

THE BRECHFA FOREST PLOTS: RESULTS AFTER 40 YEARS

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SUMMARY

The article describes the site, history and establishment of these 40-year-old forest plots in south Wales, where more than 90 tree species have been planted. The current status and health of all species is described and mensuration data are given for 22 species. Growth rates are generally high, with a number of species (*Abies grandis*, *A. procera*, *Sequoia sempervirens*, *Thuja plicata* and *Tsuga heterophylla*) having estimated general yield classes of more than 20. These plots provide the first published British growth data for *A. homolepis*, *A. veitchii*, *Picea koyamai*, *P. mariana* and *Quercus canariensis*. The future of the plots is discussed and access arrangements are described.

Introduction

The Brechfa Forest Garden is a collection of more than 90 species plots which was set up in the 1950s in Brechfa Forest, now part of the Llandoverly Forest District of Forest Enterprise. The plots were established by the local staff of the time on their own initiative. The original objective appears to have been to establish an interesting collection of species which were likely to grow in this part of south-west Wales, using plants which were available at the time in Forestry Commission nurseries. Although early data are scarce, an invaluable list of seed origins and establishment treatments has survived.

Staff of the Forestry Commission Research Division became aware of the plots in 1980 and took over their management in 1982, following a review of the surviving plots. Initial work consisted of clearing the rather neglected plots, opening up access paths and brashing the trees. Since 1982, plots have been assessed by research staff as funds permit, while local Forest Enterprise staff develop an integrated recreational proposal for the area. A number of 'sample plots' have been established by the mensuration branch to give more detailed information on the yield of less-common species. Participants at the RFS Whole Society Meeting in May 1993 had a brief view of part of the garden (Anon, 1993). The purpose of this paper is to make the existence of these plots more widely known and to describe some of the more interesting results obtained to date.

The Site

Before planting, the whole area was open hillside grazed by sheep. The site is about 14 miles west of Llandoverly, Carmarthenshire, and the plots are arranged on either side of a ridge dividing two tributaries of the Afon Gothi, with both northerly and southerly aspects (see photo). The national grid reference is SN 572 368 on OS sheet 146. The plots are located at elevations of between 200 and 250 m above sea level. The climate is very favourable to tree growth, with a mean annual rainfall of

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Table 1. List of species planted in the Brechfa Forest plots.

species	provenance	stocking	health	comments
<i>Abies amabilis</i>	Washington	full	good	rectangular plot
<i>balsamea</i>	unknown	low	poor	landslide in plot
<i>cephalonica</i>	Inverary, Argyll	good	average	not impressive
<i>concolor</i>	Colorado	failed	most died in 1980s	—
<i>concolor</i> var <i>lowiana</i>	Montana (not natural range)	fair	failing	poor crowns
<i>delavayi</i>	Benmore, Argyll	low	good	slow, attractive
<i>fraseri</i>	Crarae, Argyll	low	good	very slow
<i>grandis</i>	Kittitas County, Washington	full	excellent	some stem cracking
<i>homolepis</i>	Nagano, Japan	good	fair	—
<i>koreana</i>	unknown	low	fair	slow, attractive flowers
<i>lasiocarpa</i>	Oakridge, Oregon	fair	good, past damage	attractive colour
<i>nordmanniana</i>	south-west Germany	fair	average	—
<i>procera</i>	Washington	full	good	some stem cracking
<i>veitchii</i>	Japan	full	average	—
<i>Acer pennsylvanicum</i>	unknown	low	past stem damage	seeding into forest
<i>platanooides</i>	Northumberland	fair	good	rather thin
<i>pseudoplatanus</i>	Slebech, Pembrokeshire	fair	fair	poorer than <i>A. platanooides</i>
<i>saccharinum</i>	Tennessee	fair	average	poor form
<i>Aesculus hippocastanum</i>	unknown	low	average	poor for age
<i>Alnus glutinosa</i> [1]	unknown	very low	poor, failing	south-facing slope, too dry
<i>rubra</i>	unknown	very low	failed	attacked by <i>Chionaspis salicis</i>
<i>Betula lenta</i>	Pennsylvania	fair	healthy	poor form
<i>maximowicziana</i>	Nagano, Japan	average	fair	snow damaged
<i>pendula</i>	unknown	average	fair	rough form, snow damage
<i>Castanea sativa</i>	France	fair	good after early frosting	growth and form improved
<i>Cedrus deodara</i>	northern Italy	fair	annual dieback	weak crowns
<i>libani</i>	Italy	failed	failing by 1968	last tree died 1990
<i>Chamecyparis lawsoniana</i>	Monmouth	full	snow damaged	multi-forked, tall
<i>Cryptomeria japonica</i>	Japan	full	good	basal sweep; from seed
<i>Cupressocyparis leylandii</i> [1]	clone 11?	full	good	good form in plots

