age—22 years. Mean height—26½ ft. Quality Class—IV.

This plot was planted in two sections, the western half having been planted in the autumn of 1907, and the eastern half in the spring of 1908. The crop now forms a dense thicket with the growth rather better at the western end of the plot. The crop has grown slowly to begin with, but the growth is now improving, the leading shoots being up to 18 inches in length. The stems are straight, but heavily branched.

PLOT 27.—CORSICAN PINE.

Age—22 years. Mean height—28 ft. Quality Class—III.

The soil vegetation is scanty—*Ranunculus repens* (sc.), *Lysimachia nemorum* (sc.), *Veronica officinalis* (sc.), *Plagiothecium denticulatum* (sc.), *Catharinea undulata* (sc.). The soil consists of ½ inch raw humus over 15–18 inches brown loam with rock fragments.

This plot was planted in three sections, two-fifths of the plot in autumn, 1907, two-fifths in spring, 1908, and one-fifth in spring, 1909. There is no difference in growth between the sections planted in 1907 and 1908, but the trees planted in 1909 are not quite as tall as the others. After various tests, it was found that the best results with Corsican pine were obtained with plants which had been transplanted the previous year in the nursery, and planted out after the growing season had commenced. The growth in this plot was slow to begin with, but has now improved. The crop is irregular and gappy in places, and the trees appear to be lacking in vigour.

PLOT 28.—SCOTS PINE.

Age—22 years. Mean height—26 ft. Quality Class—II.

There is no soil vegetation. The soil is as in Plot 27.

The height growth has been good. The crop is dense and the stems slender and with heavy branching. The crowns are thin and appear to be suffering slightly from the exposure. Compared with the Corsican pine in Plot 27, the Scots pine, though quite as tall, have smaller girths. They do not seem to be resisting the exposure so well as the Corsican pine.

PLOT 29. NORWAY SPRUCE.

Age—22 years. Mean height—21 ft. Quality Class—IV.

The plants used in this plot were allowed to remain three years in the seedbed, and were four years old at the time of planting. Growth was much slower in the early stages than in Plot 26, but is now quite as fast. The crop forms a dense thicket, rather irregular in places, but similar to that in Plot 26, though not quite so tall. It does not appear to have been affected by exposure.

PLOT 30.—*THUYA PLICATA*.

Age—21 years. Mean height—20½ ft.

The first season after planting was unfavourable, and a long spell of dry weather, with east winds, caused the death of many of the young trees. The gaps were filled up and the crop was establishing itself well, when further damage was done by rabbits.

From this damage the crop has not yet recovered. A canopy is forming at the southern corner, but elsewhere the plot is open and irregular. Height growth has been slow.

Plot 31.—Oregon Douglas Fir.

Age—21 years. Quality Class—below IV.

There is no soil vegetation. There is ½ inch humus over 15 inches brown loam with stones and rock fragments.

2 + 1 transplants were used.

The plot is similar to Plot 4, but two years younger. The crop, however, is not quite so good as there are more defective trees and the branching is coarser. The plot is better sheltered, and the stems are not curved at the butt to the same extent.

Group 32.—Japanese Larch and *Abies Grandis*.

Age—23 years.

Japanese larch: Mean height—37½ ft.

Abies grandis: Mean height—22½ ft.

This is a small group consisting of Japanese larch interplanted with *Abies grandis*, the planting distance being 6 feet. The *Abies* have been badly suppressed, except at the edges of the plot, but they are healthy and in good foliage, although the tops have been badly damaged by whipping. The Japanese larch are now of good size, but taper rapidly and are heavily branched.

Group 33.—*Larix Americana*, underplanted with *Tsuga Heterophylla*.

Larix americana: Age—22 years. Mean height—30 ft.

Western hemlock: Age—17 years. Mean height—9½ ft.

The larch were planted in the spring of 1908 and underplanted with *Tsuga* in the spring of 1914. The former have grown almost as fast as the Japanese larch in Group 32, where the conditions are similar. The stems, however, are more slender and the crowns narrower, but the branching is much less coarse. There has been a slight attack by the canker fungus (*Dasycypha calycina*), but little injury has been done.

A considerable number of *Tsuga* were killed by rabbits soon after they were planted, but the surviving trees are now growing reasonably well, after a slow start.

GROUP 34.—*LARIX SIBIRICA*.

Age—22 years. Mean height—14½ ft.

This group, consisting originally of 22 trees, has been reduced to half that number by deaths. The Siberian larch comes into leaf very early, and suffers regularly from frost, and most of the deaths in this group are attributable to this cause. The plants which remain are quite healthy, but the tallest are only about half the height of the American larch in Group 33.

GROUP 37.—OREGON DOUGLAS FIR (FRASER RIVER VARIETY).

Age—22 years. Mean height—22 ft.

This group was planted at the same time as Plot 31, and makes a comparison possible between the rate of growth of this type and that of the typical Oregon Douglas fir. The Fraser River variety has grown more slowly, although it is now making leaders of more than 12 inches in length. The interesting feature is the entire absence of *Chermes cooleyi*, which is infesting the green Douglas fir in the adjoining plot.

GROUP 38.—SCOTS PINE.

This group was planned to illustrate the development of races of Scots pine from various places of origin. Unfortunately, owing to rabbit damage, very few of the pine remain.

GROUP 39.—*ABIES GRANDIS*.

Age—20 years. Mean height—30½ ft.

This species now shows excellent growth, after a slow start, the leading shoots on some of the larger trees being more than 2 feet long. The development has been rather irregular and the trees vary much both in height and in diameter. The stems are straight and the branching light.

GROUP 40.—*ABIES CONCOLOR*.

Age—20 years. Mean height—16½ ft.

Growth has been slower than in Group 39, and the canopy has not yet formed, although at the present rate of growth it will have closed in a few years' time. The crop is irregular ; the stems are straight, except for slight curvature at the butt, but have numerous moderately heavy branches and are consequently coarse in appearance.

GROUP 41.—JAPANESE LARCH.

Age—20 years. Mean height—28½ ft.

The trees in this plot were planted at 6 feet apart, and the growth may be compared with that in Plot 15, where the Japanese larch were planted at 4 feet.

The height growth in both areas is similar, and the wider planting in this group has not affected the quality of the crop in any way. The branches are slightly longer, but no heavier than in the more closely planted plot, while the individual stems are larger.

GROUP 42.—*PICEA OMORICA*.

Age—20 years. Mean height—14½ ft.

The trees in this group are of handsome appearance. Growth has been slow and the trees bear living branches down to the ground, except at the western end of the group, where a canopy is forming.

GROUP 43.—LAWSON'S CYPRESS.

Age—20 years. Mean height—20½ ft.

The plants in this group suffered severely during transport and grew poorly for the first few years after planting out. Several trees have been killed by rabbits, and the stocking is in consequence irregular.

Height growth has been slow, but is becoming faster. Almost all the trees are forked, many at ground level, and a large number of stems are curved at the butt.

GROUP 44.—OREGON DOUGLAS FIR AND SITKA SPRUCE.

Age 20 years.

Douglas fir: Mean height—35 ft.

Sitka spruce: Mean height—30½ ft.

This, an interesting mixture of alternate trees of each species, has not been touched since the time of planting. The Douglas fir are dominant, and on the average are about 4 feet taller than the Sitka spruce. The Douglas fir are still putting out long leading shoots, but most of these are wavy, and there are many bad tops. Some of the larger Douglas fir have coarse stems with long heavy branches.

A few Sitka spruce are in the uppermost crown stratum, but their leaders are shorter than those of the corresponding Douglas fir; the majority of the Sitka spruce are dominated and suppressed.

GROUP 45.—DOUGLAS FIR AND *THUYA PLICATA*.

Age—20 years.

The *Thuya* have been completely suppressed. The Douglas fir are of a bad type, with coarse and twisted stems and long heavy branches. There are many defective tops, and the trees are heavily infested with *Chermes cooleyi*.

GROUP 46.—*LARIX OCCIDENTALIS*.

Age—17 years. Mean height—19 ft.

The plants in this group have been damaged by weed growth and by rabbits, and the crop in consequence is open and irregular. Growth has been slow (although now there are leaders of 12–15 inches in length), and this species has made poorer growth than any of the other larches with the exception of *L. sibirica*. The stems are straight and the branching is light.

GROUP 47.—OREGON DOUGLAS FIR.

GROUP 48.—COLORADO DOUGLAS FIR.

Age—21 years.

Oregon Douglas fir: Mean height—29½ ft.

Colorado Douglas fir: Mean height—17½ ft.

These groups, situated side by side, are intended to illustrate the relative growth of the two common varieties of the Douglas fir. In both groups 2 + 1 + 1 plants were used. Here, as always, the Oregon variety has surpassed the other in rate of growth and is still maintaining its position. The Oregon Douglas fir in Group 47 are extremely rough and are suffering from a heavy infestation of *Chermes cooleyi*. The Colorado Douglas fir, small trees with straight stems and numerous branches, are now forming a canopy.

GROUP 49.—*PICEA MORINDA*.

Age—16 years. Mean height—6 ft.

The group consists of only a few trees which have grown extremely slowly, although they are quite healthy in appearance.

GROUP 50.—NORWAY SPRUCE.

Age—16 years.

This group consisted of 100 plants from seed obtained from Switzerland, 50 from Ponte at an altitude of 6,175 ft., and 50 from

Winterthur, which is 1,625 ft. above sea-level. The plants from the higher elevation have almost all failed, having been killed by repeated frosts, whereas those from Winterthur (10 ft. in height), though exhibiting slow growth, are healthy and developing normally.

GROUP 51.—*ABIES NOBILIS.*

Age—20 years. Mean height—15 ft.

The growth over the area has been most irregular and the individual trees vary much in height. They are now forming leading shoots of good length. The stems are straight and the crowns satisfactory.

SHELTER BELT.

The shelter belt consists of a mixture of broadleaved and coniferous species. At present, with respect to height growth, the species are arranged in the following order :—*Pinus Laricio, Picea excelsa, Betula alba, Picea alba, Pyrus aucuparia, Acer Pseudoplatanus, Pinus montana.* The conifers, and in particular *Picea alba*, appear to be withstanding the exposure better than the broadleaved species. At the extreme south-west corner of the garden, where Norway spruce and the other conifers, as a result of the severe exposure, have bare tops, the *P. alba* has preserved its crowns almost undamaged.

LITERATURE.

The following are the references to publications dealing with this forest garden :—

(1) STORY, FRASER : "Chirk Experimental Forestry Station," *Quarterly Journal of Forestry*, Vol. 1, 1907.

(2) ——"EXPERIMENTAL FORESTRY AREA IN WALES," *Trans. Royal Scottish Arboricultural Society*, Vol. 27, 1913.

(3) —— "DENBIGHSHIRE COUNTY COUNCIL FORESTRY EXPERIMENTAL AREA." University College of North Wales, Bangor, 1913.

(4) THOMSON, THOMAS : "Notes on the Ceiriog Forestry Experimental Area." University of Wales, Bangor, 1922.

(5) —— "SOME NOTES ON THE CEIRIOG FORESTRY EXPERIMENTAL AREA." *Quarterly Journal of Forestry*, Vol. 21, 1927.

CHAPTER II.

DISCUSSION OF THE RATES OF GROWTH OF SPECIES IN EACH FOREST GARDEN.

From the previous chapter a general view will have been obtained of the various species that are on trial and the conditions to which they are subject. It now remains to make certain comparisons, first, of the development of different crops in one set of conditions (viz., in each forest garden), and secondly, as far as possible, of each species in the different conditions obtaining in the various gardens. The present chapter, therefore, will be devoted to a discussion of the comparative rates of growth of the different species in each locality, while the more general matter is reserved for treatment in the next chapter.

To a great extent the comparisons are based on height growth over the period during which the gardens have been in existence. At Ceiriog and at Abbotswood height measurements have been taken from time to time and it is possible with the aid of these figures to trace the development of the plots at different ages. But as no such records exist for any other garden, it was decided to base the comparisons of the different rates of height-growth on data obtained from ring-counts of stems felled in the various plots. This method is not absolutely reliable, but it is sufficiently accurate for the present purpose. For the garden at Ceiriog, use was made of the recorded heights of each plot at different ages. These heights having been taken at short intervals formed good series and any irregularities were smoothed out by plotting the height values against the ages and drawing smooth curves which were taken as expressing the relationship between age and mean height. These curves were adjusted where necessary to give, as the final age, the age from the date of planting and as the final height the mean height of the crop.

COCKLE PARK.

As a result of the variations in the site conditions to which reference has already been made, it is difficult to make comparisons of the rates of growth of the various species.

The growth in most of the plots was very slow at the beginning. There was a heavy growth of grass over the area and repeated frostings kept the young plants in check. The effect will be noted in the accompanying photographs which show the position in Plots 3 and 4, six years after planting.

Some idea of the development of the various species may be obtained from the following table which has been prepared from

ring counts on felled trees. It shows the heights to which the various species attained at different ages and represents as far as possible average conditions within each plot. In certain cases, the curves have been prolonged so as to give for comparison the mean height at thirty years of age. The figures obtained in this way are marked with an asterisk in the table.

Plot.	Species.	Mean Height in feet at—					
		5 yrs.	10 yrs.	15 yrs.	20 yrs.	25 yrs.	30 yrs.
1	Norway Spruce ..	3½	7	12	18	25	33½
2	Scots Pine	3	7½	13	19	25½	30
3	Douglas Fir	3	9½	20½	34	45	51
4	Sitka Spruce	2½	6½	14	25	36	43
5	Norway Spruce ..	2	5	9½	14½	20½	28
6B	Beech	3	7	14	23	31	36½
7	Japanese Larch ..	7	15	23½	30	36	40
8	Norway Spruce ..	2½	5	9	14	21	30*
	European Larch ..	5	11½	19½	28	36	43½*
9A	Japanese Larch ..	5	11½	19	25	30	34*
9B	Japanese Larch ..	5½	12½	21½	29½	—	—

The following table shows the height increments for the same plots over periods of five years.

Plot.	Species.	Height Increment in feet between—				
		5–10 yrs.	11–15yrs.	16–20yrs.	21–25yrs.	26–30yrs.
1	Norway Spruce ..	3½	5	6	7	8½
2	Scots Pine	4½	5½	6	6½	4½
3	Douglas Fir.. ..	6½	11	13½	11	6
4	Sitka Spruce ..	4	7½	11	11	7
5	Norway Spruce ..	3	4½	5	6	7½
6B	Beech	4	7	9	8	5½
7	Japanese Larch ..	8	8½	6½	6	4
8	Norway Spruce ..	2½	4	5	7	9
	European Larch ..	6½	8	8½	8	7½
9A	Japanese Larch ..	6½	7½	6	5	4
9B	Japanese Larch ..	7	9	8	—	—

At the commencement the best growth was made by the larches, Japanese and European, which do not appear to have suffered any check afterplanting, and the slowest growth was that of the spruces, Norway and Sitka, both of which made very poor growth in the first fifteen years.

Norway spruce is found in three plots; as a pure crop in Plot 5 and in mixture with ash in Plot 1 and with European larch in Plot 8. In Plot 5 the growth has been slow and irregular and the crop took many years to establish itself in the heavy grass vegetation over the clay. Its establishment on the lighter soil at the eastern end of the plot was quicker. Plot 1 is now almost a pure crop of spruce and shows much better growth than either of the other plots. It occupies a well sheltered corner of the garden where the soil is moist and not quite so heavy. In Plot 8, the spruce has been outgrown and partially suppressed by the European larch at the eastern end of the plot, but at the western end the two species have grown at about the same rate. The spruce does not show the same sensitiveness as the larch to the changes in soil conditions and its growth over the plot is fairly uniform.

Sitka spruce behaves in very much the same way as the Norway spruce, but it was able to establish itself more quickly and has grown faster. It also shows better growth on the patch of lighter soil at the eastern end of the plot.

As regards height growth, Scots pine was quite satisfactory up to twenty years of age, but since then has done poorly, and is lacking in vigour. The trees are coarse and heavily branched and a large number have defective tops. This type of growth is characteristic of Scots pine on heavy clay soils.

The Douglas fir developed very slowly after planting and hung back for several years before the crop became established. Growth has been irregular, and is very much more satisfactory on the better soil in the lower half of the plot. It is generally of the fourth quality class. During the last few years there has been a falling off in the height increment, due possibly to the increasing effect of exposure.

