LLANOVER AND LLANTRISANT FORESTS REPORT

(DAY + SANZEN-BAKER)

Llanover & Llantrisant

LLANOVER & LLANTRISANT

(11)

S/233.220.3

Sub 2

FOR REFERENCE ONLY

Bound?

REPORT ON THE INVESTIGATION INTO THE CONDITION OF TREE CROPS AT LLANOVER AND LLANTRISANT FORESTS IN THE SOUTH WALES AND MONMOUTHSHIRE COALFIELD

By

W.R. Day and R.G. Sanzen-Baker

IMPERIAL FORESTRY INSTITUTE

University of Oxford

5th January, 1938

W.H. Guillebaud, Esq.,
Forestry Commission,
9 Savile Row, W.1.

Dear Guillebaud,

We have pleasure in submitting herewith our report on Llanover and Llantrisant Forests. It has developed into a document of very considerable length. We make no apology for this: when the complex nature of the problems which it has been necessary to discuss are considered, it will, we think, be seen that no short discussion could deal adequately with this matter.

In the report we attempt:-

i. To provide a history of the site and plantations (pp.1-13).

ii. To provode general information and data regarding the forests discussed, to enable some discussion and diagnosis of their present condition to be made (pp.14-45).

iii. To discuss the factors which have affected the growth of the plantations (pp.45-75).

iv. To compare conditions in other selected districts with those in these forests (pp.76-92).

v. To discuss the suitability of species for planting in these forests (pp.93-104).

A short summary of the report is also given (pp.105-108).

We would ask that the report be read as a whole in spite of its length and, incidentally, the time it must take to do so. It should also be remembered that certain aspects of the problem can only be fully elucidated after considerable research. The report is, therefore, in part, an expression of opinion based on

circumstantial evidence. We desire that this should be taken into consideration and that the report should be used, as we state in Section 11 of the Summary, to provide a basis for thought, discussion and criticism.

The need for further research into the conditions affecting the growth of forests within the South Wales and Monmouthshire coalfield is plain. You have yourself suggested the possibility of continuing the investigation into soils. We suggest that this report will be of greater service, and that the problems needing investigation will be clearer, if there is some discussion of it, at least among those closely interested in the development of State forests in this area. We shall be very glad to take part in any discussion, and in it would ask for full and frank criticism of anything we have put forward.

We are responsible for the report as a whole. The section on Vegetation (pp.28 et seq.) has, however, been written by Dr. E.W. Jones of the Imperial Forestry Institute, who accompanied us to the areas to collect the necessary data. Furthermore, the soil analyses, and much of the discussion on soils, are based on letters and reports received from Professor G.W. Robinson of Bangor. We wish to express our thanks to both, and especially to Professor Robinson, for the great amount of trouble they have taken in this matter. Our thanks are also due to Mr. F. Scott and his staff for their very great assistance in providing data of the past history of the areas concerned, and in helping us on many occasions.

It should be mentioned also that the assessment work was carried out by Research forester, M. Nimmo.

Yours sincerely,

(Signed) W.R. DAY
R.G. SANZEN-BAKER

REPORT ON THE INVESTIGATION INTO THE CONDITION OF TREE CROPS AT LLANOVER AND LLANTRISANT FORESTS IN THE SOUTH WALES AND MONMOUTHSHIRE COALFIELD

By

W.R. Day and R.G. Sanzen-Baker

REPORT ON THE INVESTIGATION INTO THE CONDITION OF TREE CROPS AT LLANOVER AND LLANTRISANT FORESTS IN THE SOUTH WALES AND MONMOUTHSHIRE COALFIELD

Contents

Appendices

REPORT ON THE INVESTIGATION INTO THE CONDITION OF TREE CROPS AT LLANOVER AND LLANTRISANT FORESTS IN THE SOUTH WALES AND MONMOUTHSHIRE COALFIELD

Introduction

Purpose of Enquiry

The investigation upon which this Report is based was undertaken with a view to finding some explanation for the unsatisfactory condition of some of the plantations in Llanover Forest in Monmouthshire and Llantrisant Forest in Glamorganshire. Llanover is the larger and more important forest and the report is mainly concerned with it, although much of what follows applies to Llantrisant Forest except when specific exception is made.

Situation

Llanover Forest is just within the south-eastern edge of the South Wales and Monmouthshire coalfield, while Llantrisant Forest occupies a central position on its southern edge. They both stand in what may be termed 'industrial' rural districts, Llanover being nearest to the greater urban development.

The coalfield in which both forests occur occupies a district of peculiar interest in forestry. It is one of the largest markets for pit-props in Britain, and, although this market is bound up with an exchange export trade, it is one that should have some considerable significance in local forestry. It also occupies an area of country in which a very high proportion of the land devoted to rural purposes is waste or poor hill grazing because of the high elevation of the plateau and steepness of the slopes. There is,

thus, a considerable area of land which might be developed for forestry and which is near to a substantial local market for certain types of forestry product.

Afforestation Difficulties

This apparently attractive area in which our two forests are situated has two great drawbacks. It is, in the first place, mainly an area of poor soils, which naturally are of low fertility. This is partly because of the large area of high lying moorland, partly because of the peculiar topography which does not favour the development of really deep soils on the steep hill sides, and partly because the soils are derived largely from rocks which, owing to their inherent character, do not produce soils of really high fertility, even under much better topographical conditions than usually prevail here.

The second drawback arises simply because the coalfield has developed as a great industrial area. Accordingly, it has an atmosphere more or less contaminated with smoke and fumes which are deleterious to plant life generally.

There is a third drawback which is, perhaps, of considerable importance. Throughout the whole of the coalfield there is little natural woodland of high exploitable value, while plantations of exotic species have had, at the best, but moderate success. The low value of the natural woodland is due mainly to past misuse and to the fact that oak and birch, of which it largely consists, are considered to be of comparatively little use for economic exploitation at the present day. The whole district is, in fact, one in which forestry

is at a low level. There is very little for the guidance of those who would practice silviculture.

It will thus be seen that the difficulties facing the forester lie chiefly in the comparatively poor soil with its accompanying difficult topography and often trying climate, in the atmosphere contaminated with smoke and fumes, and in the lack of guidance as to what should be the specific constitution of a forest which is to be raised for economic exploitation. The answer to the problem is, therefore, likely to be found mainly by attempting to understand how these things have affected the plantations, and it is along these lines that the work has proceeded.

Notes on the Report

Complex and difficult investigations are necessary for a proper understanding of the effect upon tree growth of soil, climatic and atmospheric conditions; of the degree to which the particular species planted may be regarded as fitted to the habitat which exists, or which might develop under suitable treatment; and of the suitability of the technique used in planting and tending, for developing the best in whatever species might be used. Consequently it is inevitable that the report should be somewhat superficial and include matters or opinions which are controversial. An attempt has been made, however, to collect the evidence that is available and to make a fair judgement of the situation as a whole. Under the circumstances it is impossible that the conclusions arrived at shall be altogether satisfactory as essential information does not exist and can only be obtained by means of long

continued research. In spite of this, it is possible to come to some clearer conception of the type of forest biologically suited to this district and of the reasons for the unsatisfactory condition of the plantations.

In order that as complete a view as possible may be attained of the problems before us, the report begins with a revue of the past history of the forests and of the development of the plantations. Particular attention has been paid here to Llanover Forest which, as indicated above, is the main subject of the report. The records for Llantrisant Forest have not been specially examined. In order that the condition of the forest might be kept in proper perspective, visits were made to other woodlands both in South Wales and in other parts of Wales and England. Reference is made to these woodlands where necessary.

Past History of Sites

I. Llanover Forest

Hardwoods

The area concerned in this report, namely, the moderate to steep valley slopes, was, in the main, coppice or coppice-with-standards woodland

Coppice

of varying quality. The coppice consisted mainly of oak with more or less beech and birch and occasional ash. It is reported that beech coppice of very good type was grown in the Cwm Gwyddon-Fach valley on a westerly aspect. Although the soil there is shallow and stony, good clean beech poles up to 55 feet in length

were cut. These were good pit wood size and a large quantity was despatched as copper poles for use in the copper smelting works. Good quality oak has been grown in many parts of the forest. The standards appeared to be mainly oak of fair to moderate quality of the type suitable for cleaving and fencing material.

Standards

Conifers

Occasional small coniferous plantations are known to have been in existence. These were mainly of European larch, but Norway spruce and Scots pine also occurred. It appears to have been the practice to fell these at pit wood size. Some of the larch plantations, notably on the better sites in the Cwm Gofappy and Cwm Carn areas, are described as being of good quality, but one suspects that the standard of comparison is not a very high one. They may have been good for the locality. The height of the better poles appears to have been about 50 feet; the age is not known. Other larch plantations in the main area of Cwm Gwyddon were apparently rather openly stocked with irregular and somewhat poor growth. There is a record of former agricultural ground in Compartment 8 having been subject to two crops of larch pit wood. The second crop appears to have made good growth.

Norway spruce is reported to have grown well in mixture with European larch and Scots pine on former agricultural ground at an elevation of 900-1000 feet.

It is worth noting that most of the larch plantations which were felled about 1885-1905

were not replanted but allowed to grow to scrub. It is suggested that if this larch had been of really good quality, the sites would have been replanted as the Llanover Estate did a considerable amount of planting and had a ready market for pit wood.

Details such as are known of the crops on the former Llanover property are given in Appendix I.

II. Llantrisant Forest

Previous Crop

Less is known about the previous history of Llantrisant Forest. From a study of the Ordnance Map, it would appear that the forest was under a mixed crop of conifers and hardwoods. The edition of 1921 shows that conifers predominated over the major part of the area. A greater proportion of hardwoods appears to have existed in the north of the forest, also in the outlying area of Coed Ynys-maerdy. Similar ordnance markings appear in the edition revised in 1904.

The conifers were probably largely Scots pine and the hardwoods oak with possibly occasional beech. In many parts of the area there appears to have been a thin underwood of mixed coppice, mainly oak with some birch. In Coed Ynys-maerdy there is a mixed plantation including European larch aged 35 years. This is of quite fair quality and size, but the site is in the valley with a deep alluvial soil.

History of Policy and Management

I. Llanover Forest

(a) Areas and preparation of ground.

The main area of Llanover Forest was acquired by the Forestry Commission in 1921. Subsequent additions were made between 1928 and 1933 bringing the total area up to 2415 acres of which the greater part is on steep or moderately steep ravine slopes. The general policy until 1932 was to clear fell the coppice and timbered areas and to keep up a planting programme of 100-200 acres per annum. After 1932, girdling of unsaleable standards was carried out and the annual programme was reduced to 70-80 acres. Other preparation of ground included the burning over of heather and bracken areas to facilitate planting and to reduce fire risk.

(b) Species

General planting policy

In the early years of planting the policy was to plant Douglas fir as the main crop on the lower and middle valley slopes, with Sitka spruce on the lower slopes and valley bottoms. Japanese larch was planted normally above the Douglas with Scots and Corsican pine on exposed hill tops. On the whole, however, there does not appear to have been any clear definition of sites for the three species, Douglas fir, Japanese larch, or Sitka spruce.

Principal species

Until 1924 the Green Douglas had been used almost exclusively, but in this year the Fraser River variety was introduced and, in the following year, was used extensively instead of the Green. This may have been due to a shortage of the latter

variety. However, 1925 saw the last big planting of Douglas fir. The following year, the use of this species was discontinued on account of the bad condition of the earlier plantations.

In 1924, pines were used in lieu of Japanese larch, and in 1925, European larch was introduced and substituted for Japanese. The reason for this is not apparent, but it is probable that there was a shortage of this latter species. During the next few years, European larch was regarded as the principal species for middle slope planting. Sitka spruce, in 1925, began to be used in lieu of pines on exposed hill tops, the reason being that some of the earlier planted pines were suffering from windsway and showing signs of blasting. In the following and subsequent years, Sitka was used as the standard species for planting on lower slopes and exposed tops; the pines were utilized only on the higher slopes, and in 1927 and onwards, Sitka was used as the standard species for beating up failed Douglas. This policy of regarding European larch and Sitka spruce as the major species was intensified in 1927 and continued until 1930 when Japanese larch was re-introduced and used to some extent in lieu of the European, the earlier plantations of which were apparently in a poor condition and not very promising. In 1931, the planting of European larch was restricted to the moister slopes of northern aspect, and in 1933 this species was condemned as being definitely unsuitable. The year 1934 saw the reinstation of Japanese larch as a principal species in the planting programme,

since the earlier plantations now showed some promise. This species, together with beech and sycamore, was also used largely for beating up.

In 1935, this policy was intensified and pines were planted on the poorer stony slopes generally, preference being given to Corsican pine, especially where there was a possibility of smoke contamination. The use of Sitka spruce was discontinued except for turf planting on the exposed tops and moister high slopes; the reason for this was the serious damage this species had suffered from frost and Honey fungus. (This 1935 policy has been subsequently intensified.)

It should be noted that since 1922 pines have always taken an appreciable part in the planting programme. They are obviously the safest tree to plant on a considerable part of the area, although their future success and economic value has been questioned.

Secondary species

Norway spruce has been employed steadily since 1923 as a secondary species. In this year it was introduced for planting on higher Bracken-Calluna ground. In 1929 and subsequent years it was planted in alternate rows with Scots pine on hill tops, and in 1932 Norway spruce and pines were used extensively either pure or in mixture on hard high-lying exposed ground. Beech has been employed as a minor species for fire lines, beating up, &c., in varying degree ever since planting started, but for some unapparent reason it was not used at all during the period 1928-1932.

Other species that have been planted on occasions are Ash and Poplar in the valley bottoms.

(c) Cultural operations

Drainage

Practically no drainage has been necessary except on the Molinia turfs where turf-draining was carried out from 1931 onwards.

Direct sowing

Direct sowing was attempted in 1922. The species employed were Scots pine and Douglas fir. Thirteen acres altogether were sown but the result was poor and the Douglas fir was subsequently planted with Sitka spruce.

Planting methods

In the first year of operations, the problem of supervision and labour was acute. Women were employed for the P.21 work and entrenching tools were used for the planting, but these proved to be so unsatisfactory that 5½ lb. mattocks were substituted later. Owing to the shortage of Douglas fir planting stock, 2-year seedlings were imported from Ireland. These suffered considerably in transit, so it is not to be wondered that the results from the planting of 2+0 Douglas fir were unfortunate; 74% failed. 1921 was a severe drought year. Failures in Japanese larch were 60% and in other species 17%.

In 1922 Schlich spades were introduced and used as the standard planting tool until about 1927. Planting was done by piece work, and there appears to have been no limit to the number that could be planted per man per day; 1500 and even up to 1800 are figures mentioned. Somewhere about 1928, mattock planting was re-introduced, and the number of plants that could be put in per man per day was limited to 600. This method of planting was, however, of the notch rather than of the pit type. In 1931 an improved method of

mattock planting was adopted; this was in the form of semi-pit planting. In 1935 further attention was paid to improvement in planting method, notably by increased soil cultivation. In the P.36 work at Llanfrechfa, clay spades were used to a limited extent for pit planting larch and pines on non-stony sites.

Weeding

Weeding has always been a problem and a matter of heavy expense. With the rapid increase in plantations, the annual expenditure on this work rose rapidly until 1924 when a sort of balance was arrived at; for six years the annual charge was in the region of four to five hundred pounds. In 1930 and 1931 there was a very marked curtailment of weeding. This was undoubtedly due in part to a shortage of funds, although the money available was not fully utilized. The real reason is probably psychological following the announcement of drastically cut estimates. There is evidence that at about this time insufficient weeding was done, especially in bracken areas in the pine plantations. The weeding charge for these years was between two and three hundred pounds. In 1932 it rose to its former level, if cleaning is included, and continued to rise until 1934 when the charge under the two heads, weeding and cleaning, was well over £600. It has since remained at this level, the principle being to weed all unestablished plantations as necessary.

Generally it is felt that in the earlier years insufficient attention was paid to weeding by the local supervisory staff. The reason for

this may have been the stress that was laid on economy and the need for keeping down costs. At all events, there is little doubt that much of the gappiness of the plantations is due to neglect of weeding.

II. Llantrisant Forest

General planting policy

At Llantrisant Forest, which is relatively small, most of the planting was carried out between the years 1921 and 1925. At this time Douglas fir was in favour, thus it featured largely in the planting programme, especially in P.22 and P.23. Norway spruce was also planted extensively at this time. The general policy appears to have been to plant Sitka spruce on the lower ground and wetter places, with Douglas fir, Japanese larch and European larch on the lower and middle slopes. These species were apparently more or less interchangeable in so far as site was concerned. The higher ground generally was reserved for pines, principally Corsican, and Norway spruce. In 1923 a large direct sowing of Corsican pine was carried out with considerable success.

On the whole, little European larch has been planted. The largest planting was in 1922 but unfortunately most of this was destroyed by fire. Only in 1921 were both European and Japanese larch planted. The only large planting of Japanese larch was in 1923. However, by the end of this year most of the middle and lower slopes had been planted. In 1925 Fraser River Douglas was used instead of the Green. This

former variety also appears to have been used for beating up plantations of the latter.

Previous Reports

Llanover Forest

The condition of the earlier plantations at Llanover Forest has long given cause for anxiety, and in 1932 a special report was made. This was submitted to the various officers concerned for their observations. The opinions expressed were in many instances very conflicting and no definite conclusions appear to have been arrived at apart from the fact that the causes of the poor condition of the plantations were complex and that the responsibility could not be traced to any single factor. The following deleterious factors were mentioned however:-

Inferior planting stock
Faults of planting and weeding
Delay of beating up
Large and scattered planting programmes
Dry soil conditions
Rocky nature of the soil
Wind and exposure
Insect and fungus attacks
Sheep damage
Atmospheric pollution

The forest was reported on again in 1934 and considerable improvements in the appearance of the plantations of all species were recorded. The importance of proper weeding and cleaning was again stressed.

In 1936 the area was inspected by the Chairman and the Assistant Commissioner. Many

of the plantations at this time looked particularly distressing, largely owing to the severe damage caused by late frosts of the previous year. It was felt that the poor growth of the various plantations could be attributed mainly to the industrial conditions, and the present investigation was instituted.

Topography

I. Llanover Forest

General topography

The undulating plain known in part as the Vale of Glamorgan is bounded on the south by the Bristol Channel and on the north by the southern edge of the Cambrian Mountains. Running northwards from this plain is a series of narrow steep-sided valleys. The high ground between the valley systems usually rises to above 1000 feet, the higher points being 1200-1800 feet above sea level. It is in such a system of major and minor valleys that Llanover Forest is situated.

Local topography

The main valley running approximately north and south is the Ebbw Vale. This is relatively narrow with steep to moderately steep slopes; however, only a small part of the Forestry Commission property is situated in it. The major part of the forest lies around two minor valley systems, namely, Cwm Gwyddon and Cwm Carn, and a lesser one, Cwm Gofappy.

Cwm Gwyddon is a narrow valley of the ravine type. The slopes are mainly steep or moderately steep, the elevation range being 400-1100 feet above sea level. The general direction of the

valley is north-east to south-west; a fork of the valley runs due north. Cwm Carn is a similar valley, more or less parallel except at the lower end where it runs approximately east and west. The plantations lie mainly above the 600 feet contour. Cwm Gofappy is a smaller valley lying between and almost parallel to the two previously mentioned. Some of the plateau ground above the valleys also forms part of Llanover Forest. The plateau begins at about 1000 or 1100 feet above datum and the highest part of the forest is about 1300 feet. However, the afforestation of this type of ground is not the concern of this report.

Relative elevation

The Ebbw River, which lies immediately to the west of all but a small part of the area, is here about 280 feet above sea level. The nearest point of sea level is at the Bristol Channel 11 miles south-south-east. Northwards lies a mountain mass which, in the Black Mountains of Breconshire, attains heights of well over 2000 feet.

Exposure

Exposure in this type of area, of course, shows considerable local variation, but generally, apart from the upper slopes and plateau ground, the area is not markedly exposed. The general trend of exposure, however, is to the south-west and west, which is also the direction of the prevailing winds.

II. Llantrisant Forest

Local topography

The topography of Llantrisant Forest is quite different from that of Llanover. It is situated

on Mynydd Garth Maelwg, an eminence at the end of a range of hills. The top is a plateau on which arise two knolls. The higher rises to 881 feet above sea level and the other is only slightly less. The planted slopes are steep in parts but generally less steep than those of Llanover. The high ground lies in the south-west of the forest and the main slope is thus to the north-east. Plantations start from the foot of the slope which is about 260 feet above sea level; in the south-west they continue only for a little way beyond the summits.

Relative elevation

The country north of Llantrisant Forest is mountainous, and within four miles elevations of over 1200 feet are reached. The Ely River skirts the east and north-east boundaries of the forest, the height above sea level here being 200-250 feet. To the south of the hill on which the forest stands, the land falls rapidly to the "Vale of Glamorgan" which undulates mainly between 100 and 300 feet. The Bristol Channel lies 11 miles away to the south and south-west.

Exposure

The westerly and south-westerly slopes of Llantrisant Forest are fully exposed to the prevailing winds which blow unhindered up the Bristol Channel. The north-easterly slopes are sheltered from the south-west by the hill itself but are exposed to northerly gales. There is a certain amount of local shelter but generally the area is more exposed than that of Llanover.

Climate

General

The climate of South Wales is of the mild maritime type. The main controlling factor is the position of the country on the east coast of the Atlantic Ocean and on the north shore of the Bristol Channel. In the neighbourhood of Cardiff

Wind

the prevailing winds are westerly. Observations during the years 1925-1933 show the percentage of westerly winds as 56.9. The average figure for the whole of the British Isles is 48%. The following table shows comparative wind direction figures as percentages for Cardiff and Swansea.

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
Cardiff	4.0	12.5	16.4	6.1	4.0	15.1	32.8	9.0
Swansea	10.6	11.3	15.9	6.9	4.2	21.7	15.3	14.1

(See also diagram)

The west winds are usually the most powerful and they occur with persistent regularity every year. They are felt in their full force on coasts facing west and in the exposed places in the uplands. The force with which they are felt in the valleys depends on the relative directions of wind and valley.

Rainfall

Rainfall records in South Wales have been kept for the past 40-50 years. They show a wide range of distribution. The average annual rainfall along the coast of Glamorgan is about 35 inches, while near Craig-y-Llyn in the centre of the county at an altitude of about 2000 feet, the average is 90 inches. The effect of altitude on rainfall is well marked, and the amount of precipitation in the narrow valleys differs little from that of the higher country on either side of

them. The rainfall of the larger valleys varies considerably with the direction in which they lie, for example, in the Neath Valley (Rheola Forest) which is open to the south-west, the rain bearing wind passes along its length, being gradually cooled as the valley floor rises. There is thus a marked difference between the amount of rain in the valley itself and that on the higher ground each side. Where the valleys lie across this wind direction, the rainfall in them is much the same as that on the high ground. December is the wettest month of the year, and more than 40% of the total annual rainfall occurs in January and the last three months of the year. March, April, May and June are relatively dry months.