Table 1. List of species planted in the Brechfa Forest plots. (cont)

species	provenance	stocking	health	comments
<i>Cupressus macrocarpa</i> [1]	unknown	low	unhealthy, from frost?	multi-leadered
<i>Davidia villmoriniana</i>	unknown	failed	–	–
<i>Eucalyptus debeuzvillei</i> [1]	Australia	low	good, but leaning from snow	–
<i>Fagus sylvatica</i>	unknown	full	good	poor form, forking
<i>Fraxinus excelsior</i>	unknown	very low	failing	site in a frost hollow
<i>Ginkgo biloba</i>	unknown	failed	–	–
<i>Juglans regia</i>	France	failed	–	frost had killed all trees by 1983
<i>Larix decidua</i>	Poland	low	fair	–
<i>sibirica</i>	USSR	failed	–	all dead by 1968
<i>occidentalis</i> [1]	unknown	failed	–	all dead by 1980
<i>kaempferi</i>	unknown	full	good	big, shelter belt
<i>Liriodendron tulipifera</i>	West Virginia	low	poor	–
<i>Nothofagus obliqua</i>	Chile (Malleco Forest Reserve?)	low	good	big trees, incomplete plot due to landslide
<i>Picea abies</i>	Austrian Tyrol	average	good	some trees stolen when young
<i>asperata</i>	Bedgebury, Kent	low	good	slow, incomplete plot
<i>glauca</i>	unknown	good	fair	half plot lost to road
<i>koyamai</i>	Japan	good	good	like Norway spruce
<i>mariana</i>	Ontario, Canada	good	good	thin, recent windthrow
<i>omorika</i>	unknown	good	good	recent windthrow
<i>orientalis</i>	Shin, Sutherland	good	good	small plot
<i>rubens</i>	New York State	good	good	small plot
<i>sitchensis</i> [1]	Washington	fair	good	suffered from bracken competition
<i>smithiana</i>	Uttar Pradesh, India	failed	–	dead by 1968
<i>Pinus attenuata</i>	unknown	failed	–	dead by 1963
<i>banksiana</i>	New York (not natural range)	good	average	poor form, thin
<i>contorta</i>	Lower Frazer Valley, British Columbia	fair	poor with <i>Ramichloridium pini</i> damage	not vigorous

Table 1. List of species planted in the Brechfa Forest plots. (cont)

species	provenance	stocking	health	comments
<i>contorta</i>	Long Beach, Washington	fair	healthy foliage	severe windthrow
<i>densiflora</i>	Nagano, Japan	failed in winter of 1979/80	--	
<i>jeffreyi</i>	Chester, California	poor	poor	thin crowns
<i>mugo</i>	Wareham, Dorset	average	poor	terrible form
<i>mugo</i> var <i>pumilo</i>	France	average	poor	terrible form
<i>uncinata</i>	Austrian Tyrol	poor	poor	terrible form
<i>muricata</i>	California	average	variable	some rough trees
<i>nigra</i> var <i>austriaca</i>	lower Austria	poor	poor	plot on too wet a site
<i>nigra caramanica</i>	unknown	poor	poor	plot on too wet a site
<i>peuce</i>	Macedonia	good	good	impressive
<i>ponderosa</i>	Susanville, California	fair	variable	some better trees
<i>pungens</i>	unknown	very low	poor	--
<i>radiata</i>	Austria (not natural range)	failed	--	small, exposed plot
<i>resinosa</i>	unknown	very low	very poor	few left
<i>strobos</i>	Adirondack Mountains, USA	good	no recent <i>Cronatium</i>	fine plot
<i>thunbergii</i>	Nagano, Japan	low	fair	small, but growing
<i>Populus 'robusta'</i>	--	low	poor	the four poplar areas were
<i>'serotina'</i>	--	low	poor	neglected, all were
<i>'Balsam spire'</i>	--	low	poor	planted on poor sites
<i>trichocarpa</i>	--	low	poor	
<i>Pseudotsuga menziesii</i>	Washington	average	good	tall but not best origin
<i>Quercus canariensis</i> (= <i>mirbeckii</i>)	Forest of Dean	good	good	fair growth and form
<i>cerris</i>	unknown	good	good	fair growth
<i>lusitanica</i>	Kew Gardens	fair	fair	--
<i>petraea</i>	Brechfa, Carmarthenshire	good	good	small plot, local origin
<i>robur</i>	Cilgwyn, Carmarthen	good	good	only fair growth
<i>rubra</i>	Breda, Holland	good	good	good growth
<i>Robinia pseudoacacia</i>	unknown	poor	fair	almost scrub
<i>Sequoia sempervirens</i>	California	good	good	excellent and impressive