European larch has been tried in three of the plots and in each in mixture with other species, and it is unfortunate perhaps that a pure plot was not laid down. In Plot 6A, larch and Scots pine are growing in mixture with beech; in Plot 7 European larch was planted in mixture with Japanese larch, and in Plot 8 in mixture with Norway spruce. In Plot 6A the larch is of good size, but coarse. In Plot 7 the European larch was planted in alternate lines with Japanese larch and has been almost completely suppressed. A few European larch survive near the western end of the plot where the growth of the Japanese larch has not been so rapid. In Plot 8 the larch varies a great deal. On the lighter soil to the east, the trees are of large size and have suppressed the spruce; over the heavy clay soil in the remainder of the plot the growth has been very much poorer and the larch is being overtaken by the spruce. Canker is present and on some trees is severe.

The Japanese larch made notable growth in the first few years after planting and appear to have suffered no check from frost, but the early promise which this species held out has not

been fulfilled and within recent years, the height growth has fallen away seriously. Growth on the loamy soil has been very much better than on the clay, where the trees are lacking in vigour. Japanese larch has been grown in mixture with European larch in Plot 7, with Douglas fir in Plot 9B, and with European larch and silver fir in Plots 9A and 10A. In Plot 7 the European larch has been almost completely suppressed and the Douglas fir in Plot 9B has suffered a similar fate. In mixture with the European larch and the silver fir in Plots 9A and 10A, the Japanese larch were not sufficiently numerous to kill out all the European larch, some of which survive and seem likely to outgrow the Japanese larch in a very few years. It is interesting to note the extremely slow growth of the Japanese larch in Plot 9A. The following table gives a comparison between the mean height of this crop at different ages and the heights at corresponding ages for the second quality class :—

Age	5	10	15	20	25	30 years.
Plot 9A ..	5	11½	19	25	30	34 feet.
Quality Class II	6½	16	25	33	39½	44½ feet.

The Corsican pine in Plot 10B has grown moderately well, but it is too early to say how this species will develop in the conditions in this garden. Beech, the only remaining hardwood, has reached a greater height than the Norway spruce and than some of the Japanese larch, and its height increment continues to be satisfactory. It has the appearance at the present time of a crop which is likely to prove moderately successful.

Summary.

All over the garden on the clay the growth has been slow. Japanese larch though growing quickly to begin with, is not likely to reach any great size. Scots pine is of very poor quality, while European larch is only moderately successful. On the better sites the growth of Douglas fir has been satisfactory, but on the blue clay its growth has been poor. The spruces, Norway and Sitka, appear to show the greatest promise. They are very slow to form a canopy, particularly Norway spruce, but once this has been achieved, growth is good. Sitka spruce is at present by far the larger tree, but Norway spruce may in the end prove almost as successful. None of the mixtures has succeeded.

CIRENCESTER.

At Cirencester broadleaved species are better represented than in the other forest gardens and on the shallow soil they compare favourably with the conifers both in health and in general development. At the last measurement in 1927 the species which had made the greatest height growth was grey alder and after it in the following order came the other species:—European larch, Japanese larch, Corsican pine, Scots pine, American elm, Norway maple, Norway spruce, beech, sycamore, Sitka spruce and various cypresses and silver firs.

The most widely used of the hardwoods is the beech, which, though not occurring in pure crop, is found in mixture with the following:—Norway maple, sycamore, various species of ash, Scots pine and Norway spruce. In mixture with the Norway maple it is doing poorly, but it has outgrown the sycamore and the American species of ash with the exception of *F. americana*. In the Scots pine and Norway spruce mixtures it forms an under-storey. The Norway maple has done well in mixture with beech. Sycamore, on the other hand, has been outgrown and dominated by that species and appears to be a less vigorous tree than the Norway maple. The American elm (*U. americana*) is showing promising growth and forms a uniform crop. The grey alder has grown fast and produced a large number of good stems. Oak, except for the few rows of closely planted pedunculate oak in Plot 7B, has proved exceedingly disappointing. Lime has grown satisfactorily, but the other broadleaved species are of little account.

The following table, prepared from ring-counts and analyses of felled stems, gives an impression of the height growth at different ages of the more important coniferous species in the garden. The curves have been prolonged so as to give the mean height at 25 years.

Plot.	Species.	Mean Height in feet at—				
		5 yrs.	10 yrs.	15 yrs.	20 yrs.	25 yrs.
2B	European Larch ..	4	12	22	30	36½
	Scots Pine	4	12½	22	29	33½
2D	Scots Pine	5	12	21	28	33
	Norway Spruce ..	4	11	19	25	29
4A	Japanese Larch ..	9	18	25½	30	33
4B	European Larch ..	7	18	25½	30½	34½
5A	Corsican Pine ..	4½	11½	19½	27	32
5B	Scots Pine	4	10½	20	28	33
10A	Norway Spruce ..	3½	8	15½	22½	29½
10B	Scots Pine	5	13½	22½	28½	32

The following table gives the height increments over periods of five years for the same species and plots.

Plot.	Species.	Height Increment in feet between—			
		5–10 yrs.	11–15 yrs.	16–20 yrs.	21–25 yrs.
2B	European Larch	8	10	8	6½
	Scots Pine	8½	9½	7	4½
2D	Scots Pine	7	9	7	5
	Norway Spruce ..	7	8	6	4
4A	Japanese Larch ..	9	7½	4½	3
4B	European Larch ..	11	7½	5	4
5A	Corsican Pine ..	7	8	7½	5
5B	Scots Pine	6½	9½	8	5
10A	Norway Spruce ..	4½	7½	7	7
10B	Scots Pine	8½	9	6	3½

From these tables it is seen that, while the early growth of Japanese larch was much faster and that of Norway spruce rather slower than the early growth of the other species, the development of the different crops has taken place at a remarkably uniform rate. Relatively the best growth has been that of Scots pine and Corsican pine, both of which are of Quality Class I, but the growth of European larch and Norway spruce has not been exceptionally fast, the best growth having been of Quality Classes II and III respectively. The Japanese larch belongs only to Quality Class II.

Although the Scots pine has grown so well, the trees of this species, particularly in Plot 5B, have an unhealthy appearance, and many deaths are taking place. The growth, though rapid, has been rank and coarse and the branching is heavy. Damage to stems and crowns has also been done by the *Tortrix*. Scots pine has been grown pure and also in mixture with beech, with European larch, with Norway spruce and with Corsican pine and Norway spruce. In mixture with beech in Plot 10B the pine is growing strongly and dominating the other species, but by careful thinning, it ought to be possible to reduce the number of defective stems among the pine and to form a useful mixture. The mixture with European larch in Plot 2B is passing over into a crop of pure larch, but in the spruce mixture in Plot 2D the Scots pine is dominant. In Plot 2C, originally a mixture of Corsican pine and Norway spruce, the failures in the Corsican pine were replaced by Scots pine which have not succeeded in making headway against the spruce. Plots 5A and 5B afford a comparison between the growth of Corsican pine and that of Scots pine. Height growth is similar, that of Scots pine being rather the better, but the volume production of the

Corsican pine is much superior. The trees in the plot of Corsican pine are also of better shape. These advantages are offset to a certain extent by the difficulty experienced in establishing Corsican pine under the conditions obtaining in this garden. Corsican pine has also been grown in mixture with European larch, but has been suppressed.

The plot of European larch in the garden does not compare well with other plantations of the same species in the neighbourhood. Canker has been severe and the death-rate high, but the worst of the disease appears to be over and the stand should now begin to improve.

Japanese larch has proved disappointing. At the commencement its growth was only slightly faster than that of European larch. After the first 15 years, however, the latter species has grown the faster. Japanese larch appears to be quite unsuited to the conditions at Cirencester.

The growth of Norway spruce in Plot 3B to begin with was slow and irregular. This is probably due to the fact that the soil dries out in the summer, though frost damage may also have contributed. In Plot 10A, in mixture with beech and on a deeper soil, the growth of the spruce has been more uniform.

Sitka spruce has grown very slowly in Plot 3A, behaving in the same way as the Norway spruce in Plot 3B. It is now growing much more vigorously, but still forms an irregular crop.

Summary.

In this forest garden the growth of the hardwoods has been excellent, grey alder in particular showing rapid height growth. Norway maple and certain species of *Ulmus* have also made satisfactory progress. In the first few years after planting, the growth of the conifers was moderately fast with the exception of the spruces, Norway and Sitka, which took rather longer to become established. The early height increments have not been generally maintained, the falling off being most strongly marked in the case of the Japanese larch, European larch and Scots pine. The conditions do not appear to be suitable for sustained growth of conifers.

ABBOTSWOOD.

SERIES 1.

In the plots of this series, ten different species are represented, three of them hardwoods and seven conifers. Each of the hardwood species is represented by a pure plot while there are twelve pure plots of coniferous species and six plots of mixed conifers. As the coniferous species employed are all, with the exception of Lawson's cypress and Colorado Douglas fir, of major forest importance, the plots are of considerable value. The mixed plots have, unfortunately, suffered as a result of unavoidable neglect during the years of war and some of them are now almost beyond control.

Of the three hardwood plots, one, that of *Robinia Pseudacacia*, has been a failure. The growth, however, of such trees as remain has been reasonably good, the mean height at 22 years of age being 20 feet.

The sweet chestnut has proved highly successful and appears to be eminently suited to the conditions in the garden. Up to about ten years after planting it did poorly and in 1913 was actually described as a failure. Since that time, however, it has made remarkable growth as may be seen from the graph, Fig. 3, and from the following table which gives the heights of this crop at different ages. These heights have been read from the age-height curve which has been prolonged to give a reading at 25 years :—

Age	5	10	15	20	25	years.
Mean height ..	3	7½	19	34	44½	feet.

These figures show the very rapid growth after the tenth year, the height increment of 15 feet between 15 and 20 years having been greater than that of any other species for any five-year period.

The oak in Plot 7 has had a similar course of development. Like the chestnut it grew poorly at the outset, but recovered and made rapid growth (Fig. 3). This is shown below :—

Age..	5	10	15	20	25	years.
Mean height ..	2	5½	11	24	34	feet.

The height increment of 13 feet between 15 and 20 years has been surpassed only by that of the sweet chestnut for the same period, the next highest increment for a five-year period being 12½ feet by Oregon Douglas fir between 10 and 15 years of age (Plot 10) and 12½ feet by European larch between 5 and 10 years in Plot 9. The oak is a crop that will improve as time goes on, although on this site it is hardly likely to prove as successful as either chestnut or beech. It is unfortunate that beech has not been given a place in these experimental plots, but there is sufficient evidence in the vicinity to show that in youth it grows only slightly slower than sweet chestnut and that with age it can reach a great size.

The following table, prepared from ring-counts on felled stems shows the height growth of the various conifers at different ages up to 25 years. Certain of the curves marked with an asterisk have been prolonged to give that age.

Plot.	Species.	Mean Height in feet at—				
		5 yrs.	10 yrs.	15 yrs.	20 yrs.	25 yrs.
1	Norway Spruce ..	4	9	15	22½	31*
5	,, ..	5	11	19	26½	33*
14	,, ..	5	12	21	31½	—
3	Oregon Douglas Fir	9	20½	31	37½	42*
18	,,	7½	18	28	35	—
10	,,	5½	17½	30	38	43*
4	Scots Pine	7	18	27½	34	39*
17	,, ...	6	15½	24	30	—
9	European Larch ..	6	18½	30½	40	—
10	,, ..	8	20	32	40½	—
12	Lawson's Cypress ..	6	16	26	33	—
65	Corsican Pine ..	4½	12	20½	29	—
2	Colorado Douglas Fir	1	3½	8½	18½	—
20	,,	1½	4½	11½	20	—

For the same species and plots the following table gives the height increments over periods of five years.

Plot.	Species.	Height Increment in feet between—			
		6–10 yrs.	11–15 yrs.	16–20 yrs.	21–25 yrs.
1	Norway Spruce ..	5	6	7½	8½
5	,,	6	8	7½	6½
14	,, ..	7	9	10½	—
3	Oregon Douglas Fir	11½	10½	6½	4½
18	,,	10½	10	7	—
10	,,	12	12½	8	5
4	Scots Pine	11	9½	6½	5
17	,, ...	9½	8½	6	—
9	European Larch ..	12½	12	9½	—
10	,, ..	12	12	8½	—
12	Lawson's Cypress ..	10	10	7	—
65	Corsican Pine ..	7½	8½	8½	—
2	Colorado Douglas Fir	2½	5	10	—
20	,,	3	7	8½	—

At the outset the best growth was made by the Oregon Douglas fir, European larch and Scots pine and the poorest by the Norway

spruce in Plot 1 and the Colorado Douglas fir in Plots 2 and 20. During recent years the height growth of the Oregon Douglas fir has been severely checked by *Chermes cooleyi*, with the result that at the present time the tallest trees in the garden are the European larch in Plots 9 and 10. The effect of the *Chermes* attack on the height growth is shown by the age-height curve for the Douglas fir in Plot 3 (Fig. 9). This shows that whereas the height increment between 10 and 15 years of age was 10½ feet, between 15 and 20 years it was only 6½ feet and that it fell still further to 4½ feet between 20 and 25 years. This is less than half the normal rate.

Norway spruce is represented by Quality Classes II and III, Douglas fir by Quality Class IV, Scots pine by growth rather better than Quality Class I, European larch by Quality Class II and Corsican pine by Quality Classes I–II. Norway spruce which occurs pure in three plots and as a component of the mixture in three others shows considerable variation in the rate of growth. In Plots 1, 5 and 8 the growth is only of third quality class, being best in Plot 8 and poorest in Plot 1. In these plots the soil conditions appear to be too dry for rapid growth. In Plot 14, where Norway spruce was mixed originally with Colorado Douglas fir which has been suppressed and removed, the faster height growth (Quality Class II) is undoubtedly due to the moister soil conditions; as a result of the wider spacing, the trees are also larger. In mixture with European larch and with Scots pine the spruce has been suppressed by each of these species at a comparatively early stage. This is not unusual where European larch is concerned, but the suppression of the spruce by Scots pine on soil which is favourable to both species is evidence of exceptionally rapid growth of the pine. In Plot 12A the spruce was overtaken by Lawson's cypress at 20 years of age.

The Oregon Douglas fir is found pure in Plots 3 and 18 and mixed with European larch in Plot 10 and with Scots pine in Plot 11. In Plots 3 and 18 different planting distances were adopted, but the 5-feet planting distance in Plot 18 has produced trees which are no more heavily branched than those in Plot 3 where the plants were spaced at about 3 ft. by 3 ft. The growth has not been fast and even if the attacks by *Chermes cooleyi* had not taken place would not have been better than Quality Class III. The mixtures with European larch and with Scots pine are interesting. The former is not an uncommon mixture and generally results in a pure crop of Douglas fir at a comparatively early age. Here, however, the larch have kept pace with the Douglas fir up to the present time, and the future of the crop is a matter of some interest and will depend on whether the Douglas fir recover their normal growth after attacks by *Chermes*. The most recent thinning in 1928 was carried out with a view to preserving the mixture for as long as possible. The mixture of Douglas fir and Scots pine is not one which is frequently seen nor is it to be recommended in view of the very different rates of growth of the two species under normal conditions.

In Plot 11, however, the Scots pine at 24 years of age still survives and in point of height growth is little behind the Douglas fir, the mean height of the Douglas fir being 40½ ft. at 22 years of age and that of the Scots pine 38 ft. Had it not been for the checking of the Douglas fir by the *Chermes*, it is probable that the majority of the pine in this plot would have been suppressed in spite of its exceptionally fast growth.

Colorado Douglas fir occurs pure in Plots 2 and 20 and in mixture with Norway spruce in Plot 14 where it was suppressed. Plot 2 was formed with 2-year seedlings at a planting distance of 3 ft. by 3 ft., whereas in Plot 14, 2 + 4 transplants were employed and were planted at 4 ft. by 4 ft. Both plots suffered from frost, and growth to begin with was very slow and irregular; thus, five years after planting the height was only 1 ft. in Plot 2 and 1½ ft. in Plot 20, while after 10 years these had increased only to 3½ ft. and 4½ ft. respectively. Within the last five years, however, growth has become much more rapid, the average annual height increment in Plot 20 having been approximately 1½ ft. and in Plot 2, 2 ft. The larger trees in the latter plot are now growing vigorously.