Snow

The mild winters permit only a relatively small proportion of snow. At Cardiff, snow falls on an average of 6 days per annum lying on the ground only 4.7 days. There is, of course, more in the higher country and it lies longer, especially on north facing slopes.

Hail

Hail occurs on an average of 10 days per annum at Cardiff distributed throughout the year.

Llanover Forest

The monthly rainfall for the years 1920 to 1936 inclusive at Cwm Carn is shown in Appendix III. (See also diagram). The mean annual rainfall for this period is approximately 54 inches. The rainfall in Llanover Forest may be slightly in excess of this, probably in the region of 55-60 inches per annum. The distribution shows very much the same tendencies as that for the district as a whole, December again being the wettest month.

June is definitely the driest. During the recorded period there are two outstanding relatively dry years, namely, 1921 with 37.69 inches and 1933 with 34.95 inches. Even during the "drought" year of 1934 there were 51.03 inches. In the table in Appendix II, dry months of less than 2 inches rain and dry periods have been especially marked. These will be seen to occur more frequently in the spring and early summer, that is, during the early growing season for trees. This is felt to be of some importance.

Llantrisant Forest

The average annual rainfall at Llantrisant Forest is about 55 inches. The distribution is similar.

Fog

South Wales generally is subject to less fog than the average for the British Isles. The mean at Cardiff is 15.7 days. This occurs mainly in the winter. Fog in the industrial valleys is more frequent and of greater intensity owing to the high proportion of soot in the atmosphere. In addition, mountain mists occur in the upland areas.

Sunshine

The region enjoys about 4-4½ hours of bright sunshine per day on the average. The deeper valleys miss sunshine both in the morning and evening, particularly in the winter, on account of their steep sides.

Temperature

Compared with the Midlands and the East coast, the temperatures experienced in South Wales are mild. The coastal regions enjoy warm nights in all seasons owing to the effect of the Bristol Channel. Night temperatures decrease away from

the coast. Temperature records are not available for the valley regions but averages over 20 years at Cardiff (202 feet) show that February is the coldest month with a daily temperature of 40.4°F. (the mean night temperature is 35.3°F.). July is the hottest month with a mean of 60.9°. Thus there is a mean seasonal change of 20.5°F.

In the uplands the mean temperature of the air falls 1° for an ascent of 300 feet. Colder nights are experienced as radiation is more rapid and frosts are more frequent than in the lowlands. The deeper valleys have colder winter days, thus snow and frost persist longer.

Micro-climate

The peculiar topography of the areas concerned, particularly of Llanover Forest, causes a considerable variation in micro-climate. Opposing aspects mean differences in light and temperature, also wind exposure. The deep valleys cause accumulations of cold air and thus severe frosts are liable to occur. (The relation of micro-climate to tree growth will be discussed in detail in a later section.)

Geology

I. Llanover Forest

Rocks

Llanover Forest lies on Pennant Grit, except in the valley bottoms where very narrow and entirely unimportant strips of alluvium occur. The grit is a hard and much fissured felspathic sandstone, supposedly derived from the granite in Devon and

Dip

Cornwall. The dip of the rocks is towards the west. Near Abercarn the angle of dip is very slight; it probably becomes much more steep in the

easterly parts of the forest and especially in Cwm Carn, the eastern end of which is very near the eastern edge of the coalfield. In general, thus, the southerly and easterly sides of the valleys are dip-slopes, and the westerly and northerly slopes are across the strike. There is a certain amount of faulting and contortion of the strata. At an elevation of between 900 and 1100 feet on the dip (southern and eastern) slopes

Springs

of Cwm Gwyddon a series of springs rises which suggests that an impermeable stratum occurs near this horizon. The springs have only a very local influence and there is no suggestion of any general change in type of rock at the level at which they occur.

II. Llantrisant Forest

Rocks

Llantrisant Forest is also situated on Pennant Grit, except for the small part of the lower slopes which lies in the valley of the Ely River. This latter part is situated mainly to the east of the road which runs to Coed-Ely Colliery, and lies on Boulder Clay. The hill, Mynydd Garth Maelwg, on which Llantrisant Forest is situated, forms part

Dip

of an anti-cline. It is a somewhat flat-topped, steep-sided hill with mainly dip slopes. There is no quarry or other place at which the rock can be examined, but this is, presumably, the usually well-fissured Pennant Grit, giving ample or even

Springs

excessive drainage as a rule. Springs are not uncommon, however, both on the upper and lower slopes, and a number of these are included within the forest area.

Water System

I. Llanover Forest

It is necessary to refer to the system of streams and springs in Llanover Forest because, locally, the ill-thriving of plantations has been put down to changes which have taken place in the condition of these since mining operations began in this district in the latter half of the

Streams

last century. The streams for the main part of Llanover Forest rise on the high plateau, Mynydd Maen, and presumably in peat bogs overlying the Pennant Grit of which this consists. They thus arise by draining the water held in purely superficial deposits, for it cannot be assumed that the main underground water-table ever rose much higher in the hills than the bottoms of the deeply cut ravines on the sides of which the forest mainly stands. Apart from this source of water,

Springs

the streams are fed from springs which arise in the hill sides. These have always been small

Drying up of these

and some have gone dry, it is said, since pumping operations were begun by the mines. Moreover, some of the smaller streams have gone dry in part or as a whole since then, presumably owing to the lowering of the general ground water-table. Thus Cwm Hafod-fach, one mile north of Cwm Gwyddon and on the Llanover Estate, has gone dry, while Cwm Carn, within Llanover Forest, has gone dry in

Effect on tree growth

part. It is doubtful whether this partial drying up of the surface water supply has ever had much effect on the woodland because, even before mining began, the fissured nature of the rock on which it stands would ensure that the water-table would

be out of reach of tree roots, except near springs or streams. The argument that the ill-thriving of the woodland is partly to be accounted for by a fall in the water-table may thus be dismissed.

II. Llantrisant Forest

The surface water system at Llantrisant Forest does not seem to have been affected by the mining. No special examination has been made of the drainage system in this forest, but springs occur in the upper part of Cwm Du near to the hill top, and between 700 and 800 feet above sea level, and at various other lower places. On the lower northern slopes springs are particularly abundant and patches of quite wet ground occur. The lower part of Coed Ynys Maerdy (Compts. 1 and 2) is also wet. On the whole, in this forest, the ground water-table must be well below the depth to which roots penetrate, but, as indicated, there are certain areas where this is not true. There appears to be no reason whatever to consider either a rise or fall of the ground water-table to be a cause of the ill-thriving of the plantations.

Soils at Llanover and Llantrisant Forests

Main type

The soils, both at Llanover and Llantrisant Forests, are mainly derived from the Pennant Series of the Coal Measure Rocks. The soils not so derived cover no large area and have not been examined in connection with this report. They are:-

Other types

1. The peat soils of the hill tops at Llanover. These form but a smal proportion of the forest.
2. The alluvium of the valleys at Llanover. This is quite unimportant and covers no considerable area.
3. The boulder clay on the lower eastern slopes of Llantrisant Forest. The main block of woodland on this type is Coed Ynys Maerdy (Compts. 1 and 2) in the valley of the Ely River. Some of the best soil at Llantrisant probably occurs on this formation.
4. Peaty soil on the lower northern slopes of Llantrisant Forest. The area of this was not determined but is probably not great; it appears to be a decidedly wet soil.

Pennant Grit

The Pennant Grit, from which the remainder and vast majority of the soils are derived, is a felspathic sandstone of markedly flaggy structure and well jointed. The indications are that it favours drainage, although locally impermeable beds may occur causing springs to arise. Generally the soils are freely or excessively drained and show no evidence of impedance. The extent to which the flaggy nature of the brash in the lower subsoil favours or prevents deep root penetration is not known, but it might be of importance, especially on the warmer slopes, in making for or against an abundant or restricted available water supply. The felspathic and micaceous constituents of the Pennant Grit ultimately constitute a base-reserve in the soil

and doubtless prevent podsolisation proceeding to the extent found in upland soil of a typical Millstone Grit, which is composed mainly of quartz grains. The soils are, nevertheless, acid and there is no indication of a high available base reserve. (See analysis, Appendix V).

Derived soils

These soils derived from Pennant Grit vary from place to place but may generally be described as light gravelly loams in which rock fragments are usually abundant, and in which the subsoil passes, often rapidly, into a brash with soil in the rock interstices. On the hill tops and slopes the soils are sedentary or sedentary and colluvial, but on the lower slopes deep colluvial soils seem to occur (especially on the more gentle lower slopes of Llantrisant Forest). The depth of soil is fairly satisfactory for upland country. The profiles examined showed, as a rule, about 2 feet of loose material, but the stony brash might be reached in 10 inches or lie lower than 3 feet. As a rule there was no very marked compaction and often no marked development of a humic layer; where the latter has developed it was, in the places sampled, quite thin.

The profiles examined seem to indicate that generally speaking these Pennant Grit soils exhibit podsolisation to a greater or less degree. The profiles differed mainly according to topographical position, and may be classified on this basis as follows:-

1. Podsols with a marked bleached horizon and occurring on the hill tops - sampled at Llantrisant.

2. Truncated podsols on the slopes with no marked bleached horizon.
3. Podsols with a marked bleached horizon and occurring on the lower slopes - sampled at Llantrisant.
4. Cultivated soils in which the podsolisation has become masked - sampled at Llantrisant.

This classification is convenient, but it might be proved to be inadequate or inaccurate if a detailed and thorough soil survey were made.

Profile description

All these soils may be regarded as variants of one general profile with the following principal features:-

1. Inch or two of litter.

A

2. An horizon in which bleaching is masked by humus.

2a. An horizon in which the soil is bleached - this is absent or very thin in the truncated podsols.

B

3. An horizon with an orange-brown colour (sesquioxides) masked and dull by humus - this is probably absent when 2a is present to any degree.
4. An horizon showing bright orange-brown colour and varying from brashy loam to brash with orange-brown loam in interstices.

Parent material appears here

5. A dark grey horizon (not always reached in a 3 ft. deep pit) in which the orange-brown colour is recessive. Generally this is shattered rock, but in some cases it consists of disintegrated and disintegrating material passing to shattered rock.

On the slopes, which constitute the major portion of these forests, most of the profile actually consists of B horizon material. The A horizon is rarely more than 3 inches thick but the B character of the third horizon is not always so evident in some profiles as in others. (See profile descriptions, Appendix IV). Professor Robinson points out that the principal character of B horizon material under Welsh conditions is the presence of notable proportions of free hydrated ferric oxide, and he questioned whether this might have an adverse effect on growth by depressing phosphate availability and thus the fertility of the soil. There appears to be no evidence available on this matter, and the Professor points out that a considerable amount of investigation would be needed to decide it. *The insistence on the necessity for the application of phosphates for the improvement of grasslands on soils of this type indicates, however, that one is here probably dealing with soils in which phosphorus is available im minimal rather than optimal amounts.

Rooting depth

The pits dug seem to indicate that trees make rather a superficial type of root system on these soils, for roots usually cease to be common below 24 inches in many cases. Actually a very careful and, on such sites as these, extremely laborious, excavation of root systems would be needed to determine this. It is quite possible

---

* Professor R.G. Stapledon's 'A Survey of the Agricultural and Waste Lands of Wales'.

that large roots fail to penetrate deeply, as a rule, owing to the flaggy nature of the rocky subsoil, but that the finer roots go down to a considerable depth. This often occurs on rocky soils.

Vegetation at Llanover and Llantrisant Forests

As usual on the palaeozoic soils of Wales, the flora is poor in species; everywhere a few species, of which Pteris, Calluna and Deschampsia flexuosa are the most conspicuous, form the bulk of the vegetation. They vary greatly in relative abundance, however, and there is every gradation between communities in which Pteris is nearly pure and those in which Calluna is nearly pure. The principal forms will be outlined.

Grass-bracken type

(a) Steep well drained slopes with relatively deep soil.

Pteris and Deschampsia flexuosa dom.

Calluna and Vaccinium myrtillus local and rare.

Galium saxatile, Potentilla erecta, Rubus fruticosus, all generally distributed in small amounts.

Hedera helix often present.

Polytrichum formosum, Brachythecium purum, Hypnum cupressiforme var. ericetorum and Dicranum scoparium are the commonest mosses.

In the drier places Deschampsia is dominant and Pteris sparse, while Rubus is relatively rare and Hedera absent. With increasing moisture Pteris becomes more strongly dominant, Rubus and Hedera more abundant, Holcus mollis enters, and ferns (especially Aspidium dilatatum) are found.

This transition from the dry upper slopes to the moister lower slopes is very well seen at Llanover. At Llantrisant the south-easterly slopes with good Douglas are of an intermediate character.

Many species other than those listed are liable to occur in the young plantations, e.g. Hypericum pulchrum, Epilobium angustifolium, Teucrium scorodonia, Digitalis purpurea.

Heather-bracken-grass type

(b) On similar steep slopes where the soil becomes shallower and stonier, Pteris decreases in luxuriance and Calluna, Erica cinerea and Vaccinium myrtillus increase in abundance, until in the extreme case these are found nearly pure. At Llantrisant steep slopes were seen with Pteris subdominant but small, and Calluna and Erica cinerea codominant. At Llanover were seen similar slopes, and also slopes with Vaccinium myrtillus mixed, or in places nearly pure Vaccinium. Patches of pure Vaccinium were also seen at Llantrisant but they were of very much smaller extent. At both places there is every transition between slopes such as these with mixed Pteris and Ericaceae to slopes with either Vaccinium or Calluna plus Erica cinerea nearly pure. It is not clear whether the dominance of Vaccinium instead of Calluna is due to history or to difference of site. Patches of pure Vaccinium often remain as a relic of the ground flora of old oak coppice.

On these slopes the growth of spruce and Douglas fir varies almost directly as the luxuriance of Pteris; where this is absent or very stunted

they suffer a very long period of check.

At Llanover, on the upper slopes of the south side of Cwm Gwyddon, are many alternations of the shallower type - Pteris with Deschampsia flexuosa and some Ericaceae - with the deeper, moister type - Pteris with Deschampsia, Holcus mollis and Hedera. Here it can be seen that the former community corresponds to a community beneath the patches of old oak and beech coppice with Deschampsia dominant and Vaccinium in the lighter places, while the latter corresponds to a community with Deschampsia dom., Holcus mollis v.a., Hedera, Rubus and Oxalis frequent.

Bracken type

(c) Communities with Pteris dominant on colluvial soils. Of small extent - seen at Llanover in the floor of a small lateral valley. The Pteris is exceedingly tall and luxuriant, nearly pure in the extreme form; Agrostis alba and Rubus the principal associates.

Agrostis type

(d) Agrostis communities occur on many of the lower slopes at Llantrisant, on soils which are partly colluvial and perhaps partly glacial drift; these are fresh but have no tendency to water-logging. They are mostly covered with fairly good larch. Agrostis is dominant in the rides and in gaps in the plantations. Most of the land is old farm land; it is probable that, except for this, Pteris would be strongly dominant. Vegetation is mostly very sparse in the stands, but the following species are conspicuous:- Hedera helix, Rubus fruticosus, Viola riviniana (?), Dactylis glomeratus, Oxalis acetosella, Hylocomium squarrosum.

Valley-woodland type

(e) Slopes on heavy soil with springs. The older woods in the valley which were examined at Llantrisant had a flora much more nearly resembling that of the Old Red Sandstone, and suggesting a soil of much higher base status than any of the preceding. Oxalis, Deschampsia caespitosa, Carex sylvatica, Angelica sylvestris and other plants of more basic heavy soils were frequent, and locally also Brachypodium sylvaticum.

Heather type

(f) Pure or nearly pure Calluna. The steep slopes on which a nearly pure Ericaceous vegetation is found usually have a mixture of Calluna and Erica cinerea. On the gentler slopes and the plateau at Llantrisant, however, are many areas in which Calluna is nearly pure. Every transition is to be found from these, through areas with scattered stunted fronds of Pteris to areas with Pteris dominant, and, as before, the growth of Douglas and spruce varies almost directly as the luxuriance of Pteris. The areas of pure Calluna usually seem to have a markedly podsolized soil.

General remarks

Most of the differences between Llantrisant and Llanover can be ascribed to the different topography - the prevalence of a large plateau in the one and of steep slopes in the other. One feature of Llantrisant which deserves comment is the vegetation of the eastern slopes. It is doubtless closely allied to that described under (a) though the slopes are much less steep. Deschampsia flexuosa is dominant; Pteris is

abundant but not tall; Ericaceae rare or occasional. Polytrichum commune is abundant and surprisingly luxuriant for so dry a situation. The soil shows no signs of water logging or flow of water.

At Llanover, vertical banks of earth by road sides, etc., had communities of Polytrichum aloides, with Whalenbergia hederacea locally very abundant. This is a very common community in such situations in Central and South Wales, though curiously enough it was not seen at Llantrisant. On the whole, there is no suggestion of any adverse effect of smoke on the cryptogamic flora. At Llantrisant, Alicularia scalaris, Diplophyllum albicans and Marsupella emarginata were abundant by path sides, etc., while Cephaloziella myriantha - a very rare species - was gathered in a decaying stump on the northern slopes in one of the areas where Scots pine and Douglas are said to be suffering from the fumes of a colliery just below.

At Llanover, the south side of the valley is markedly moister than the north, and this is shown in the much greater abundance of Bryophytes on this slope. Thus Plagiothecium undulatum and P. denticulatum were frequent on this slope. Other species seen were Lepidozia reptans, Lophozia ventricosa, Lejeunia cavifolia. These are all common species; without more prolonged examination it would be impossible to say whether the area shows any marked poverty of Bryophytes. The same applies to lichens - it would be easy to walk through an area in the most smokeless part of England without seeing any more species than were seen here.

The plant communities are all of types which are widespread on similar soils in Wales - the pure Calluna is probably the worst from the forester's point of view, though even in this drainage is relatively good, and the admixture with Erica tetralix, Scirpus caespitosus, and Sphagna which is found in many places is absent. The moss communities which are often found on the shallowest soils on steep slopes also seem to be absent as far as could be judged from the small relics of the old hardwood coppice which are left.

Present Condition of Crops

General

It is not possible in the present report to give a detailed description of tree crops in the forests concerned. For a considerable time many plantations have been in an unhappy and very unsatisfactory condition. The species mainly concerned are Douglas fir and European larch; these have been notably unsuccessful. The spruces, both Sitka and Norway, cannot be described as being very promising as regards growth. On the other hand, Japanese larch and Scots and Corsican pine have been relatively successful although growth even with these species is not outstanding.

Assessment

In order to obtain data regarding growth and failures, an assessment was carried out early in 1937. Measurements were made in several compartments in each forest of the height and shoot growth of various species. Different

aspects and slopes and various vegetation types were sampled. The resulting data have been summarized in Appendix VI.

Douglas fir

During the years 1921-24, large areas at Llanover and Llantrisant forests were planted up with Green Douglas fir. This species has proved most disappointing, particularly at Llanover. Actual deaths have been very numerous, but in this respect the plantations vary considerably as the following table indicates:

Percentage failures in Green Douglas fir

	Minimum	Maximum	Average
Llanover	26	67	44.5
Llantrisant	16	66	26

(Figures refer to blocks, not to small groups, and to plantations assessed only.)

These plantations have been beaten up in recent years, but they still have a gappy appearance. The species which have been employed for beating up are: (a) at Llanover, Sitka spruce mainly but sometimes beech or Japanese larch; (b) at Llantrisant, Corsican pine generally but some Sitka spruce. Also in the earlier days, Fraser River Douglas fir appears to have been used extensively at both forests. The actual blanks still occurring vary from 4 to 23% at Llanover, but at Llantrisant they are generally under 10%. (Part of Compartment 20 is an exception where the figure is 29% owing to tall gorse.)

With regard to the surviving Green Douglas fir, the growth of these trees at Llanover Forest

is poor generally and very irregular; only scattered trees are growing at all well. A typical example of growth is: Compartment 5, P.21, average height 6 feet and average shoot growth (over five years) 6 inches. In certain sheltered and more favourable sites growth is very much better and even moderately good. The following are examples of this: in the dingle running across Compartment 46 where the average height of P.23 trees is 11 feet; in the valley bottom in Compartment 16, P.23, average height 12 feet, maximum 23 feet, average shoot 15 inches, maximum 36 inches; in the shelter of coppice in Compartment 3A, P.22, average height nearly 13 feet, average shoot for the past five years about 15 inches.

At Llantrisant Forest the growth of the Douglas, while generally better, is even more irregular. Some of the poorest occurs on an exposed site in Compartment 10 where P.23 trees average only about 4 feet in height. On the other hand, in a sheltered valley bottom in Compartment 22, at the same age, the average height is over 15 feet. On the sheltered lower slopes there are relatively good plantations, but even here growth is irregular and the stocking patchy.

Douglas fir, when growing in an exposed situation, shows a marked one-sided development and windblow is not uncommon. The foliage in most plantations has an unhealthy appearance; this, in part, is due to chermes, Adelges cooleyi. Generally speaking, the trees are thin crowned with short needles.

Further details regarding growth &c. will be found in Appendix VIa. Reference should be made also to photographs 1, 4, 5, 6, 7, 8, 9, 10 and 11.

Fraser River Douglas fir

Pseudotsuga Douglasii var. caesia (Schwerin), the variety of Douglas fir known as the Fraser River or Intermediate form, appears to be better suited to the conditions prevailing in these forests than the Green form. Generally, failures are much fewer and the appearance of the trees very much healthier and sturdier. The foliage looks cleaner than that of Green Douglas, which frequently has a begrimed appearance. Growth also is, on the whole, better and more uniform. On the more favourable sites, however, which, at Llanover particularly, are of very limited extent, the Fraser River Douglas shows no better growth than the Green. The table below indicates the extent of failures in this species. The reasons for these are discussed elsewhere in this report.

Percentage failures in Fraser River Douglas fir

	Minimum	Maximum	Average
Llanover	17	34	26.5
Llantrisant	10	24	15

The following table illustrates the differences in growth that are possible within the same compartment. The averages apply to the higher and lower portions of the same lines.

Fraser River Douglas P.25

	Compt. 29	Compt. 35	Vegetation
Lower slope	78.5 ins.	65.1 ins.	Bramble-bracken.
Upper slope	59.9	49.5	Scattered Calluna with bracken, Aira and little bramble.

Typical trees of Fraser River Douglas are illustrated in photographs numbered 4, 5, 11 and 12, and details of growth are in Appendix VIa also.

European larch

Very little European larch has been planted at Llantrisant; therefore, unless otherwise stated, the following remarks apply to Llanover Forest. Although this species came into favour for planting somewhat later than Douglas fir, yet it has been employed rather more extensively.

The earlier plantations (P.25 and onwards) in the Graig Wen area present a very poor, gappy and unpromising appearance. This is due largely to the depredations of the Larch Shoot-borer, Argyresthia atmoriella, Banks, which has caused the die-back of many leading shoots and innumerable side shoots. The type of damage is illustrated in photographs 19, 20 and 21, and its effect on height growth is demonstrated by the following figures:

Compartment 47, P.27, European larch

	Average height inches
Trees with Shoot-borer affecting leaders	57.5
Trees free from Shoot-borer	83.3

In some compartments, over 50% of the

surviving trees have been attacked, and of these about 60% have no definite leading shoot. It is improbable that this pest is a primary cause of trouble.

