Analysis of age structure in Atlantic oakwoods – implications for future woodland management

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Acknowledgements

An exceptional amount of experience and knowledge about woodland history exists at a national and local level. Investigations within this study can only hope to explore the uses of woodland history for future woodland management and are not an attempt to replicate detailed studies undertaken elsewhere.

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Introduction

The structure and species composition of all Atlantic oakwoods within the UK has, to a greater or lesser extent, been influenced by past management. Records suggest that many stands were worked intensively for coppice production, some of these having been planted originally. Other stands retain large trees which appear to be relicts of pastoral management systems.

This study has been carried out under the Life '97 Atlantic Oakwoods project to produce age structure profiles in five Atlantic oak stands. These profiles have provided a framework in which to consider how the stands originated and what changes have taken place. Comparisons have been made between different stand types, providing an assessment of: the processes taking place; the rate of change and interactions between past management and site type. From this information, an attempt has been made to identify the implications for future management needs.

Four plots were located on the west coast of Scotland: Taynish (Dun Taynish and Barr Mor); Kinlochmoidart and; Glen Beasdale. The fifth plot was located in Coed Cymerau, north-west Wales.

Aims

The initial objective was to sample minimum intervention stands which have only had limited disturbance. The aim was to provide a template for restoration management (i.e. an indication of what temporal and spatial patterns are likely to develop a self sustaining ecosystem). As the project progressed, its scope was broadened to include stands with uniform structure (indicating a history of intensive management) as well as those of a more diverse nature. This has allowed us to look at the initial impacts of natural processes on artificial structures as well as those occurring within a well established environment.

Methods

Sampling methodology

The four Scottish plots were part of a series of Biodiversity Research Plots. These cover an area of 1 hectare (i.e. 100m x 100m). Cores were taken from eight 25m x 25m sub-plots (i.e. 0.5ha). See Figure 1 for locations of sampled sub-plots within main plots.

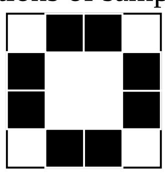


Figure 1 Arrangement of sampled sub-plots

The Coed Cymerau cores were taken from 4 randomly located 25m x 25m sub-plots (i.e. 0.25ha) (see figures 18 and 19).

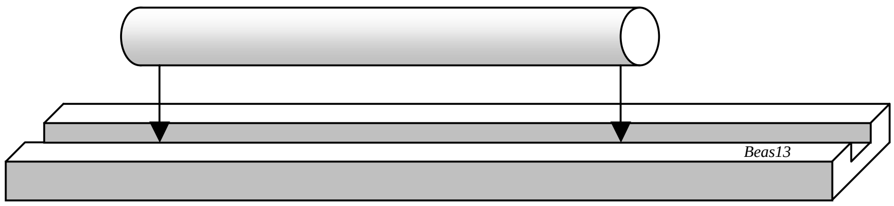
Coring

Increment cores were removed at a standard height of 1.3 m above ground level using a hand-held Presler increment borer, and the tree diameter at this point (DBH) measured. Only trees or saplings with a diameter of >10cm were cored as smaller saplings would be damaged by the corer. Coring was carried out perpendicular to the axis of the tree stem, sampling the stem from bark to central pith. Each core was marked with the orientation of the grain and individually identified so that it could be tallied with the diameter measurement. Cores were temporarily stored and transported inside plastic straws with their ends sealed with masking tape to prevent complete or partial cores falling out. To eliminate the risk of spreading infections between trees, the borer was rinsed in white spirit before each tree was sampled. Only oak cores were taken due to difficulties with reading those of other species (particularly birch).

Core preparation and measurement

Cores were removed from their straws and air dried for a period of one to seven days, depending on core condition, before being mounted in grooved wooden batons bearing their identifying numbers. Cores were fixed in place with wood adhesive (**Fig. 2**) to prevent movement during subsequent operations, and reduce expansion/shrinkage due to changes in atmospheric conditions. Once the adhesive had set the upper face of each core was shaved flat with a scalpel to reveal the pattern of growth rings.

Figure 2 – Mounting the core in a grooved baton (not to scale)



Annual growth rings were counted by mounting prepared cores on a travelling platform beneath a binocular microscope. The core surface was illuminated by a ‘cold’ light source to prevent drying and cracking of cores. Movement of the platform was controlled by the operator and measured electronically to an accuracy of 0.01 mm. The distance from the start of spring produced cells to the end of autumn cell growth was measured and is equivalent to one calendar year. Counting the number of measured rings gives the trees estimated age at 1.3 m height. Values were stored by using a computer program. Additional text could be entered at any time to record damage to cores, double rings and other anomalies. Every core was measured twice, once from bark to pith and once from pith to bark.

Data analysis

Once estimates had been achieved for all readable cores from each site, the ages were divided into classes and combined to produce a histogram of age class distribution. DBH data for each site were also divided into classes and used to produce a histogram.

Collection of field evidence

All sites were then visited with local woodland historians to gain an impression of stand characteristics and record features which may have resulted from past woodland management (e.g. presence of boundary dykes, evidence of past habitation and physiognomy of trees). Field evidence was then used to interpret age profiles.

Use of lichens to indicate degrees of disturbance

Within each of the Scottish plots, Peter Quelch identified lichen species to develop a fuller understanding of the history of woodland management. At Coed Cymerau, reference was made to a paper on bryophytes to provide an indication of disturbance history.