Scots pine, which is represented by pure crops in Plots 4, 16 and 17 and by mixtures with Oregon Douglas fir in Plot 12, with Norway spruce in Plot 13 and with Lawson's cypress in Plot 15, is remarkable in this garden for the rapidity of its growth. Of the three pure Plots, Nos. 16 and 17 were originally planted with bad plants from Plot 4, but as a large number of those plants died in their first year, the areas were filled up with good 2-year seedlings. The three plots may therefore be taken as giving a rough comparison between crops raised at 3 ft. by 3 ft. (Plot 4), 4 ft. by 4 ft. (Plot 16) and 5 ft. by 5 ft. (Plot 17). Growth in all the plots has been rapid and the trees are rank and coarse. It is clear that the close planting has given the best results. There are fewer definitely bad trees and the crop is capable of considerable improvement by thinning. With the wider planting distances the trees are coarser while early thinnings are difficult to carry out. The Scots pine in mixture with the Norway spruce is exceedingly coarse as a result of the ample space which each tree obtained by the suppression of the companion species. The mixture with Lawson's cypress is an uncommon one and of some interest. Both species have grown at about the same rate, but the pine is now falling behind.

European larch does not occur pure in this series and the only available opportunities of studying its developnent are found in Plot 9 where it is mixed with Norway spruce and in Plot 10 where it is mixed with Oregon Douglas fir. In both plots it is of the second quality class and shows excellent growth. There is a fair amount of larch canker, but the damage done is not serious. In the conditions obtaining in the forest garden, European larch appears to be the most satisfactory of all the conifers.

Lawson's cypress is not commonly planted as a forest tree and in consequence Plots 12, 12A and 15 are of especial interest. The growth has been surprisingly good, the height growth being about equal to that of the best Scots pine and faster than that of the Norway spruce. In mixture with Lawson's cypress, the spruce has been suppressed while the Scots pine is seriously threatened.

Corsican pine has grown in a satisfactory manner and it is unfortunate that this plot (No. 65) was so badly damaged by wind. The height growth is on the border line between Quality Classes I and II, but has not been so fast as that of the Scots pine in Plot 4.

Summary.

The most successful species in this garden have been sweet chestnut among the hardwoods and European larch among the conifers. Scots pine has grown very fast, but is rank and of poor quality. Norway spruce is not successful on the drier sites and is not likely to reach a very large size. Oregon Douglas fir is disappointing, but the Colorado Douglas fir is now growing satisfactorily and may reach a good size. Lawson's cypress has done very well, but Corsican pine not as well as might have been expected.

It is interesting to note the heavy death-rate among the large transplants of Scots pine which were used to form Plots 16 and 17, and among those of Douglas fir in Plot 18.

SERIES 2.

This series of plots affords a good opportunity of studying the relative growth of European, Japanese and hybrid larches. The best growth has been made by the hybrid larch which in 12 years has reached a height of 31 feet, corresponding to Quality Class I of the yield tables for Japanese larch. The plots of Japanese larch, despite the different origins of the plants, have all grown at about the same rate, their mean heights at 14 years of age varying between 30 and 33 feet. This though not remarkably fast is a satisfactory rate of growth. For the age the stems of this species are of large size and volume production is likely to reach a high figure at a comparatively early age. European larch has grown fast, but the trees are generally 5 to 6 feet shorter than the Japanese larch and are very much more slender. There is more variation in the rate of growth of this species than there is in the Japanese larch.

Beech has been suppressed and killed by Japanese larch and by hybrid larch, but survives in mixture with the European species and is likely to overtake it. Up to the present time, chestnut has grown at approximately the same rate as European larch, but is likely to grow faster and in mixture to suppress that species. It has not been used in mixture with either Japanese or hybrid larch.

Series 3

In the plots of this series, Sitka spruce has been planted pure and also in mixture with Douglas fir, *Thuya plicata* and beech. The growth of the Sitka spruce has been irregular and a canopy has not yet formed in any of the plots. Up to the present time its rate of growth has been slower than that of Douglas fir in Plots 54 and 55, approximately equal to that of *Thuya plicata* in Plots 59 and 60 and rather faster than that of beech in Plots 57 and 58.

Alice Holt.

The five species which have been planted at Alice Holt are of widely different character, and for this reason it is of great interest to observe the different responses which they have made to the conditions in the garden. The study of the rates of growth has been carried out in the usual way, and the following table has been prepared from ring-counts on felled trees to show the height growth of the various species at different ages up to 20 years :—

Plot.	Species.	Mean Height in feet at—			
		5 yrs.	10 yrs.	15 yrs.	20 yrs.
1	Japanese Larch ..	5	15	27½	35
2	*Thuya plicata* ..	3	10½	19	28½
3	Weymouth Pine ..	4	11½	21	30
4	Colorado Douglas Fir	2½	5	11	20
5	Oregon Douglas Fir	4	11	19	31

The following table gives the height increments over periods of five years for the same species and plots.

Plot.	Species.	Height Increment in feet between—		
		5–10 yrs.	10–15 yrs.	15–20 yrs.
1	Japanese Larch	10	12½	7½
2	*Thuya plicata*	7½	8½	9½
3	Weymouth Pine	7½	9½	9
4	Colorado Douglas Fir ..	2½	6	9
5	Oregon Douglas Fir ..	7	8	12

These tables show that on the whole the growth has not been fast and indicate that the heavy soil in Alice Holt Forest is not likely to produce the best coniferous growth.

At the commencement, the growth of all the species was relatively slow and frost may have checked the plants, and in particular Douglas fir, in the initial stages. Japanese larch has made the best height growth, but the height increment culminated early and is now falling off. The volume production has been low and for the age of the crop the stems are small.

The height growth of the Oregon Douglas fir has been relatively slow throughout, but there was a satisfactory height increment between 15 and 20 years of age. The crop is only of the fourth quality class, but the production has been about normal for the rate of growth.

The rate of growth of the *Thuya* appears to be generally similar to that in other parts of the country as recorded in sample plots, but perhaps a little slower. It is interesting to note that between 10 and 20 years of age it has put on 18 feet in height, which compares well with 20 feet put on by Japanese larch and by Douglas fir in the same period. Height increments have been consistent throughout and are still increasing.

The Weymouth pine has grown exceedingly well, and now that it is overcoming the attacks of *Cronartium ribicola*—the blister rust—it should continue to make good growth. The volume production has been much higher than that of any of the other species and the tree generally appears to be well suited to the conditions.

The Colorado Douglas fir grew much more slowly than the other species in the first 15 years, but after reaching that age it commenced to grow with greater vigour and in the five-year period between 15 and 20 years of age its height increment of 9 feet was greater than that of the Japanese larch for the same period and equal to that of the Weymouth pine. Its recent development has been slightly checked by the heavy attack of *Rhabdocline* to which reference was made in the last chapter.

Summary.

The best crop in this garden is the Weymouth pine in Plot 3 which has shown satisfactory growth on the heavy clay soil. Japanese larch has grown slowly throughout and is not a vigorous crop, but Oregon Douglas fir is now improving in height growth after growing slowly at the commencement. The growth of *Thuya plicata* is about the average for this country while the Colorado Douglas fir is now showing a little more promise.

CEIRIOG.

In this forest garden the large number of species and the number and variety of the mixtures make the discussion of the comparative rates of growth a matter of some difficulty. In all 25 species have been employed and there are 25 pure plots and 24 plots where mixtures have been tried.

Broadleaved species are represented in only four of the plots the species used being sycamore, ash, beech and pedunculate oak. Of these, beech and sycamore grow at about the same rate with sycamore as rather the more vigorous tree. In Plot 1, where these two species are growing along with oak, the mixture is likely to end as one of beech and sycamore with patches of pure sycamore where the beech has been killed by rabbits. Sycamore occurs also in Plot 7 in mixture with European larch and although at first it was outgrown by the larch it is now overtaking it. The larch in this plot is doing badly and is suffering from exposure which does not seem to affect the sycamore. Beech was planted in Plot 3 in mixture with European larch, but rabbits killed out most of the beech plants and the larch is now almost a pure crop. This is unfortunate as this mixture might have offered an interesting comparison with Plots 6 and 7. Beech has also been planted along with ash and has suffered the same damage. The ash is of poor quality and is growing only moderately well.

Among the conifers the genus *Larix* is represented by five species, viz., *L. europaea*, *L. leptolepis*, *L. americana*, *L. occidentalis* and *L. sibirica*. Age-height curves for these species are shown in Fig. 1, while the following table gives details of the height growth of these species at different stages of development.

Plot.	Species.	Mean Height in feet at—				
		5 yrs.	10 yrs.	15 yrs.	20 yrs.	25 yrs.
3	European Larch ..	7	16	23½	28½	32
6	,, ..	5½	12	19	23	26½
7	,, ..	4½	10	18	26	32
15	Japanese Larch ..	9	17	25	31½	—
10	,, ..	6½	14½	22	27½	31½
32	,, ..	7½	16	25½	33½	39½
9	,, ..	7½	16	28½	37½	—
33	American Larch ..	7½	17½	25	29	—
34	Siberian Larch ..	4	7	10	13	—
46	Western Larch ..	4	7½	14½	—	—

The height increments for the same plots over five-year periods are shown in the table below.

Plot.	Species.	Height Increment in feet between—			
		5–10 yrs.	10–15 yrs.	15–20 yrs.	20–25 yrs.
3	European Larch ..	9	7½	5	3½
6	,, ..	6½	7	4	3½
7	,, ..	5½	8	8	6
15	Japanese Larch ..	8	8	6½	—
10	,, ..	8	7½	5½	4
32	,, ..	8½	9½	8	6
9	,, ..	8½	12½	9	—
33	American Larch ..	10	7½	4	—
34	Siberian Larch ..	3	3	3	—
46	Western Larch ..	3½	7	—	—

These tables and the curves show that European larch, Japanese larch and *L. americana* all grew comparatively rapidly after planting and up to about 15 years of age. Though the Japanese larch in certain plots has continued to grow well beyond that age the height increments of the other species have fallen off.

European larch has been planted pure in Plots 6, 24 and 25 and forms a constituent of the mixtures in thirteen other plots and groups. In the pure plots plants from two different origins have been employed, plants from German seed in Plots 6 and 25 and plants from Scottish seed from the Atholl estates in Perthshire in Plot 24. The German plants which were of poor quality when planted have given inferior results as compared with the plants from Scotland. Of the various mixtures in which European larch finds a place those with beech and sycamore have already been discussed. In mixture with Douglas fir the larch is now being suppressed, but will remain in the crop for some time longer because of the slow growth of the Douglas fir. This mixture is of some importance, as many of the oldest plantations of Douglas fir in Great Britain were raised in this way and it is quite a successful method where the Douglas fir is slow growing. In Plots 13 and 14 European larch occurs in mixture with Scots pine and Norway spruce respectively. The Norway spruce has been completely suppressed, but the pine, though falling behind the larch, still maintains a place in the canopy. It should be possible to keep the mixture of larch and pine in Plot 13, but it is now probably too late to save the spruce in Plot 14. The series formed by Plots 16–20 in which European larch, Scots pine and Norway spruce are mixed together have already been discussed in Chapter I. The larch has generally grown faster than the other species, but has

not been able to suppress them, except in Plot 20 where the planting distance was 3 feet. On the more exposed sites, however, the larch has been overtaken by both the Scots pine and the Norway spruce. In the mixture of four species in Plot 21, only the European larch and the Douglas fir survive, the latter dominating the larch. In Plots 22 and 23, which are the highest plots in the forest garden, the mixture was one of European larch, Scots pine and common silver fir. The last mentioned has been badly damaged by *Chermes (Dreyfusia) nüsslini* and the mixture is now one of larch and pine. The pine seems to be the more vigorous tree in the conditions and is growing faster than the larch, particularly in Plot 22. This is in distinction to the conditions in Plot 13 where the pine has been partially suppressed. Throughout the garden the sensitiveness of European larch to exposure is well marked and variations in rates of growth appear to be due mainly to this fact.

Japanese larch occurs as a pure crop in Plots 15 and 41, and in mixture in Plots 9, 10, 11 and 32. There are considerable variations in the rate of growth of this species, and appear to be due chiefly to variations in exposure. Thus, as may be seen from the diagram, Fig. 1, and tables, the growth in Plot 10, which is on the western and more exposed side of the garden, is very much poorer than that in the more sheltered Plots 9 and 15, near the eastern edge of the area. Before the full effect of exposure was felt and up to ten years of age, the rates of growth were similar, the mean height of Plot 9 at that age having been 16 ft. and that of Plot 10, 14½ ft. In the next ten years, however, Plot 9 put on 21½ ft. in height, whereas the corresponding height increment for Plot 10 was only 13 ft. Japanese larch is much better than European larch all over the garden and in the more sheltered places is still vigorous and shows no marked falling off in height increment. Of the mixtures in which Japanese larch occurs, that with the Douglas fir in Plot 9 has resulted in an almost pure crop of larch and a similar end has been reached in Plots 10 and 11 where the larch was mixed with Corsican pine and Sitka spruce and with Scots pine and Norway spruce respectively. In both the last mentioned plots the pines have been killed out and the spruces completely suppressed. In the mixture with *Abies grandis* the Japanese larch has succeeded in almost completely suppressing that species.

The American larch (*L. americana*) has grown comparatively well, although its height growth is now falling off, but the Siberian larch and the West American larch (*L. occidentalis*) have done poorly. The last-named, however, has improved in growth in the last few years.

Only two species of pine have been planted, Scots pine and Corsican pine and only one pure plot of each species has been formed. These plots have been planted side by side and it is thus possible

to compare the growth of each species. The following table shows that the height growth has been similar in each plot.

Plot.	Species.	Mean Height in feet at—			
		5 yrs.	10 yrs.	15 yrs.	20 yrs.
28	Scots Pine	6	12½	18½	23½
27	Corsican Pine	5½	11	17	24½

Plot.	Species.	Height Increment in feet between—		
		5–10 yrs.	10–15 yrs.	15–20 yrs.
28	Scots Pine	6½	6	5
27	Corsican Pine	5½	6	7½

Corsican pine has stood the exposure better than the Scots pine, but does not appear to be healthy. Scots pine occurs in several mixtures which have already been mentioned. The mixture of Corsican pine, Japanese larch and Sitka spruce has also been described.

Four species of spruce have been tested, viz., *Picea excelsa*, *P. sitchensis*, *P. morinda* and *P. Omorika*. Of these, the *Picea morinda* has made exceedingly poor growth, while the *Picea Omorika*, though healthy in appearance, has grown slowly. The height growth of the various species at different ages is shown in the following table and is illustrated further by the age-height curves in Fig. 2 :—

Plot.	Species.	Mean Height in feet at—				
		5 yrs.	10 yrs.	15 yrs.	20 yrs.	25 yrs.
26	Norway Spruce ..	3½	7	12	21½	—
29	,, ..	3½	6½	11	18	—
12	,, ..	3½	7	11	18	27
5	Sitka Spruce ..	3½	7½	15	26	36
44	,, ...	4½	9	18	30½	—
49	Himalayan Spruce	1	3	5	—	—
42	Serbian Spruce ..	3	6	10	14½	—

Plot.	Species.	Height Increment in feet between—			
		5–10 yrs.	10–15 yrs.	15–20 yrs.	20–25 yrs.
26	Norway Spruce ..	3½	5	9½	—
29	,, ..	3	4½	7	—
12	,, ..	3½	4	7	9
5	Sitka Spruce ..	4	7½	11	10
44	,, ..	4½	9	12½	—
49	Himalayan Spruce..	2	2	—	—
42	Serbian Spruce ..	3	4	4½	—

A comparison of the curves for spruce at Ceiriog in Fig. 2, with those in Fig. 1 for species of larch brings out the chief difference in the behaviour in early life of the principal species of each genus. It will be seen that whereas the larch generally shows excellent growth after planting, the spruce, on the other hand, hangs back for a more or less lengthy period. After about 15 years the height increments of the larch begin to diminish, while those of the spruce begin to expand.

Norway spruce is found pure in two plots, Nos. 26 and 29, and after a slow start is now growing well, the height increment of 9½ ft. in the last five years being especially noteworthy. It has not been affected by the exposure and is altogether a promising crop. In mixture with Sitka spruce in Plot 5, Norway spruce has already been suppressed in places and is likely to be suppressed all over the plot in the course of a few years. In Plot 12, which was a mixture of Norway spruce and the common silver fir (*A. pectinata*), the silver fir has almost disappeared, having been killed out by *Chermes* (*Dreyfusia*) *nüsslini* and the plot is now one of pure Norway spruce.