The younger plantations of larch (P.31 and P.32) in the Cwm Carn area have, on the whole, a much better appearance; the stocking is better and growth appears to be more promising. At the same time the percentage of trees attacked by the Shoot-borer is very low (1-3%).

Failures in the European larch plantations, while not as heavy as those in the Douglas fir, nevertheless are very numerous and irregular as the following table shows:

Percentage failures in European larch

	Minimum	Maximum	Average
Graig Wen plantations	10	56	28
Cwm Carn plantations	4	32	17

(Figures refer to blocks, not to small groups).

Beating up has been carried out mainly with Japanese larch and beech, but Scots pine, Sitka spruce, sycamore and alder have been used for this purpose also. Blanks occurring in the plantations at the time of assessment varied from 2% to 27%.

At Llantrisant, the only new plantation of European larch (P.29) shows 27% failures but these have been beaten up. Here 20% of the trees are attacked by the Shoot-borer.

The growth of European larch generally is very poor and extremely irregular; the assessment summaries are given in Appendix VIb. Examples of the growth in some of the better areas are:

Compartment 54, P.28, average height 93 inches, average shoot (over five years) 11 inches; Compartment 72, P.32, average height 57 inches, average shoot (over four years) 11 inches. On the other hand, in Compartment 36, P.27, the average height is only 55 inches and the average shoot growth (over five years) 6 inches. This is one of the worst plantations, but there are considerable areas, apart from this, where the average height of, say, 10-year old trees is just about 6 feet.

European larch does not appear to show the same response to shelter that is so marked in the case of the Douglas fir. Growth does tend to fall off, however, as one ascends a slope, e.g. in Compartment 41, P.27, the average height in the lower portion of the plantation is 98 inches while in the upper part it is 69 inches. The following table shows to some extent the variation in growth according to the vegetation type of the site.

Compt. No.	P.Year	Average height inches	Vegetation type
41	27	58.2	Vaccinium
41	27	106.8	Aira-bramble
36	27	46.2	Calluna-Vaccinium
36	27	68.8	Bracken-Aira

Small patches of dense bramble showed greatly increased tree growth in several compartments, but there were insufficient trees in such sites, in any single compartment, to obtain comparable figures.

Japanese larch

Japanese larch is one of the more successful species that have been planted in the forests under report. At Llanover, there have been two periods of planting, viz. P.21 - P.24 and P.30 onwards with minor gaps. During the interval, European larch was substituted for Japanese. It will be sufficient to consider the progress of the older plantations of Japanese larch as indicators of the possibilities of this species. The stocking of these, at both Llanover and Llantrisant, is very good with minor exceptions - failures are only about 10%. It is understood that the plantations have received very little beating up.

With regard to growth, reference should be made to Appendix VId. It will be seen that at Llanover Forest, on the average, a height of 18-19 feet is attained in 14 years. This, according to the preliminary yield table for this species in Bulletin No. 10, is below Quality Class II. On the other hand, growth at Llantrisant is very much better. At the same age one plot shows an average height of 30 feet; this comes into Quality Class I. The other plots, however, are definitely Quality II.

Among the younger plantations assessed, P.30, Japanese larch at Llanover (Compartment 63A) shows an average height of about 4 ft. 10 ins. with shoots averaging 10 inches for the 1936 season. Failures are here 10%. At Llantrisant, a plantation of the same age (Compartment 4) has an average height of about 13 feet with an average 1936 shoot of 30 inches. Failures here are only 4%.

It will be seen that when Japanese larch at Llanover Forest is described as 'growing well', this is purely a relative matter and in relation to other species in the same forest. The tree has suffered to some extent from frost in the valley bottoms and has been attacked only slightly by the Shoot-borer.

Sitka spruce

Apart from the pines, Sitka spruce is probably the most widely planted species at Llanover. Every year since 1921 considerable numbers have been used; many of these, of course, have been planted on the plateau ground which is not the concern of this report. Sitka spruce has been used largely also for planting the lower slopes and bottoms of the valleys. In addition, it has been employed extensively for beating up failures in Douglas fir and European larch. From this it would appear that the earlier plantations of Sitka spruce had shown signs of considerable promise, hence it is all the more disappointing to find that the tree has suffered from ravages of various kinds. The most disastrous scourge has been frost; this has devastated many promising plantations. Honey fungus, Armillaria mellea, has killed very many trees. It is suspected that the vitality of these had been lowered by previous frosting. The Green Spruce Aphis, Neomyzaphis abietina, has caused very considerable defoliation. The result is that now many of the Sitka plantations are gappy and irregular; an appreciable number of trees in the lower sites have dead tops. A fairly typical example of this is shown in

photograph 15. The percentage of trees with frosted leaders is as high as 69% in Compartment 46 (P.21), Llanover Forest, but the average for plantations assessed is about 28%. The percentage of actual deaths in the Sitka at this forest is not, however, very high, the range being 1 to 19% and the average about 7%. (These figures apply to plantations assessed only.)

The growth of the Sitka, as with other species, varies considerably with site and vegetation type as the following tables indicate.

Growth in relation to elevation

Sitka spruce

Llanover Forest	P.Year	Av. height - ins. Lower slope	Higher up slope
Compt. 13	26	94.8	61.1
Compt. 35	25	116.0	103.9
Compt. 29	24	134.0	89.5

Growth in relation to vegetation type

Sitka spruce

Llanover Forest	P.Year	Av.height ins.	Vegetation type
Compt. 21	23	52.2	Calluna
Compt. 21	23	104.0	Bracken

Further information regarding the growth of Sitka is given in Appendix VIe. It will be seen that in certain cases there has been a tendency for growth to fall off in recent years. In part, this may be accounted for by the period of dry years.

At Llantrisant Forest no assessments were

made in the Sitka spruce. On favourable moist sites, which are usually of limited extent, this species has made very good growth. Generally speaking, there has been considerably less damage by frost at this forest than at Llanover.

Norway spruce

Norway spruce has not been used nearly as extensively as the Sitka, but what plantations there are at both Llanover and Llantrisant Forests show good stocking mainly and have a healthy appearance. Growth, however, has been very slow with the exception of individual trees and small groups on favoured sites. Failures at Llantrisant average about 5%, and at Llanover about 8% (excluding a high and exposed plot in Compartment 9A). Details of growth in the plantations assessed will be found in Appendix VIf. On dense Calluna ground Norway spruce appears to go into a long period of check but eventually it seems to get over this. The growth of P.22 trees on this type of ground (Compartment 19, Llanover) averages less than 40 inches; on the somewhat better sites in this forest the annual shoot growth is about 7 to 9 inches. On a relatively good site at Llantrisant (Compartment 13) the average height of P.22 Norway spruce is under 9 ft.; this comes into Quality Class V of the yield table in Bulletin No. 10. Most of the other plantations of this species are poorer still.

The Pines

The pine plantations at both Llanover and Llantrisant forests are fairly satisfactory on the whole. Any gaps can be accounted for usually by the presence of strong bracken and

delayed weeding. It is not possible to give any details regarding growth and stocking as no assessment has been made in the pine plantations. Generally speaking, the pines have been relegated to the poorer sites, but in spite of this many plantations show considerable promise.

Corsican pine

Corsican pine appears to stand exposure well and shows no marked falling off in shoot growth anywhere. A direct sowing of this species P.23 at Llantrisant Forest has had particularly good results. A portion of this crop is shown in photograph 18. The growth of Corsican pine at Llanover, while rather irregular, compares very favourably with that of other species. Photograph 17 illustrates a particular example of this.

Scots pine

Scots pine, as might be expected, has not grown quite as rapidly as the Corsican on the whole, and, in some cases, does not look so healthy. One plantation of Scots pine in the main valley at Llanover Forest above Abercarn appears to be very unhappy owing to continued attacks of Pine shoot moth, Evetria buoliana, Schiff. Possibly due to the poor conditions prevailing in the soil and atmosphere at this point, the trees appear to be unable to make any recovery from the attacks. Elsewhere at Llanover, however, Scots pine appears to be quite healthy and makes steady growth. Failures on the whole are not high and are usually confined to patches. At Llantrisant, defoliation of all but the younger needles of Scots pine is

fairly common. It is thought that this may be due to recurrent attacks of a Pine aphid, Lachnus sp. However, growth does not appear to be affected seriously by this.

Hardwoods

There are no hardwood plantations of any size at either forest. A small area in a valley bottom at Llanover was planted with Poplar about P.24, but this species has not met with any degree of success, largely because of the frosty nature of the site and its liability to flooding. Ash was employed for ride side planting about the same time. Sycamore was planted (P.25) in belts at 1300 ft. in Calluna at Llanover and has also been used for beating up to some small extent. Grey alder also has been tried for beating up. None of the species have produced any conspicuously good results. Beech, on the other hand, when not in a frost hollow, is looking quite promising generally, both in belts and as a beat-up tree. The growth in recent years has been quite good and the foliage and buds, on the whole, have a healthy appearance at both forests.

Factors affecting the Growth of the Plantations.

Some of the factors affecting the growth of the plantations have already been discussed in some of the above sections. There are others, however, which have not been referred to or, at least, have not been properly discussed. These are discussed in full, while a summary statement is made with regard to the others.

(a) Climate

The climate at Llanover and Llantrisant Forests is similar in general features, but the latter forest is nearer to the sea and in rather the more exposed position. The following remarks apply to both unless there is a statement to the contrary.

Wind

The Douglas firs, which are wind-susceptible species, show die-back owing to exposure to strong winds. This is very marked at Llantrisant, but is also to be observed on open slopes at Llanover. Frequently it can be noted that the die-back from exposure faces towards a different angle of the compass to that at which the principal near-by sources of fumes stand, or, sometimes, there is no considerable source of fumes near-by, as on the southern aspects of Llantrisant Forest. The winds in the ravines or narrow valleys, on the sides of which Llanover Forest is situated, tend to be diverted up or down the valley. In the more exposed places on the middle and upper slopes, die-back or one-sided development of European larch is common though usually not severe.

Among the Douglas fir, a good many wind-blown or loosened trees have occurred, but these have mostly been removed for beating-up and it is not now possible to judge of their number.

In most parts of these forests the influence of wind would be much reduced if the stands were growing strongly and in close canopy, and usually there is no suggestion that die-back owing to exposure to strong winds is anything but a contributory factor to the general state

of ill-health.

Rainfall — Rainfall has been discussed fully in the section dealing with climate. On the whole, dry periods lasting for several months are very exceptional at Llanover. This is probably the case at Llantrisant also. There is, therefore, usually no fear of die-back owing to drought. On the other hand, the effect of the moderately high rainfall is counteracted by the rapidity of run-off and the very free drainage. Added to this is the fact that the drier months usually occur during the growing season.

Frost — Radiation frosts are a very real source of danger to frost susceptible species in many parts of the forests, and especially at Llanover, causing the loss of new shoots, the browning of needles, the cutting back of old wood, and sometimes the death of trees. Frost will be discussed in further detail in the section following.

(b) Micro-climate — In this report it is possible only to refer to some of the more obvious characteristics of the micro-climate and their relation to the growth of trees. These are factors which affect the growth of young trees more than that of older ones and, therefore, exert their greatest influence during periods of regeneration or afforestation.

I. Llanover Forest

Effect of topography — The characteristics of the micro-climate, which are particularly worthy of notice, are related to the peculiar topography of the forest. The steep ravine slopes have strongly contrasting

aspects. The temperature conditions of the soil, and of the air lying immediately over it, are determined largely by aspect and slope, which are important in this respect in that they determine the amount and intensity of insolation, exposure to, or shelter from wind, and the development of valley (anabatic and katabatic) winds, for any particular weather conditions.

Effect of aspect

With slopes such as exist at Llanover Forest, the northerly aspects receive much less sunshine and are much cooler and moister than the southerly ones. It would appear, indeed, that the relative darkness and brightness of these opposing aspects is recognized, in Cwm Gwyddon, by the slope names Graig Wen (or Gwyn) and Graig Ddu, that is, respectively, the white and the black or deeply shadowed hillside. According to the rather insufficient data collected concerning rate of growth, the various aspects do not seem to have had any appreciable influence on the growth of the various species. There are, however, suggestions that such a difference does exist. For instance, the European larch on Graig Wen, which has a southern aspect, are somewhat shorter on the average than those of the same age in Coed Sara with an easterly and cooler aspect; but this difference is not statistically significant. The more or less evenly distributed and relatively high rainfall presumably counteracts the temperature effects to a very great extent. Possibly the differences in growth on the various aspects would be much more pronounced during exceptionally

dry years.

Frost

A comparison of severity of frost damage on the various slopes is more difficult owing to the distribution of species. Thus, in both Cwm Gwyddon and Cwm Carn, the frost tender Sitka spruce is situated mostly on the cooler slopes where usually frost damage is least. However, very severe damage occurred there around mid month during the frosts of May 1935, indicating that the trees were not sufficiently delayed in development by the lower average temperature of air and soil to affect appreciably their frost hardiness.

All these valleys are dangerous places for frost tender trees owing to the manner in which they fill up with cold freezing air on any night when a severe radiation frost is taking place. Thus, in the valley bottom below Graig-y-Glyn, Cwm Carn, in a private estate plantation, European larch over twenty feet high have been killed or seriously injured, while in Cwm Gwyddon extremely serious frost injury to Sitka spruce has occurred. Much of the slope as well as the valley bottom is dangerous to small trees because of frost. Frost tender trees are least liable to injury on the middle of the slopes, and especially on the upper part of this. One has, thus, a zone in the valley bottom where even tall trees may be injured during a radiation frost in the growing season, and belts above, on either side, where the cold air is much shallower but still sufficiently deep to affect a small tree. Judging by actual frost damage, temperatures

again become lower on the upper limit of the slopes and so continue over the flat hill tops, on all of which severe ground frosts may occur. The forest includes, thus, extensive areas in which frost tender trees may not be planted without risk of grave injury.

Shelter from frost

Shelter to provide protection against frost is likely to be least effective in the valley bottoms and most effective on the upper slopes and flat tops, this depending on the depth to which the freezing air lies. Nothing is known of the actual frequency with which severely damaging frosts occur, but, on account of the slow growth made by the trees and the great depth to which freezing air may lie in the valley bottoms, even an average of only one in ten years would have probably a serious effect. Thus, the European larch in the bottom of Graig-y-Glyn grew to a height of over twenty feet without serious damage until, in 1935, many were injured with extreme severity.

II. Llantrisant Forest

Frost

The micro-climatic conditions in Llantrisant Forest are similar to, though less severe, than those at Llanover. Difficult places do occur, however, as, for example, in the peat bog on the hill top which is a bad frost flat. The lower slopes in the valley of the Ely River are somewhat frosty, but soil conditions are comparatively good and trees grow fairly quickly through the early and most dangerous stage when they are small.

Conclusion

Thus, in either forest, frost appears to be the only factor in the micro-climate which is markedly dangerous to trees. Of the species widely planted, Sitka spruce has proved to be a markedly frost tender tree and not suited for planting in the more frosty places, which, however, are those in which it grows fastest (i.e. the valley bottoms and lower slopes; see comparative figures of rates of growth page 42).

Sitka spruce

Douglas fir is almost equally liable to severe frost injury, and this probably accounts, in part, for the high proportion of deaths in this species which has occurred since the time of planting.

Douglas fir

Norway spruce has not been planted to any extent in the more frosty places, but it would be severely injured if grown in them, though probably less so than Sitka spruce.

Norway spruce

The larches (European and Japanese) also do not occur extensively in the valley bottoms; where they do, both species have received appreciable frost injury, the European larch being the most damaged. It seems probable, however, that the extensive browning of foliage, which especially affects European larch and occurs in the spring, is caused by frost.

Larch

None of the above conifers, especially while small, are suited for growth in places where severe frost occurs. In ravines, such conifers may be grown on the middle slopes without great risk of severe frost injury.

In places, however, the comparatively safe belts between the exposed upper rims and the sheltered but frosty bottoms of the ravines may be narrow, so that the planting of some species, as e.g. European larch, becomes a highly speculative matter.

(c) Soil

Deficiencies

The nature of the soils at Llanover and Llantrisant Forests has been discussed in an earlier section of this report (page 23). The main soil factors affecting tree growth appear to be availability of nitrogen and mineral food substances and of water. The widespread chlorosis, affecting especially European larch and Norway spruce, which was noted in the late spring of 1936, indicates that sometimes there is an insufficiency of food substances available in the soil, at least for such species as these when in a comparatively early stage of establishment (i.e. 15 years planted or younger). The fact that other trees, e.g. Scots pine and the broadleaved coppice, did not show this chlorosis seems, however, to indicate that this insufficiency is caused by a lack of specific adaptation to the general soil conditions existing, rather than by any actual absence in an available form of the necessary minimal amounts of food substance.

It is impossible to explain this matter without very considerable further investigation, but various possibilities seem to arise. Thus the coppice certainly, and the Scots pine probably, may be regarded as being rooted more

deeply and widely than the species which suffered from chlorosis. The latter, thus, may have been associated with the extremely dry month experienced in this part of the country during May 1936. Another factor coming in may have been the competition for water and food substances on the part of the ground vegetation. This might not be serious in a wet season and, indeed, may have a marked effect only after a really dry period. The effect of grass on fruit trees is suggestive here. Thus Messrs. Bedford and Pickering found that, in the east of England, with a relatively low rainfall, grass growing over the roots had a toxic effect on fruit trees; whereas in the west of England, with a much heavier rainfall, it was found that grass may be of advantage, from the point of view of the fruit grower, in that it helps to keep sufficiently low the amount of nitrogen available for the trees. Experience shows that similar effects are obtained with forest trees - e.g. the poor growth of ash planted into grass - and where food substances tend to be available in minimal rather than in optimal amounts, it is probable that these effects are increased for susceptible species.

Root competition

Availability of water

The low availability of water is part of this problem. Its influence in producing chlorosis is seen commonly in Norway spruce recently transplanted The pale yellow colour which this tree assumes until its root system is re-established is well known, also the

comparative greenness of trees which have been recently transplanted but are shaded and, therefore, have a lower transpiration rate than unshaded trees, may be observed commonly. It seems to be probable that the dense mat of ground vegetation may help to cause a low available water supply in the upper horizons of these soils. The impenetrability of such a mat to rainfall is noted by Davies, and the dry nature of the soil beneath it is frequently to be noted. It is unlikely that with so high a rainfall as occurs here there is any real danger of drought, except perhaps to newly planted trees, but the available supply may be sufficiently low to reduce the fertility of the soil and the rate of growth of the trees.

A further factor, which influences the growth of trees on the Pennant Grit soils, is the high proportion of rock occurring. If this proportion could be measured it would probably be found that, frequently, within a very short distance of the surface, there was much more rock than soil. The rooting space available to the trees is diminished in proportion as the amount of rock increases, and a wider spreading root system becomes necessary to support any given amount of sub-aerial growth. The stonier is the subsoil, therefore, the more important is the fertility of the top soil and of the competition within it of subsidiary species in relation to the growth of a forest crop. General observation seems to show that this dilution of

Rooting

Stones

the soil by rock fragments may be an important factor determining the fertility of soil for the growth of the deeper rooted plants - such as trees are - and both at Llanover and Llantrisant it must certainly be taken into account.

Fertility

Another matter may also be raised. The fertility of soils is directly related to their biological activity. The more fertile the soil, the richer is its micro-flora and -fauna, and the greater is the number of its small animals, such as moles and earth-worms. It is impossible to make any definite statement on this matter with regard to the soils in question, but it would appear to be probable that the zone of appreciable biological activity, on the part of the micro-flora and -fauna, is often very superficial. The orange-brown colour of the soil looks rich but, in reality, is nothing more than a colouration due to ferric oxide and is no indication of fertility. If the biologically active zone tends thus to be of limited development, its availability for root development becomes a matter of great importance to the forest crop, and the competition of a dense ground vegetation, such as frequently exists in these forests, again comes up as a factor of importance as reducing the fertility available for small trees.

Effect of fumes

Finally, the effect upon the soil of atmospheric contamination with industrial fumes has to be considered. This is a matter which can only be considered effectively after careful

comparative analysis of soils similar in type but placed so as to be differently affected by the fumes precipitated in rain. No such comparisons are available for the South Wales and Monmouthshire areas, so far as is known, and accordingly, it is not possible to say much on this matter.

The fumes which contaminate the air are mainly oxides of sulphur given off in the burning of coal. These are soluble in water; they accordingly form acids in and are precipitated by rain. The result is that rain in an industrial district is more acid than it would be if the district were rural and the air uncontaminated. A certain amount of soot is also deposited, but it is doubtful if this has any deleterious effect on trees at Llanover and Llantrisant Forests. It is possible that close to a considerable source of fumes, as on Craig-y-Darren, above the tin-plate works at Abercarn, the acidification of the soil in this manner has had some appreciable effect, but one cannot judge this merely from the condition of the plants which are directly affected by fume contamination in the air as well as indirectly by deterioration of soil conditions owing to acidification. It is useless to discuss this matter any further in view of the lack of data relating to the conditions prevailing. An investigation of this problem would involve a considerable amount of time and trouble, and is a matter which needs separate and special

consideration. It may be taken, however, that in so far as an effect exists, its influence will be proportionately greater, the poorer and more acid is the soil. If, therefore, on soils of the type under discussion, there is no obvious sign of the influence of undue and excessive acidification, it would appear to be very unlikely that the influence of atmospheric contamination on them has been very appreciable up to the present, and, generally speaking, this seems to be the case.

Conclusion

In conclusion and summary it may be said that both at Llanover and Llantrisant Forests the soils occurring appear physically to be perfectly healthy for the growth of plants, including forest trees. Chemically, they are probably rather poor; in lime content they are certainly very poor, but there is nothing to indicate that with right treatment a forest crop cannot be satisfactorily maintained. There are, however, decided indications that, during a period of establishment by clear felling and planting, followed by persistent clean weeding, the general soil conditions are not favourable to some species, as e.g. European larch and Douglas fir, although other species, such as Scots pine, Corsican pine and Japanese larch, may develop satisfactorily. It is very unlikely that atmospheric contamination, in so far as it affects the soil, has anything to do with the difficulty of establishing certain species, certain restricted areas excepted.

The soil conditions which help to cause this have yet to be proved, but it is suggested that they are to be found among the following:-

Adverse soil factors

(1) The low availability of mineral food substances and nitrogen. This is caused by:

(a) the inherent though not extreme poverty of the soil;

(b) the competition of a dense ground vegetation;

(c) possibly by the high concentration of ferric oxides - affecting the availability of phosphorus.

(2) The low availability of water, except when rain is plentiful, owing largely to (1b), although partly also to the freely drained soil and steep slopes allowing free run off.

(3) The dilution of the soil by rock fragments, resulting in a comparative scarcity of soil available for root activity.