Certain species of lichen, particularly those belonging to the Lobarion group, are very susceptible to disturbance and are slow to colonise disturbed stands from adjoining woodland. This group also benefit from open but sheltered conditions created within wood pasture. Other species prefer old trees but, in the context of Atlantic oakwoods (particularly where the air is unpolluted) are more able to colonise from adjacent stands (e.g. *Parmelia crinita*). Attempts have been made to identify which species best reflect the least altered relicts of ancient woodland (e.g. Rose's New Index of Ecological Continuity 1993 and Quelch 2000). Atlantic bryophytes can to some extent be used in a similar way to old growth lichens although their distribution can be heavily influenced by factors such as aspect, spray from water courses, presence of rock outcrops etc.

General background to the history of Atlantic oakwoods

Although man's influence began to significantly affect the structure of the "wild wood" in Neolithic times, the earliest substantial influence still detectable in the structure and composition of existing Atlantic oakwoods dates back to the Mediaeval period. The following gives a general account of changes in use of oakwoods and associated management:

Scottish history

1. Mediaeval Period

Wood pasture was the normal form of woodland management (i.e. stock grazing in very open woodland with pollarding of the trees to produce fodder, fuel wood etc). There was also some management as high forest and some coppicing although this was only to provide materials for local uses and not done intensively (Lindsay: Scottish Forestry)

2. 1650 - 1789

The structure of many woods was still clearly influenced by wood pasture management at least until the mid 1700's. Records from Sunart (Dye et al) suggests that in 1723, numbers of trees in one township could have been as low as 35 per acre.
More intensively managed oak coppice gradually development to provide raw materials for tanning and iron smelting. Number of bloomeries (small iron smelters) increased from the late 1600's, to utilise locally produced charcoal (Tittensor, Dye et al). The use of coppice for charcoal production intensified as large commercial smelters came into operation (e.g. Bonawe furnace which opened in 1753). The west coast of Scotland provided new sources of raw material following the prohibited use of charcoal for iron smelting from certain regions of England as the new process developed for production of guns used substantial volumes of timber (Tittensor). The market for spoke wood also became important in the latter part of this period as large wheeled vehicles became common (Lindsay). In areas with metal mining (e.g. Sunart), use of timber for mine construction also became important.

Within this period, woodland management came under more control, with some woods being enclosed to exclude livestock and increased controls placed on removal of timber for unauthorised uses (Dye et al). By the 1730's, in managed coppice woods, felling was carried out on rotations of between 19 to 30 years (Lindsay) with 24 years quoted for woods around Loch Lomond (Tittensor). Common practice was to exclude stock for 4 years or less after cutting, raising to 6 or 7 years by the end of the 1700's. Some studies report that the retention of standards was common during this period (Lindsay, Tittensor).

3. 1790 - 1815

The Napoleonic Wars saw an accelerated rate of growth in demand for coppice derived materials. Prices for raw materials from oak coppice climbed steeply and reached a peak at the end of this period.

There was an increase in the conversion of mixed woodlands to stands of almost pure oak, with the removal of "barren timber" or "black wood" (i.e. species such as birch, rowan and hazel). Gaps were enriched with oak and new areas of oak were planted.

As bark prices rose, the coppice rotation was reduced to 20 years. Larger woods were cut on full rotations but smaller woods were usually felled over three or four years followed by 20 years until the beginning of the next cutting cycle (Lidsay). Some studies suggest that the retention of standards went out of fashion as the negative effect on coppice production became more of a consideration. However, others report (Dye et al) that the shortage of timber for ship building increased the number of standards recruited. In 1797, in Knapdale, sale of several lots was conditional on the retention of 500 standards (Anderson 1967). Records from Loch Eil (dated 1790), show that 40 trees per acre were identified as standards and marked with red paint (J.Kirby Pers.comm.)

Even during this most intensive period of coppice production, some pasture woods survived whilst other stands remained unmanaged and unenclosed but were exploited for what coppice occurred.

4. 1816 - 1900

After 1815 prices for bark and coppice wood soon fell to their pre-war levels and by 1825, many coppices were incorporated into sheep pasture. The area of managed coppice was still fairly substantial in the 1870's but after the 1890's "formal" coppicing appears to have ceased in Scotland (Lindsay) with enclosures fallen into disrepair (Tittensor).

Welsh history

1500 - 1700

Intensive use of oakwoods in Wales began much earlier than in Scotland. Sussex iron masters transferred their operations to South Wales in the 1500's and records show a very active coppice industry there in the mid 1600's. In North Wales, records show that English speculators built an iron furnace at Ganllwyd (Merioneth) in 1588. Between 1588 and 1603, 30,000 oaks were felled in Penrhos Common, the Forest of Snowdon, to supply the iron works.

Ship building was also an important industry. There are records of 1🗁 to 2 " oak planks sold from Gwydyr to Liverpool in the 1680's. These records show a systematic programme of felling and conversion to supply the ship building industry, they also show the there was an active tanbark industry in the area by this time. Tanbark was a by-product with some larger trees being peeled standing, the timber being felled subsequently (Linnard 2000).

1700 -1789

Coke replaced charcoal for most iron smelting operations during the 1700's although charcoal production continued in south and north-east Wales in retort kilns to produce pyroligneous acids as well as charcoal. In more remote areas, traditional charcoal burning continued.