Sitka spruce has been used to only a small extent in this garden, being found in two plots, in mixture with Norway spruce in Plot 5 and with Douglas fir in Plot 44. Growth to begin with was similar to that of Norway spruce, but after ten years of age, the height increments became much faster. The increment of 11 ft. and 12½ ft. in Plots 5 and 44 respectively for the five-year period between 15 and 20 years of age are very satisfactory when the elevation and exposure are taken into consideration. In Plot 5 the growth has been irregular, but has been fast enough to suppress the Norway spruce over half the plot. In mixture with Douglas fir the Sitka spruce has grown well and is maintaining a place in the mixture, although it is neither so tall nor so vigorous as the Douglas fir.

Douglas fir has been used quite extensively, but has been planted mainly on the better sites. There are three pure plots of Oregon

Douglas fir and five plots in which it occurs in mixture ; in addition to these there is one group of the Fraser River Douglas fir and one of the Colorado type. The following tables give the height growth and height increments at different ages :—

Plot.	Species.	Mean Height in feet at—				
		5 yrs.	10 yrs.	15 yrs.	20 yrs.	25 yrs.
4	Oregon Douglas Fir	6½	13½	23	30½	36½
44	,,	6	12½	23	35	—
47	,,	5	10½	20	28	—
48	Colorado Douglas Fir	1	5	9½	16	—
37	Fraser River Douglas Fir	3	7½	14	20	—

Plot.	Species.	Height Increment in feet between—			
		5–10 yrs.	10–15 yrs.	15–20 yrs.	20–25 yrs.
4	Oregon Douglas Fir	7	9½	7½	6
44	,,	6½	10½	12	—
47	,,	5½	9½	8	—
48	Colorado Douglas Fir	4	4½	6½	—
37	Fraser River Douglas Fir	4½	6½	6	—

Considering the elevation the growth is quite satisfactory, but it will be noticed that the growth of the Oregon Douglas fir is better in Plot 4, and in Group 44 than in Group 47, which is situated at a higher elevation and in a more exposed place. The Fraser River variety has grown slowly, but appears to be free from attack by *Chermes cooleyi* while the Colorado Douglas fir has grown even more slowly. In mixture, the Oregon Douglas fir has proved too vigorous for all the species tried, with the exception of Japanese larch which has suppressed it and of Sitka spruce which still maintains its place in the mixture. European larch has been partially suppressed, while *Thuya plicata* and Norway spruce have been killed out.

Thuya plicata and Lawson's cypress have grown at about the same rate, the mean height of each species at 25 years of age being 22 feet. Both species suffered from drought after planting out and have grown very slowly, but both are now showing satisfactory height increments.

Of the various silver firs, *Abies grandis* is the most successful and the only species to be considered of value. *A. pectinata* has

been a failure and *A. nobilis* and *A. concolor* have grown at about the same rate as the Colorado Douglas fir.

Summary.

At the present time, in order of height growth, the species come as follows :—Japanese larch, Douglas fir, Sitka spruce, *Abies grandis*, European larch, *Larix americana*, Corsican pine, sycamore, Scots pine, Norway spruce, ash, *Thuya plicata* and Lawson's cypress. At the outset the best growth was made by Japanese larch, European larch and Douglas fir, with the other species growing more slowly. Within recent years certain of these others, and in particular Sitka spruce and Norway spruce, have increased rapidly in height growth, while European larch and the Japanese larch in exposed sites have shown diminishing height increments. In sheltered plots Japanese larch has shown very good growth and Douglas fir has also grown well. European larch appears to be more sensitive to exposure than any other species and compares unfavourably in this respect with Japanese larch and Oregon Douglas fir. Sycamore, Corsican pine, Norway spruce, Sitka spruce and Scots pine are more resistant.

CHAPTER III.

GENERAL DISCUSSION: RATES OF GROWTH OF EACH SPECIES IN RELATION TO FACTORS OF LOCALITY.

1. Factors of Locality.

In Bulletin 10 of the Forestry Commission, Chapter VI, there appears a general account of the rates of growth of conifers in relation to the factors of locality and in particular to climate, elevation, exposure and soil. The same four factors are discussed below in so far as they seem to have influenced the growth of the different species in the various forest gardens.

Climate.

The distribution of the gardens over England is irregular, in that three out of the five are situated in the west and south-west, while of the others, one is in the south and the other in the extreme north-east. Consequently, they do not quite represent the widest available range of climatic conditions. The mean annual temperature, for example, of the gardens at Abbotswood, Ceiriog, Cirencester and Alice Holt is in the neighbourhood of 48°-49° F., and the range in each case is similar though it is rather wider at Cirencester and Alice Holt. The mean annual temperature at Cockle Park is lower and as a result of the lower summer temperature, the range is narrower.

None of the gardens is in an area of heavy rainfall. The lowest rainfall is that at Cockle Park, where it is about 29 inches per annum, but the fall at Alice Holt is little heavier and amounts to 30 inches. At Cirencester the annual rainfall is 33 inches, in the Forest of Dean about 34 inches and at Ceiriog about 40 inches. These differences are not great and in addition variations in rainfall cannot be directly related to variations in rates of tree growth. Drought is not usually a serious factor in this country, but spells of dry weather after planting may result in heavy death rates among the plants, as happened with the large transplants of Scots pine in the plots at Abbotswood. Drought, however, is a factor which is very closely inter-related with the edaphic factors and cannot very well be discussed apart from the question of soil.

Speaking generally, it may be said that the growth of most conifers and of almost all hardwoods is faster in the climate of the south-west, but, on the other hand, in such mild climates late frosts when they occur can do much more extensive damage. Late spring frost is the climatic factor which has the greatest direct influence on the growth of trees in this country. It makes the establishment of plantations a matter of extreme difficulty in many places and prevents the raising of certain species altogether, except in the most genial localities. To this cause was due the slow growth

in early life of the spruces and the Douglas fir in the heavy grass vegetation at Cockle Park as well as the poor showing made by the chestnut and the oak in the first few years after planting in the garden at Abbotswood. Certain species, such as the *Larix sibirica* at Ceiriog, which come early into leaf, are regularly cut back and rarely succeed in establishing themselves. At Cirencester it has been possible to raise successfully certain frost-tender species of silver fir under nurses.

Elevation.

The elevations at which the various forest gardens are situated are as follows :—Alice Holt and Cockle Park, 300 feet ; Abbotswood, 350 feet ; Cirencester, 470 feet ; Ceiriog, 1,000 to 1,250 feet. The relative elevation, *i.e.*, the elevation of any site above valley level, is negligible in all the areas but one, Ceiriog, where the garden is situated at an elevation of 600 to 700 feet above the level of the valley immediately below. Thus, in this area, both absolute and relative elevation become important and the general effect is seen in the slower growth which is obtained. The various graphs show that with the notable exception of Japanese larch, the growth of all the more important species is slower at Ceiriog than in any other of the areas.

Exposure.

This is a factor of very great importance in a country such as Great Britain exposed to constant and at times violent winds, but fortunately it is a factor the effects of which are evident and unmistakeable. The prevailing wind comes from the south-west and exposure is generally estimated in relation to that wind. At the present time the gardens at Cirencester and Alice Holt are fully sheltered and that at Abbotswood almost equally so, although subject to irregular valley winds. At Cockle Park the force of the western winds is broken by a shelter belt of Scots pine, but species such as Douglas fir which have outgrown this shelter, are now becoming affected by the exposure. Cold east winds which are particularly troublesome on the north-east coast, especially in the spring, have also affected certain plots in that garden. At Ceiriog exposure has been an important factor in the slowing down of the growth, and the effect of constant wind from the earliest stages is seen in the trees, most of which over a great part of the area, are curved at the butts away from the direction of the prevailing wind. The part of this garden to the west of the main central ride is much more seriously exposed than the remainder and the difference between the rate of growth in this part and the rate of growth elsewhere is in some species quite striking.

Soil.

It has already been stated that the soils represented in the various forest gardens are, with one exception, all residual soils.

The exception is that at Cockle Park which is derived from Boulder Till overlying the Millstone Grit. Soil conditions in all the plots are fairly uniform, except at Cockle Park where there are alternations between a stiff clay and a light sandy loam. The soils vary from heavy clays at Alice Holt and Cockle Park to a deep moderate loam at Abbotswood and light loams, moderately deep at Ceiriog and shallow at Cirencester. Generally the growth of conifers on the heavy clay soils has been slow. On the loam at Abbotswood certain coniferous species have done well, but others have been less successful. On the light shallow soil at Cirencester, initial growth was good, but the crops of conifers have lost vigour in recent years and failed to fulfil their early promise.

In the following sections, the growth of the various species is discussed in relation to the locality factors and comparisons made of the growth in the different forest gardens.

2. Species.

Hardwoods have been planted in four of the gardens and all the more important species are represented. Age-height curves for certain species are given in Figs. 3 and 4.

Oak.—This species has been grown pure at Abbotswood and at Cirencester, where a small patch of pedunculate oak has grown well, and it occurs in mixture with beech and sycamore in Plot 1 at Ceiriog. The age-height curves for this species, which are given in Fig. 3, show the characteristic development. After planting, there is generally a prolonged period of slow growth, while the crop is establishing itself. This is followed by a period during which the growth is rapid and which has extended without check up to 25 years of age in the plots at Abbotswood and Ceiriog.

Beech.—Beech occurs in the gardens at Cockle Park, Ceiriog and Cirencester, but was nowhere planted pure. In mixture with other hardwoods, it has completely suppressed oak at Cockle Park and sycamore at Cirencester ; at Ceiriog, it grows at about the same rate as sycamore, while at Cirencester, it has been suppressed by Norway maple. With conifers it is as a rule suppressed, as may be seen at Cirencester, where it has been mixed with Scots pine and with Norway spruce. At Abbotswood, certain of the plots in Series 2 show that while it is capable of suppressing European larch at a comparatively early age, it is suppressed and killed by Japanese larch.

Ash.—Ash is poorly represented as it occurs in only two plots, one at Ceiriog in mixture with beech and one at Cockle Park in mixture with Norway spruce. The growth at Ceiriog has been faster than that of other hardwoods, with the exception of sycamore, but height increments are falling off, whereas those of beech, oak and sycamore are being maintained. (Figs. 3 and 4.)

Sycamore.—This species does quite well at Ceiriog and is the most vigorous of the hardwoods which have been tried on that area. In one plot it is growing much more strongly than European larch, with which it is mixed, and in another it is growing rather more rapidly than beech and much faster than oak. At Cirencester, on the other hand, it is easily suppressed by beech.

Sweet Chestnut.—This species which has made noteworthy growth at Abbotswood, has been a failure at Cirencester and has not been tried at any of the other gardens.

Other Hardwoods.—Of these, grey alder, Norway maple, lime and certain American elms have grown in a satisfactory manner at Cirencester.

The tests that have been made of the various broadleaved trees have been so arranged that it is difficult to make proper comparisons or indeed to form any definite conclusions as to their value. One can only comment on certain features which stand out, such as the good growth of beech on the Boulder Till at Cockle Park, the vigour of sycamore at the high elevation at Ceiriog, the excellent growth of sweet chestnut at Abbotswood, where it has grown much faster than most of the conifers and has been exceeded in height growth by European larch and Douglas fir only, and the general excellence of the hardwoods at Cirencester.

Much more material is available for the study of the growth of conifers, although only one species, Japanese larch, is common to all the gardens. Of the major species, Scots pine, European larch, Norway spruce and Douglas fir are found in four areas and Corsican pine and Sitka spruce in three.

The following table shows the average quality class of each of the more important species in the different gardens :—

Locality.	Mean Quality Class.						
	Scots Pine.	European Larch.	Norway Spruce.	Douglas Fir.	Corsican Pine.	Sitka Spruce.	Japanese Larch.
Cockle Park ..	II	III	IV	IV	—	IV	II
Cirencester ..	I	II–III	III	—	I	IV	II
Abbotswood ..	I	II	II–III	IV	I–II	—	I–II
Alice Holt ..	—	—	—	IV	—	—	II
Ceiriog	II–III	III	IV	IV	III	IV	II

From this table it will be seen that the fastest growth, considering the seven species, has been obtained in the gardens at Cirencester and Abbotswood and the slowest at Cockle Park and Ceiriog. The uniformly low quality classes of Douglas fir and Sitka spruce are also worthy of notice.

Scots Pine.—The above table, together with the curves in Fig. 5, gives an impression which on the whole is very favourable of the height growth of this species in the different areas. The poorest growth that has been found is on the borderline between Quality Classes II and III, while the best growth exceeds the average for Quality Class I. Growth has been faster in the south and south-west of England at Abbotswood and at Cirencester, while at Ceiriog and at Cockle Park it has been slower. As to soil, Scots pine is extremely accommodating and can thrive in a wide variety of conditions, but the nature of the soil is generally reflected in the type of tree and the quality of the crop. Thus, though the rich loam at Abbotswood has given an extremely rapid growth, that growth has been rank and the trees are of a heavily branched type with badly shaped crowns. Similar though less pronounced features are also characteristic of the Scots pine at Cirencester. The heavy clay of the Boulder Till at Cockle Park has also yielded a coarse crop now in an unhealthy condition. At Ceiriog, the height growth at the commencement was remarkably fast, but after the tenth year it began to slow down as the effects of elevation and exposure were felt. Nevertheless, the growth in that garden, in view of the circumstances, is definitely satisfactory. The pine does not seem to be seriously affected by exposure in any of the gardens, and is standing up well both at Ceiriog and in the shelter belt at Cockle Park.

Scots pine has entered into some interesting mixtures, but in many cases these have suffered from insufficient attention during the years 1914–1919 and it is necessary to bear this fact in mind in considering the results. Scots pine has been suppressed by European larch at Cirencester and partially suppressed by the same species at Ceiriog. At Abbotswood and at Cirencester it has completely suppressed Norway spruce, whereas at Ceiriog both species grow at about the same rate. As an illustration of the rapid rate of height growth of Scots pine in the south-west, the mixture with Douglas fir at Abbotswood may be instanced. Here the pine has been able to maintain a place in the mixture up to the present time.

Corsican Pine.—This species has not been utilised very fully in these forest gardens, although it is represented in all but Alice Holt. Pure plots occur at Abbotswood, Ceiriog and Cirencester and in each of these localities the growth has proved to be similar to that of Scots pine. At Abbotswood the crop is healthy and vigorous, but both at Ceiriog and Cirencester the trees have an unhealthy appearance. At Cockle Park a small patch of Corsican pine is growing satisfactorily.

Weymouth Pine.—Satisfactory results have been obtained with this species at Alice Holt and the height growth corresponds to Quality Class I of the Scots pine yield tables.

European Larch.—Pure plots of European larch are found at Cirencester and at Ceiriog, and mixtures with other species at Abbotswood and at Cockle Park; in some of these mixtures the European larch has become dominant and forms almost pure crops, but in others it has been completely or partially suppressed. As may be seen from Fig. 6, the best growth has been made at Abbotswood, where the crop is almost of the first quality class, while at Cockle Park this species has grown moderately slowly but at a fairly uniform rate throughout. On the other hand, the age-height curves for this species at Cirencester and Ceiriog are of interest as showing rapid height growth in early years followed by a slacking off between 15 and 25 years of age. At Ceiriog, Cockle Park and Abbotswood, trials have been made of European larch raised from seed of different origins. At Ceiriog the German seed has given poor results while the Scottish seed has yielded much more satisfactory plants; at Cockle Park it is no longer possible to make any comparison as most of the original larch have disappeared, while the plots at Abbotswood are still too young to permit of an effective comparison.

Of the various soils, that at Abbotswood is probably the most suitable for the production of crops of European larch, but the rapid initial growth at Ceiriog shows that the soil there is also well adapted for this purpose. The shallow soil at Cirencester gave at first a rapid growth, which was not kept up, while the heavy soil at Cockle Park has given a slower but more sustained growth. The falling away of the height growth at Ceiriog is due, not to the nature of the soil as at Cirencester, but to the combined effects of elevation and exposure.

In mixture European larch has suppressed Scots pine at Cirencester, but at Ceiriog has grown only slightly faster as the Scots pine is less affected by exposure. At Abbotswood and at Ceiriog it has completely suppressed Norway spruce and at Cockle Park this same phenomenon may be seen in part of Plot 8. At Ceiriog it is now being suppressed by Douglas fir, but in the same mixture at Abbotswood the larch and the Douglas fir are growing at about the same rate.