Conservation of top soil

Under these conditions it becomes especially important to conserve the top soil for the use of trees, or to plant those species which are able satisfactorily to compete with the ground vegetation and so quickly to suppress it. The inherent character of the soil has to be accepted, and the problem of its utilization for forestry becomes mainly one of maintaining the important top soil in a condition suited to the growth and regeneration of the forest. One of the main difficulties in these forests, from the point of view of soil, has been that the

Effect of treatment

methods used for afforestation have tended to favour the development of hill grass- or heath-land. The rigorous suppression of coppice growth and the necessity of keeping down bracken has brought this about. It is suggested that, under these conditions, a more moist and rich soil than usually occurs at Llanover and Llantrisant is required for the satisfactory growth and rapid establishment of such species as European larch and Douglas fir, while a strong growth of heath plants is, as is well known, very inimical to the growth of the spruces.

(d) Topography This is important mainly in its effect on micro-climate and the drainage and run off of water. The topography, especially at Llanover, is of a difficult type in that the steepness of the slopes makes it less easy to plant and tend the trees efficiently. This is a point referred to below.

(e) Planting and Tending It has been pointed out, in the section dealing with the History of Policy and Management, that misconceptions existed at first as to how satisfactory planting could be carried out in forests of the type of those here discussed.

Planting This was reflected in the demand for an excessively high rate of planting, in the correspondingly low price paid for carrying this out, and in the tools and methods used. This, undoubtedly, resulted in a certain amount of bad planting being done, and it may be taken as certain that this was, in turn, reflected in the amount of beating up required, as well as in a

slow rate of establishment. It is impossible now to determine what the influence of this has been, and it is, fortunately, now fully recognized that the planting methods first adopted, and the planting prices then enforced, were unsatisfactory and, in the end, gave most costly and discouraging results.

Weeding

As regards tending, there is evidence that it was unduly neglected in the past. The presence of blanks, often of considerable size, in Scots pine and European larch plantations seems, thus, to be due to little else than neglect to cut down the vigorous growth of bracken which frequently occurs in these forests. It is also not improbable that similar lack of attention was, in part, responsible for the very high death rate which has occurred in the Douglas fir plantations. Other species have undoubtedly also suffered, though to a less extent. The topography of these forests tends to make the task of inspection of stands extremely laborious, and it is possible that, in the past, this has helped towards both inefficient planting and tending. Obviously this should not be, but the point is not to be overlooked in forests containing so many steep slopes as do these.

The question as to whether or not the method of establishment used is necessarily the best, from the biological standpoint, for the species used, and whether, if this is not so, the treatment has had an adverse influence on the establishment of the stands, is reserved for discussion elsewhere.

(f) Fungi

The only fungus which seems to exert any great adverse influence on the plantations concerned is Armillaria mellea - the honey fungus. The species principally affected is Sitka spruce, especially when this tree is planted in coppice on the old stumps of which the fungus develops. The severity of this attack is probably related to the comparative debility of the trees owing to defoliation by Neomyzaphis abietina, Walker, and frost injury. Perhaps other factors also come in here. If, and when, the stands of Sitka spruce become better established, it is unlikely that this fungus will cause much trouble, for Sitka is frequently one of the more resistant species to its attack.

Honey fungus

There is no point in discussing at length other plant parasites. Meria laricis, Vuill., probably is common on European larch but there is no indication that it is causing any serious damage. Various weak parasites, such as Phomopsis pseudotsugae, Wilson, could undoubtedly be found, and in certain exposed places, as on the western rim of Craig-y-Glyn, Cwm Carn, Dasyscypha calycina, Fuckel., is common on dying back and cankered European larch. In the latter case, exposure and frost are the real causes of trouble, however.

Larch leaf-cast

Larch canker

No examination of mycorrhiza has been made but it is not unlikely that this is sometimes of an adverse type where growth is poor. Cultural operations tending to improve growth will automatically improve this.

(g) Insects — There are present in the forests under review various insect pests which cause considerable trouble.

Pine Shoot Moth — Evetria buoliana, Schiff., the Pine Shoot Moth. The Scots pine plantations are somewhat infested with the larvae of this moth. In some places the infestation is not yet serious but badly affected plantings do occur, as in Compt. 9b on Craig Llwylas in the Ebbw Vale, overlooking the Prince of Wales Colliery. It is possible that the pines here are appreciably affected by smoke and fumes. This pest is a factor to be considered in any extended planting of Scots pine. The Corsican pine is, as usual, very much less affected.

Douglas fir Chermes — Adelges (Chermes) cooleyi, Börner. The green Douglas fir are more or less seriously affected by this pest, and it would appear to be one of the factors which help to prevent the satisfactory growth of this tree. The influence of such a pest as this presumably becomes increasingly important as the site becomes increasingly unfavourable for its host. It would, therefore, be greater in these forests than in those on more fertile soils.

Larch Chermes — Adelges (Cnaphalodes) strobilobius, Kalt. This insect occurs on the European larch but it does not seem to have had any marked adverse effect on them. In the Derwent Valley Water Board plantations, the forester considered that this pest was the fundamental cause of the wide-spread failure of this tree; but this seems to

us to be unlikely, although extremely heavy infestation, such as sometimes occurs, must have a very serious effect upon the host.

Spruce Green Fly

Neomyzaphis abietina, the Green Spruce Aphis. Severe defoliation of Sitka spruce by this insect has been widespread, and this must have seriously affected their rate of growth. This pest does not cause trees to die back, but, in conjunction with frost injury, its effect can be very great. In these forests, Sitka spruce is far from being in an optimum habitat, therefore the influence of the pest will be felt more severely than on sites where growth is more vigorous. Consequently, here the pest must be regarded seriously as an adverse factor to good growth.

Coleophora laricilla, Hübn, the Larch Leaf-Miner. No evidence was seen of any considerable damage by the larvae of this moth.

Larch Shoot Borer

Argyresthia atmoriella, Bankes, the Larch Shoot Borer. This is a very serious pest on European larch. The extent of the damage has been discussed in an earlier section (see page 37). This insect is the chief cause of the death of shoots, except in some very frosty places. Consequently, it is a factor of great importance when considering the reasons for the unsatisfactory growth of European larch. Here, again, the severity of damage by the pest is much increased by the slow rate of growth of its host and by the lack of vigour in recovery.

Pine Aphis

Lachnus sp. A Pine Aphis is thought to be responsible for the considerable defoliation of

the older needles that occurs in some of the Scots pine plantations at Llantrisant. Severe damage from this pest usually occurs only where pines are growing on poor soil.

Conclusion

It will be seen from the foregoing remarks that there are several insect pests of importance affecting the conifers in these forests. All but one affect the vigour of the host infested; that one, the Pine Shoot Moth, merely causes deformed growth of the stems but is not the less to be feared owing to the lower value of affected stems. In a situation such as probably exists in these forests, where there has been no opportunity to develop a proper balance of parasites, this shoot moth may do much damage.

Those insects which affect vigour of growth must be counted as items in the complex of factors which tends to depress the health and vitality of certain species, although, by themselves, they are usually unable to cause the death of their hosts.

(h) Atmospheric contamination. There is no more difficult problem to discuss, in this report, than that raised by the presence of atmospheric contamination with poisonous fumes throughout the South Wales and Monmouthshire Coalfield in which Llantrisant and Llanover Forests are situated. Many, both of those who have visited and who administer these forests, have felt compelled to explain the ill-thriving of certain species, and especially that of European larch and Douglas fir, as being caused mainly by the presence of

these noxious fumes in the air. The same has been felt with regard to other forests in South Wales. The problem is, thus, one of considerable importance, for if the hill wastes of this coal-field are to be developed as forest land, it is inevitable that the new woodlands shall be within the influence of smoke and fumes.

South Wales coal has a high carbon content, thus it burns with a minimum of black smoke and has a comparatively low sulphur content. It is probable, therefore, that the gases and smoke given off by industrial and domestic fires here are less injurious than in other parts of the country, where coals with a higher sulphur content are used, these burn with more smoke. So far as is known, no other type of poisonous fumes is produced in quantity in the vicinity of either Llanover or Llantrisant Forests and, therefore, the possible influence of such does not arise.

Relative importance of sources of smoke

The effect of individual sources of smoke upon vegetation varies with their distance from the site under consideration, the amount of smoke produced and its concentration. Thus, the fumes from a relatively minor source near to a wood-land may cause much more damage to the trees than those from a much larger source further away; on the other hand, those from a larger source will have a wider range of influence. Also, any source of fumes which include large quantities of sulphur gases, e.g. from a lead smelting works, may have a much more injurious effect than a whole town possessing no such

virulent source of fumes. It is plain, therefore, that a more careful survey than it was possible to make of the industries of a district is needed before the importance of possible injurious fumes can be estimated properly.

The following is a brief review of the position as far as Llanover Forest is concerned:-

Smoke of local origin

Nearby sources of smoke:

1. Industrial - these are all in the Ebbw Vale.

(a) The two tin plate works at Abercarn. The larger of these is situated in the valley immediately below and to the east of the plantation on Craig-y-Darren. This is the principal single source of fumes near to the forest.

(b) The Prince of Wales Colliery. This stands below and to the west of Craig-Llwyfas, the upper slopes of which are within the forest. This colliery has been largely closed down for some time and produces but little smoke.

(c) The Celynen Collieries. This pit lies up the valley north of Llanover Forest and is one of the principal sources of smoke in this part of the Ebbw Vale. It lies too far north, however, to have much direct effect on the Commission plantations.

(d) The Cwm Carn Colliery. This produces practically no smoke since it is mainly electric.

(e) The Ebbw Vale railway. This is also a fairly continuous, if slight, source of smoke.

2. Domestic - the main valley is lined almost continuously with houses, and where space has permitted, small towns or industrial villages have developed. Cross Keys, Cwm Carn and Abercarn are nearest to Llanover Forest. Risca is a little further away to the south and New Bridge to the north. Smoke from the latter, in particular, probably has little direct effect on this forest.

Smoke of distant origin

Distant sources of smoke:

Llanover Forest lies just within the south-eastern corner of the coalfield. The main distant source of smoke lies to the north in the district which includes and lies between Cwm Avon Lwyd and the Rhymney Valley. Northerly, north-easterly or north-westerly winds blow smoke and fumes from this district towards the forest, which lies about two miles from its edge and seven from its centre. To the east, south and west of the forest, the country is less industrialized, but Newport and Cardiff occur as somewhat distant but large sources of smoke, and collieries are still fairly numerous. The east is the direction from which least fumes come.

General comment

It should be noted that, with the exception of Newport and Cardiff, no large intensely populated urban or industrial districts occur. The mountainous nature of the country makes it inevitable that the industrialized areas occur as thin zones between which lie upland and rural districts of considerably greater area. This

necessarily causes the fumes given off within any one zone to be much diluted before they meet with those from other zones. From this point of view, there occurs a number of industrial areas which are more intensely developed, and probably always will be. On the other hand, owing to the nature of the country, the urban districts lie within narrow and sometimes almost ravine-like valleys - the towns of the coastal plain excepted. Smoke or fumes emitted into such narrow mountain valleys tend to be confined to them and disperse and become reduced in concentration much more slowly than in flatter country. This local concentration of the fumes makes it most probable that the air on the uplands and in rural side valleys, such as those in which Llanover Forest is mainly situated, contains a smaller concentration of fumes than would otherwise be the case. In this connection, it should be remembered that in country such as this the prevailing wind tends to be diverted up or down the valley, even though, on the hill tops, it may blow strongly across it.

The general conclusion to be drawn from this is that contamination of the air to an injurious degree is most likely to occur in the main valleys where the townships and industries lie, and to be especially acute near to any large source of fumes, as e.g. the Tin Plate Works at Abercarn. On the uplands and in the rural side valleys, such injurious contamination is much less likely to occur. This is as far as it is possible to carry the argument without

further evidence. It may be pointed out here how great a lack of concrete evidence there is with regard to this matter. The identification of the type of fumes, the measurement of their concentration and of the constancy of this, the effect of various weather conditions on this, has not been studied, and until this has been done one cannot know the conditions with which forest trees, or other plants, have to contend.

Manner of spread

Around any considerable source of fumes there is a local zone of high concentration which extends furthest in the opposite direction to that from which the prevailing wind blows. Outside this there is a much wider and more extended zone in which the concentration of fumes becomes increasingly less. If the fumes are led up a stack, either because this is necessary to provide draught for fires, or in order to avoid intense local contamination of the atmosphere and to attempt to obtain better dilution of the fumes, these may travel for some distance in a comparatively concentrated mass, as smoke can be seen to do frequently. Under these conditions a concentrated precipitation of fumes at some distance from the source of emission may take place. This is a common experience in the vicinity of smelting works, for example.

Manner of injury by fumes

Fumes may come into contact with plant tissues in various ways:

(1) by being precipitated in rain;

(2) by becoming dissolved in mist which, in

turn, becomes condensed on the plants;

(3) by being absorbed into the moist walls of the leaf parenchyma from the air taken in through stomata.

Methods (2) and (3) are usually the more important. Acute, quickly developing injury only occurs where there is a sufficiently high concentration of poison; this is usually near to some strong source of fumes. Chronic types of damage are naturally more widespread and develop less quickly to a serious extent. Unless the source of fumes is large, one usually passes quite quickly out of the zone of obvious damage.

Soot as an indicator

The importance of soot as an indication of the intensity of fume damage tends to be overestimated since soot, being sticky, is cumulative. The amount of damage depends on the relative amounts of soot and fumes as emitted; unfortunately, nothing is known of this in respect of the subjects of this investigation. Blackness of foliage at the end of the year, or, in the case of evergreens, after two or more years, is thus not necessarily an indication of intense fume contamination. It has already been indicated that the quantity of soot deposited in any region depends on the type of coal in general use there. Thus, South Wales coal produces much less soot than most other coals in Britain. On the other hand, of the South Wales coals, those mined in Monmouthshire are the most bituminous and, therefore, burn with most smoke.

Plants as indicators

The intensity of atmospheric pollution by smoke and its accompanying fumes is reflected in the degree of impoverishment of plant life. Thus, as the intensity increases, lichens and liverworts tend not to occur or become much impoverished; the finer grasses become reduced or disappear; soft and especially crinkly-leaved plants, such as primroses, gradually die out, being much more sensitive than those with harder glaucous leaves; conifers become difficult to grow and eventually die; broad-leaved trees survive better, but tend to lose their leaves early and to become stag-headed; garden and other crops become increasingly difficult to raise to a proper state of maturity.

Symptoms

General evidence of the injury which accompanies this adverse development is seen most easily in leaves. When suffering from injury by smoke or fumes, these become more or less discoloured apart from any blackness caused by soot. They lose the healthy green look, become yellower, or actually browned and dead at the edges or between the veins. They may suffer from brown spotting when the acid has become concentrated in drops of moisture deposited either as rain or as condensation from mist. Injuries of this type are often extremely difficult to distinguish from those caused by other agencies, such as strong winds, saline deposits carried by wind, frost and fungus, and are quite commonly mixed up with them.

Absence of definite symptoms

A prolonged and very careful investigation would be needed before one could say with complete certainty whether or not the vegetation in the forests in question had been affected by smoke. It is possible to say, however, that with the exception of certain places in the Ebbw Vale, near to sources of smoke, there is no easily detectable sure sign that it has been so affected. This point is noted in an earlier section dealing with the vegetation types in these forests.

Available evidence

So far as this Report is concerned, the most important evidence is that obtained from the plantation and other trees. The conifers planted may be placed in the following order, beginning with the species which is thriving least well, all things considered:- Green Douglas fir, Fraser River Douglas fir, European larch, Sitka spruce, Norway spruce, Japanese larch, Scots and Corsican pine. This is by no means the order in which these species would necessarily be arranged if placed in order of susceptibility to smoke fumes. Thus, on the continent, no species has proved to be more susceptible than Norway spruce, which here gives no special indication of suffering from smoke damage. Scots pine is also to be regarded as a susceptible species, although again, in these forests, it is impossible to find any evidence that clearly shows that injury from smoke has occurred - certain small areas in the immediate vicinity of a source of fumes being excepted.

One of the most unsatisfactory things about the claims that the cause of the ill-thriving of plantations is largely to be found in atmospheric contaminations is this very success of Scots pine and especially Norway spruce. For example, Norway spruce occurs in Compartments 9A and 10 in Llanover Forest, on an upper slope near, and to the westward of the larger Tin Plate Works; yet, considering the site generally, the trees are growing healthily. Sitka spruce is similarly healthy.

Douglas fir

The position with regard to Douglas fir is even more unsatisfactory in both forests, for there are many hundreds of surviving trees, of both the green and intermediate type, which give every sign of being healthy, even though slow growing. It is difficult to apply the saying 'one shall be taken and another left' to smoke damage when so many surviving trees are involved, and especially when its persistent and cumulative action is borne in mind. These Douglas fir, instead of showing signs of recovery, as in the case with many, should all of them be getting increasingly weaker and nearer to death were they being persistently and significantly affected by fumes.

European larch

This is also mainly true of European larch, the average annual height growth of which, for the last four years, is greater than the average for the whole period since planting. If this indicates anything, it is that these trees are becoming more vigorous rather than less.

Evidence of the same type can be collected in other plantations in this coalfield. Thus

Llanover Estate

the conifer stands on the Llanover Estate in Cwm Hafod-fach (about a mile to the north of Cwm Gwyddon in Llanover Forest) lie to the north-east of the main local sources of smoke and are in the track of the prevailing wind blowing from these up the valley, yet the trees show no obvious sign of being affected by the fumes. Similarly, in the very interesting and suggestive

Rheola Forest

report on Rheola Forest, in the western part of the coalfield, submitted to his Divisional Officer by Mr. Backhouse and kindly sent to us, the general conclusion is reached that it is only when environmental conditions, other than atmospheric contamination, are unfavourable to the trees that there is any real sign of debility. This is the general impression received by us from an inspection of that area.

Conclusion

This argument leads one inevitably to the conclusion that it is necessary to isolate the various factors which have been responsible for the unsatisfactory growth of the various tree species, and the influence each has had in causing the debility of the plantations. It seems to us that the influence of atmospheric contaminations has frequently been much over-emphasised, and it will be gathered from what has preceded that we consider that other factors have been usually of greater importance.

It should be recognized that it is quite impossible to speak with any real accuracy with regard to the actual effect the smoke has on the

forests under report, without carrying out a great deal of detailed investigation into the whole question of atmospheric contamination and tree poisoning in these parts of the coalfield. Plainly, poisonous acid fumes will not improve the condition either of the plant, or of the soil, especially when this is already an acid one.

At Llantrisant, where there is only one considerable nearby source of smoke, there is no really satisfactory evidence that any of the plantations are being vitally affected. At Llanover, this evidence is only to be found on the slopes of the main valley, especially at the foot of Craig-y-Darren, although the gardens near here seem to grow reasonably good vegetables and flowers - a thing which is impossible in many parts of Leeds and other large, smokey cities.* Consequently, one would expect any woodland, not actually in an industrialized and smokey valley, to do well providing soil conditions are satisfactory.

On the other hand, there must be an appreciable amount of general atmospheric contamination over the whole coalfield, although the low sulphur content of the anthracitic coals has to be taken into account. It is probable, therefore, that a careful analysis of plant tissues would reveal a higher sulphur content than normal for plants on similar soils in pure air. Apart from the exceptions stated, there does not appear to be any real evidence that this is causing any appreciable loss of vigour although the rate of growth may be depressed somewhat.

---

*Cohen & Ruston: 'Smoke. A Study of Town Air'.

Notes on Woodland Areas other than Llanover and Llantrisant Forests.

It is of considerable interest to compare the growth of trees in the forests immediately concerned in this report with that which occurs in other woodlands, especially in plantations in the same industrial district but on different soils and in other industrial districts on similar or, at least, on poor soils. First, we will discuss neighbouring woodlands occurring both on soils derived from Pennant Grit and on soils derived from other rocks. Later, we will refer to our experience outside the eastern part of the South Wales and Monmouthshire coalfield.

Neighbouring woodlands

The main opportunity for observing tree growth on other soils in the neighbourhood of Llanover and Llantrisant Forests occurs along the outcrop of the Lower Carboniferous Rocks and of the Old Red Sandstone on the southern edge of the coalfield. A series of hills stands here on which a number of woods of some size occur. This narrow strip of country is rural and yet within the industrial zone, and is subject to the influence of the general atmospheric contamination which affects both Llanover and Llantrisant Forests. At the western end of the part of the outcrop surveyed is Fforest Fawr, Coed Caerdydd immediately behind Cardiff and in line with the smoke coming from that city. An adjacent section of woodland is in the immediate vicinity of Caerphilly. The survey ended at Ruperra Draethen Castle, which is three and a half miles south

Woods surveyed

of Llanover Forest and lies to the north-east of Cardiff. To the north of the area is a vast extent of country developed for mining and industrial purposes.

Relative position

Llantrisant Forest stands in an essentially similar position, while Llanover Forest lies embedded from a half to two miles within the edge of the coalfield a little further to the east.

One may justly claim, therefore, that, although this remains one of the most pleasant and rural parts of the hill-country in this part of Wales, the atmospheric conditions are not vastly different from those at the two forests under consideration in this report as regards fume contamination. A useful comparison can be made of the tree growth as a means of obtaining some idea of the influence of soil quality on the growth of the trees in this part of the country.

The woodlands are described in reference to the strata on which they stand.

Old Red Sandstone

Coed Craig Ruperra

Coed Craig Ruperra, on the Tredegar Estate, rises to a height of 500 feet and stands on the conglomerate, sandstone, and red marl of the Old Red Sandstone. The axis of the hill runs east and west, so that the main aspects are southerly and northerly. The slopes are mainly steep except on the red marl, where they are gentle.

The crop is partly European and partly Japanese larch. It has been planted about twelve years, and the Japanese larch is decidedly ahead

of the European. The latter is, however, definitely superior to the slightly younger (P.25 and 26) plantings of this species at Llanover Forest, even allowing for the difference in age. Both the larches, in fact, stand in a higher quality class than those at Llanover and Llantrisant, with the possible exception of the stands in the richer soils in the Ely Valley. There can be no doubt, in the opinion of the authors, that this better growth is simply a reflection of better soil conditions. A marked characteristic of the plantation is the comparatively even growth. On Pennant Grit this tends not to occur, especially with European larch.

The soils are typical brown earths such as are commonly found on Old Red Sandstone, e.g. at Mynydd Ddu Forest in the Black Mountains and in the High Meadow Woods. The quality is reflected in the good size and height growth of beech and other broadleaved trees in the western part of this woodland. Douglas fir, Sitka spruce and Scots pine grow quite well on these soils, although only small groups have been planted.

Carboniferous Limestone

A belt of European larch of about 25-30 years of age stands on the Carboniferous Limestone (Lower Avonian) at the foot of Coed Cefn-pwll-du, on the opposite side of the Caerphilly road to Coed Craig Ruperra. The stand is of good height and condition and very even in growth. Again, the even growth is in strong contrast to that which one sees on poorer soils. No soil profile

Coed Cefn-pwll-du

was examined at this place. The woodland belongs to the Plymouth Estate.