Table 1. List of species planted in the Brechfa Forest plots. (cont)

species	provenance	stocking	health	comments
<i>Sequoiadendron giganteum</i>	California	good	fair	tall but thin crowns
<i>Stranvaesia davidiana</i>	Hexham, Northumberland	dense thicket	good	regenerating in forest
<i>Thuja plicata</i>	Ladysmith, BC	good	good	excellent and impressive
<i>Tilia cordata</i>	lower Austria	poor	fair	still just bushes
<i>platyphyllos</i>	lower Austria	poor	fair	still just bushes
<i>Tsuga heterophylla mertensiana</i>	Queen Charlotte Islands, BC	high	good	tall, thin, severe fluting
<i>Ulmus glabra</i>	unknown	low	poor	mostly bushes
	unknown	low	fair, not diseased	poor growth, shrub like

[1] *Alnus glutinosa* was planted in 1968; *Cupressocyparis leylandii* in 1965; *Cupressus macrocarpa* in 1968; *Eucalyptus debeauxvillei* in 1986; *Larix occidentalis* in 1968; and *Picea sitchensis* in 1981. All other plots were planted in the period 1955-60.



General view of the conifers in the Brechfa Forest Garden.

1,700 mm and accumulated day degrees (>5.6 deg C) of 1,375-1,650. The plots lie within the 'warm-moist' climatic zone defined by the Ecological Site Classification (Pyatt, 1995). The only climatic problem, in this otherwise mild area, is a frost pocket in the flatter areas. The soil is generally a deep forest brown earth derived from glaciated Silurian rocks and has a low pH - 4.5-5.0. Some gleying occurs below flushes on the north face and in the flatter areas near the Afon Gorlech. Vegetation in open spaces is now dominated by dense bracken and brambles. In the flat gleyed area, purple moor grass (*Molinia caerulea*) is dominant.

Most plots were planted between 1955 and 1960, although a few are of later date. The layout and size of each plot varied depending on the number of plants which were available and the lie of the land. Most plots are 0.05-0.15 ha, allowing the establishment of volume assessment plots. At first, some grouping of genera was attempted but, as subsequent lots became available, this was not followed. Growth or survival sometimes reflects where the species was sited. A complete list of species planted to date is given in Table 1. Establishment was by semi pit planting, although there is some evidence of turf planting in places. Initial spacing was either 1.5 m x 1.5 m or 1.8 m x 1.8 m (ie 5 ft x 5 ft or 6 ft x 6 ft). Despite appearing a rich site now, each tree was given 57 g (2 oz) of superphosphate. This assumed need must have reflected the impoverished vegetation at the time of planting after years of heavy grazing. First thinnings were started in 1983, which was rather late for some species, such as western hemlock, but was on time for others. The most recent selective thinning was extracted by horse to minimise ground and stem damage.

Results and Discussions

Ninety-three plots of different species or clones have been established in this forest garden since 1955. Two-thirds of the plots were of conifers, which reflects the traditional emphasis upon such species for forestry in Britain during this century. Forty-two species are still in good health, although growth may not be vigorous. Some 22 species have failed completely (Table 1). The remainder are of uncertain health but may improve with time.

A relative weakness of the collection is that a number of species are represented by material either of unknown provenance or which was derived from seed collections in small plots elsewhere in Britain. The latter may have been subject to cross-pollination by other species, for example the plot of *Abies cephalonica* has some trees which appear morphologically close to *Abies alba*. In such cases, the species performance should be considered as indicative rather than conclusive. In some cases, the provenance records are inadequate even where the identity numbers conform to those cited in official records (Anon, 1965). Thus the *Pinus radiata* quoted from Austria, the *Pinus banksiana* from New York and the *Abies concolor* var *lowiana* from Montana reflect the business location of the seed merchant from whom the seed was purchased, rather than the natural distribution of the species.