Japanese Larch.—Much use has been made of this tree in the different forest gardens and some interesting facts emerge from a study of the measurement data. At Abbotswood it was not employed in any of the plots of Series 1, but on each of the other areas it is quite well represented. The age-height curves in Fig. 7 are of considerable interest as showing the growth of this species in each locality. By far the fastest growth has been obtained in the young plots at Abbotswood. At Cirencester the Japanese larch has behaved in a manner very similar to the European species, having grown fast in the first 15 years and then having fallen away. At Alice Holt the growth though slow has been well maintained up to the twentieth year although it is now falling off slightly. The

best height growth at Cockle Park has been only moderately satisfactory and the worst has been exceedingly poor. The most interesting feature of the whole series, however, is the manner in which the height growth at the high elevation at Ceiriog has been maintained without sign of falling off except in the more exposed plots.

Japanese larch has done very much better than the European species at Ceiriog, but has not grown any faster than that species either at Cockle Park or at Cirencester. At Abbotswood, the height growth of the Japanese larch is rather faster and up to 15 years of age at least it is more productive.

Japanese larch seems to flourish much better in the mild moist climate of Wales and the west of England than in the other areas. It does not appear to be successful on heavy soils, as it is now practically at a standstill at Cockle Park and is lacking in vigour in the plantation at Alice Holt. At Cirencester, its behaviour has been similar to that of the European larch but more pronounced, and the shallow soil in that garden is obviously unsuitable for sustained growth.

Exposure has affected Japanese larch both at Cockle Park and at Ceiriog and particularly at the latter, where the differences in growth between the Japanese larch on the sheltered side and that on the exposed side of the garden have already been commented on.

In mixture, Japanese larch has suppressed most of the species with which it has been planted, including European larch at Cockle Park, Douglas fir at Cockle Park and at Ceiriog, and Norway and Sitka spruces and Scots and Corsican pines also at Ceiriog.

Norway Spruce.—Pure plantations of Norway spruce are to be found in all the gardens with the exception of that at Alice Holt and there is also available a considerable quantity of information as to the growth of this species in mixture with other trees. The age-height curves illustrated in Fig. 8 show that the best growth has been obtained in one of the plots at Abbotswood and the slowest growth at Cockle Park. In all localities the trend of developments has been similar. There has been a more or less prolonged check in early youth followed by moderately rapid growth. The check period has been most prolonged on the clay soil at Cockle Park, and in Plot 36 at Cirencester; as a rule, too, it has lasted longer with spruce in pure plantations than with this species in mixture.

The current annual height increments are now satisfactory in all the gardens, although the growth is becoming less vigorous at Cirencester and in one plot (5) at Abbotswood. At Cockle Park, Norway spruce is one of the most promising of the various species on trial there, although it hung back for a long period after planting, and it seems to be better adapted than most conifers for growth on the heavy clay of the Boulder Till. The deep loam at Abbotswood has given comparatively fast growth, but the crops with one exception are lacking in vigour. This appears to be due to the

drying out of the soil in the summer, for the area (Plot 14), which contains the best growth of Norway spruce in that garden is distinctly moister. The same trouble is arising at Cirencester and in neither place is a large size of spruce to be expected. Growth, though slower, is quite satisfactory at Ceiriog and good crops should be obtained. Exposure has not yet affected any plot of this species.

In mixture, Norway spruce has been suppressed by European larch wherever this mixture has been tried and it has also been suppressed by the fast growing Scots pine at Cirencester and at Abbotswood. At Ceiriog, however, Norway spruce and Scots pine grow at about the same rate. At Cirencester, Norway spruce has suppressed beech and at Abbotswood, Colorado Douglas fir, while it has been suppressed by Japanese larch and by Douglas fir at Ceiriog.

Sitka Spruce.—This species has not been tried so extensively as some of the others, which is unfortunate in view of its importance in British forestry. It occurs in only five plots, in pure crop at Cockle Park and at Cirencester and in mixture with Norway spruce, with Douglas fir, and with Japanese larch and Corsican pine at Ceiriog. Both at Cockle Park and at Cirencester, the Sitka spruce in pure crop has grown irregularly, but the growth at Cockle Park has been very much more satisfactory. At Cirencester, Sitka spruce has not grown very much faster than the Norway spruce and at 24 years of age had not formed a complete canopy. The current height growth of this species, however, has improved in recent years in most of the plots where it occurs. At Ceiriog the Sitka spruce has been suppressed by Japanese larch, but is suppressing Norway spruce, while in mixture with Douglas fir it is maintaining a place in the canopy though below the Douglas fir in height.

Oregon Douglas Fir.—Pure plots of Douglas fir are in existence at Alice Holt, Abbotswood, Ceiriog and Cockle Park, but none at Cirencester, where this species has not been tried. The outstanding feature of the various plots has been the slow growth that has been obtained in all the forest gardens. The average quality class is IV and the best growth does not exceed that of the third quality class. None of the gardens happens to offer a site suitable for the fastest growth of Douglas fir, which gives the best results only in fully sheltered situations where the soil is of a fresh loamy type. Age-height curves for the various gardens are given in Fig. 9. The fastest growth to commence with was made by the Douglas fir at Abbotswood, but in that garden *Chermes cooleyi* has done considerable damage within the last few years and has checked the height growth materially. This check is reflected in the shape of the curve. At Cockle Park the best growth is found on the more loamy soil and where the shelter is sufficient. In the more exposed part of the plot where the soil also is heavier, the growth has been slow. Slow growth is also a feature of the plantation at Alice Holt

and it would seem that on heavy clay soils Douglas fir is not likely to give its highest production. The plants do not establish themselves readily and growth is relatively slow throughout the life of the plantation. At Ceiriog, the Douglas fir has grown remarkedly well, when the elevation and the exposure are taken into account, and the soil conditions appear to be quite suitable. On lower ground in this district much faster growth might be expected. The effect of exposure on Douglas fir is known to be serious, but up to the present none of the plots in any of the gardens has been seriously affected. Douglas fir is a constituent of several mixtures with other conifers. At Abbotswood it is mixed with Scots pine and with European larch and has not succeeded in suppressing either species. Normally, in 25 years, the pine would have succumbed and the larch would have been partially suppressed by the Douglas fir, but in this area the growth of the Douglas fir has been checked by *Chermes cooleyi* and has had to compete with fast-growing Scots pine and moderately fast-growing European larch. At Ceiriog where *Chermes cooleyi* has not been so severe in its attacks, Douglas fir is suppressing the European larch. Douglas fir has been completely suppressed by Japanese larch both at Cockle Park and at Ceiriog. It is generally no match for that species, which grows very rapidly in early youth on most soils.

Colorado Douglas Fir.—This species has been fairly extensively used and has given interesting results. Growth as may be seen from the curves in Fig. 9 has been slow, especially in the first 15 years. Between 15 and 25 years of age it has made much better growth, particularly at Abbotswood, where it is growing vigorously. In all the gardens, however, it has grown very coarsely with heavy branching, and it is possible that, as in the case of the Scots pine, the soils are too rich for the production of poles of good quality. With the single exception of its greater resistence to exposure it appears to be inferior in all respects to the Oregon Douglas fir.

Thuya plicata.—At Cirencester, Alice Holt and Ceiriog, pure plots of this species have been laid out, while at Ceiriog it occurs in mixture with Douglas fir. The best growth is that at Alice Holt where the *Thuya* has grown at about the same rate as Douglas fir ; at Ceiriog it has grown more slowly, but at Cirencester it is disappointing and has made exceptionally poor growth.

Lawson's Cypress.—This species has grown exceptionally well at Abbotswood and moderately well at Ceiriog and Cirencester. At Abbotswood it is one of the most vigorous of the coniferous species and is suppressing Scots pine. A characteristic of this species, seen in all the plots, is the forking of the stem ; this, however, generally occurs low down and the offending forks can be removed without much difficulty.

Silver Firs.—The following species of *Abies* have been used :—*A. pectinata* at Ceiriog and at Cockle Park, *A. grandis* and *A. nobilis*

at Ceiriog, *A. concolor* at Ceiriog and at Cirencester and *A. Nordmanniana* at Cirencester. *Abies pectinata,* has been killed out almost entirely by *Chermes* (*Dreyfusia*) *nüsslini,* although surviving trees are growing quite well, both at Ceiriog and at Cockle Park. *A. grandis* and *A. nobilis* are both growing satisfactorily and do not seem to be affected overmuch by exposure. *Abies concolor* has grown slowly at Ceiriog and more rapidly at Cirencester under a nurse crop of birch. *Abies Nordmanniana* has been successfully raised at Cirencester under larch and under *Robinia.*

This chapter has brought to an end a bulletin which has had as its object the study of the development of a large number of tree species in five rather widely scattered areas. The discussion in Chapter II of the relative growth of the species in each area and the comments on the individual species in relation to different locality conditions contained in the present chapter have been based on a large quantity of data obtained by measurement. It is evident from a consideration of these data that the plots are all too young for any final appraisal of the results, but nevertheless, certain interesting facts have emerged. In view of the fact that the species used were almost exclusively coniferous, it is, perhaps, unfortunate that none of the areas, with the exception of Ceiriog, is on a typical site for conifers, as the soils are generally of the hardwood type. It is noticeable that where hardwoods have been tried they have succeeded. Thus, at Abbotswood both sweet chestnut and oak have grown rapidly after a slow start and have put on height increments exceeding those of any conifer. At Cirencester, the hardwoods compare favourably with the conifers both in rate of growth and in general health, while at Ceiriog sycamore has succeeded at an elevation of over 1,000 feet. Of the conifers, Scots pine, Lawson's cypress and Japanese larch have grown rapidly at Abbotswood, and European larch moderately so. At Ceiriog there has been remarkable growth of Japanese larch at a high elevation and excellent growth of Douglas fir, while at Alice Holt the good development of Weymouth pine is worthy of mention. Norway spruce and Sitka spruce have everywhere grown slowly and irregularly in the first few years after planting, but they are now in most cases growing rapidly and overtaking species such as Japanese larch which started off more quickly. At Cockle Park, the best plots are those of Sitka spruce and Douglas fir, and this indicates that indifferent growth in early years need not prevent the development of a successful crop later on.

Throughout this work the effects of local conditions on the growth of the different species have been carefully noted, and it has been found that these effects are generally clearly marked. The range of sites afforded by the five gardens is, however, a limited one. Before the great range of conditions in Great Britain could be regarded as fully covered, such experimental areas would have to be multiplied almost indefinitely.

APPENDIX.

PLOT DATA

In this appendix full data are given for the plots that have been measured at Cockle Park, Cirencester, Abbotswood, Alice Holt and Ceiriog. The age given is the age at the time of measurement; figures for number of stems, basal area and volume are expressed as per acre; while figures for girth, basal area and volume are given in quarter-girth measure. The girth is taken at 4 feet 3 inches above ground and the volumes given are underbark volumes.

To convert cubic feet quarter-girth to cubic feet true measure, the following factor should be used :—

Cubic feet true measure = Cubic feet, quarter-girth × 1·273.

The following factors may be employed to convert these tables from the quarter-girth system with British units of measurement to the diameter system, true measure with metric units :—

Feet to metres = feet × 0·3048.

Inches quarter-girth to centimetres diameter = inches quarter-girth × 3·234.

Number of stems per acre to number of stems per hectare = number of stems per acre × 2·471.

Square feet quarter-girth per acre to square metres per hectare = square feet quarter-girth per acre × 0·2922.

Cubic feet quarter-girth per acre to cubic metres per hectare = cubic feet quarter-girth per acre × 0·0891.

Cockle Park.

Plot No.	Species.	Age.	Main Crop.							Thinnings.			Total Crop.	
			Number of stems per acre.	Mean height.	Mean quarter-girth.	Basal area per acre.	Volume per acre.	Form factor.	Bark percentage.	Number of stems per acre.	Basal area per acre.	Volume per acre.	Basal area per acre.	Volume per acre.
		Years.		Feet.	Inches.	Square feet.	Cubic feet.				Square feet.	Cubic feet.	Square feet.	Cubic feet.
2	Scots Pine ..	30	1,635	30	3¼	123·3	1,310	0·354	16	250	5·2	35	128·5	1,345
3	Douglas Fir ..	30	520	51	5¼	98·4	2,040	0·406	13	260	16·8	190	115·2	2,230
4	Sitka Spruce ..	30	1,315	43	3¾	129	2,500	0·450	10	680	34·7	340	163·7	2,840
5	Norway Spruce	30	2,190	28	2¾	112·3	985	0·400	9	410	11·8	55	124·1	1,040
7	Japanese Larch	30	670	40	4¼	86·8	1,310	0·377	22	235	17·6	190	104·4	1,500
8	Norway Spruce	29	1,250	28	2¾	68·1	980	0·515	9	850	19·6	50	87·7	1,030
	European Larch	29	200	42	5½	36·3	620	0·408	17	25	2·0	20	38·3	640
9B	Japanese Larch	22	1,245	32½	3	76·4	705	0·283	11	965	29·8	102	106·2	807

Plot No.	Species.	Age.	Main Crop.							Thinnings.			Total Crop.	
			Number of stems per acre.	Mean height.	Mean quarter-girth.	Basal area per acre.	Volume per acre.	Form factor.	Bark percentage.	Number of stems per acre.	Basal area per acre.	Volume per acre.	Basal area per acre.	Volume per acre.
		Years.		Feet.	Inches.	Square feet.	Cubic feet.				Square feet.	Cubic feet.	Square feet.	Cubic feet.
2B	European Larch	24	620	35½	3¾	60	734	0·344	23	230	12	93	72	827
	Scots Pine ..	24	310	32½	3¼	23	222	0·288	20	490	21	95	44	317
2D	Scots Pine ..	24	740	32	3½	64	795	0·388	14	430	29	264	93	1,059
	Norway Spruce	24	600	28	2¾	32	372	0·415	18	70	—	—	—	372
3B	Norway Spruce..	24	2,585	20	2	78	—	—	—	—	—	—	78	—
4A	Japanese Larch	15	1,935	27	2¾	105	800	0·284	23	520	13	—	118	800
		24	1,111	32½	3½	94	1,186	0·388	18	758	38	138	132	1,324
4B	European Larch	15	1,780	28	2½	79	540	0·246	16	230	6	—	85	540
		24	830	34	3¼	94·9	1,367	0·424	18	300	15	132	109·9	1,499
5A	Corsican Pine ..	15	2,340	19	2¾	108	585	0·285	27	265	3	—	111	585
		24	1,000	31	4	111	1,290	0·375	20	400	16	102	127	1,392
5B	Scots Pine ..	15	2,805	22	2½	98	625	0·290	20	390	9	—	107	625
		24	925	32	3½	81	1,010	0·390	13	472	19	150	100	1,160
10A	Norway Spruce..	23	840	27	3¼	76	723	0·352	16	620	27	131	103	854
10B	Scots Pine ..	23	710	31	3¾	68	751	0·356	16	325	36	134	104	885

105·4	1,600	0·408	16	285	11·8	85	117·2	1,685
98·7	1,225	0·401	10	120	10·4	20	109·1	1,245
102·3	1,435	0·339	11	365	—	90	—	1,525
79·6	660	0·260	14	295	7·4	—	87·0	660
72·1	955	0·310	19	141	16	230	88·1	1,185
54·4	895	0·384	11	80	16·5	225	70·9	1,120
40·1	725	0·468	12	250	3·6	50	43·7	775
125·7	1,806	0·403	16	164	4·7	15	130·4	1,821
104·4	1,590	0·413	12	225	11·2	90	115·6	1,680
72·4	970	0·450	12	20	1·1	7	73·5	977
86·9	1,460	0·480	15	65	3	20	89·9	1,480
129	1,385	0·330	21	650	34	270	163	1,655

Plot No.	Species.	Age.	Main Crop.							Thinnings.			Total Crop.	
			Number of stems per acre.	Mean height.	Mean quarter-girth.	Basal area per acre.	Volume per acre.	Form factor.	Bark percentage.	Number of stems per acre.	Basal area per acre.	Volume per acre.	Basal area per acre.	Volume per acre.
		Years.		Feet.	Inches.	Square feet.	Cubic feet.				Square feet.	Cubic feet.	Square feet.	Cubic feet.
1	Japanese Larch	21	725	36½	3⅜	57·8	760	0·361	17	485	25·6	195	83·4	955
2	*Thuya plicata* ..	21	1,250	30	3⅝	116·3	1,225	0·351	16	770	11·1	10	127·4	1,235
3	Weymouth Pine	21	1,270	31	3⅝	117·0	1,450	0·400	11	1,040	44·8	295	161·8	1,745
5	Oregon Douglas Fir	21	1,130	32	3½	95·9	1,205	0·392	17	850	33·4	215	129·3	1,420

Ceiriog Forest Garden.