Coal Measures Sandstone

Rudry Wood

Rudry Colliery is a small working standing in a plantation consisting mainly of conifers. The strata covered by the woodland are the Millstone Grit Shales and Sandstone, and the Steam Coal Series of the Coal Measures. At one point, adjacent stands of European and Japanese larch occur on Coal Measure Sandstone. They are of equal age (about 25-30 years); but whereas the Japanese larch forms an even, dense stand which has already been thinned, the European larch are very sparse, the gaps being filled with broadleaved trees. Such European larch as do exist are healthy and of nearly as good height growth as the neighbouring Japanese larch.

The soil here is shallow and lies over a brashy grit; it is much more comparable with Pennant Grit soils than with those mentioned above. The uneven take of the European larch is also typical of those soils, and suggests that similar difficulties in establishment occur on both. The Japanese larch, on the other hand, show every sign of an even and regular growth with few or no gaps, and this again agrees with the manner of growth of this species on Pennant Grit soils.

Pennant Grit

The Warren

The woodlands known as the Warren, belonging to the Plymouth Estate and situated near Caerphilly, stand partly on Pennant Grit and exhibit soils which are strictly comparable to those at Llanover and Llantrisant. These

woodlands are well-managed; they consist almost entirely of conifers and are run on a rotation of about 30 years for pit-props. European larch was planted largely at first, but experience here has shown conclusively that it is a most difficult tree to establish, producing gappy plantations with many weakly trees. When planted in mixture with Japanese larch, it is largely suppressed, although the better of the surviving trees may come to equal the better of the Japanese larch. (See photograph 26). The latter species is now used as the main crop and, as at Llanover and Llantrisant, has proved fairly easy to establish and makes an even and satisfactory plantation.

Scots pine grows satisfactorily mixed in with the larch, and makes a very similar height growth. It is now planted as a change crop after larch.

Other soils at the Warren

Other and more moist soils than Pennant Grit occur here. These are mainly clays or loams derived from shales of the Steam Coal Series. On these, Douglas fir and Sitka spruce grow healthily and moderately fast, and some Silver fir and Thuja also occur. There is, however, some danger of frost. On either side of the Caerphilly-Newport road, an area of glacial pebble gravel occurs, and on this also Japanese larch succeeds but European larch is again unsatisfactory.

Carboniferous Limestone

Some very interesting woodlands occur on Carboniferous Limestone at Castell Coch on the Bute Estate. The areas are known as Fforest

Fforest Fawr & Fforest Ganol

Fawr and Fforest Ganol. The soils here are of good quality and are probably the most desirable of those examined in South Wales or Monmouthshire. Beech, Scots pine, Douglas fir, ash, Japanese and European larch, Norway and Sitka spruce, Thuja plicata all do well. Some of the finest beech and Scots pine in South Wales probably occur here. Many of the younger conifer plantations have been grossly under-thinned and have suffered much because of this. There is no reason to suppose that this is an especially smoke-free site, and it lies only three miles from the Warren where, on Pennant Grit, European larch do badly. With proper management, very fine trees might be produced here.

General remarks

This short survey of woodlands occurring along a strip of country adjacent to Llanover Forest indicates that the success of plantations is directly related to the quality of the soil. Where this is comparatively poor, as on Coal Measure Sandstone and Pennant Grit, the growth of European larch is uneven and poor, while that of less difficult trees is relatively poor. Where the soil is good, growth becomes more even and faster, as on Old Red Sandstone at Coed Craig Ruperra; where the soil is of high quality, as on the Carboniferous Limestone at Fforest Fawr and Fforest Ganol, a difficult species such as European larch withstands successfully an appreciable amount of overcrowding, still remaining healthy and making good height growth, while Japanese larch succeeds, even in very dense

stands, in making tall and, considering the conditions, wonderfully good trees.

This supports the suggestions already made, that one of the fundamental troubles with the development of European larch and Douglas fir in Llanover and Llantrisant Forests lies in the quality of the soil which is not rich, and in which the difficulties inevitable during a period of regeneration have a much greater adverse influence on the growth of small trees than where the soil is more fertile and conditions more favourable to growth.

Other woodlands

We were able to gather much valuable evidence relating to the problem in woodlands occurring outside the eastern section of the South Wales and Monmouthshire Coalfield. The main points of interest are discussed below because of the support they lend to the conclusions already reached.

Old Red Sandstone

Plantations in the Black Mountains

A visit was made, under the guidance of the Divisional Officer, No. 3 Division, to see plantations growing on Old Red Sandstone in the Llanthony Valley and in Mynydd Ddu Forest in the Black Mountains. The plantations consisted mainly of European and Japanese larch, though some other species, especially young Douglas fir, were also seen. The European larch were of various ages from very tall mature trees of 80 years of age downwards. The striking feature of all the stands was the evenness of take and the good vigour of growth - the oldest stand was open owing to indiscriminate utilization.

There is, here, no evidence of any difficulty of establishment, except on the high and exposed hill tops where soil conditions are poor, either with the two larches or with Douglas fir. The general aspect of the crops agrees with what was seen on Old Red Sandstone soil on Coed Craig Ruperra, mentioned above. The latter plantations are within the general sphere of contamination in the South Wales Coalfield, but in the Black Mountains there can be no appreciable smoke contamination. The unifying factor between the two sites is the similarity in soil conditions; the difference in atmospheric contamination is comparatively unimportant.

Pennant Grit

Forest of Dean

European larch plantations growing on soil derived from Pennant Grit were inspected in the Forest of Dean. They stand either on flat or gently sloping land. The flat area is subject to rather severe ground frosts. Older larch here show good height growth; younger, but established larch, of about 20-25 years of age, are vigorous and capable of making satisfactory stands. The more recently planted trees, however, show much the same signs of slow growth during establishment, and of irregular uneven growth, that are exhibited at Llanover. Owing to the comparatively flat topography the soil is usually deeper here than on the steep hill-sides at Llanover, and it is probably more fertile. Because of this, the difficulties of early growth are not so great. There is a certain amount of smoke contamination in the

Forest of Dean, but it is certainly not so great as in South Wales and Monmouthshire. Again, the similarities in manner of early growth between two districts are related to similar soil types.

Gelli-ddu-fâch

At Gelli-ddu-fâch near Mountain Ash, Glamorgan, on the Aberdare Estate, there are some interesting plantations on the upper slopes of this smokey industrial valley. Two are worth mentioning; these occur on a deep light sandy loam over Pennant Grit on Coal Measures, on a moderate slope at an elevation of about 750 feet. The older plantation is of European larch, age about 76 years. This is rather gappy but there are several well-formed trees; the height is about 70 feet, which represents Quality Class IV. (Photograph 24). The younger plantation is of Douglas fir; this is 10 years old with a height range of 4 to 15 feet, the average being 8 to 10 feet. The crop is very gappy, and while many trees appear to be thriving well, others look very unhappy. (Photograph 25). Soil conditions would appear to be better here than at Llanover Forest generally by reason of the greater depth on the more moderate slope. Nevertheless, the evidence indicates the same difficulties in establishment of such species as Douglas fir.

Carboniferous Limestone

High Meadow Woods

There is a plantation of European larch, mixed in with coppice, growing on a soil derived from Carboniferous Limestone, on the south side of the road entering Staunton from the east. This is within a short distance of the larch on Pennant Grit, mentioned above, but the trees show

much more vigorous growth, not only in length of shoot but also in length of needle. The larch appear able to compete with the quite vigorous coppice, a thing which they would be much less likely to do on a Pennant Grit soil. These were some of the most vigorously growing European larch seen, and their vigour is undoubtedly related to soil conditions.

Lower Carboniferous Grits and Shales

West Riding & Derbyshire

Plantations were inspected in the vicinity of the Peak, Derbyshire, (a) near one of the Sheffield Waterworks reservoirs, (b) around the Derwent Valley Waterboard reservoirs, and (c) on either side of the Glossop-Sheffield road, in Lady's Clough, Hope Forest. These three places sample one of the most smoke contaminated areas of rural England, and lie between the great industrial districts of Lancashire and Yorkshire. Plantations were also examined at Chatworth, further south in Derbyshire, in a district not free from smoke contamination although by no means as bad as the above.

The plantations first referred to consist mainly of conifers. European and Japanese larch occur, also Sitka and Norway spruce, Douglas fir, Scots and Corsican pine. In addition, oak, sycamore, ash, and beech are grown, and birch commonly occurs. The most interesting of the plantations seen were those of the Derwent Valley Waterboard. These have been established for some time, whereas most of the others are quite young. The experience of the Waterboard is that neither European larch nor Douglas fir

Derwent Valley Waterboard plantations

can be established with any certainty of satisfaction, although both were tried quite extensively at one time. The species which are most easily dealt with are the spruces, the pines and Japanese larch. They have tended to plant Sitka spruce and Japanese larch as their main crop species in the more recent plantations. Ash, oak, sycamore and beech will grow satisfactorily, sycamore especially is favoured and may grow faster than some conifers, at least when young. Oak has been planted in mixture with conifers up to 1100-1200 feet above sea level and is growing about as fast as them. On the other hand, European larch has failed completely in mixture with Scots pine, and practically so when planted pure. Where it has succeeded to some extent, its growth is much less satisfactory than that of Japanese larch. It will, however, make perfectly healthy foliage and growth when once well established, and the diseases by which it is affected do not seem to have any relation to smoke injury. The position with regard to Douglas fir is very similar. In one place a small belt of this species, part of a larger planting, has succeeded and is making a moderate and not unsatisfactory growth, but in most places it has been a great failure. Again the surviving and well established trees show no sign of injury, or failure to make good growth, because of smoke contamination.

These plantations, as a whole, are very sooty, in fact one cannot go through them without

getting exceedingly dirty, much more so than at Llanover Forest, for example. Nevertheless, there is no evidence of any appreciable acute or chronic injury owing to the pollution of the atmosphere by smoke and its accompanying fumes. Rather the problem seems to be one of difficulty of establishment of certain species under particular soil conditions. (Relative photographs, 28 and 29).

Other species are not so susceptible to whatever adverse factors may occur, and their establishment is comparatively easy. It is not possible to ascribe the general diseases which occur to smoke contamination. Admittedly, injury from this cause may occur, but not to a sufficient extent to make it a major and fundamental cause of failure of particular species. Indeed, it does not seem possible that larch and Douglas fir should fail so completely owing to fume contamination and yet leave a quite considerable number of perfectly healthy survivors, also that this should happen side by side with healthy plantations of such species as Scots pine and spruce which have been proved elsewhere to be among the most susceptible to injury in a smoke-contaminated atmosphere. One is thus forced to the conclusion that in this case one is dealing with difficulties which are due to other causes, and that these are to be found largely in soil conditions can hardly be doubted.

It is impossible to discuss soil conditions

in the Peak District, neither space nor data are available, but one example which gives proof of difficult conditions may be cited. In

Hope Forest

Lady's Clough, Hope Forest, Sitka spruce has been set directly into the ground so that the roots lie in the mineral soil, and has also been turf planted. The site is well-drained upland grassland at this point. The trees directly planted have quite frequently died back, whereas, on the whole, the turf planted trees have developed without any such die-back. An examination of the trees makes it plain why this has taken place. The roots of the turf-planted trees are so placed that root development takes place at first in the debris between the underlying and the overturned sod. This is a favourable rooting medium and one which permits of healthy, if slow, development. The trees planted directly into the mineral soil are unable at first to make any appreciable root growth, however. They accordingly die back until adventitious roots have developed to a sufficient extent to support them. These adventitious roots grow within the dead grass debris which is to be found immediately over the thin, peaty layer at the base of the sod, and, therefore, they develop in a similar medium to those of the turf planted trees. All these trees have their needles black with soot, but the die-back is to be explained by soil conditions. The mineral soil at this place has the deep, rich, orange-brown colour which is to be observed so commonly at Llanover,

and, as there, it may consist largely of B horizon material coloured by the presence of ferric oxides. Whether the factors adverse to root development are to be found in conditions specially related to the mineral soil, or whether they are more closely related to the dense sod which covers the soil, is not known; but the latter seems to be quite probable in view of the difficulty the roots have in penetrating this.

It must not be supposed that the type of rocks which occur in the Peak District of necessity produce soils on which a species such as European larch does badly. A little further

Chatsworth

south at Chatsworth, at somewhat lower elevations and on gentler slopes, deeper and more fertile soils occur over the same types of rock, and here many kinds of trees grow, including European larch, perfectly well. The situation is more favourable both from the point of view of climate and soil fertility, and, while the air is cleaner, it would appear that the better soil and climate are the important deciding factors in producing more rapid and even growth. This is also shown

Ashopton

in the Peak District where, on the side of the road leading to the Derwent Valley Reservoirs, a line of European larch (photograph 27) has grown healthily to a good height on alluvium in the river valley within a mile of the site of the failure of this species in more upland conditions. On the lower hillsides here, healthy, if rather short, European larch are by no means uncommon.

Bunter Pebble Beds

The old Sherwood Forest covers mainly an area of poor soil derived from the Bunter Pebble Beds. There are several Commission Forests in this area, and the authors spent a day examining plantations

Clipstone Forest

in and near Clipstone Forest. This forest lies within the eastern edge of the Nottinghamshire coalfield and is one of those in which smoke damage is supposed to occur. Certain species have proved difficult to establish, Douglas fir and Japanese larch being, perhaps, the worst, at least in the parts we saw. It is quite possible that here smoke has some influence in the bad development of these trees, but it seems to us that, probably, other conditions are much more important.

It is not possible here to enter into a detailed discussion of this matter, nor have we the data necessary for it. One may say, however, that where a generally smoke-susceptible species such as Scots pine does comparatively well, and where, in the older plantations, European larch can be seen growing quite healthily and equally as fast as the pines, it is unlikely that Douglas fir and, still more so, Japanese larch, which does comparatively well in other smokey districts, will be very seriously affected by smoke or fumes. It is a different matter if the trees are planted in such a position that they receive fumes directly from some considerable nearby source such as a burning pit-bank, a large works, or a colliery. We feel, again, that in climate and soil are to be found the most important adverse factors, and that these usually are not even

indirectly connected with smoke or fumes. This does not mean that fumes are an advantage, but it does mean that, up to the present, they have not provided the preponderating adverse influence, in our opinion

General conclusion

The point of this discussion is to bring out the fundamentally important fact that, in the semi-rural, semi-industrial, districts with which we have been concerned mainly, and in which certain species do badly or are slow to establish themselves, one is not only dealing with a fume-contaminated atmosphere, but also with what is usually much more important, difficult soils. These, in their present condition, are not favourable for the growth of small trees of such species as, e.g. European larch, Douglas fir, and - sometimes, as in Nottinghamshire - Japanese larch.

Evidence of the comparative infertility of the soil will be found undoubtedly if an examination is made of the rental value for agriculture of adjacent land with similar soil. These are, in fact, districts of poor soils compared with those in which the high quality agricultural lands of England and Wales occur. It may be possible to produce perfectly good forests on such soils, although, usually, the timber will not fall into the higher quality classes. The soil, however, must be conserved as a 'forest soil', otherwise difficulties are bound to occur during regeneration and establishment with those species which are not particularly adapted to act

as pioneers in what are, or would become very soon, essentially heaths or grasslands of a rather poor type. Such difficult conditions exist at present, and it is necessary to chose those species which are able to contend with them if a closed stand is to be developed rapidly.

To the difficult soil conditions are often added difficult climatic conditions, frost being, perhaps, the most important directly injurious adverse factor. Examples of this have already been given above, but the case of Japanese larch at Clipstone Forest may also be mentioned. There, this species has suffered very severely from frost damage, much more so than it would have done on a richer soil or even on one in better forest condition, owing to the very poor powers of recovery possessed by the slowly growing or stagnating trees. Adverse micro-climatic conditions thus doubly increase the difficulties which exist owing to soil conditions. This is true of all these areas, including Llanover and Llantrisant Forests.

From the biological point of view, the afforestation of the areas with which this report is concerned, and of some of those mentioned above, should have as its aim, in the first place, not merely the establishment of a woodland of some kind, but also of a forest soil of good type as quickly as possible. This can only be done by beginning with those species which are adapted to establish themselves with reasonable rapidity under the conditions existing.

Discussion of Suitability of Species

It will be seen from what has gone before that, in our opinion, the difficulties which have occurred in establishing plantations of conifers in Llanover and Llantrisant Forests have their origin in a number of causes. The fundamental trouble, and one which still largely exists, has been the failure to understand the habitat in which the establishment of a forest has had to be attempted. The work was, in fact, speculative, and done without any proper foundation of knowledge. Under the circumstances this may have been unavoidable.

nderstanding f habitat a fundamental requirement

It is important, therefore, to understand what types of habitat for forest trees occur in these forests, and then to fit in suitable forest trees as economic crops. Much has been learned, in this connection, from the experience of the last sixteen years, but many difficulties in interpretation of this experience still remain. Some idea may be obtained of the suitability to habitat of the principal species hitherto planted if they are considered in relation to the ease of establishment and quality of growth.

Summary discussion of species

i. Species which can be established satisfactorily even, usually, on inferior sites.

The pines

Scots and Corsican pine are the only trees which can be placed here with reasonable certainty. The only serious trouble affecting the establishment of a pine crop has arisen owing to lack of weeding. The other possibly serious matter is the Pine shoot moth, but this does not

seriously affect the establishment of the tree. Both pines thrive well, taking soil conditions into account, and there are plain indications that they are suitable for afforestation in these areas. No growth assessments were made in the pine stands, but we believe that at present they fall into higher quality classes than stands of other species growing on similar soil, with the possible exception, on the better soil types, of Japanese larch.

ii. Species which may be established satisfactorily on the better vegetation types, and are free from serious disease.

Japanese larch

Japanese larch and Norway spruce may be considered here. Japanese larch has been confined almost entirely to the better vegetation types and the lower slopes. On the whole, the plantations are satisfactorily stocked. They have suffered from no serious disease except that, in the bottom of Cwm Gwyddon, even trees 18 or 20 feet high have had their leaders killed by frost. This type of injury does not appear to have been very serious so far, but it shows that this species is not immune from danger.

In Llanover Forest, the plantations at present fall into Quality Classes II and III (Bulletin 10), but in Llantrisant Forest Quality I also occurs. There are undoubted indications that this is one of the right species to plant as a first conifer crop, but Llantrisant Forest offers much better sites for its growth than does Llanover. (Photographs 22 and 23). The fact that most of

the older samples taken by us fall well below second quality, and might be still lower in a revised yield table, seems to show that this is a tree which should be kept to the better vegetation and soil types.

Norway spruce

Norway spruce is a more difficult species to discuss, for much less of it has been planted. So far it has suffered very little from disease, though there is no doubt that if planted in very frosty situations it would, from time to time, be seriously injured. The best of the samples taken by us (Llantrisant Forest, Cpt. 13) is only fifth quality at present, although it occurs on one of the better vegetation types. The samples taken at Llanover have not even begun to qualify for a Quality Class although planted 13 to 15 years ago, and this is true of this species at Llantrisant Forest when growing on the poorer vegetation types. (Photographs 13 and 14). It would appear that this is a very doubtful species for general planting. One has, in fact, to consider whether it is worth while planting at all in view of the better growth obtained from the pines and Japanese larch. Atmospheric contamination seems to have had no appreciable effect on it, although the general experience is that it is markedly affected by this.

iii. Species which may be satisfactorily established on the better soil types but are liable to be seriously affected by disease.

Sitka spruce

Sitka spruce is the only species under this heading. This is, in many ways, one of the

more disappointing species planted. Its rate of growth, as indicated by our samples, is below fourth quality, even in the valley bottom where the deeper, moister, and more fertile soil occurs. The shoot measurements show that even before the frost of May 1935 the average increment in height was very poor, and that the frost has not affected this so markedly as might have been expected.

It would appear, therefore, apart from its susceptibility to injury by frost, to defoliation by the spruce aphis, and to death owing to infection with the honey fungus, that the habitat afforded Sitka spruce in Llanover Forest is a decidedly poor one, judging by the plantations sampled. There is, however, no doubt that in the lower parts of Llantrisant Forest very much better quality sites could be found, although they would cover no large area. In fact, one has to consider very seriously whether from any point of view this is a species worth planting on most of the hillsides in this type of country. A deeper study of this matter is needed, but there are strong indications that a suitable pine, or Japanese larch, might be much more desirable both from the economic and biological standpoints.

Wonder what R.L. Robinson said on reading this

iv. Species which are difficult to establish and may, or may not, grow healthily afterwards.

European larch, Green Douglas fir and the Fraser River Douglas fir come in here. None of the many samples of European larch (Appendix VIb and d) are above Quality Class IV and many are Class V or below, with the one exception of a small

European larch

Odd that provenance of Larch is never alluded to, although that of Douglas fir several times

block of older larch in Cpt. 1, Llantrisant Forest. This is on a better soil than are the other plantations. So far as average individual height growth is concerned, this tree falls into line, as regards Quality Class, with the two spruces; this is a fact which is often not realized, owing to the poor appearance of the trees and the irregular gappy nature of the plantations. The gaps have been caused largely by lack of proper care in weeding. The poor appearance of the trees is due to their weak and rather spindly growth, the frequent strong infestation with the larch shoot moth, the short needle length, and the frequent and often extensive occurrence of a browning of needles which is accompanied sometimes by a certain amount of defoliation.

In our opinion, the troubles enumerated aggravate, but do not bring about, the slow growth which is typical of this species when growing in South Wales and Monmouthshire on sites similar to those occurring in these forests, e.g. the trees shown in photograph 24. Even if one could discount entirely the dangers of injury by frost and the debility encouraged by needle browning, defoliation &c., and could select sites suitably removed from any strong source of atmospheric contamination, it does not seem that this species is worth growing when second and third quality Japanese larch can be grown instead. On the other hand, it seems to be probable that the existing plantations will grow to saleable size in the course of a sufficiently long time,

providing, of course, they escape the dangers already enumerated, especially that of frost.

The Douglas Firs

The two varieties of Douglas fir provide further examples of slow disappointing growth. None of our samples have any claim to be included in any of the quality classes given in Bulletin 10. This is true even of a good plot such as the first one in Cpt. 6, in Llantrisant Forest (see Appendix VIa). It is plain that with such slow growth any adverse factor is liable to affect small trees very seriously during the first years after planting. Thus, the poor growth, the extreme gappiness and, sometimes, the complete failure of plantations are, in part, to be accounted for simply by the lack of vigour in growth making it impossible for this tree to withstand adverse factors such as excessive weed growth, frost injury, infestation with chermes, or, should it occur to appreciable extent, poisoning by atmospheric contamination.

There are, thus, at least two major difficulties with regard to these trees. First, the habitat provided is one of relatively low fertility, so far as they are concerned; second, trees planted in open cleared areas in this habitat largely die out during the early years of growth. The slow growth might be accepted providing the difficulties of establishment were not too great. It would be merely a matter of considering whether the type of timber obtained was worth marketing. If it proved to be acceptable, the establishment of Douglas fir

would become one of the major problems in connection with its silvicultural treatment.