The Seven Years War (1756-63) increased the utilisation of Welsh oak for shipbuilding although naval timber was in short supply. This was thought to be due to felling of wood to supply furnaces and forges of the iron works coupled with lack of care in protecting coppices or neglect of planting (Linnard 2000).

During the 1700's bark was exported to many countries from Wales. The tanbark industry appeared to be stable until 1780 when prices began to rise.

1790 - 1810

As with Scotland, the Napoleonic war (1798 - 1810) had a profound affect on the use of materials from oakwoods. There was a dramatic rise in the price of tanbark, and a further increase in the utilisation of oak for ship building.

A small amount of traditional charcoal burning continued.

1811 - 1900

There was a constant demand for good ship building timber until 1862 when Iron ships proved superior to wooden men of war at The Battle of Hapton Roads. Tanbark prices began to fall and were at the same level as 1790 by 1850. In the 1880's imported vegetable tanstuffs proved to be a cheaper alternative to oak bark although there are records of tanbark collections over 20 years beyond this date (e.g. At Caerynwch near Dolgellau in 1890's, where records describe a barking party of 30 men and boys).

There was still some traditional charcoal burning in more remote areas until the end of the 1800's

1901 - 1960

During the first and second world wars, there was a short revival of the tanbark industry in Mid-Wales. This ended in the 1960's when the Rhayader Tannery closed.

The supply of pitwood was also important but was more relevant in South Wales and to a lesser extent Mid Wales, particularly during the first world war.

Assessment of stand character and field interpretation of woodland history

<u>Dun Taynish</u>

Description of the stand

This plot is within an area of very diverse woodland. The stand has a very irregular structure and an open canopy. Oaks are composed of old coppice (some of which has naturally self singled) and maidens with a range of diameters. One very large oak occurs within the centre of the plot.

The stand also contains frequent birch, rowan and hazel, many of which are senescent (see slide 1).

Lichen flora
There is a well developed lichen flora (see slide 2) and this appears to be richer on old coppice, the large oak in the plot centre, several hazel and trees which have blown down (these had good communities on the horizontal branches, presumably due to more light and better trapping of moisture). The old hazel in particular, provide an important substrate for a range of the old growth lichens including three species of Lobarion. The lichen communities on the smaller maidens did not appear to be as rich as on those trees mentioned above and it was suggested that, despite their larger diameter (compared to the coppiced stems), these may have seeded in after coppicing ceased.

Archaeological features
An old trackway runs through the centre of the plot (see slide 3) This was possibly a route from the old corn mill to the loch side and may subsequently have been used to extract coppice material. The hazel mentioned above are restricted to this track side together with old pollards of oak and other species. The track and boundary walls appeared to date from an early period. On the one edge of the plot are the outlined foundations of an old dwelling. The large tree in the middle of the plot is growing on the edge of a level terrace clear of trees which was possibly used for arable ground at one time. Due to the nature of the terrain (knap and dale), there were many other possible extraction routes for coppice material.

Natural processes
Some oaks have blown down at the top of the plot since the beginning of this project. Open areas have dense bracken and there is some concern about the long-term prospects for regeneration. There were some signs of deer pressure with one moderately browsed holly and only a few oak seedlings, despite a good mast in 2000.

Old gaps have regenerated with birch and rowan. Judging by their well developed lichen flora, some of these trees appear to date back to around the early 1900's. The range of birch and rowan age classes is not clear but few saplings or obviously young trees exist suggesting that seedlings have not been recruited for at least 15 years.

However, there are signs that oak and hazel within this stand have the capacity to regenerate vegetatively. Several trees could be seen that had fallen over and regrown, either as a new stem from the root or as development of side branches into main stems (woodland historians give this growth form the name "phoenix tree" - as in risen again - see slides 4 and 5).

Analysis of historic records
Records from local people in 1792 (Anderson1967) refer to memories of extensive woodland where not a single tree had survived due to clearances for agriculture. Records also suggest that Bonawe Iron works negotiated with the owner of Taynish to buy wood for charcoal prior

to 1799 and again in 1806.There are also records of the woodland being grazed by cattle as the woodland was on a drove route from Jura (Bohan 1997). The first edition Ordnance survey map (1861) indicates open woodland in the area of this plot. There is also some evidence of this on George Langland's map of 1801, with open areas existing either side of this stand. This map also shows a track which may be that observed on site.

Analysis of age histogram and cores (see figures 3-5).
Some of the older cores have smaller diameters and appear to come from coppiced stems. Lichens indicate that some of the maidens are younger and have seeded in since coppice was last cut over. There is further evidence for this from the Age / DBH scatter chart, some trees with diameters in the middle of the range being of a younger age class.

The profile indicates a 55 year regeneration period from 1860 to 1915 following cessation of coppicing. Younger trees (reaching 1.3m in the 1930's) may have regenerated due to relaxation of grazing between World Wars one and two.
Within the plot are large diameter wood pasture trees (>60cm) which were not sampled due to systematic methodology. These will be assessed in the future to improve our understanding of the site.

Statistics

	Minimum	Maximum	Mean	Standard deviation
Age (years)	60	140	112.2	18.1
DBH (cm)	14	65	37.1	13.4

Site type
The soil nutrient status of this site is moderate with a moist soil moisture regime

Summary of past management
The area has not been managed as systematic coppice, with some of the plot appearing to have been managed more as wood pasture and other areas possibly subject to ad hoc exploitation rather than intensive woodland management. It was thought that when the plot was last cut over, it would not have been well stocked. It may also have been grazed fairly heavily, not allowing some of the cut over coppice to regrow. A boundary wall divides the bank and it is suggested that the stand on the other side (which is much more uniform and well stocked) could have been leased by another tenant and managed more intensively for coppice production. Slides 6 and 7 are taken looking either side of this boundary with slide 6 looking into the plot.