Plot No.	Species.	Age.	Main Crop.			Thinnings.			Total Crop.	
			Number of stems per acre.	Basal area per acre.	Volume per acre.	Number of stems per acre.	Basal area per acre.	Volume per acre.	Basal area per acre.	Volume per acre.
		Years.		Square feet.	Cubic feet.		Square feet.	Cubic feet.	Square feet.	Cubic feet.
4	Douglas Fir	22	1,032	132	2,586	—	—	—	132	2,586
9	Japanese Larch	18	856	93	—	—	—	—	93	—
10	Japanese Larch	21	668	—	1,494	112	—	159	—	1,653
15	Japanese Larch (heavily thinned)	21	960	93·6	1,686	348	20·4	350	114	2,036
24	European Larch	18	1,484	80	—	—	—	—	80	—
25	European Larch	18	1,156	69	—	—	—	—	69	—
31	Douglas Fir (heavily thinned)	18	1,204	116·5	2,111	248	13	62	129·5	2,173

Printed under the authority of His Majesty's Stationery Office
by Harrison and Sons, Ltd., 44-47, St. Martin's Lane, W.C.2.
(B 12/2030)Q Wt. 12084—580/941 1,000 5/31 H & S, Ltd. Gp. 12,

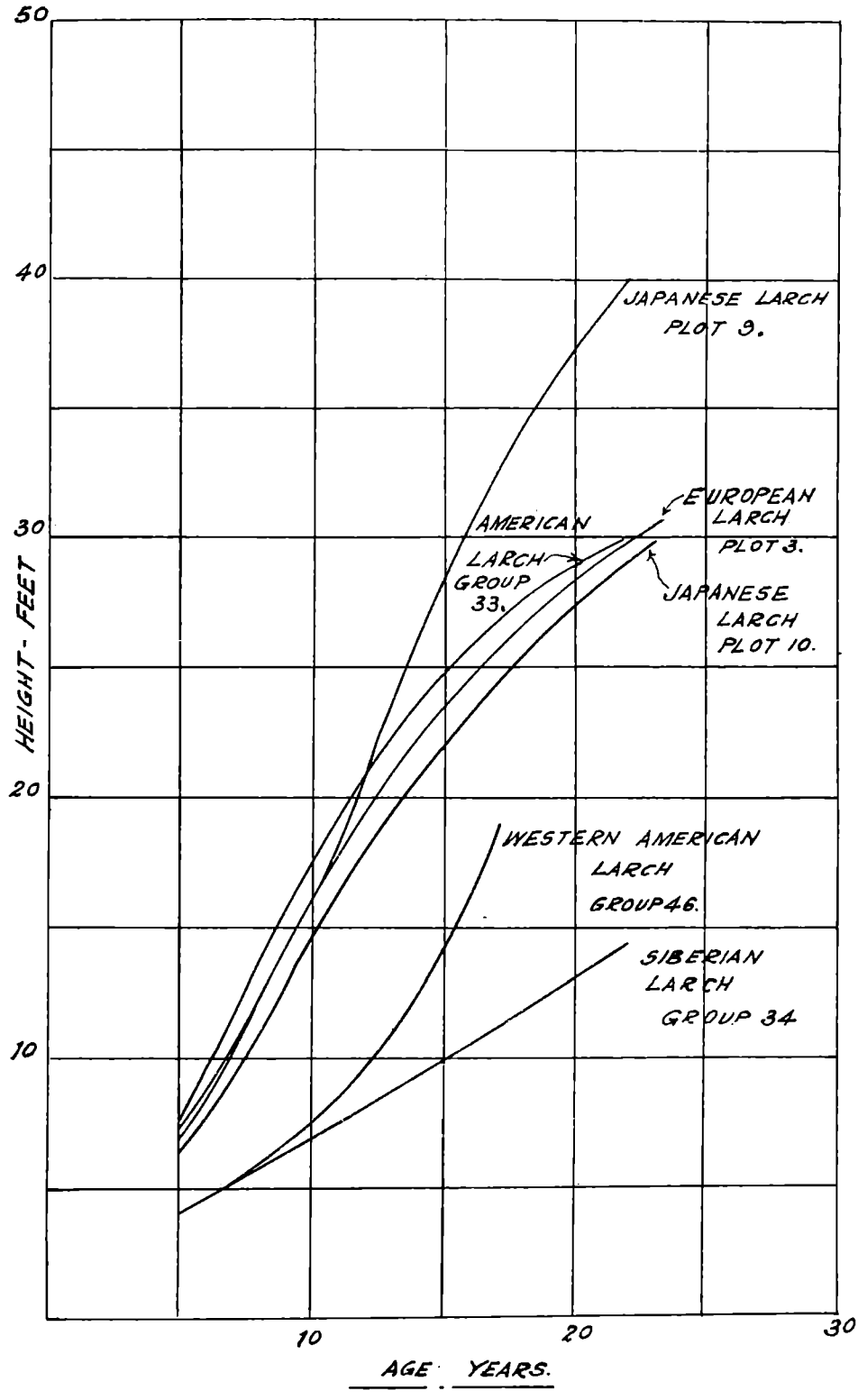


FIG. 1. CURVES SHOWING COMPARATIVE HEIGHT GROWTH OF DIFFERENT SPECIES OF LARCH — AT CEIRIOG. —

B3647, 12/30 T.S&C. 941, 1000, 4/31. Malby & Sons, Photo Litho

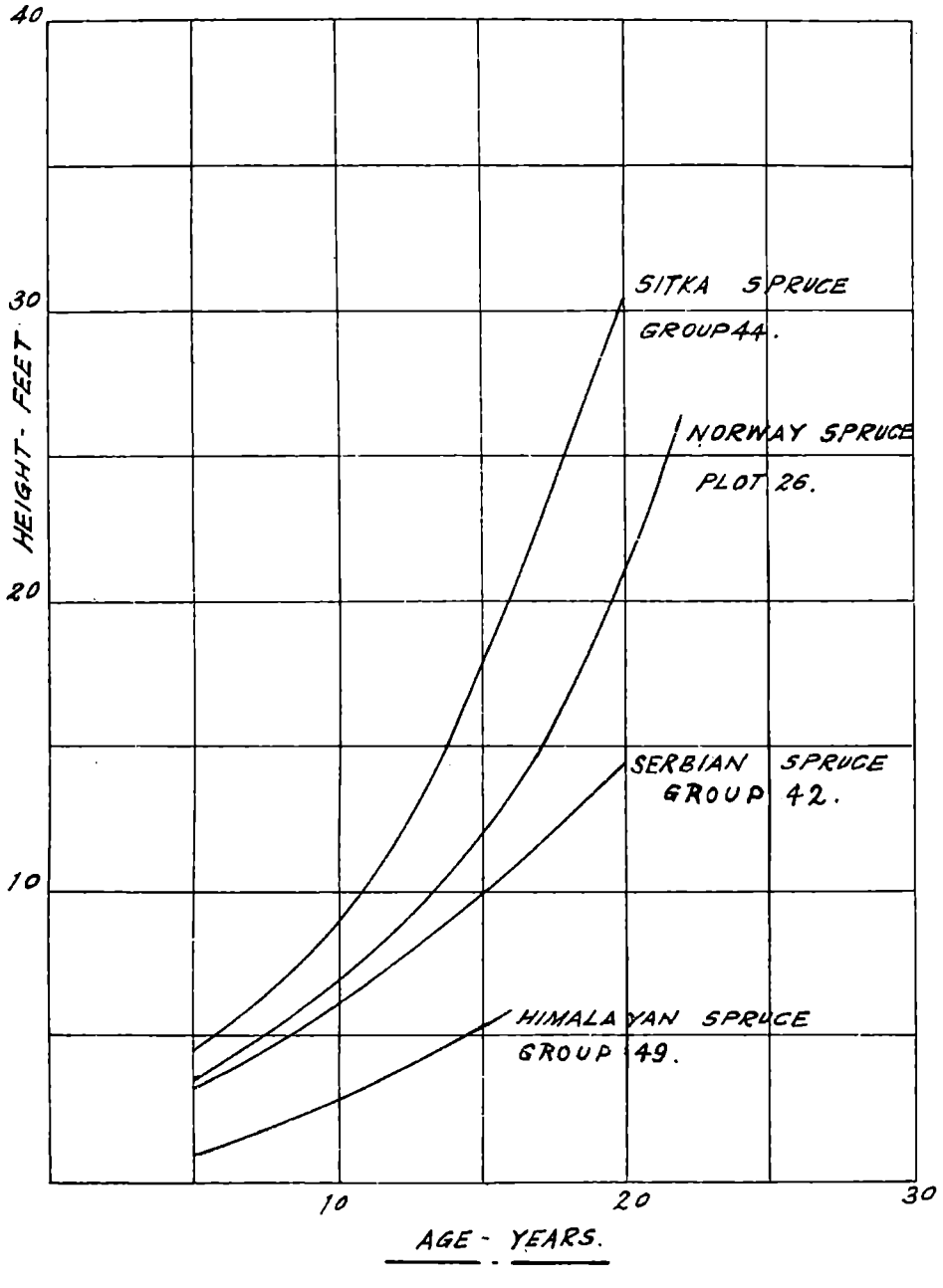


FIG. 2. CURVES SHOWING COMPARATIVE HEIGHT GROWTH OF DIFFERENT SPECIES OF SPRUCE.
— AT CEIRIOG. —

P3647

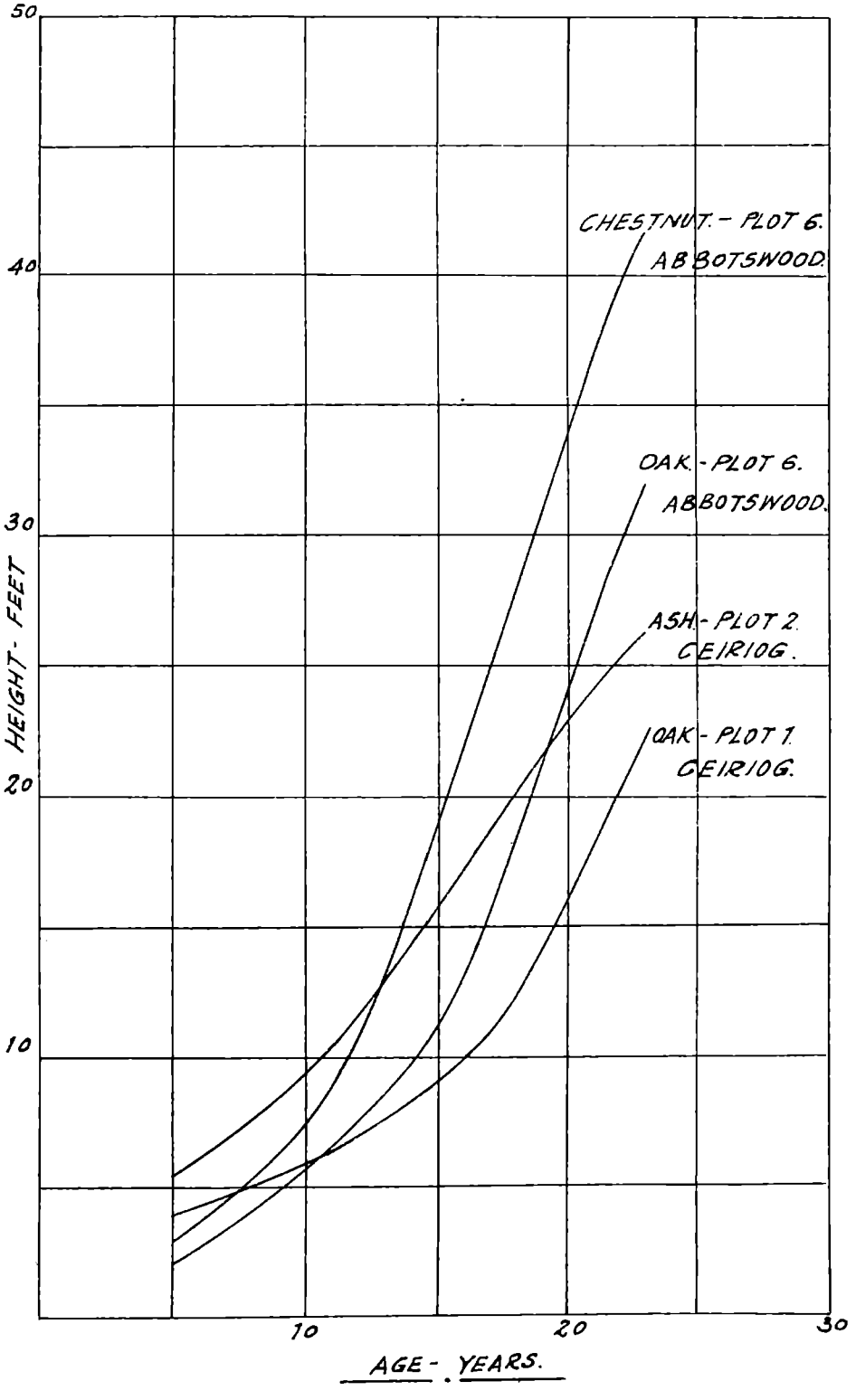


FIG.3. AGE HEIGHT CURVES FOR HARDWOODS.

P3647

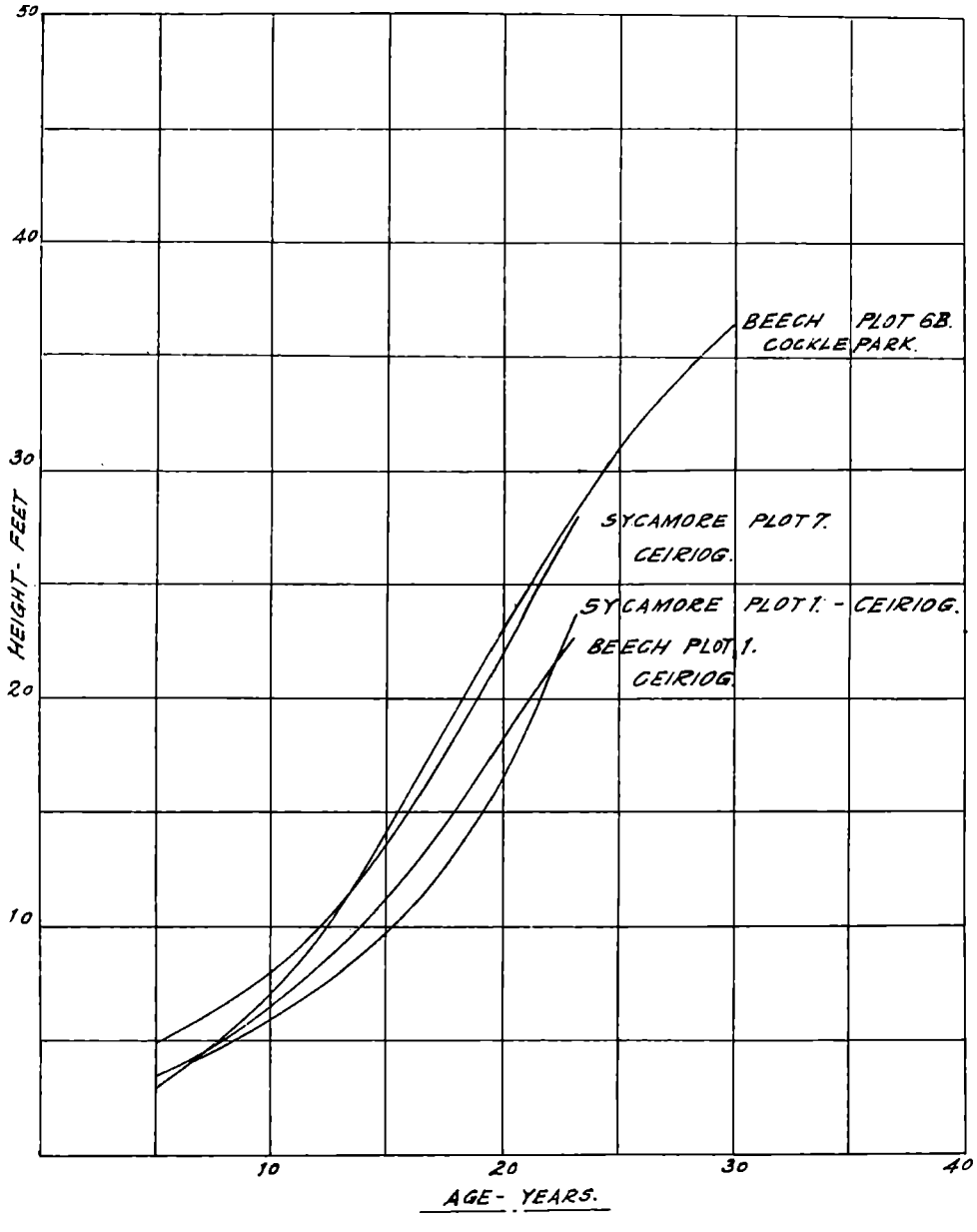


FIG.4. AGE HEIGHT CURVES FOR HARDWOODS.