The comparative value of the Green and Fraser River types of this species provides a further problem for consideration. On the whole, we think that the Fraser River type is the better suited to these forests. It seems to be equally, and sometimes more fast growing, than the Green type, and to be decidedly the healthier tree. This, probably, is true apart from its immunity from infestation by chermes. On the other hand, it can be markedly susceptible to infection with Rhabdocline pseudotsugae, but so far this fungus does not seem to have appeared in either of the forests with which this report is concerned.

On the whole, it seems to be clear that neither of the Douglas firs is worth planting in such forests as these on any wide scale, but it might prove to be of value in restricted localities where the micro-climate is good and where some of the better soils occur, providing its regular establishment proves possible. The latter seems to be an especially important point, for it is not improbable that the extreme thinness of the Douglas fir, and often its almost complete absence, is, in part, due to lack of proper silvicultural preparation and care.

General

The above survey seems to indicate clearly that on hillsides such as comprise most of Llanover and Llantrisant Forests, any timber raised will, at the best, be of but moderate quality as judged by height growth, and that

certain species, viz. the two pines and Japanese larch, show a better adaptation to the habitat than do others and thus are more likely to produce satisfactory plantations. It is, of course, unsatisfactory that this judgement has to be based mainly on the growth in young plantations and that, as the Quality Class curves in Bulletin 10 are not directly related to habitat types, it is impossible to prophecy from them what the future development of a stand will be. There is, however, no local evidence to indicate that there is any real hope of any great future betterment in quality class, though, doubtless, some may be expected as better surface soil conditions develop and a more truly forest habitat is produced. Thus, the twenty-three year planted European larch in Craig-y-Glyn (Appendix VId) is below Quality Class V.

Under these circumstances, there would seem to be much less risk of future disappointment in the quality of the crop, and of loss from disease of whatever origin, if species were planted which have shown themselves to grow the more strongly or which may be found to be capable of similarly so growing. Such a policy would eliminate the spruces, the Douglas firs and European larch, except where known favourable conditions exist for their growth, and, in our opinion, this is certainly a policy which is well worthy of serious consideration and discussion. Certain factors must be taken into account, of course, which cannot be discussed here, such as e.g. the

relative market value of the various quality classes of different species.

Other possible species

The above policy would eliminate the species at present giving trouble, but it would also eliminate the majority of the conifers of economic importance in Britain, and it may be asked with what, if anything, they may be replaced in order to extend the range of choice for planting. There is a number of possibilities, both among broadleaved trees and among conifers. Oak is the main native tree in these localities; it would be good biologically but would be probably of no great economic value. Beech, birch and sycamore will grow successfully and are worthy of consideration. Another tree which, in some places at Llanover Forest, has been able to keep up in rate of growth with Japanese larch is the Turkey oak, Quercus cerris, but the low value of its timber would make it useless as a main crop. The London plane (Platanus acerifolia) and the Tree of Heaven (Ailanthus glandulosa) are being tried experimentally. Sweet chestnut can also be grown on the less frosty slopes.

A similar list might be made from the conifers. For example, Picea Omorika is to be recommended because of its comparative hardiness to frost. Chamaecyparis Lawsoniana and Thuja plicata also seem to be possibilities, and are reported from other parts of the coalfield as being resistant to fumes. Even a tree such as Libocedrus decurrens might be considered since it grows well in this country and produces a useful timber.

It has to be remembered, when considering this problem, that two things are expected of any species chosen. First, its timber should have a sufficient market value; second, the species must fit sufficiently well, ecologically, into the localities in question. We are especially concerned with the latter point, and any species which will not grow sufficiently well must, from our point of view, be rejected. Thus it seems to be certain that, apart from anything else, the silver firs would be very risky trees to plant in most places in these forests, owing to the danger of frost injury. It is plain, therefore, that any species new to this type of locality must be tested on a small scale before it is widely planted; also, until the new species has been proved, the species already known to be reliable must be used if the troubles hitherto experienced are to be avoided.

Suggested policy

Here we may suggest a policy which, in our opinion, offers most chance of avoiding loss by disease and the lowering of returns by excessively slow growth. Primarily, no new species should be planted widely on this type of site until it has been proved. The main planting, in the first instance, should be confined to Scots or Corsican pine, or Japanese larch, preferably mixed with a suitable broadleaved species. The larch should be used only on the better vegetation types, and preference should be given to pines on hot dry slopes. Beech and sycamore are suggested as being suitable species of

broadleaved tree. Birch, Sessile oak and Turkey oak also are suitable biologically. The establishment of such species would have to be considered carefully, in the light of past experience. In the vicinity of strong sources of fumes, as in parts of Craig-y-Darren, Llanover Forest, only broadleaved trees should be planted.

Of the species already tried, European larch should be avoided entirely. Sitka spruce might be planted with caution on the better vegetation types where there is indication of a moist soil and freedom from severe early and late frosts. Norway spruce also might be planted on such sites. The peat soils on the hill tops are outside the reference of this report. The Douglas firs might be introduced in the more fertile places, but they seem to have no advantage over Japanese larch. If they are used, a method of establishment must be adopted which will ensure the development of sufficiently regular plantations. Probably it would be advisable to use a suitable strain of Intermediate Douglas fir rather than the Green coastal form, but the danger of defoliation by Rhabdocline pseudotsugae has to be considered in this connection.

It may be pointed out that in relying on species known to be successful, and by confining them to sites to which it is reasonably certain that they are suited, there is the maximum possibility of escaping loss from disease due to any cause, including poisoning by atmospheric contamination.

Certain experimental work seems to be necessary in connection with this policy. Regarding the species on trial, investigations might be made into methods of establishment, both on new, i.e. cleared, ground, and in conjunction with a standing crop becoming ready for final exploitation. Further research into methods of establishing Douglas fir is also indicated if any type of this tree is to be used. Other experimental work might be directed towards the improvement of some of the present slow growing crops. This, probably, would prove to be difficult and very likely unremunerative work, but it would be of great interest to see if these localities have any potential fertility which could be developed by suitable cultural methods. Such experiments would have to be concerned, in the main, with the improvement of the surface soil conditions and the encouragement of root development.

Summary

1. This report is concerned with the condition of the crops in Llanover Forest in Monmouthshire and Llantrisant Forest in Glamorganshire. The plantations on the high plateau at Llanover are not dealt with.

2. It is demonstrated that the plantations at present fall mainly into low height quality classes.

3. Samples of the rate of growth of Scots and Corsican pine were not taken, but the general indications are that these species, together with Japanese larch, fall into higher quality classes and show better adaptation to the localities than do any of the others planted.

4. The species which thrive less well are European larch, Sitka and Norway spruce, and the two Douglas firs. Broadleaved species have been planted to an insignificant extent.

5. Similar relative growth of the species concerned can be observed elsewhere in similar habitats in the South Wales and Monmouthshire coalfield. Where older plantations exist there is no indication of any appreciable improvement in growth leading to a rise into higher quality classes.

6. In our opinion, the low height quality of the stands is to be explained mainly by characters inherent in the soil. This is, in general, of moderate or low fertility, and, on the hillsides

of which the forests mainly consist, is excessively drained and little retentive of water.

7. A comparison of growth on the less fertile soils derived from the Coal Measure Rocks (which include the Pennant Grits on which the above forests stand) and the much more fertile soils derived from Carboniferous Limestone and Old Red Sandstone can be made on the southern edge of the coalfield, the atmospheric conditions being similar throughout. This comparison provides confirmation of the opinion expressed above that the low height quality is related directly and mainly to soil fertility.

8. While the inherent character of the soil provides the fundamental cause of the slow growth of certain species, other factors also have been of importance in helping to bring about the present unsatisfactory condition. These may be summarized as follows:-

(a) Cheaply paid and inefficient planting during the early years: this is a factor the value of which it is difficult to assess, but general experience shows that it can be of considerable importance.

(b) Wrong methods of establishment: the indications are that the primary cause of the extreme gappiness of the Douglas fir plantations is to be found here.

(c) Neglect of weeding: this has resulted in large gaps developing in Scots pine and European larch plantations, and may have affected plantations of other species also.

Even after reading the text I am not clear what is implied here - unless it is the thoughtless effort to have the planting done cheaply on difficult terrain, mostly with inexperienced men; and the later neglect of regular inspections and bracken control. These applied to species other than Douglas fir.

(d) The development of a dense mat of grass or heath vegetation: this is considered to be markedly adverse to certain species, especially considering the inherent character of the soil. The pines and Japanese larch, which thrive best, are those which are best able to deal with this.

(e) Difficult conditions such as:-

i. Severe ground and valley frost.

ii. Exposure to strong winds in certain places only.

iii. Intense insolation of slopes with a southern aspect.

iv. The tendency of dry periods to occur during the growing season, and for the heaviest rainfall to occur during winter.

(f) Certain insect pests and fungal parasites: these have a deleterious influence on the plantations. The most important are, probably, the Larch Shoot Borer, the Green Spruce Aphis, the Douglas fir Chermes, and the Honey Fungus, Armillaria mellea, mainly on Sitka spruce.

(g) Atmospheric contamination with industrial and other fumes: an accurately measured account of the influence of this could be given after very careful expert investigation. Our conclusion is that it is not a major adverse factor anywhere except near to a strong source of fumes (e.g. on

parts of Craig-y-Darren near the Tin Plate works at Abercarn). The healthy growth of species known to be susceptible to atmospheric contamination, e.g. Norway spruce and Scots pine, is part of the evidence supporting this. Similar evidence is to be found in plantations of conifers in certain districts of Nottinghamshire and Derbyshire.

9. It is concluded that the present condition of certain plantations in Llanover and Llantrisant Forests has arisen from a number of causes as summarized above, but that the root of the whole trouble lay in the failure to assess with sufficient accuracy the types of habitat for forest growth which these areas provide. This resulted in a misconception of the species which were suited for growth in them and led, inevitably, to extravagant expectations and to the failure, or partial failure, of species which have been placed unsuitably or established with undue care or in an incorrect manner.

A little too censorious. Early planting in Lobau (mostly 1922-29) came before FC foresters had gained much experience of upland afforestation. I wonder what sort of comments R.L. Robinson and others made after the inspections mentioned by Day.

10. A policy is suggested which, we think, would greatly minimise the failures and difficulties of the past.

11. This report has been written, not only to give information regarding the above forests and to give explanations of certain difficulties which have arisen, but also to provide a basis for thought, discussion and criticism in regard to these matters. It is hoped that it will be so used by all concerned.

There does not appear to have been any constructive follow-up

APPENDIX I

Past history of former Llanover Estate

Name of Wood	Compt. No.	Previous crop
Cwm Carn		
Coed Llanerchi	51, 53b.	Oak standards; good on lower slopes (before 1886). Small areas of European larch cut in 1886 (length 55 feet, diameter 5-8-9 inches).
Cwm Gofappy		
Coed Gnwc	5	Strong oak, beech and birch coppice with oak standards of small size (fencing material). On upper site, 2½ acres of larch (pit wood size, length 35-40 feet, diameter 4-6 inches). All cut 1901.
Coed Dafydd	6a	Strong oak coppice with some beech and birch. Oak standards medium size, clean boles. At top of slope about 3 acres of good larch (length 50 feet, diameter 6-9-10 inches); cut about 1903.
Coed y Rhiw	8	Good strong oak, beech and birch coppice, some ash. Oak standards of good size and quality. At S.W. end on upper slope, 4 acres of larch felled about 1897; replanted with larch 1898; felled 1920. Good growth (length 50-55 feet, diameter 6-8 inches). The site was, at least in part, formerly agricultural land.
Graig Llwyfas	9a, 9b.	Oak coppice with some beech and birch. No standards. At N.E. end of 9a on top of slope, about 3 acres European larch, Norway spruce and Scots pine. Spruce good (length 60 feet, diameter 6-9+ inches). Formerly agricultural ground. Altitude 900-1000 feet.

Name of Wood	Compt. No.	Previous crop
Cwm Gwyddon		
Graig Wen	47	Strong oak and beech coppice with some birch. Oak standards of good size and quality cut about 1889; re-planted with European larch about 1903; felled 1930. Some useful pit wood but irregular growth.
Graig Pant-glas	26, 31.	Planted European larch 1887-88-89. Several plots of useful poles about the middle of the slope but crop generally poor, partly on account of high altitude and sheep damage, but soil shallow. Felled during the war for pit wood.
Gwyddon Fawr	32	Moderate European larch cut 1929 for pit wood.
Cwm Gwyddon-Fach		
Coed Buartha	29, 34, 35. Valley slopes	Formerly some of the best oak and beech coppice in the neighbourhood. In lower portion some of the beech poles were 55 feet in length, clean and of good size; sold as copper poles for copper smelting works. Some good oak standards of useful size for cleaving. Felled about 1889 and subsequently untreated.

The above woods received very little cleaning or thinning.

APPENDIX IIa

Llanover Forest

Table of Areas Acquired and Planted, 1921 - 1936.

F.Y.	Areas acquired acres	Planted acres	Burnt acres	Replanted after fire acres	Net plantations acres	Acquisitions
21	1614	93			93	
22		195		29	166	
23		178			178	
24		150		6	144	
25		200		6	194	
26		202		28	174	
27		180			180	
28	161	140			140	Pant-gwyn.
29	431	149	37	13	173	Ty'n-y-ffynnon 133.6 Coed Medart 297.4
30	62	131	29		160	Llanover Extension 20.0 Pen-y-pant 42.0
31	39	104			104	Craig y Darren
32		130			130	
33	108	71			71	Llanfrechfa.
34		82			82	
35		69	13		82	
36		84			84	

APPENDIX IIb

Llanover Forest

Table of Plants Used, 1921 - 1936.

Forest year	Conifers						Hardwoods			Total
	S.P. & C.P.	E.L.	J.L.	D.F.	N.S.	S.S.	Ash	Beech	Other	
	Thousands									
21	2		38	59		30		2		131
22	66		21	125		88		24		329
23	63		136	92	17	34	14	11		367
24	337		21	71	22	38		13		502
25	183	22		107	44	56		28	5	445
26	252	79		30		12		8	25	407
27	148	109		22	60	60		2	4	406
28	42	183		4	9	90			4	332
29	235	115			31	17				398
30	61	84	60		93	127				425
31	22	151	2		23	62				260
32	100	78	23		91	37			4	332
33	101	7			82	125		28	12	355
34	33		177		3	124		9	2	343
35	34		138		8	42		2	1	225
36	85		87		29	19		20	7	247

APPENDIX IIc

Llanover Forest

Table showing Expenditure on Weeding and Cleaning, 1921 - 1936.

Forest Year	Weeding £	Cleaning £
21	25	
22	106	
23	158	
24	430	
25	343	
26	486	
27	460	
28	497	
29	483	
30	299	
31	213	3
32	378	106
33	494	59
34	634 x	24 x
35	630 x	-
36	506 x	103 x

Note:- The above include overhead charges except in the case marked thus x.

APPENDIX III

RAINFALL RECORDS 1920 TO 1936 - CWMCARN, MONMOUTH.

Llanover Forest is approx. 2 miles N.E. and averages about 700 ft. above sea level.

Year	Total for year	Monthly falls											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1920	64.15	9.70	2.52	5.26	7.50	4.12	3.66	7.74	2.14	3.77	3.48	4.75	9.51
1921	37.69	5.97	+4.32	4.25	1.08	3.25	0.47	1.45	3.56	2.93	1.80	4.90	3.71
1922	49.16	6.02	6.04	5.15	4.00	1.35	1.06	5.04	3.68	3.15	2.56	2.52	8.59
1923	51.83	2.59	11.55	2.60	3.68	2.00	1.00	1.91	4.62	4.71	7.59	5.15	4.43
1924	67.58	5.99	0.77	2.43	4.88	7.81	3.21	5.42	6.26	9.64	7.78	4.18	9.21
1925	52.39	6.28	8.51	0.28	3.00	6.26	0	3.39	5.38	4.95	6.12	3.09	5.13
1926	45.30	9.56	3.28	0.93	2.77	3.18	2.48	2.67	4.39	0.91	4.86	9.98	0.29
1927	56.99	5.22	4.32	4.34	1.71	1.22	4.89	5.16	6.40	7.27	6.45	5.80	4.21
1928	59.52	9.66	6.14	6.30	1.31	0.64	3.53	2.71	2.43	0.74	10.41	8.70	6.95
1929	58.92	1.04	1.80	0.89	1.02	4.04	3.52	3.54	3.85	1.06	8.44	16.74	12.98
1930	62.13	11.17	0.63	3.59	3.66	2.26	1.86	5.68	7.06	5.18	6.89	7.29	6.86
1931	54.56	4.77	4.31	1.39	4.65	6.87	4.88	4.14	5.51	2.67	0.89	11.14	3.34
1932	58.25	9.48	+4.32	3.11	4.93	8.22	2.46	3.45	2.06	4.80	8.12	3.32	3.98
1933	34.95	3.02	+4.32	5.33	2.33	3.21	1.75	2.85	1.59	2.10	5.44	1.17	1.84
1934	51.03	5.64	0.55	4.78	3.57	1.76	1.42	1.32	3.70	4.82	5.36	2.07	16.04
1935	57.59	0.92	6.26	1.45	8.17	0.80	7.65	1.00	2.14	8.03	7.32	8.18	5.67
1936	58.37	8.38	3.85	4.66	4.54	1.35	3.28	10.38	1.06	3.53	2.28	5.50	9.56
Monthly averages		6.20	4.32	3.34	3.69	3.43	2.77	3.99	3.87	4.13	5.63	6.15	6.61

Average yearly rainfall for the seventeen years = 54.14 ins.

These records were taken in Cwmcarn about 2 miles from the centre of Llanover Forest. Up to 1927 the site of the rain-gauge was 428 ft. above sea level. From 1928 onwards the site was 310 ft. above sea level.

Note:- The three occasions when the February rainfall is marked + are average figures for that month as in these cases no records were available.

The figures which have been underlined represent the rainfall for months in which this was less than 2 inches.

APPENDIX IVa

Soil Profile Descriptions. Llanover Forest.

No. 1. Compartment 43. Cwm Gwyddon.

Parent Material: Pennant Grit. Sedentary or colluvial soil.

Altitude: 700 ft.

Slope: Steep to south.

Drainage: Free.

Crop: European larch.

Ground vegetation: Deschampsia flexuosa, bracken and bramble. Site of old oak wood.

Profile:

I. About 2 ins. of litter.

II. About 2 ins. of greyish-brown or dark brownish grey loam, loose structure, abundant roots.

III. About 6 ins. of buff-brown very strong gritty loam with roots fairly abundant.

IV. Unknown depth (probably 1-2 ft.) of stony brash with orange-brown light loam in interstices; occasional roots.

No. 2. Compartment 18. Cwm Gwyddon.

Parent Material: As in 1.

Altitude: 750 ft.

Slope: Steep to north.

Drainage: Free.

Crop: Originally Douglas fir, now Sitka spruce.

Ground vegetation: Deschampsia flexuosa and bracken.

Profile: As in 1 but IV replaced by 18 ins. ± of bright orange-brown loamy brash, somewhat compact, passing to shattered rock with orange-brown loam in interstices, of unknown depth.

Note:- Sample taken of Horizons II, III and IV in this profile.

No. 3. Compartment 19. Cwm Gwyddon.

Parent Material: As in 1.

Altitude: 1000 ft.

Slope: Steep.

Drainage: Free.

Crop: Norway spruce.

Ground vegetation: Deschampsia flexuosa, Vaccinium and Calluna.

Profile:

I. About 2 ins. of litter.

II. 1 or 2 ins. of dark humic brownish-grey silty loam, loose.

III. 6 ins. of buff-grey-brown stony gritty light loam.

IV. 24 ins. of stony and brashy light loam, orange-brown, moderately compact.

V. Greyish brash rather wet. Sampled.

Roots down to III. Few roots in IV and V.

No. 4. Compartment 14. Graigŵdu.

Parent Material: As in 1.

Altitude: 900+ ft.

Slope: Very steep to north.

Drainage: Free.

Crop: Japanese larch.

Ground vegetation: Deschampsia flexuosa, brambles, some Calluna and Vaccinium. Site of old beech, oak and birch wood.

Profile:

I. Thick litter (3 ins. or more).

II. Thin humic layer.

III. Brownish grey silty stony loam about 3 ins., with loose structure. Suggestion of A_2 development.

IV. Loose brash with orange-brown loam in interstices. Fibrous roots abundant in profile down to 2 ft. where there is a change to

V. More stony material with less bright orange colour and less roots.

No. 5. Compartment 13. Graigddu.

Parent Material: As in 1.

Altitude: 750+ ft.

Slope: As in 4.

Drainage: Free.

Crop: Douglas fir.

Ground vegetation: Deschampsia flexuosa, bracken.

Profile:

I. Thick mat.

II. About 2 ins. of humic dark brown loam.

III. About 6 ins. buff brown stony light loam.

IV. Orange-brown brash with light loam about 20 ins.

V. Brash with less bright colour and suggestion of C horizon. Depth unknown. Roots less abundant than in 4 but fairly abundant to 2 ft. 6 ins.

Note:- Profile 1 is on strike slope.
Profiles 2-5 are on dip slope.

No. 6. Compartment 49. Craig y Daren, Abercarn.

Parent Material: As in 1. Strike slope.

Altitude: 650 ft.

Slope: Very steep.

Drainage: Free.

Crop: European larch originally, now Japanese larch, Norway spruce, etc.

Ground vegetation: Bracken and Holcus. Old oak, birch, etc., coppice.

Profile:

I. Litter 2 ins.

II. Slight peaty layer.

III. Grey-brown very stony light loam becoming increasingly stony. About 2 ft. to 2½ ft.

IV. Brash and orange-brown loam.

Note:- Strike slope, abundant stones on surface.
Fume damage possible.

No. 7. Compartment 1. Gnwc.

Parent Material: As in 1.

Altitude: 500 ft.

Slope: Very steep to S.W.

Drainage: Free.

Crop: Douglas fir.

Ground vegetation: Some gorse and much bracken, little else.

Profile:

I. Bracken litter.

II. About 2 ins. of peaty silty loam.

III. About 20 ins. of grey brown stony light loam. Rhizomes to 18 ins., few roots below.

IV. Brashy orange-brown loam. Unknown depth.

No. 8. Compartment 73. Cwm Carn above colliery.

Parent Material: As in 1.

Slope: Gentle to steep at foot of steep slope.

Drainage: Free.

Crop: European larch.

Ground vegetation: Agrostis and bracken.

Profile:

I. About 1-2 ins. litter.

II. About 2 ins. of humic loam.

III. About 20 ins. of brashy orange-brown loam becoming increasingly stony.

IV. Brash of unknown depth.

Note:- Light was failing during inspection of profiles 7 and 8. Difficult to make description.

APPENDIX IVb

Soil Profile Descriptions - Llantrisant Forest

No. 1. Compartment 8.

Parent Material: Pennant Grit. Sedentary or colluvial.

Altitude: About 500 ft.

Slope: At the point of change-over from a moderate to steep slope.

Aspect: North-east (near ridge where aspect changes to north-west. Corsican pine on this ridge suffers from wind exposure.)