Barr Mor

Description of the stand
This stand is of a very different character to that described for Plot 1 (see slide 8). Structure is very uniform. Coppice has naturally singled, with dead coppice stems evident at the base of living trees (see slide 9). There are few signs of maidens and no veteran trees.

Lichen flora
Lichen flora is largely composed of species characteristic of early successional habitat and is not as species rich as in plot 1. There is a sparse representation of old growth species (i.e. *Parmelia crinita*) although Lobarion are not present which (in a Taynish context) indicates that the stand has been subject to disturbance. The likely reasons are thought to be a lack of

continuity of key habitat (particularly the old hazel at the other site) and the higher basal area reducing available light.

Archaeological features
A stone wall dating from around the early 1800's runs along the bottom of the hill (see slide 10) and it was thought that this may have been a deliberate coppice protection dyke. A number of very obvious charcoal hearths or platforms can be seen in the vicinity of this plot indicating that the stand was intensively worked (see slide 11), these appear to be interconnected by pony tracks.

Natural processes
The "phoenix" trees seen around plot 1 were not evident at this site and it was thought that lower fertility, poorer rooting and smaller crowns may work against successful vegetative regeneration within this stand. However, there appeared to be low deer pressure and regeneration of holly, oak, rowan and hazel were doing well in a new windblown gap where shallow rooted oaks have recently blown. The seedlings were young and it was not clear whether they would be recruited if bracken becomes dominant.
There was a general feeling that this stand may soon begin to suffer from extensive mortality, either due to windblow of shallow rooted trees or death of senescent coppice stems with small crowns and old stools.

Analysis of historic records
It was not possible to trace any historic records for this site. The mapped evidence supports observations, with the first edition ordnance survey map (1869) showing open ground above the rock outcrops as shown in slides 12 and 13. However, this conflicts to some extent with findings from the age histogram (see below) and it is unclear how young coppiced trees would have been represented on first edition maps.

Analysis of age histogram and cores (see figures 3-8).
The similarity with plot 1 is surprising given contrasting stand structures (note differences in frequency scale and lack of data for wood pasture trees in plot 1).
The profile indicates that coppicing was last undertaken around 1850 to 1860. If the stand was planted around 1800, two coppice rotations of 24-30 years may have been completed prior to abandonment.

The presence of trees in recent periods is more constant than in plot 1. Cores of younger trees show rapid early growth and some have relatively large DBH's. As cores were taken above browse height, it is not clear whether these trees are regrowth from coppice stumps or natural regeneration where coppice stools have failed to regrow.

Statistics

	Minimum	Maximum	Mean	Standard deviation
Age (years)	39	150	104	18.96
DBH (cm)	11	47	22	5.89

Site type
The soil nutrient status of this site is poor to very poor with a moist to slightly dry soil moisture regime

Summary of past management

From the uniformity of the stand (see slide 8), the lack of veteran trees, a relatively poor lichen flora and evidence of intensive coppice production, it was suggested that this stand was originally planted onto a previously open hill during the time of highest economic returns for oak coppice. The planted trees would have been subsequently coppiced once or perhaps twice.

Slide 12 looks down into the suggested upper boundary of the ancient semi-natural woodland (note a greater range of species, including aspen in the foreground, more irregular structure and open grown veteran oaks). Slide 13 is taken from the same location looking uphill into the stand containing the plot.

Kinlochmoidart

Description of the stand

This stand is on a steep south facing bank above Loch Moidart. Structure indicates that this was once a pasture woodland which has partially filled in with patches of high forest. Local historians commented that it is distinctly irregular and species rich compared to more typical uniform stands elsewhere within the district, with an ancient character and many natural features.

The composition of oak trees is summarised by Peter Quelch:

- Widely spaced coppice stems, which appear to be several hundred years old, commonest on steep and rocky ground (see slide 14).
- Large pollards (circa 200 years) again scattered at wide spacing but on better and less rocky ground (see slide 15).
- Younger maidens, perhaps self seeded, sometimes forming patches of high forest. Mosaics of high forest are seen by some woodland ecologists (i.e. Sanderson - New Forest) as natural components within wood pasture.

There were also suggestions that some of the maiden oaks could have been planted and there is some limited evidence for this with one line of trees evident (see slide 16).

Many trees show evidence of past management. (slide 17 shows two fused coppice stems, one of which has subsequently been pollarded). Some pollards have basal swelling at the bottom confirming a long history of wood pasture (even though these trees may now be in high forest): a sustained period of grazing of adventitious shoots causing burrs (Quelch - 2000). There was some evidence of phoenix trees.

With regard to other tree species, there are several large patches of birch trees which are around 40 years old. Several veteran holly can be seen across the bank and these appear to have been heavily managed as pollards in the past (thought to be used for livestock fodder).

Originally, the site had good birch pollards which can now be seen as fallen deadwood. Some old birch still occur within the stand (see slide 18). The tree illustrated shows *ropey* bark structure which only develops in trees of old age (Quelch 2000)

Within the mid slope (at the top of the plot) are a number of large pollarded ash which are still in very open woodland. Lower down the slope, trees are denser and it was thought that this area would always have been more wooded due to the steeper bank and thinner soils. Other species include rowan, hazel and elm although non of these are frequent.