P3647

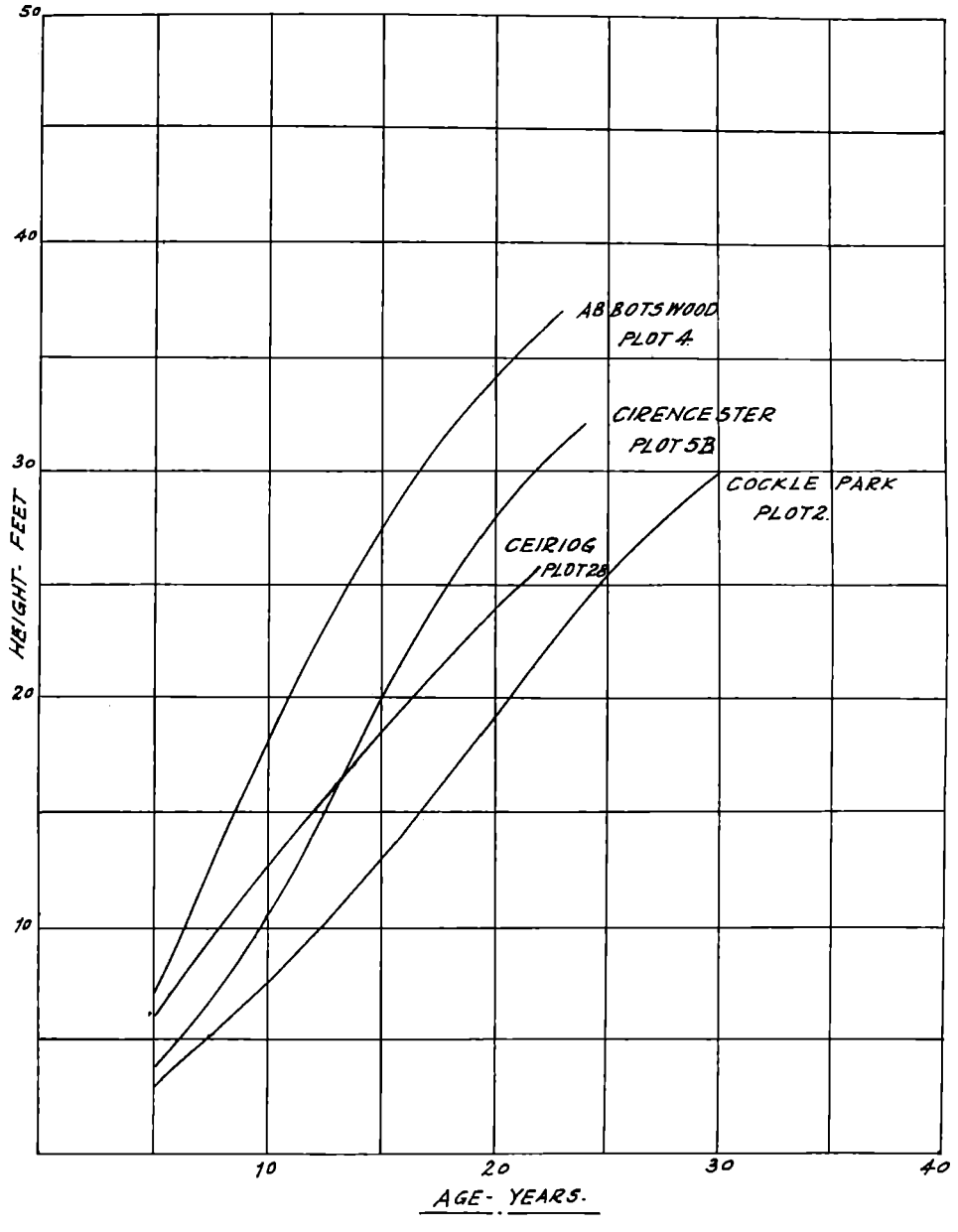


FIG. 5. AGE HEIGHT CURVES FOR SCOTS PINE.

P3647

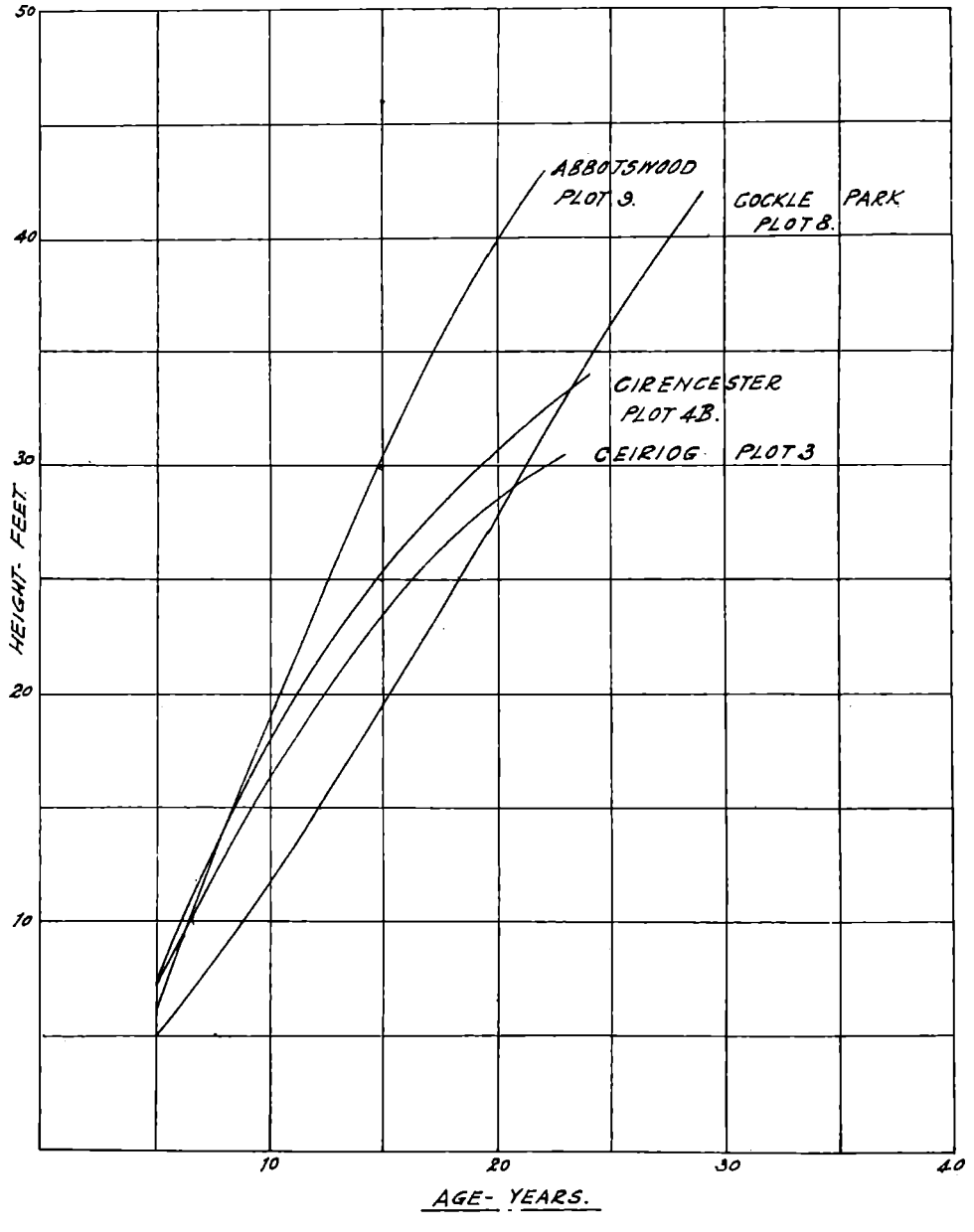


FIG. 6. AGE HEIGHT CURVES FOR EUROPEAN LARCH.