Nevertheless, after 40 years' growth some general trends are apparent, although these are based upon single plots located in varying parts of the garden. Conifer species which are adapted to wet moist climatic conditions (such as various *Abies* species, some *Picea* species and western hemlock) have generally grown well, whereas those which are more characteristic of drier climates (such as most pine species and cedars) have either failed completely or are in poor health.

The generally poor performance of the pine species agrees with other reports from Wales (such as Danby, 1993), although the healthy plots of *P. peuce* and *P. strobus* show that there may be some pine species which may be worth considering

Table 2. Cumulative basal-area production, top height and estimated yield class of selected plots at Brechfa Forest Garden.

a. Sample plots.

species	age	top height, m	mean dbh, cm	cumulative production		general yield class	local yield class
				basal area, sq m/ha	volume, cu m/ha		
<i>Abies homolepis</i>	34	16.9	20.9	45.2	331	14	12
<i>nordmanniana</i>	35	19.3	18.5	53.3	362	16	13
<i>veitchii</i>	35	16.6	19.3	42.2	283	12	10
<i>Picea mariana</i>	33	13.5	12.2	37.5	163	10	9
<i>omorika</i>	34	15.0	18.9	53.8	324	16	14
<i>Pinus peuce</i>	33	16.5	22.5	71.1	447	14	15
<i>strobus</i>	34	17.1	19.3	67.4	413	16	16
<i>Quercus canariensis</i>	34	12.5	12.0	28.1	96	6	5
<i>Sequoia sempervirens</i>	34	21.2	38.6	112.5	863	30	28
<i>Sequoiadendron giganteum</i>	33	17.3	30.2	108.7	630	18	22
<i>Thuja plicata</i>	33	18.9	23.6	96.9	708	22	24
<i>Tsuga heterophylla</i>	35	27.9	23.9	81.3	835	24	26

b. Other plots.

species	age	cumulative basal -area production, sq m/ha [1]	top height, m [1]	general yield class
<i>Abies amabilis</i>	37	58.7	21.4	22
<i>grandis</i>	39	80.6	28.4	24
<i>procera</i>	39	83.4	29.9	28
<i>Chamaecyparis lawsoniana</i>	39	69.4	21.7	20
<i>Cryptomeria japonica</i>	37	73.5	20.8	20
<i>Cupressocyparis leylandii</i>	31	62.9	16.0	16
<i>Picea abies</i>	39	46.3	21.5	18
<i>koyamai</i>	34	43.4	19.1	18
<i>Pinus contorta</i> (south coastal)	40	—	27.9	16
<i>contorta</i> (lower Frazer Valley)	40	38.3	17.9	10
<i>Pseudotsuga menziesii</i>	39	63.4	32.3	26

[1] Note that, in these plots, top heights were assessed after one growing season more than the basal areas.

on a wider scale in Wales. The healthy growth of *Pinus peuce* (see photo) in wetter parts of Britain has been reported elsewhere (Lines, 1985). *Pinus strobus* has fallen out of favour in this century because of the risks from *Cronartium ribicola* but Chard (1962) felt that this high-yielding pine merited further consideration provided that the tree was planted in mixture and/or stands were well thinned. The disappointing performance of both lodgepole pine plots reflects unsuitable provenances due to susceptibility to windthrow and/or low vigour (see Lines, 1996).

The more limited range of broadleaved species planted (see photo) to date show variable results. Most Acers, birches, oaks, beech and *Nothofagus obliqua* have shown reasonable growth, even if the form of the trees is not of the best. Others, such as alders, ash, walnut and limes, have either failed or have grown poorly. It is debatable whether some of these failures may reflect a poor choice of seed source,

Table 3. Comparison of General Yield Class in species plots at Brechfa with other published Welsh or British data.