Lichen flora
This is not well developed on oaks despite the area exhibiting many ancient semi-natural characteristics. There are good old growth lichens on pollarded ash in more open pasture woodland further up the slope (including Lobarion). It is not clear why species from the Lobarion community are not abundant further down the bank as pollards and old coppice appear to be well suited, being open grown within a stand that appears to have been continuously wooded for many centuries. It was suggested that the lower area may have been very open and too exposed for good lichen development prior to being infilled with birch and younger oaks.

Archaeological features
On the upper edge of the denser woodland, there is an excellent example of a charcoal hearth with a well built retaining wall (see slide19). A stone with a well defined concave surface, can be seen by the side of the hearth and it was suggested had been used for sharpening tools (see slide20). A hypothesis was put forward that this platform was previously a dwelling - it is well built and on a very good location for a house site (i.e. above the frost line and south facing).

Natural processes
Phoenix trees are evident within the plot, in one example, a vertical oak stem arises from the root plate of a fallen pollard.
Higher up the slope, oak and birch are regenerating well into sparse bracken and heather. Eventually these will presumably futher infill the pasture woodland.
Oak may in time regenerate under the large patches of birch given low enough browsing pressure although there is some debate about this (see comments in discussion about recommendations in Peterken and Worrell 2001).

Analysis of historic records
Records show that in 1794, a contract was made between Clanranald and Bonawe furnace for the sale of "all and whole the woods growing on Arisaig and Moidart ". However, the woods to the north of Loch Moidart (of which this is one), then belonged to Kinlochmoidart estate and thus escaped the large scale clearance which is thought to have taken place between 1795 and 1796. Within the vicinity, only these stands and the woodlands on the Shona Beag penninsular are thought to predate this period of clearance (Murray et al 1999).

Analysis of age histogram and cores (see figures 9-11).
The histogram suggests that a cut may have taken place to produce the peak around 1850 . There is a possibility that some enrichment planting also occurred at this time. The lack of older age classes does not reflect the presence of trees throughout the plot which appear to be over 200 years old. Of the sampled trees, eight over 46cm DBH have hollow centres and it was therefore not possible to get an accurate age. Growth rates indicate that a number of the bigger trees were open grown for the first 20-30 years followed by 30-60 years moderate growth and the remainder very slow. One core shows rapid growth for the first 90 years.

A core from a coppiced stem with a hollow centre, shows very slow growth at the beginning (i.e. the inner section of the tree), followed by rapid growth for 15 years, moderate growth for 77 years and very slow growth for the remaining 44 years. This grows on the same stool as a stem which doesn't have a hollow centre, which grew moderately well for the first 36 years and then very slowly for the remaining 99 years. The majority of coppiced stems appear to have grown very slowly after an initial period of moderate growth in the first 5-10 years. This

tends to suggest that most coppice stools were suppressed under a mosaic of high forest and pollards or that stools are very old and lacking in vigour.
The great variability between growth rates and tree age is illustrated in the Age / DBH scatter chart (figure 11) which shows greater variation than in the other stands. In a few examples, growth rates may be declining due to old age of pollards or coppice stools.

Statistics

	Minimum	Maximum	Mean	Standard deviation
Age (years)	55	201	131.4	27.9
DBH (cm)	15	109	42.7	18.4

Site type
This plot is on the richest site type of all plots assessed within this study. The presence of ash and elm indicate a high base status.

Summary of past management
This was thought to be periodic coppicing and pollarding in the same operation. Not organised coppice but perhaps cut over every 30 years during the period of highest returns for coppice material and as long as every 100 years at other times.

Glen Beasdale

Description of the stand
The majority of this stand is very uniform although more open than Taynish Plot 2 (see slide 21).

Approaching the plot from the north, there is evidence that coppice stems have been stored (i.e. cut to leave a single stem) to develop high forest (see slide 22). Within the plot, however, stems have naturally singled: dead stems are still evident at the base of many coppiced trees (see slide 23) This was also observed in the second Taynish plot.

There are no veteran trees on the bank. However, in amongst the younger trees there appear to be older stools (see slide 24), and some standards of a range of diameters.

On the crest of the hill is more open woodland and it is possible that this area was previously sparse woodland, enriched, rather than: cleared and restocked or; new woodland planted on open ground. This area includes old birch and rowan. There are no pollards on the bank or the hill crest.

Lichen flora
There are few old growth lichen species within the plot. These include sparse *Lobaria pulmonaria* on more open grown oaks along the top of the bank (see slide 25) and more abundant growth of the same species on old birch in the same location. The oaks thought to have been planted and subsequently coppiced have early colonising species such as *Ochrolechia androgyna* which is a frequent coloniser in this area. On one of these stems, *Thelotreanca lepodinum* was also seen which is indicative of old growth.

Archaeological features

This area appears to have been intensively worked for coppice in the past. Several charcoal hearths could be seen within the locality of the plot (see slide 26). No other features were obvious.

Natural processes
As described above, coppiced stools within the plot have self singled. This only appears to have happened with trees thought to have been planted during the period of highest returns for oak coppice and it was hypothesised that younger stools are more prone to singling as the root reserves are unable to support a large number of stems (Peter Quelch Pers. comm.).