P3647

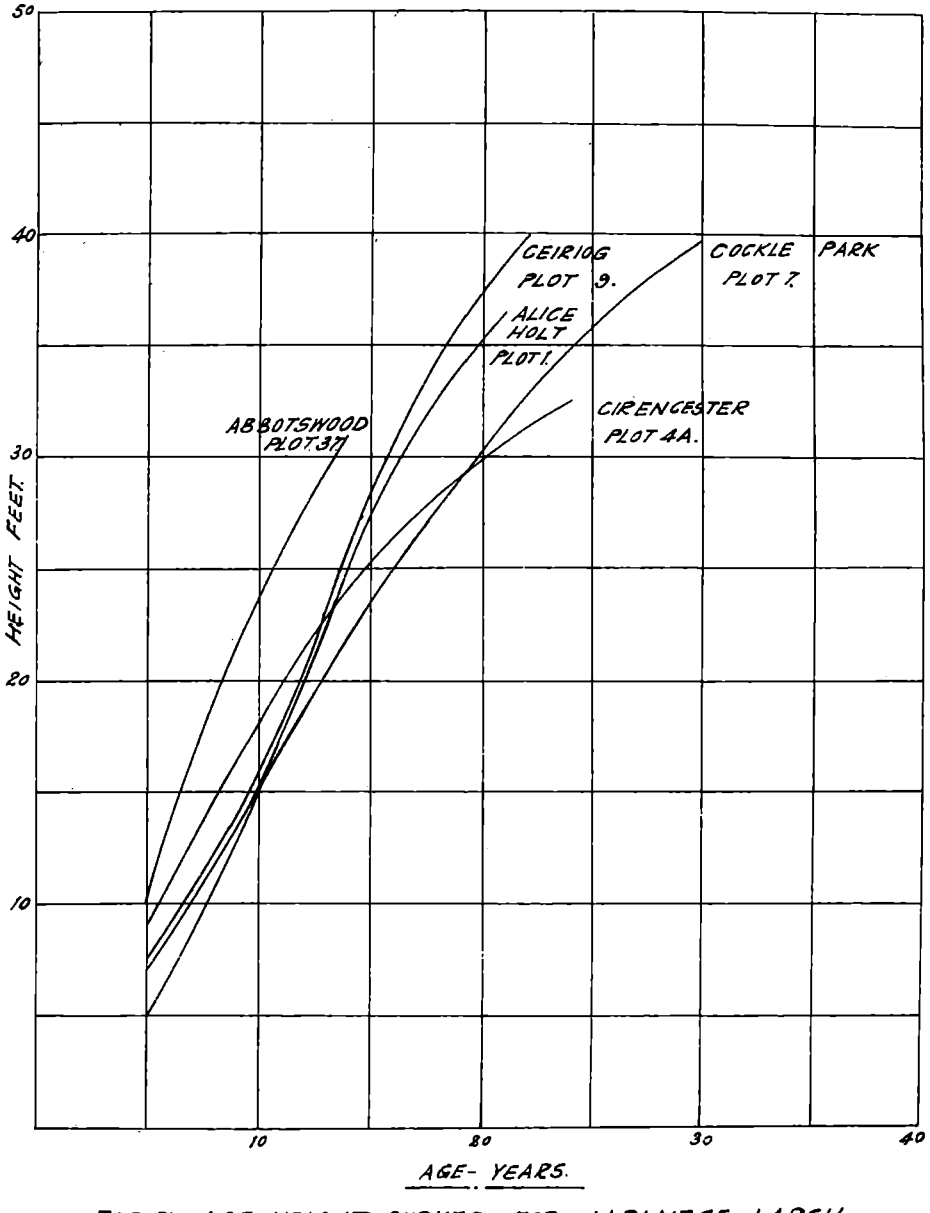


FIG. 7. AGE HEIGHT CURVES FOR JAPANESE LARCH

P3647

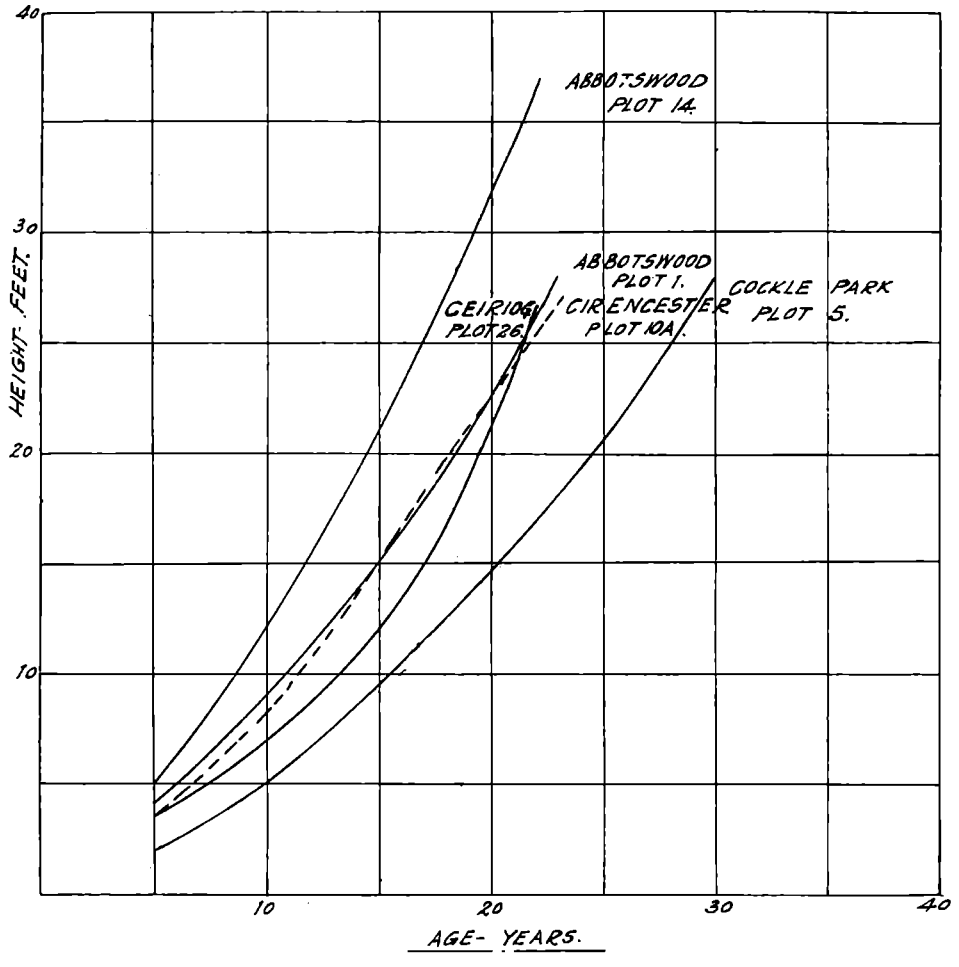


FIG. 8. AGE HEIGHT CURVES FOR NORWAY SPRUCE

P3647

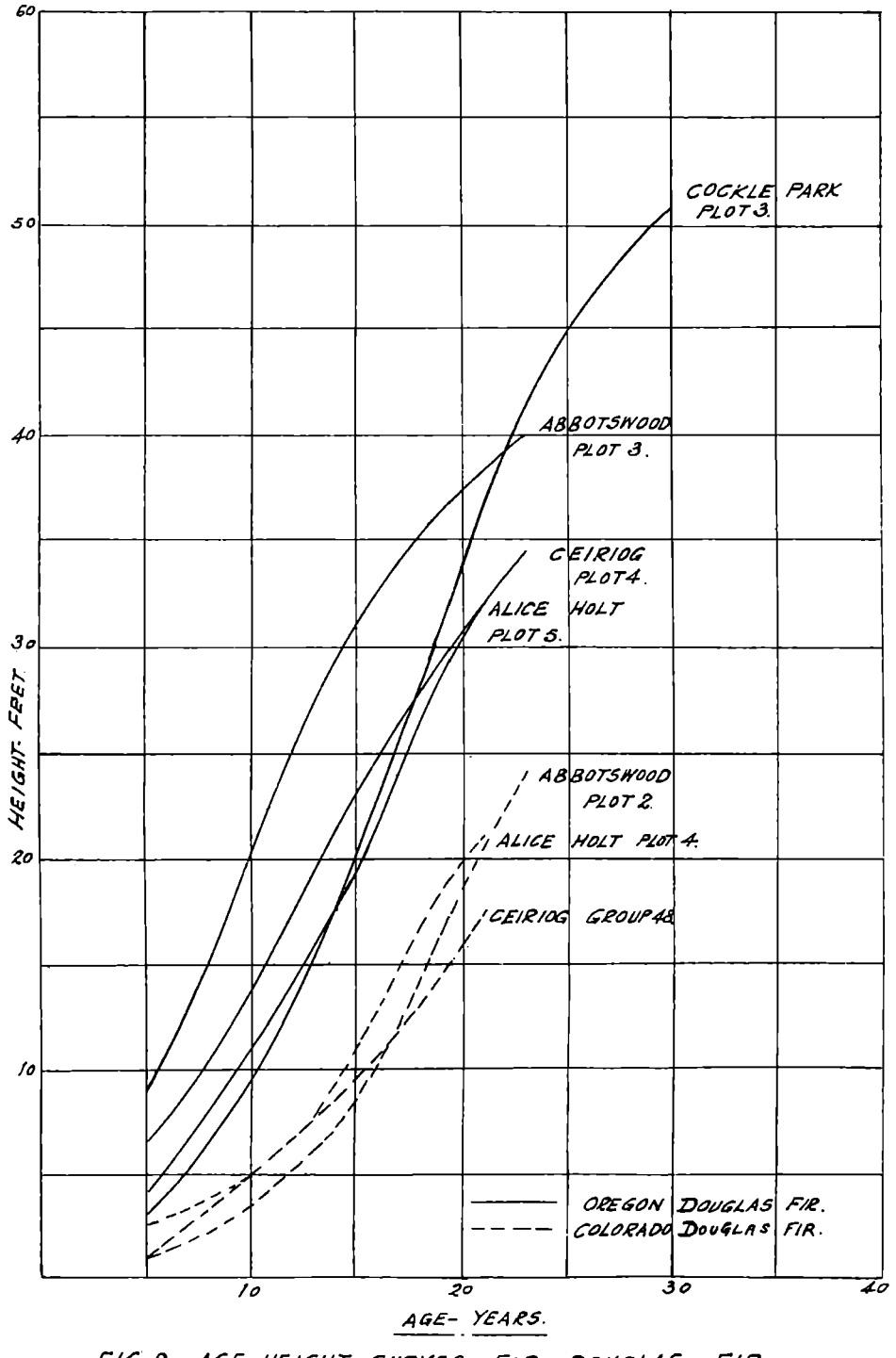


FIG 9. AGE HEIGHT CURVES FOR DOUGLAS FIR.

P3647

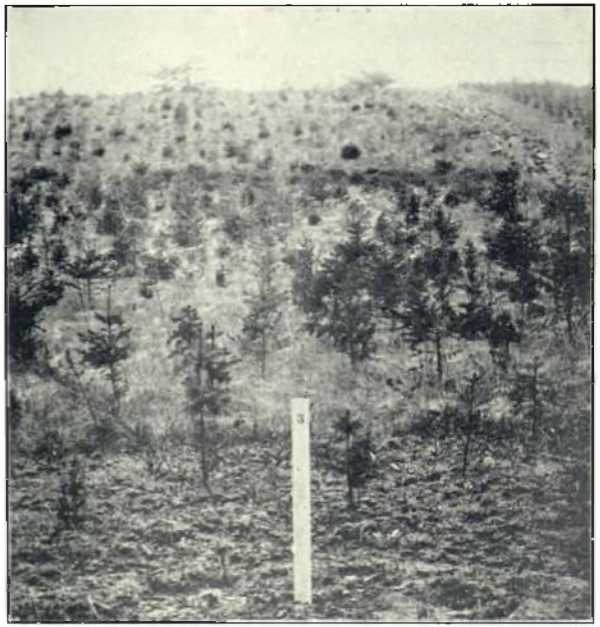


FIG. 1.

Douglas fir, age 6 years, Cockle Park, Plot 3.
Photographed 1904 (p. 12).

FIG. 2.

Douglas fir, Cockle Park, same plot as Fig. 1.
Photographed 1930.

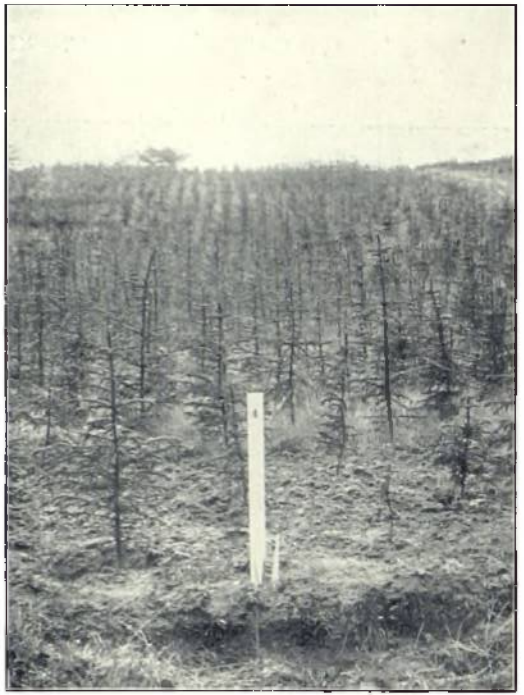


FIG. 3.

Sitka spruce, age 6 years, Cockle Park, Plot 4.
Photographed 1904 (p. 13).

FIG. 4.

Sitka spruce, Cockle Park, same plot as Fig. 3.
Photographed 1930.

FIG. 5.
Norway spruce, age 24 years, Cirencester.
Plot 3B (p. 23).

FIG. 6.
Japanese larch, age 24 years, Cirencester.
Plot 4A (p. 23).

FIG. 7.
Scots pine, age 23 years, Abbotswood.
Plot 4 (p. 34).

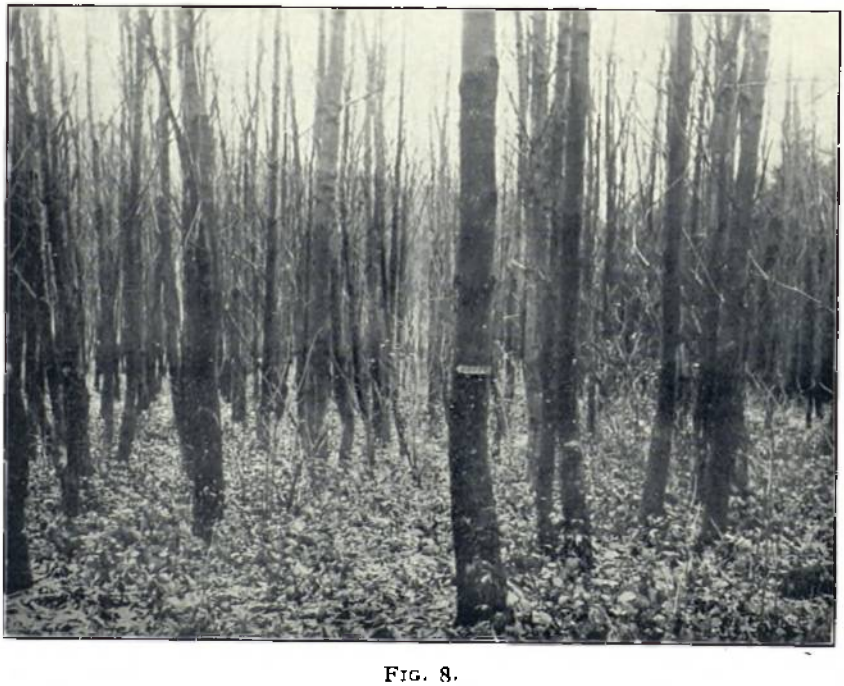


FIG. 8.
Sweet chestnut, age 23 years, Abbotswood.
Plot 6 (p. 35).

FIG. 9.
Pedunculate oak, age 23 years, Abbotswood.
Plot 7 (p. 35).

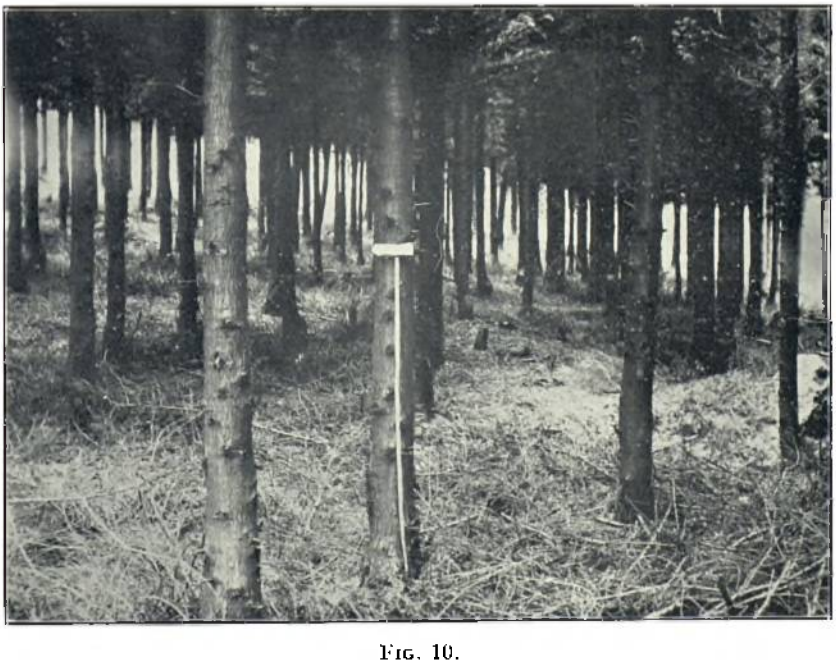


FIG. 10.
Lawson's cypress, age 22 years, Abbotswood.
Plot 12 (p. 38).

FIG. 11.
Japanese larch, age 21 years, Alice Holt.
Plot 1 (p. 56).

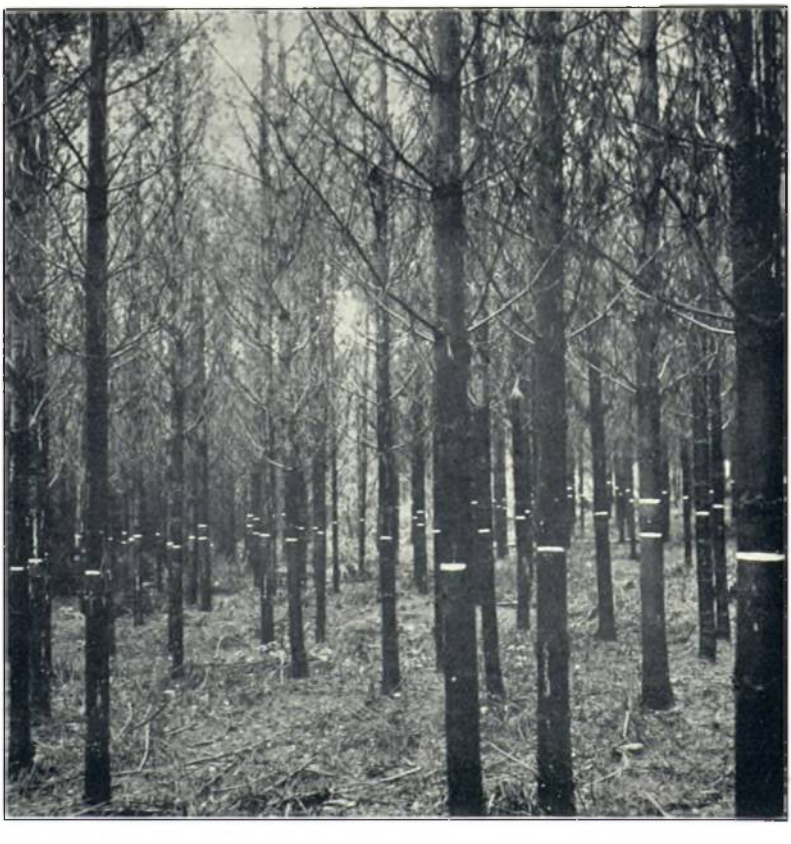


FIG. 12.
Weymouth pine, age 21 years, Alice Holt.
Plot 3 (p. 57).

FIG. 13.
Colorado Douglas fir, age 21 years, Alice Holt.
Plot 4 (p. 57).

FIG. 14.
Oregon Douglas fir, age 21 years, Alice Holt.
Plot 5 (p. 58).

FIG. 15.
Oregon Douglas fir, age 23 years, Ceiriog.
Plot 4 (p. 65).

FIG. 16.
Larix occidentalis, age 17 years, Ceiriog.
Group 46 (p. 78).

PUBLICATIONS OF THE FORESTRY COMMISSION.

	Price. s. d.	Post free. s. d.
BRITISH EMPIRE FORESTRY CONFERENCE, 1920	7 6	7 10½
BRITISH YIELD TABLES (Reprinted from Bulletin No. 10)	1 0	1 1
REPORT ON CENSUS OF WOODLANDS AND CENSUS OF PRODUCTION OF HOME-GROWN TIMBER, 1924	1 9	1 10
BULLETINS :—		
1. Collection of Data as to the Rate of Growth of Timber ..	0 4	0 5
2. Survey of Forest Insect Conditions	*Out of Print*	
3. Rate of Growth of Conifers in the British Isles	*Out of Print*	
4. The Douglas Fir Chermes (Chermes Cooleyi)	2 0	2 1
5. Poplars	1 6	1 7
6. The Phomopsis Disease of Conifers	1 6	1 7
7. The Silver Fir Chermes	1 6	1 7
8. British Bark-Beetles	2 6	2 7
9. Beetles Injurious to Timber	1 3	1 4
10. Growth and Yield of Conifers in Great Britain	4 0	4 3
11. Nursery Investigations	3 6	3 9
12. Forest Gardens	2 6	2 9

ANNUAL REPORTS OF THE FORESTRY COMMISSIONERS :—

Year ending September 30th—

	Price s. d.	Post free. s. d.		Price s. d.	Post free. s. d.
1920—H.C. 128 ..	*Out of Print*		1925—H.C. 89 ..	0 9	0 10
1921—H.C. 108 ..	1 0	1 1	1926—H.C. 72 ..	1 0	1 1
1922—H.C. 50 ..	1 0	1 1	1927—H.C. 85 ..	0 9	0 10
1923—H.C. 93 ..	*Out of Print*		1928—H.C. 5 ..	0 9	0 10
1924—H.C. 107 ..	1 0	1 1	1929—H.C. 148 ..	1 3	1 4

Copies of the above publications may be purchased directly from H.M. Stationery Office, Adastral House, Kingsway, London, W.C.2, or through any Bookseller. They cannot be obtained from the Forestry Commission.

LEAFLETS.

1. Pine Weevils.
2. Chermes Cooleyi.
3. The Pine Shoot Beetle.
4. The Black Pine Beetle
5. Conifer Heart Rot.
6. Honey Fungus.
7. Chermes attacking Spruce and other Conifers.
8. Douglas Fir Seed Fly.
9. Forest Fires.
10. The Oak-leaf Roller Moth.
11. Larch-shoot Moths.
12. Income Tax and Death Duties on Woodlands.
13. The Larch Longicorn Beetle.
14. The Phomopsis Disease of Conifers
15. The Felted Beech Coccus.
16. Larch Canker.
17. Chafer Beetles.
18. Douglas Fir Leaf-cast Disease.
19. The Dutch Elm Disease.
20. The Watermark Disease of the Cricket Bat Willow.

Published by the Ministry of Agriculture and now issued by the Forestry Commission.

103. The Pine Sawfly.
186. The Large Larch Sawfly.

Copies of the leaflets may be obtained free of charge on application to the Secretary, Forestry Commission, 9, Savile Row, London, W.1.