Drainage: Free

Crop history: Previously under grass, now planted with Green Douglas fir, many of which have failed or grown very slowly, but some, and quite a number near this pit, are growing quite well. Corsican pine and Norway spruce also grow well a few yards from here.

Ground vegetation: Dense Deschampsia flexuosa with some bracken, Calluna vulgaris and Vaccinium myrtillus; also a little bramble.

Profile:

1-3 ins. of decomposing litter (the lower part of this duff or mor).

2 ins. thick humic layer in which the sand grains showed marked leaching.

2-3 ins. of purplish-red-brown moderately compact sandy and rather gritty loam.

15 ins. or more of orange-brown sandy loam, at first with small angular fragments of grit, then gradually changing into brash with the interstices filled with the above loam. Moderately compact in the upper 6 ins., looser below.

Rooting: Fine roots down to 18 ins.; a definite root mat of the grasses at the surface.

No. 2. Compartment 10 (about 300 yards S.W. of No. 1.)

Parent Material: As in No. 1. Sedentary.

Altitude: About 500 ft. (a little higher than No. 1).

Slope: Moderate; the slope here changes from gentle to steep.

Aspect: North-west.

Drainage: Free

Crop history: Previously under grass. Present crop Green Douglas fir, much of which has failed and been beaten up with Corsican pine. There is a little birch and oak also. Much of the remaining Douglas fir is now beginning to grow more satisfactorily at this point, but the crop as a whole - the pines excepted - is very unsatisfactory.

Ground vegetation: Deschampsia flexuosa with some Vaccinium myrtillus, Calluna vulgaris, bracken, Polytrichum commune and occasional brambles.

Profile:

2-4 ins. of litter, mainly from grass, and changed into mor at the base.

2 ins. black humic layer, fairly compact.

9 ins. dark grey-brown sandy loam, moderately compact and finely gritty. This merges into:

15 ins. orange-brown gritty loam with angular fragments of stone; less compact than the above layer. It merges into:

Buff-brown sandy loam in the interstices of brash which continues down to and beyond 4 ft.

Rooting: A root mat in the top 6 ins.; fine roots down to 30 ins.

No. 3. Compartment 19. (About 400-500 yards from No. 2)

Parent Material: As in No. 1. Sedentary.

Altitude: About 750 ft.

Slope: Gentle to moderate.

Aspect: North-east.

Drainage: Free.

Crop history: This is a newly afforested area. The present crop is Norway spruce which are doing very badly on the whole, although a few trees are slowly improving in growth.

Ground vegetation: Nearly pure Calluna vulgaris with a very little bracken and Deschampsia flexuosa. Lichen is abundant on the soil.

Profile:

½ inch of dark, short textured, almost granular litter.

1½-2 ins. fibrous, black, peaty, humic layer with leached sand grains. A thin grey sandy layer occurred at the base of this layer but it had no very appreciable thickness.

2 ins. compact, dark purplish-red-brown fairly coarse grained sandy loam. This merged into:

Dark orange-brown sandy loam with angular fragments of grit. The depth of this layer was not ascertained. It was somewhat less compact than the layer above.

Note: It was observed that the growth of the spruce near this place increased in quality the more the ground vegetation became of a grass-bracken type.

No. 4. Compartment 18 (within a mile of colliery).

Parent Material: As in No. 1. Sedentary.

Altitude: 600-700 ft.

Slope: Moderately steep (at the point of change from moderate to steep).

Aspect: North-north-west.

Drainage: Free

Crop history: This is a newly afforested area. The present crop is Fraser River Douglas fir, of poor quality as regards growth, but on the average better than the green Douglas fir referred to above.

Ground vegetation: Calluna vulgaris with a very little moss and grass.

Profile:

½ inch dark, short textured, almost granular litter.

1 inch tough black peaty layer full of ling roots.

1 inch humic stained compact soil with marked leaching of the sand grains.

5 ins. very compact light grey gritty sandy loam. Occasional small patches of orange and peat stain occur in this layer and also angular fragments of stone. It merges into:

9 ins. deep orange-brown compact sandy loam, gritty, with angular fragments of stone; most compact and most darkly coloured at the top; only moderately compact in lower part. This layer merges into:

Darkish grey-buff light, coarsely gritty, sandy loam, very stony, and, after 4-5 ins., found only in the interstices of brash.

Note: There was a suggestion of a dark purplish-red-brown colour at the top of the orange-brown layer. Also this layer was decidedly less gritty than the one below.

Rooting: Few roots penetrate below 8 ins., i.e. below 4th layer.

No. 5. Compartment 24. (About ¾ mile from colliery).

Parent Material: As in No. 1. Probably colluvial.

Altitude: About 350 ft.

Slope: Gentle.

Aspect: North-east.

Drainage: Free

Crop history: Has been under cultivation. Present crop is Japanese larch which is doing very well for the locality. Planted 1922.

Ground vegetation: Practically a bare floor with weak and sparse male fern and ivy and an occasional bramble.

Profile:

1 inch of larch needle litter. The lower half inch of this consisted of duff in which were many larch roots.

Humic zone - a trace of this, with a suggestion of grey soil below it in places.

4 ins. moderately compact dark purplish-grey-brown sandy loam.

8 ins. buff-brown moderately compact sandy loam with red (haematite coloured) concretions about ¼ inch across and angular fragments of grit rock. This is a fairly fine and not very gritty loam.

6 ins. much less compact orange-brown sandy loam merging into:

Brash with the interstices filled with a darker coloured sandy loam for more than two feet.

Note: The pieces of rock in this soil were of Pennant Grit, judging by appearance. Judging by the crop, this is the most fertile soil examined at Llantrisant. There was no sign that the solid formation had appeared at the bottom of the pit.

No. 6. Compartment 25. (About 300 yards north-west of No. 5.)

Parent Material: As in No. 1. This does not appear to be a sedentary soil; on the other hand, the large number of big rocks and stones in it seem to make it doubtful whether it is of an ordinary colluvial type.

Altitude: 350 ft.

Slope: Gentle.

Aspect: North-east.

Drainage: Free

Crop history: Site of old woodland. After crossing a stream 50 yards south-east of this pit there is a decided change in soil fertility. This has not been followed out in detail but this pit shows a very different soil to that at No. 5. Present crop green Douglas fir, much of which has failed or done very badly; it is now filled in with oak and birch coppice.

Ground vegetation: Strong bracken with much Vaccinium myrtillus, Aira flexuosa, Molinia caerulea, some bramble and a little ivy.

Profile:

1 inch litter, mainly derived from broad-leaved trees, bracken and grass.

1 inch of tough peaty layer penetrated with Vaccinium roots.

3 ins. black humus stained fairly gritty sandy loam with leached sand grains. There is a trace of iron brown staining at the base of this.

5 ins. pinkish light grey-fawn gritty sandy loam, moderately compact. This merges into:

13 ins. very deep bright rich orange-brown sandy loam, comparatively fine and smooth in texture. The first 6 ins. consisted of loam with angular fragments of stone; the lower 7 ins. of brash with vividly dark bright orange-brown loam in the interstices. In this layer the colour was darker in the lower part than in the upper. Less compact.

Below: brash with dark brown gritty sandy loam in the interstices. This was a much more gritty soil than the layer above and continued to an unknown depth. Less compact than previous layer.

Note:- Size of stones - up to 10-12 ins. across. Large stones also occur on the surface here.

APPENDIX V

Analysis of Pennant Grit Soil from Llanover Forest

Soil Pits Nos. 2 and 3.

Analysis of Air-dry 2 mm. Sample

	2-4"	4-10"	10-30"	30"+
Coarse Sand	27.6	27.0	34.2	45.1
Fine Sand	34.0	38.7	34.1	37.5
Silt	15.2	13.0	12.5	10.5
Clay	15.5	19.0	16.2	8.0
Moisture	2.7	1.8	2.2	1.3
Calcium Carbonate	0.0	0.0	0.0	0.0
Loss by solution, etc.	5.0	0.5	0.8	-2.4
Loss on ignition	11.3	5.8	5.8	5.4
Org. Carbon	5.9	2.3	1.6	1.3
Nitrogen	-	-	-	-
pH	3.8	4.1	4.5	4.7
Exch. CaO	0.019	0.009	0.007	0.007
" MgO	0.029	0.017	0.022	0.019
Citric Sol. P_2O_5	-	-	-	-
" " K_2O	-	-	-	-
Stones in bulk sample	44.0	46.0	61.0	54.0
	Clay Fraction			
SiO_2/Al_2O_3	3.18	2.44	1.88	2.72
SiO_2/R_2O_3	2.36	1.85	1.48	2.11
Al_2O_3/Fe_2O_3	2.89	3.16	3.74	3.46

For Field Description see Appendix IVa.

Analysis of Soil from Llantrisant Forest

Soil Pit No. 4.

Analysis of Air-dry 2 mm. Sample

	2½"-7½"	7½"-16½"	16½"+
Coarse Sand	31.93	27.79	44.15
Fine Sand	39.59	34.60	39.12
Silt	16.25	17.25	10.25
Clay	10.00	16.25	7.50
Moisture	0.82	2.42	0.54
Loss by solution, etc.	0.56	1.96	0.56
Loss on ignition	5.10	6.60	2.92
Org. Carbon	2.56	1.716	0.428
pH	3.63	4.31	4.84
Exch. CaO	0.009	0.009	0.004
" MgO	0.0058	0.0072	0.0101
Stones in bulk sample	nil	4.28	28.47

Analysis of Soil from Llantrisant Forest

Soil Pit No. 5

Analysis of Air-dry 2 mm. Sample

	1-5"	5-13"	13-19"	19"+
Coarse Sand	21.64	23.27	32.73	34.10
Fine Sand	35.15	37.07	30.49	31.44
Silt	18.25	18.50	17.25	16.25
Clay	16.25	17.50	14.00	15.50
Moisture	2.32	1.56	2.80	0.96
Loss by solution, etc.	2.38	1.75	1.82	1.47
Loss on ignition	10.90	6.56	7.00	5.46
Org. Carbon	4.996	2.296	1.892	1.564
pH	4.16	4.97	5.69	5.68
Exch. CaO	0.020	0.080	0.121	0.077
" MgO	0.0115	0.0158	0.0114	0.0101
Stones in bulk sample	5.19	22.99	53.67	53.51

Analysis of Soil from Coed Craig Ruperra

Soil Pit No. 9

Analysis of Air-dry 2 mm. Sample

	1-3"	3-15"
Coarse Sand	19.86	23.42
Fine Sand	41.23	44.96
Silt	13.75	13.75
Clay	14.75	16.75
Moisture	2.56	1.38
Loss by Solution, etc.	2.03	1.26
Loss on ignition	12.70	4.28
Org. Carbon	6.76	1.288
pH	4.08	4.55
Exch. CaO	0.035	0.010
" MgO	0.0173	0.0173
Stones in bulk sample	44.6	14.62

Analysis of Soil from Coed Craig Ruperra

Soil Pit No. 11

Analysis of Air-dry 2 mm. Sample

	2-9"	2-9" Ignited	9-18"	9-18" Ignited
Coarse Sand	11.51	11.26	1.01	0.96
Fine Sand	33.94	33.48	14.10	13.64
Silt	20.00	19.95	36.00	34.50
Clay	28.50	24.50	46.75	42.25
Moisture	3.14	3.14	4.36	4.36
Loss by solution, etc.	1.26	1.26	1.12	1.12
Loss on ignition	8.28		5.84	
Org. Carbon	3.16		0.192	
pH	5.4		6.9	
Exch. CaO	0.168		0.142	
" MgO	0.0732		0.0835	
Stones in bulk sample	1.86		0.04	

APPENDIX Va

Discussion of Soil Analysis Data.

The fourteen analyses of soil samples shown in Appendix V (pages A.17a - A.17d) were received from Professor Robinson too late for discussion in the main body of this report. They represent four distinct profiles: two in Llantrisant Forest (Nos. 4 and 5) and two in Coed Craig Ruperra (Nos. 9 and 11). These two last ones are from the larch plantations referred to on page 77 of this report.

If the soils were to be arranged in order of fertility beginning with the least fertile, this probably would be as follows:-

1. Pit No. 4, Llantrisant.
2. (Pit No. 5, Llantrisant.
   (Pit No. 9, Ruperra.
3. Pit No. 11, Ruperra.

Of the four areas sampled, that around Pit No. 4 at Llantrisant is markedly the least fertile as judged by tree growth; the others are much more difficult to place and there may be little or no difference between Pit No. 5, Llantrisant, and Pit No. 9, Ruperra, which are placed together.

Professor Robinson has suggested that a clue to their relative fertility may be found in the respective base content of these soils. The data show that Pit No. 11, Ruperra, has markedly the highest and Pit No. 4, Llantrisant, markedly the lowest base status. A point of difficulty lies, as he points out, in the relatively low base status of the sample from the lower layer in Pit No. 9, Ruperra. This may be more than counteracted,

however, by the much higher base status of the top two inches or so of the soil, as represented by the sample.

The idea of fertility, as indicated by quality of tree growth, being correlated with base content of soil is not new but has been observed definitely elsewhere, as for example in Finland. It would seem that this is a clue which is worth following up in Monmouthshire and South Wales.

Both the localities represented by the aforementioned samples stand on the southern edge of the coalfield, but there is no colliery quite so near to Coed Craig Ruperra as the one near to Llantrisant. Moreover, at this latter forest, both the profiles sampled stand on the side of the hill facing the colliery. The analyses indicate, however, that, as suggested in the report above, there is a definite correlation between soil quality and growth quality. Thus Pit No. 5, Llantrisant, is nearer the colliery than Pit No. 4, nevertheless it occurs amid very much better growth and the analyses show that this is related to soil conditions.

It would be valuable to have this work followed up so that one might know more of the relationship between soil conditions and fertility, and of the value of ground vegetation as an indicator of this.

Appendix VIa

Assessment Summary

Llanover Forest. Douglas Fir.

DOUGLAS FIR. in early 1937 — LLANOVER FOREST. — ASSESSMENT SUMMARY. — APPENDIX VIa.

Why no figures for ALTITUDE

Type	Cpt. No.	P.Y.	Av. ht. ins.	Shoot (ins.) 1936	'35	'34	'33	'32	Deaths in original species %	Severe Chermes %	Badly wind blown %	One-sided branching due to wind %	Direction of wind damage	No leader %	Aspect	Slope	Exposure	Soil	General vegetation type	Remarks
Green	5	21	72.5 16yrs	5½	4½	7	6½	6	67	0	9	Not noted	S.W.	12	N.W.	Fairly steep	Not very exposed except to valley winds.	Av.	Aira-bramble. Scattered bracken.	Very poor lot. Many wind-blown trees replaced. Strong winds come up the valley.
Gr.	46	21	79.1 16	6½	6	6½	8	6½	37	11	-	-	-	11	S.E.	Mod. to fairly steep	Fairly exposed and near smoke.	Just above av.	Aira-bramble. Some bracken.	Wind-blown trees recently replaced. Compare growth in dingle P.23.
Gr.	1A	22	109.2 15	12	12	10	9½	9½	57	6	16	30	W.	-	S.W.	Very flat	Exposed	Above av. Soil pit near.	Bracken dom. Aira and some bramble.	Good growth of survivors, perhaps mainly due to flatness of site.
Gr.	1A	22	73.4 15	7½	7½	10	9½	8	55	0	30	68	S.W.	9	S.	Steep	Exposed	Av. to stony.	Aira-bracken. Scattered oak and beech.	Apparently lack of weeding in some dense bracken patches.
Gr.	3A	22	129.9 15	14	17	14	15	13	39	0	0	0	-	0	S.W.	Mod. to fairly steep.	Very exposed. (See remarks)	Av.	Bracken-Aira. Birch and oak coppice.	Very good growth in shelter of coppice. Compare with next plot.
Gr.	3A	22	80.4 15	7	7	6½	8½	6½	45	-	6	22	S.W.	12	S.W.	"	"	Av.	Bracken-Aira.	No coppice to afford shelter, otherwise similar site to previous plot.
Gr.	18	22	70.5 15	6½	5½	7½	7	7	29	8	11	27	W.	0	W.	Fairly steep	Rather exposed	Av.to rather poor.	Calluna dom. Some bracken.	Calluna often up to 3 ft. high. Majority of crop Green type (see next line for Fraser type).
Fraser	18	22	82.6 15	-	-	-	-	-	-	-	-	-	-	-	W.	"	"	"	"	Refers to scattered trees in Cpt. 18.
Gr.	13	23	82.4 14	8	7	8	9	10	45	24	8	15	W.	-	N.W.	"	Fairly exposed to W. and smoke.	Av.	Aira-bracken. Some bramble.	Crop mainly Green type in this compt. See next line for Fraser type which forms 8% of crop.
Fr.	13	23	116.9 14	-	-	-	-	-	-	-	-	-	-	-	N.W.	"	"	"	"	
Gr.	16	23	12 ft. 14	15	-	-	-	-	See remarks	-	-	-	-	-	-	-	-	-	-	Surviving trees very vigorous. See individual record for details of this plot.
Gr.	46	23	11 ft. 14	11	-	-	-	-	Representative sample of the trees in the dingle running across this compt.						See Compt. 46 above.					Shows influence of shelter. Soil, vegetation, etc., appear similar to rest of compartment.

DOUGLAS FIR. LLANOVER FOREST. ASSESSMENT SUMMARY. APPENDIX VIa (contd.)

Type	Cpt. No.	P.Y.	Av. ht. ins.	Shoot (ins.) 1936	'35	'34	'33	'32	Deaths in original species %	Severe Chermes %	Badly wind blown %	One-sided branching due to wind. %	Direction of wind damage	No leader %	Aspect	Slope	Exposure	Soil	General vegetation type	Remarks
Gr.	46	23	84.4	8½	7½	7½	9	8	55	6	0	20	W.	0	S.S.E.	Steep	Exposed to W.	Av.	Bracken-bramble.	Wind-blown trees replaced. Some deaths due to lack of weeding.
Gr.	20	24	70.1	12	9½	8½	7	7	) 34	3	0	0	-	0	S.S.W.	Fairly steep to mod.	High but fairly sheltered.	"	Bracken-Aira. Patches of Calluna.	Rather a good lot, especially the Fraser.
Fr.	20	24	83.6	13	9½	8½	5	5½	)	0										
Fr.	29	25	70.2	11	9	10	9	9	17	0	0	0	-	0	W.S.W.	Fairly steep	Mod. exposed.	"	Bracken-Aira-bramble. Scattered Calluna.	A good lot.
Fr.	35	25	63.8	9½	7	9½	10	8½	26	0	0	0	-	0	W.S.W.	"	Fairly exposed.	"	Bramble-bracken-Aira.	A good lot.
Fr.	42	25	77.5	9	7½	11	9½	10	32	0	0	0	-	0	S.E.	"	Fairly sheltered.	"	Bracken-bramble.	Several deaths due to lack of weeding.
Gr.	42	25	57.6	8	5	5½	7	7½	26	0	0	0	-	0	S.E.	"	"	"	Bramble-bracken.	Most of this compt. is Green type.
Fr.	46	25	84.2	11	9	11	9½	9½	23	0	0	10	W.	0	S.S.E.	Steep	Exposed to W.	"	Bracken-bramble.	

The order of nearness of the above compartments to Abercarn is:-
46, 13, 42, 16, 18, 35, 20, 29.
Compts. 1A, 3A and 5 are nearer Cwm Carn.

Appendix VIa

Assessment Summary

Llantrisant Forest. Douglas Fir.

DOUGLAS FIR. LLANTRISANT FOREST. ASSESSMENT SUMMARY. APPENDIX VIa (contd.)

Type	Cpt. No.	P.Y.	Av. ht. ins.	Shoot (ins.) 1936	'35	'34	'33	'32	Deaths in original species %	Severe Chermes %	Badly wind blown %	One-sided branching due to wind. %	Direction of wind damage	No leader %	Aspect	Slope	Exposure	Soil	General vegetation type	Remarks
Gr.	6	22	84.9	6½	5	3½	4½	5½	25	38	Have been removed	68	E.N.E.	6	E.	Steep	Very exposed	Av.	Calluna-bracken.	Plot at top of slope
Gr.	6	22	125.0	15	11	8	8	8	20	24	"	0	-	0	E.	"	Less exposed than previous plot.	"	Bracken-bramble.	¾ way down slope. No Calluna. Compare with previous plot.
Fr.	6	22	159.0	18	16	14	13	13	14	0	"	0	-	0	E.	"	Exposed to E.	"	"	An excellent plot but gappy.
Gr.	6	22	91.0	-	-	-	-	-	13	0	"	0	-	6	S.	Mod.	See remarks	Below av.	Calluna dom. Some Aira and bracken.	Sheltered to W. by Corsican pine compt.
Gr.	6	22	66.0	-	-	-	-	-	26	0	"	0	-	7	S.	"	"	"	"	Well away from shelter, otherwise similar to previous plot.
Fr.	9	22	54.0	9	8½	8½	8	7	22	0	"	39	W.	6	N.	"	Exposed	Av.	Aira, thin bracken, scattered Calluna.	Colliery lies to the N.W. of this plot but trees are one-sided to the W.
Gr.	10	22	117.8	14	18	16	15	12	10	52	"	10	N.W.	0	N.W.	"	Sheltered	"	Aira, scattered bracken and Calluna.	A sheltered site half-way down slope.
Fr.	10	22	90.0	15	11	12	9½	7½	9	0	"	4	N.W.	0	N.W.	"	Fairly sheltered	Below av.	Calluna dom. Some bracken and Aira.	Very good growth considering vegetation. Halfway down slope.
Gr.	10	22	48.8	6½	6	5	5½	5½	22	13	"	71	W.	15	N.W.	Mod. to fairly steep	Exposed	Av.	Aira-Calluna. Scattered Vacc. and bracken.	Plot near top of hill.
Fr.	10	22	56.3	8	7½	7½	7	5½	13	0	"	69	W.S.W.	8	W.N.W.	Mod.	"	"	Aira-bracken. Some Vacc.	Plot near top of hill and comparable with previous plot.
Fr.	10	22	46.5	6½	5½	5½	6	5½	34	0	"	81	N.W.	25	N.	"	Very exposed	"	Calluna dom. Bracken patches.	Colliery N.N.W. Trees one-sided to N.W.
Gr.	13	22	68.2	8	9½	8	7	8	38	28	"	94	S.W.	8	S.S.W.	"	"	"	Bracken-Aira-bramble. Some gorse.	There is no source of smoke for several miles in a S.W. direction.
Gr.	20	23	62.7	7½	6	5½	5½	6	31	21	"	40	N.W.	11	N.E.	Mod. to fairly steep	Exposed	Below av.	Calluna dom. Scattered bracken, Vacc. and Aira.	Plot near top of compt.

DOUGLAS FIR. LLANTRISANT FOREST. ASSESSMENT SUMMARY. APPENDIX VIa (contd.)