Within the locality, die back of oak could be seen in extensive patches (see slide 27). This was thought to be due to exposure, woodlands locally being subject to strong winds coming off the Sound of Arisaig. It is probable that relatively even-aged stored coppice with poor root stocks will be more prone to this type of mortality than a stand containing maidens or coppice and pollards whose reserves have been gradually developed through successive cycles of management.

Analysis of historic records
Records dated 1790 show that 40 standards were selected /acre on Clanranald ground in Sunart (20km to the south). Glen Beasdale was part of this estate at that time.

Historic records presented in Murray et al 1999, show that there was considerable activity in establishing plantations around the Beasdale area (referred to in the documents as Arisaig and Borrordale). A nursery was established in 1796 and operations continued up until the summer of 1815 when "Clanranald agreed that improvements at Arisaig were ‘entirely to cease’ and that any expense that might be necessary was to be paid out of his allowance."

From documentary evidence, it seems very likely that Glen Beasdale planting would have been carried out between 1800 and 1815 (the plants normally taking four years to produce in a nursery (Dye et al 2000)). This suggests that all stools were coppiced twice, with standards planted at the start of the second coppice cycle.

Analysis of age histogram and cores(see figures 12-14).
The histogram shows an initial peak around 1843-1857. Two factors have been interpreted from this. 1. The lack of trees represented in older age classes suggests that the stand was planted and; 2. That the fifteen trees present in the first peak are from the initial planting and were retained as standards. It is possible that trees represented between 1860 and 1880 may have been planted as standards to replace failures in the initial planting.

The histogram also shows a peak around 1885. This suggests that the stand was only coppiced once on a cycle of 30-35 years.

Statistics

	Minimum	Maximum	Mean	Standard deviation
Age (years)	19	154	111.9	32.3
DBH (cm)	12	80	32.9	12.7

Site type
Plant indicators suggest that this site has a very poor soil nutrient regime, fitting it into NVC type W17. Soil moisture is slightly dry.

Summary of past management

The consensus view of visiting woodland historians was that much of the slope has been planted and subsequently coppiced with standards planted/retained. This is supported by the analysis of the age histogram and documentary evidence. The top of the bank appears to have been sparse woodland that was enriched with oak at the time that the main bank was planted.

Coed Cymerau

Description of the stand

The stand is on a steep north-west facing bank. It is composed predominantly of maiden oaks, with very little sign of coppicing (only one tree observed) and no signs of pollarding (either within or on the edge of the woodland) (see slide 28). A moderate range of size classes are present, with a substantial understorey of rowan, birch and hazel on the middle bank. The woodland is a little more open at the base of the bank, with taller trees. At the top of the bank is an area of young birch and oak (approximately 6m in height). The sub-plots where coring was undertaken are within a fenced exclosure which was established in 1965. A substantial amount of research was undertaken at this site by Wally Shaw, who made important findings about the ecology of upland oakwoods. Trees within the plot were recorded in 1964 and again in 1988 (by Backmeroff and Peterken). Figure19 shows the original map of the plot and indicates the sub-plots in which trees were cored for this project.

Lichen and bryophyte flora

The lichen flora in North Wales is more restricted than on the west coast of Scotland due to air quality and greater fragmentation of native woodlands. However, isolated colonies of Lobaria do exist within this region and, as with Scottish examples, their occurrence is related to the presence of diverse woodland with old trees, a range of tree species and other indications of continuity of woodland cover. There were no signs of Lobaria species either within the plot, on trees around the edge of the wood, or elsewhere within the woodland.

Work has been done on the distribution of Atlantic bryophytes in four Snowdonian woodlands including Coed Cymerau and these distributions have been considered in relation to woodland disturbance histories (Edwards 1986). The west facing bank at Coed Cymerau (which includes this stand) showed a relative paucity of species although this was in part put down to a poor substrate and pollution from the water course in the gorge. Only one species which occurred on the west bank (Adelanthus decipiens) had been thought to indicate a lack of disturbance although the tolerance of this species to disturbance was questioned by Edwards. It was suggested in this paper that the present woodland may have regenerated after clearfelling or may be a plantation.

Archaeological features

The only archaeological features observed within Coed Cymerau were dry stone walls (see slide 29). These are thought to date back to the enclosure period.

Natural processes

Prior to the erection of a fenced exclosure, this stand was heavily browsed. Apart from occasional incursion by goats, the plot has not been grazed for 40 years.

Reduction in grazing pressure has resulted in: a substantial change in vegetation (see Site Type below); the recruitment of natural regeneration on an area at the top of the bank (which is known to have been treeless in the early 1960's - (see slide 30)) and; the development of an understorey. (see slide31])

At the top of the bank, trees are still in the stand initiation phase. Observations from Wally Shaw suggest that a lot of small birch have gone into decline or died in the last 8 yrs and oak and rowan now appear to be doing better.

Stems on the middle bank are competing for space and going through a stem exclusion phase (i.e. suppressed and sub-dominant trees are dying due to competition from dominants and co-dominants). At the same time, a substantial recruitment of saplings is taking place in the understorey. Peterken (1996) suggest that in present natural conditions, the less vigorous nature of canopy trees on poor upland sites would allow a more vigorous growth of "underwood tolerants" such as hazel, holly and rowan.