species	GYC	
	Brechfa	other
<i>Abies amabilis</i>	22	14 [1]
<i>grandis</i>	24	24:14-30 [2]
<i>homolepis</i>	14	-
<i>nordmanniana</i>	16	12 [1]
<i>procera</i>	28	18:14-22 [2]
<i>veitchii</i>	12	-
<i>Chamaecyparis lawsoniana</i>	20	20:18-22
<i>Cryptomeria japonica</i>	20	20 [1]
<i>Cupressocyparis leylandii</i>	16	-
<i>Picea abies</i>	18	18:14-22 [2]
<i>koyamai</i>	18	-
<i>mariana</i>	10	-
<i>omorika</i>	16	12 [1]
<i>Pinus contorta</i> (south coastal)	16	8-10 [3]
<i>contorta</i> (lower Frazer Valley)	10	8-10 [3]
<i>peuce</i>	14	6-12 [3]
<i>strobus</i>	16	14 [1]
<i>Pseudotsuga menziesii</i>	26	18:12-22 [2]
<i>Quercus canariensis</i>	6	-
<i>Sequoia sempervirens</i>	30	20-30 [1]
<i>Sequoiadendron giganteum</i>	18	14 [1]
<i>Thuja plicata</i>	22	20:12-26 [2]
<i>Tsuga heterophylla</i>	24	20:14-26 [2]

Sources: [1] MacDonald *et al.*, 1957;
[2] Aldhous and Low, 1974;
[3] Danby, 1993.

In 'other' column, the average and the range of GYC are given if data from more than one plot are available.

since the provenances are either unknown or are from Continental Europe. Recent work by Worrell (1992) has indicated that British seed sources are generally better than imported ones for a range of native tree species.

The growth of the most productive and/or interesting species has been assessed at intervals since 1982 and the most recent data are given in Table 2. Greatest attention has been given to conifer species plots. Yield classes have been derived by examination of the most appropriate tables in Hamilton and Christie (1971). It is unfortunate that no Sitka spruce was included in the early plantings, so that direct comparisons with the standard forest species in this area of Wales are not possible. However, operational plantings on similar sites in nearby forests suggest yield classes of 14-16 can be reliably obtained with this species. The fertile growing conditions at Brechfa are underlined by the high yield classes recorded for most species. Five species have estimated yield classes over 20 and a further 10 of more than 14. Seven species (*Abies grandis*, *A. procera*, *Pseudotsuga menziesii*, *Sequoia sempervirens*, *Sequoiadendron giganteum*, *Thuja plicata* and *Tsuga heterophylla*) are growing at rates in excess of that expected from Sitka spruce in this area, and a number of others are growing at least at equivalent rates. The results for four out of the seven fast-growing species (*Abies grandis*, *A. procera*, *Thuja plicata* and *Tsuga heterophylla*) are in general agreement with a previous survey of plantations of these species throughout Britain (Aldhous and Low, 1974). Those authors found that these four species produced higher volumes than Sitka spruce on better-quality sites (such as Brechfa) but that this advantage was offset by an anticipated loss in timber quality.

In Table 3, a comparison is drawn between the yield classes of various plots at Brechfa and other published British or Welsh data. For the better-known species (ie *Abies grandis*, *A. procera*, *Chamaecyparis lawsoniana*, *Picea abies*, *Pinus contorta*, *Pseudotsuga menziesii*, *Sequoia sempervirens* (see photo), *Thuja plicata* and *Tsuga heterophylla*), the growth rates are generally similar to those reported previously. The high productivity which can be obtained on fertile sites in Wales from some of these species (for example, *Sequoia sempervirens*) is clear. As far as the lesser-known species are concerned, these data are either the first published information for Britain or there is, at the best, information from only one or two other plots. In a number of cases (for example, *A. nordmanniana* and *P. omorika*), growth rates are higher than in previous reports. The figures indicate the wide range of species which could be planted on sheltered fertile sites in this part of Wales.

It should be noted that the growth rates reported here may not represent the maximum attainable from the best provenances for each species. For example, *Abies grandis* is represented by material derived from east of the Cascade Mountains, which is less productive than sources from north coastal Washington (Samuel, 1996). This may explain why growth rates for *Abies grandis* and *Abies procera* are so similar at Brechfa, since there is appreciably less variation within the Washington zone of the latter species (C.J.A. Samuel, *pers comm*). A further example of poor growth due to the wrong provenance choice is in Norway spruce. Here the Austrian seed source has shown much slower growth than might be achieved with fast-growing origins from the Carpathian mountains in Eastern Europe (Lines, 1987).