Type	Cpt. No.	P.Y.	Av. ht. ins.	Shoot (ins.) 1936	'35	'34	'33	'32	Deaths in original species %	Severe Chermes %	Badly wind blown %	One-sided branching due to wind %	Direction of wind damage	No leader %	Aspect	Slope	Exposure	Soil	General vegetation type	Remarks
Gr.	20	23	136.0	10	11	13	18	15	8	40	Have been removed	0	-	5	N.E.	Mod.	Sheltered	Av.	Aira-bracken. Scattered Calluna and Vacc.	Sheltered site half-way down slope.
Gr.	20	23	65.6	7½	7½	6½	6	6	27	7	"	0	-	7	E.N.E.	"	Not very exposed	Rather poor.	Calluna dom. A little bracken.	Plot near top of compt.
Gr.	20	23	135.0	9½	12	15	17	16	29	85	"	0	-	2	N.E.	Rather flat	Not very exposed.	Av. to stony	Tall gorse dom. Some bracken and bramble.	Many trees smothered by dense gorse. Surviving crop good except for severe Chermes.
Fr.	20	23	14'8"	18	-	-	-	-	Not taken	0	"	0	-	0	S.E.	Fairly steep	Very sheltered	Above av.	Bracken-bramble. Some gorse.	Low sheltered N.E. corner of compt. near stream. Growth excellent.
Gr.	21	23	126.0	15	17	15	15	13	27	22	"	20	W.	9	N.	Slight	Rather sheltered	"	Bracken-gorse-bramble.	Good growth. Plot near base of mountain.
Fr.	21	23	75.9	10	9	7½	7	6	9	0	"	50	W.	5	N.N.W.	Mod.	Exposed towards pit.	Below av.	Calluna dom. Some bracken.	Pit to N. Trees one-sided to W.
Gr.	22	23	15'2"	12	18	25	-	-	66	68	"	0	-	0	S.	Slight	Very sheltered. In valley bottom.	Much above av.	Bracken-Holcus-bramble. Some natural birch and hazel.	Chermes very severe and has cut growth. In past years severe frosting.
Fr.	18	25	53.9	7½	6½	5½	5	4½	16	0	"	0	-	2	N.	Mod.	Very exposed to N.	Poor leached top soil.	Dense Calluna.	Compare with bracken type in next plot.
Fr.	18	25	85.4	14	11	10	9	8	5	0	"	0	-	2	N.	Slight	Fairly sheltered	Av.	Bracken-Aira-bramble.	Excellent growth. More sheltered and better vegetation than previous plot.

Appendix VIb

Assessment Summary

Llanover Forest. European larch.

EUROPEAN LARCH. — LLANOVER FOREST — ASSESSMENT SUMMARY. — APPENDIX VIb.

Cpt. No.	P.Y.	Av. ht. ins.	Shoot (ins.) 1936	'35	'34	'33	'32	Deaths in original species %	Total attacked by shoot moth %	% of total attacked with no leader yet formed %	Flat topped type of tree %	Aspect	Slope	Exposure	Soil	General vegetation type	Remarks
11	25	73.3	5½	6½	6	7	7	19	48	68	2	N.W.	Fairly steep	An exposed site close to Abercarn.	Av. to rather stony.	Aira-bracken. A little Vacc.	Would get as much smoke as any compt.
11	25	84.5	9	11	14	12	11	43	33	70	0	N.N.W.	"	"	"	"	"
47	26	99.8	6½	7½	11	14	13	16	50	58	2	S.S.W.	Mod. to fairly steep.	Exposed and close to Abercarn.	Av.	Bracken-Aira. Some bramble and oak coppice.	
36	27	55.1	6	6½	6	6½	6	36	49	55	15	E.	Steep	Not very exposed.	Very stony.	Much Vacc., some bracken and Calluna and a few patches of dense bracken.	
36	27	90.6	8½	8½	11	11	10	19	47	36	4	E.S.E.	Fairly steep	"	Fairly stony.	Aira-bracken with only a little Vacc. and Calluna.	Vegetation the main difference between this and the previous plot in this compt.
41	27	79.5	9	8	7½	12	11	16	49	34	10	E.	Steep	"	Shallow and stony	A lot of Vacc. but some good patches of bramble-Aira.	
41	27	76.2	9½	9	9½	11	8	18	47	52	9	E.N.E.	Steep to very steep	"	"	Aira with much Vacc. and some Calluna and bracken.	
47	27	71.5	5½	5½	6½	8	9	42	40	56	6	S.E.	Mod.	Exposed and close to Abercarn	Av.	Bracken-Aira. Some oak coppice and birch.	
43	28	65.8	6½	6	8½	10	9	29	55	53	11	S.E.	Fairly steep.	Rather exposed.	"	Bracken-Aira. Scattered Vacc. and Calluna.	
43	28	70.4	7½	7½	10	11	8½	25	51	61	10	E.S.E.	"	A little more exposed than previous row.	"	Aira dom. Some bramble and bracken.	Some good trees sheltered by coppice.
45	28	68.8	5	6½	9	10	9½	20	43	57	16	S.E.	"	Exposed	"	Bracken-Aira. Scattered oak coppice, bramble and Vacc.	
22	29	63.0	4½	7½	11	10	7½	12	39	38	1	W.	"	Exposed but 3 miles from Abercarn.	"	Aira dom. Patches of Calluna dom. Some bracken.	
22	29	83.2	8	12	14	15	8	10	22	29	2	S.W.	"	Less exposed than above.	Rather above av.	Aira dom. Some bracken and bramble.	Exceptionally good growth in a small patch of dense bramble.

EUROPEAN LARCH. LLANOVER FOREST. ASSESSMENT SUMMARY. APPENDIX VIb (contd.)

Cpt. No.	P.Y.	Av. ht. ins.	Shoot (ins.) 1936	'35	'34	'33	'32	Deaths in original species %	Total attacked by shoot moth %	% of total attacked with no leader yet formed %	Flat topped type of tree %	Aspect	Slope	Exposure	Soil	General vegetation type	Remarks
32	31	48.3	7	8	7½	7½	-	63	5	66	0	E.	Mod.	Exposed site	Av. to rather stony.	Aira dom. Some bracken and Calluna.	Pine weevil partly responsible for heavy deaths. S.P. used for B.U. doing well.
32	31	45.4	9½	8½	8	8	-	48	9	66	0	E.S.E.	Mod.to fairly steep.	"	"	"	
Most of the above compts. are in Graig Wen and their order of nearness to Abercarn is: 11, 47, 45, 43, 41, 36, 32, 22.																	
52	28	92.7	10	11	10	9	9½	18	49	45	2	S.E.	Mod.	Fairly exposed to S.W.	Rather above av.	Bracken-Aira. bracken usually dom.	Deaths due to lack of weeding in heavy bracken.
53A	28	88.5	7½	9½	11	11	10	24	33	47	7	S.E.	"	"	Av.	Bracken dom. Some Aira.	"
54	28	70.6	7½	9½	9½	8½	7	19	37	50	2	N.E.	"	Not very exposed	"	Bracken-Aira. Some Vacc.	
54	28	81.1	7½	9	10	10	5	17	43	70	4	S.E.	"	Fairly exposed	A little above av.	Bracken dom. Some Aira. A little scattered Calluna.	
54	28	93.0	7	11	12	13	12	11	40	56	2	S.	"	Faces into side valley rather sheltered.	"	"	
55	29	71.9	7	13	13	11	8	16	57	69	0	S.	"	Exposed to S.E.	Rather below av.	Calluna-bracken-Aira.	Some bad patches where Calluna is heavy.
56	29	55.0	9	9	9	9½	8	21	40	55	2	S.E.	"	Exposed site to S.W. & N.E.	Poor and stony.	Calluna-Vacc.-bracken-Aira.	Calluna and Vacc. bad in several places.
53B	30	77.4	8	13	18	11	-	18	22	50	0	E.	Fairly steep	A fairly sheltered site.	Above av.	Bramble-Aira. Bracken almost absent.	Rather a good lot.
53B	30	63.7	12	14	11	9	-	14	9	0	0	S.E.	"	Fairly exposed	Rather rocky	Aira-bramble. Bracken almost absent.	Very few shoot moths.
73	31	43.4	9½	6½	8	6½	-	14	3	50	5	N.	"	An exposed site	Av.	Aira and thin bracken. A little scattered Vacc.	Scarcely any shoot moths.
73	31	54.5	9½	9½	10	8½	-	17	3	50	4	E.	Steep	Facing side valley fairly sheltered	"	Aira and thin bracken.	"

Appendix VIb (contd.)

Assessment Summary

Llanover & Llantrisant Forests. European Larch.

Appendix VIc

Assessment Summary

Llanover & Llantrisant Forests. Japanese Larch.

EUROPEAN LARCH. LLANOVER AND LLANTRISANT FORESTS. ASSESSMENT SUMMARY. APPENDIX VIb (contd.)

Cpt. No.	P.Y.	Av. ht. ins.	Shoot (ins.) 1936	'35	'34	'33	'32	Deaths in original species %	Total attacked by shoot moth %	% of total attacked with no leader yet formed %	Flat topped type of tree %	Aspect	Slope	Exposure	Soil	General vegetation type	Remarks
76	31	52.9	12	10	9½	7½	-	19	0	0	0	S.E.	Steep	An exposed site	Stony	Aira and thin bracken.	A strong lot. No shoot moths.
72	32	57.4	13	10	10	11	-	4	1	100	1	W.	Rather flat	Fairly sheltered	Less stony than av.	Aira and thin bracken.	The best plot of E.L. measured.
72	32	34.4	8	7½	8	6	-	32	1	0	6	N.W.	Fairly steep	Fairly exposed	Av. to rather stony.	Aira and thin bracken. A little scattered Calluna.	Plants said to be of different type and origin to the others in this cpt.

The above compts. are in the Cwmcarn area and their order of nearness to Cwmcarn Colliery (mainly electric) is:
73, 72, 76, 52, 53A, 54, 55, 56.

LLANTRISANT

9	29	67.8	9	9½	9½	9½	7½	27	11	20	11	N.N.E.	Very mod.	Fairly sheltered	Av.	Bracken-bramble-Aira. Some Holcus.	Compare with Llanover compts. of similar age.

JAPANESE LARCH. LLANOVER AND LLANTRISANT FORESTS. ASSESSMENT SUMMARY. APPENDIX VIc.

Cpt. No.	P.Y.	Av. ht. ins.	Shoot (ins.) 1936	'35	'34	'33	'32	Deaths in original species %	Total attacked by shoot moth %	% of total attacked with no leader yet formed %	Flat topped type of tree %	Aspect	Slope	Exposure	Soil	General vegetation type	Remarks
LLANOVER																	
63A	30	57.7	10	11	11	6½	-	10	15	33	3	N.W.	Mod.	High and exposed.	Av.	Aira-bracken.	A good lot though rather uneven.
LLANTRISANT																	
4	30	157.0	30	23	31	25	18	4	0	0	2	N.E.	Very mod.	Fairly exposed.	Of the good valley type.	Dense bramble-bracken.	Plot near valley bottom but nevertheless fairly exposed. Most excellent growth although exposed towards colliery and less than 1 mile distant.

Appendix VId

Assessment Summary

Llanover & Llantrisant Forests. Older Larch Plantations.

OLDER LARCH PLANTATIONS. LLANOVER AND LLANTRISANT FORESTS. ASSESSMENT SUMMARY. APPENDIX VId.

Species	Cpt. No.	P.Y.	Av. ht. Ft.ins.	¼-girth at 4'3" Ins.	Failures %	1936 shoots Ins.	Aspect	Slope	Exposure	Soil	General vegetation type	Remarks
LLANOVER												
E.L.	Graig-y-Glyn	14	24'4"	3	6	-	S.W.	Mod. to fairly steep	Sheltered	Decidedly above av.	Canopy nearly closed. Bracken-Aira in more open places.	An estate planted wood situated W. of Cpt. 55, P.29, Cwmcarn. Many J.L. on edge of wood.
J.L.	6A	21	18'3"	2.35	10	14	S.E.	Steep	Fairly sheltered	Av.	Grasses-bramble-bracken in more open places.	Plantation rather gappy.
J.L.	12	23	17'8"	2.27	-	-	N.W.	"	Very exposed	"	Bracken-bramble. Some Vacc.	Plot nearer Abercarn than next sample. Crop gappy. Much oak and birch coppice.
J.L.	12	23	18'11"	2.30	-	-	N.W.	"	"	"	"	Plot lies E. of previous sample and is further from Abercarn. Crop less gappy. Less oak and birch.
J.L.	15	23	20'4"	2.37	7	12	E.N.E.	Mod.	Exposed to N. & N.W.	"	Scanty. Canopy almost closed.	Plot faces into side valley. A good lot.
J.L.	15	23	17'9"	2.05	11	10	N.W.	Fairly steep	Exposed to W. & N.	"	Grasses, bramble and occasional bracken, Vacc. and Calluna.	Smaller trees than in previous plot. Canopy much more open. Plot faces into main valley.
J.L.	16	23	17'6"	2.15	10	12	N.E.	"	Exposed to N.W.	"	Bracken, grasses and ferns in more open places.	Faces into side valley. Some bent stems due to wind.
J.L.	16	23	19'3"	2.37	10	9	N.W.	"	Exposed to W.	"	Canopy nearly closed. Some bracken and ferns.	Faces into main valley. Appears to get less wind than previous plot.
The order of nearness of the above compartments to Abercarn is:- 12, 16, 15. Compts. 6A and Graig-y-Glyn are in Cwm Carn valley.												
LLANTRISANT												
E.L.	1	02	58'0"	7.02	-	-	E.	Slight	Fairly sheltered	Of the better valley type	Dense bramble and a little bracken and elder coppice.	Plot near valley bottom and estate planted.
E.L.	5	21	18'3"	2.14	18	-	N.E.	Mod.	Fairly exposed	Above av.	Bramble-bracken.	Plot near valley bottom. Canopy not yet closed.
J.L.	3	21	28'0"	3.16	28 (see remarks)	-	E.N.E.	Very mod.	Fairly sheltered	Above av. and fairly heavy.	Ivy, bramble and Oxalis. A little fern and moss.	Figure for deaths includes trees cut out in thinning. Plot low down in valley.
J.L.	21	23	23'1"	2.66	4	-	N.E.	Mod.	Fairly exposed	Above av.	Canopy mainly closed. Some bracken and bramble.	Plot higher up the slope than sample in Cpt. 24.
J.L.	24	23	29'9"	3.94	10	-	E.N.E.	Mod. to fairly flat.	Not very exposed	"	Canopy closed. Little vegetation.	Very good growth. Plot fairly low down in valley. This plot is by far the nearest to Coedely Colliery.

Appendix VIe

Assessment Summary

Llanover Forest. Sitka Spruce.

SITKA SPRUCE. LLANOVER FOREST. ASSESSMENT SUMMARY. APPENDIX VIe.

Cpt. No.	P.Y.	Av.ht. ins.	Shoot (ins.) 1936	'35	'34	'33	'32	Deaths in original species %	Severely frosted %	Leader frosted %	Aspect	Slope	Exposure	Soil	General vegetation type	Remarks
46	21	180.0	12	16	17	17	20	19	69	69	-	Flat	Sheltered	Much above av.	Bracken-bramble and grasses.	Plot in valley bottom near stream.
18	23	164.0	15	14	16	10	11	6	17	9	N.	Steep	Fairly sheltered	Av.	Bracken dom. Some Calluna and Vacc.	Plot in a side valley.
21	23	107.6	9½	11	14	13	16	2	56	27	W.	Fairly steep	Mod.	"	Bracken dom.	More exposed than next plot. Very severe frosting near valley bottom.
21	23	74.1	7	5½	7½	6	6	7	26	7	N.	Steep	Fairly sheltered	"	Calluna and bracken alternately dom.	Compare with previous plot. Poor growth in Calluna.
29	24	115.4	8	8½	12	12	14	11	61	43	W.	Fairly steep	Sheltered	Above av.	Bracken-bramble.	Sheltered site in valley bottom.
31	25	111.9	8	8½	9½	8½	9½	5	70	35	E.	Steep	"	Slightly above av.	Bracken dom. Some Aira, Calluna and Vacc.	Sheltered site in valley bottom. Very severe frosting. A good deal of aphide damage.
35	25	109.8	6½	7	10	11	11	0	63	29	W.	Mod. to steep	"	Above av.	Dense bracken-bramble.	"
31	26	79.6	6	6	7½	7½	8½	10	28	7	E.	Fairly steep to steep	"	Mainly above av.	Bracken with patches of dom. Calluna and Vacc.	Poor growth in Vacc. and Calluna, good in bracken. Less frosting than in previous three sites.
41	27	68.7	4½	6	7	7	7½	0	59	27	E.	Mod. to steep	"	Above av.	Even bramble-bracken. Some Aira.	Sheltered site in valley bottom. Severe frosting.

The order of nearness of the above compartments to Abercarn is:-
46, 41, 18, 35, 21, 29, 31.

Appendix VIf

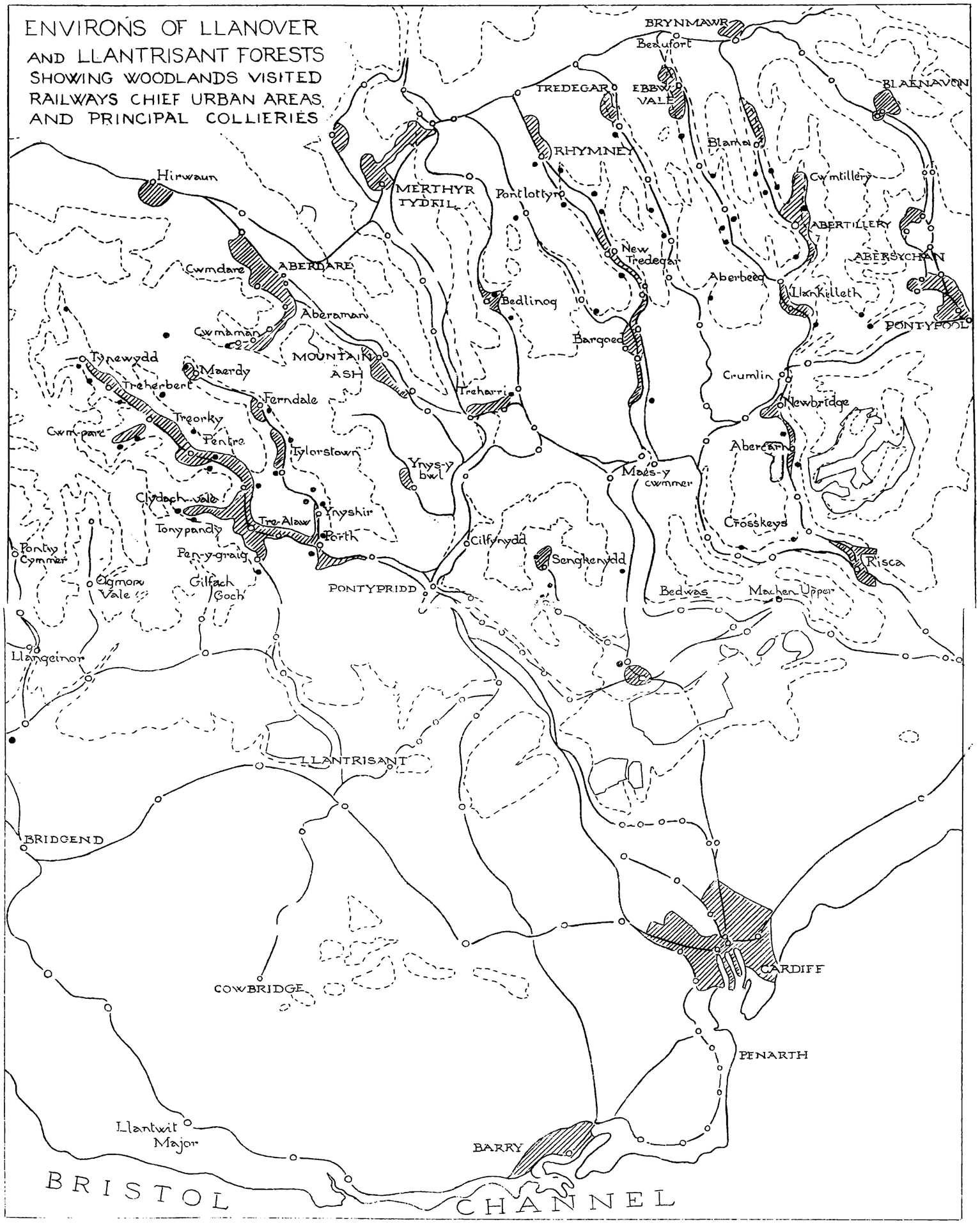
Assessment Summary

Llanover & Llantrisant Forests. Norway Spruce.

NORWAY SPRUCE. LLANOVER AND LLANTRISANT FORESTS. ASSESSMENT SUMMARY. APPENDIX VII.

Cpt. No.	P.Y.	Av. ht. Ins.	Shoot (ins.) 1936	'35	'34	'33	'32	Deaths in original species %	Aspect	Slope	Exposure	Soil	General vegetation type	Remarks
LLANOVER														
19	22	39.3	4	3½	4½	5	4	11	N.W.	Convex and mod.	High and exposed.	Poor and stony	Tall Calluna dom.	This sample represents growth on the worst dense Calluna type. Trees are decidedly better in the same compt. where bracken comes in.
10	22	68.8	7½	6	9	7½	5½	6	N.W.	Fairly steep	"	Rather below av.	Calluna-bracken-Aira.	A little uneven but crop now generally improving with good leads. A decidedly better vegetation type than previous plot.
20	23	66.6	8	-	-	-	-	7	N.N.W.	Mod.	Very exposed (see remarks)	Below av.	Calluna dom. Some patches of Vacc. and Aira.	This plot directly overlooks Abercarn and lies between the 900 and 1000 ft. contours. It is most exposed both to smoke and high winds yet the trees are coming out of check and, except in specially dense Calluna, are doing well.
9A	24	50.4	10	-	-	-	-	See remarks	N.W.	Mod. to rather flat.	Very exposed	Rather above av.	Aira-bracken-Holcus.	A high and exposed plot (1000 ft. level) close to Abercarn. Heavy deaths recorded the year after planting. The crop is at present about 40% S.P. The remaining spruce are healthy and growing strongly.
LLANTRISANT														
13	22	105.8	12	8	11	11	8½	2	S.	Mod.	Exposed	Av. for Llantrisant	Bracken-bramble.	A really excellent plot. Vigorous shoots and healthy needles. Higher up in the same compt. Calluna comes in and growth is much less.

ENVIRONS OF LLANOVER AND LLANTRISANT FORESTS SHOWING WOODLANDS VISITED RAILWAYS CHIEF URBAN AREAS AND PRINCIPAL COLLIERIES



REFERENCE

- Woodlands visited
- Chief urban areas
- Railways
- Principal collieries
- 1500 ft. and over
- 1000 to 1500 ft.
- 400 to 1000 ft.
- 0 to 400 ft.

1. Llanover Forest
2. Llantrisant Forest
3. The Warren
4. Fforest Fawr
5. Fforest Ganol
6. Coed Craig Ruperra
7. Rudry Wood
8. Coed Coesau-whips
9. Gelli-ddu-fach
10. Neuadd y Wenallt
11. Coedcae Aberaman