In the lower bank (where the slope becomes shallower, soils become moister, light levels and temperatures are lower), several isolated dominant and co-dominant oak trees are dying or dead (canopy tree mortality - Peterken 1996). Some of these appear to have flushes or slumps above them and it was suggested that cause of mortality may be siltation of feeder roots. In addition to this, some dead trees are on the river terrace which occasionally floods (see slide 32). Some of the gaps created are filling with rowan from the understorey.

The experiments carried out in the 1960's, included planting oak seedlings at the top and base of the bank. Recruitment was successful in ground with very poor soil nutrient regimes but competition from *Hollcus mollis* in the lower bank caused seedling mortality. Now saplings at the base of the bank are rowan, hazel and sycamore. The experiments also involved the felling of 20 oak trees to assess the response of seedlings to increased light levels and reduction of throughfall from canopy dwelling defoliating invertebrates. These gaps have now regenerated with a high density of stems of birch and rowan. The site was resurveyed in 1988. By this stage, 12 of the cut stumps had died (i.e. no coppice regrowth) and 8 had only produced small shoots. Casual observations suggest that the majority of this growth has now been suppressed by saplings of birch and rowan.

Grazing pressure outwith the fenced exclosure has also reduced over the last 40 years. Within this oak dominated woodland are discrete patches of birch. One of these is composed of mature birch trees, with several dead trees evident (see slide 33). Within this gap, several oak saplings are well established (see slide 34).

Analysis of historical records

Timber from the Maentwrog oakwoods is known to have been used largely for ship building from the late 1700's until 1820. A quay built especially for the export of timber was constructed on the tidal estuary below Cymerau in 1816 (Gwyn 2001). A photograph (page 99, Linnard 2000) shows a merchant vessel being constructed from Maentwrog oak at Porthmadog), with the bark being used at a tannery at Glan-llyn, located on the southern edge of Coed Cymerau. Other records show that timber from the estate went to the Pembrokeshire collieries and that some was used for charcoal.

The following is an extract from a Gwynedd Archaeological Trust Report (Gwyn 2001):

Specific reference to the timber felling at Coed Cymerau come in "Journeys" of Sir Richard Colt Hoare in 1801 who describes walking through Cymerau:

> "I continued my rough and Alpine track through some oak groves, in some of which the axe has lately been introduced; £900 of timber was cut last year and a considerable fall

> has been made in the present. It is a lamentable sight for a lover of picturesque scenery; in a few years little wood will be left in Merionethshire. During the few years [since 1797, when he first visited the area] I have been frequenting this county the havoc has been great; several of my favourite groves which I have so often admired have already fallen, and I hear of more where speedy doom is impending. But the evil does not only arise from felling the wood but from not properly fencing them out when cut by which the young shoots and prospects of a future copse are totally annihilated."

Agricultural reports published in 1810 (Davies) refer to the fact that Merionethshire was sparsely wooded which suggests that many of the woodlands in the Vale of Ffestiniog have been planted. 1807 Merioneth Quarter Sessions records confirm that local landowners were encouraging new plantations (Gwyn 2001). There is further evidence for this from reports of the activities of William Oakley (the owner of the estate which included Coed Cymerau), who was recognised for the active management of his woods. 1 mile east of Coed Cymerau, at Cancoed Isaf, was a tree nursery and records suggest that trees from here were used to plant up clearings after felling. It is possible that tree planting by William Oakley's staff was restricted to the more accessible sites with better soils and that poorer sites were left for grazing or to regenerate naturally after clearfelling.

There is evidence (from work done by M.McGrath - post-graduate student Botany Department, University College of North Wales) that the stand to the south-east of this plot (the most accessible part of the wood) was planted between 1850 and 1860.

Many of the best oaks in Maentwrog were felled during and immediately after the two world wars although there is no evidence of this activity in the plot.

Analysis of age histogram and cores (see figures 15 to 19).

The histogram of oak age classes shows the main period of recruitment between 1828 and 1892. As a disproportionate number of younger individuals will have been lost due to early stem exclusion this range of age classes may be disproportionately weighted towards the upper age limit (Peterken 1996). Limited recruitment has also taken place between 1903 and 1947. Figure 18 shows that age classes are irregularly distributed throughout the sub-plots. Ring counts from the felling done in the 1960's concurred with these findings.

Despite the evidence for planting within woodlands on this estate, analysis of the histogram shows that it is unlikely that this stand was planted. The main difference between data from this plot and those data collected from Barr Mor and Glen Beasdale is that the majority of trees within those plots had been coppiced, with some limited evidence of maidens, therefore, after one or two cycles of coppicing and retention of standards, a greater range of age classes may be expected. At Coed Cymerau, it is unlikely that maidens would show such a long period of establishment, with such a diverse distribution of age classes, if the trees had been planted. It is also unlikely that there was an initial planting which infilled with natural regeneration as this would have showed up on the age distribution chart. It is however, possible that a naturally colonised clearfell or previously grazed area would take longer to establish, particularly if oak saplings were recruited after initial colonisation by birch.

A possible explanation for the area at the top of the bank, which was treeless in the early 1960's, could have been the loss of a group of birch trees without the replacement of oak as seen elsewhere, due to pressure from grazing.