The growth data should not be considered without ignoring potential disease risks, whether from fungal, insect or climatic causes. Thus some of the species are relatively susceptible to *Fomes* (for example, western hemlock and western red



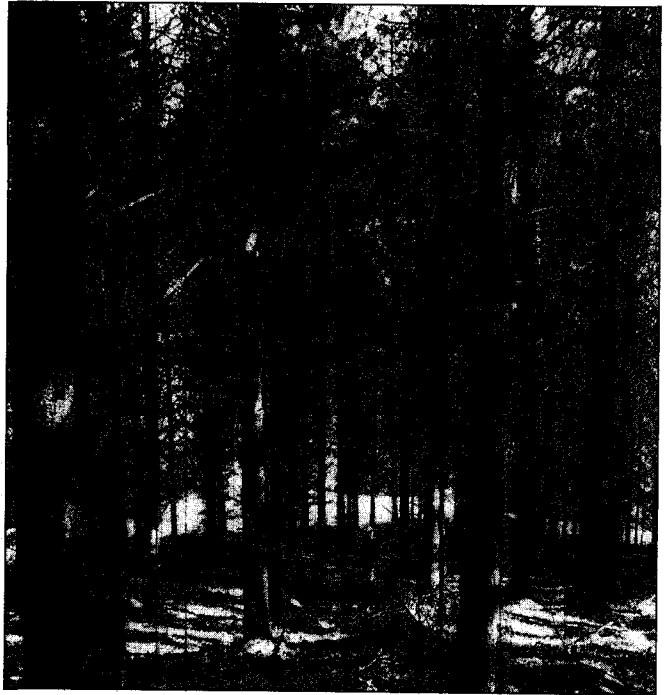
The Sequoia sempervirens plot, Yield Class 30.

cedar), while others may be sensitive to frost (for example, *Sequoia sempervirens*). Anybody wishing to consider the use of these species on a wider scale would be well advised to consult the relevant specialists in the Forestry Commission Research Agency.

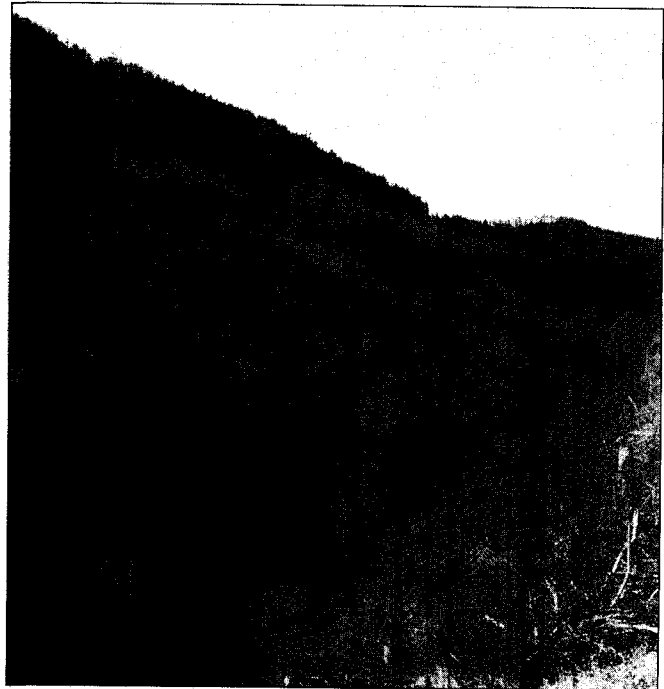
The Future

The value of the Brechfa plots is above all as a living demonstration of a wide range of tree species growing side by side under forest conditions in Wales. The main aim is to retain each plot until biological rotation and to collect appropriate data on growth, yield and other aspects (such as soil changes) which may be helpful for foresters now and in the future. Greater emphasis will be given to collecting data from the broadleaved plots. A subsidiary objective is to replace some of the failed plots by other species, particularly broadleaves, which could be expected to grow well in this area. Achieving this target will depend on the finances available. The plots can serve as an educational resource for successive generations of foresters, as well as for interested members of the public. In an era where there is an increasing

*The impressive plot
of Pinus peuce.*



*Broadleaved species
on the lower slopes.*



interest in the wider aspects of forestry, such as biodiversity, species diversity and landscape design, the information from these plots can be a helpful reminder of the need to select species which are ecologically adapted to the differing climatic regions in Britain.

Access

Public access at present is by walking via the path from the recreation area at Abergorlech. Vehicle access is limited but is possible up a forest road alongside the Afon Gothi, which was dubbed the 'Burma Road' by the forest staff who built it. Permission must be obtained from the Llandoverly Forest District Office (tel 01550 720394). The number of visitors is small at present but, when the Forest District recreation work has been completed, more visitors are expected.

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