Of the oaks <75yrs: 2 grew up in the immediate vicinity of older oaks, one growing very fast initially and the other growing moderately fast; one grew up in an area recorded as a gap in 1988 and; the other 2 grew up within groups of birch and rowan (one growing fast for the first 4 years and the other growing slowly for the first 2 years followed by fast growth for 7 years). The birch and rowan around the last two oak trees described had an average dbh of 13cm in 1988. This indicates that these oaks were recruited into a relatively young stand of birch and rowan in contrast to the saplings seen in slide 34 which are being recruited into a senescent stand of birch as described above. It also indicates that oak can grow relatively fast from when the tree reaches 1.3 m, even if it is under a canopy of other species. It is therefore unclear whether the oldest oaks within this plot were recruited under birch and rowan or whether they were the initial trees to colonise the site after clearance.

Statistics

	Minimum	Maximum	Mean	Standard deviation
Age (years)	43	167	124.8	26.9
DBH (cm)	12	54	28.98	7.52

Site type

Prior to exclosure, the top and middle bank were dominated by a sward of Deschampsia flexuosa. This has largely gone today, with *Vaccinium myrtilus* predominating. Both species are good indicators of a very poor soil nutrient regime. The bank is also thought to have a slightly to moderately dry soil moisture regime (i.e. NVC W17). Prior to exclosure, the lower bank was dominated by *Hollcus mollis*. Today, *Rubus fruticosus* and *Pteridium aquilinum* dominate. These indicate a poor soil nutrient regime (as opposed to very poor above) and soil moisture regime is thought to be moist.

Summary of past management

As the trees are maidens and the histogram shows a 50 year period of recruitment, this stand does not appear to have been planted. Other factors also point to this: Planted woodlands in the area generally have the name "Nurse" preceding the rest of the name as in Nurse Pandy - ddwyryd". In addition to this, oaks within the stand show very good *Q. petraea* characteristics and woods in the area thought to be planted generally show strong *Q. robur* characteristics (*Q. robur* acorns are much easier to store and Wally Shaw suggested that this species was therefore used preferentially by nurserymen).

It is likely that this site was previously wooded and quickly regenerated with trees following clearfelling. The site type is mostly very poor and would therefore have colonised easily.

It appears that, apart from experimental treatments, very little management of the existing stand has taken place.

Discussion

Despite the relatively short duration of industrial use and "improvement" of Atlantic oakwoods in Scotland, profound effects on their structure and species composition are obvious today and will continue for many year to come. However, features that pre-date this period of intense activity, remain in many stands. A striking feature of Scottish history is the rate of loss in woodland area and speed of replacement, particularly in the case of Taynish and Beasdale.

A longer history of industrial use of Welsh Atlantic oakwoods and the consequent scarcity of timber has resulted in exploitation of all but the most inaccessible stands. This together with less of a tradition for upland wood pasture management (and therefore a lack of large, poorly formed, often hollow trees which may have escaped the blade) has led to more isolated refugia for indicators of ancient woodland (e.g. species such as Lobarion lichens and other old growth features).

Although the period of greatest activity reduced the diversity of many upland woods, it also led to the replacement or creation of many stands that would otherwise be grazed open hill today. A significant proportion of existing upland oakwoods are the legacy of "improving" land owners such as Clanranald and William Oakley.

The lack of ancient, unmanaged upland oakwoods in the UK makes it difficult to assess how natural woodlands function and what structural components and species composition would be present without man's influence. It is possible, however, to look at stands which have been subjected to varying degrees of management and to assess how natural processes are changing structures which are to a greater or lesser extent artificial.

Observations from this study suggest that the naturalness of an existing stand is, in itself, less important for biodiversity values than the continuity of woodland conditions, retention of mature features and, implicitly, lack of major large scale disturbance. If, for example, one contrasts the complex structure and rich diversity of features in Kinlochmoidart and Duntaynish with the comparative uniformity of Coed Cymerau it can be seen that a long history of low intensity management has created a richer environment than a stand which appears to have developed purely from natural processes but regenerated after major disturbance and the removal of old woodland features. This view is, however, compounded by the difference in site type and geographic location.

Coed Cymerau is a valuable research resource, not only due to the detailed recording carried out in 1964 and 1988 but also due to it's apparent origin as a naturally regenerated stand. Although this stand could be said to be in a relatively early stage of initiation following clearfell (and therefore moving towards a more stable structure and species composition), it nevertheless shows the important role of other tree species, particularly birch and rowan, in the regeneration of oak. It also demonstrates the natural rate of mortality due to competition from other trees and due to other natural processes. Where stands have been planted and subsequently coppiced, the rate of mortality will be influenced by the artefacts of original planting density, pattern and subsequent treatment (i.e. frequency of coppice cycle). The majority of mortality in intensively managed stands appears to be self singling of coppiced stools. It was hypothesised that this may reflect the limited strength of the root stocks due to the age of the trees when coppicing ceased. This suggests to the authors that planted and subsequently managed woods may be more prone to large scale mortality in the future, particularly those stands which are on poor skeletal soils.

It is interesting that the two wood pasture stands are on better site types and it is likely that upland farmers would have favoured the more nutrient rich sites for this type of management. The converse may be true in the lowlands (see Peterken 1996). The best known upland wood pasture in Scotland, Glen Finglas, is also on a relatively rich site as are other woods which show signs of similar management (e.g. Rassal ash wood and Glasdrum). Not only would the grazing value be higher but also the range of tree species suited to the site and value of their products (e.g. fodder, small round wood, larger timber and many other products from ash and elm as well as species that tolerate a wider range of conditions such as holly and hazel).

The contrasting woodland histories of sites with very poor soil nutrient values and those with poor to moderate values make comparisons of natural processes at each site difficult. However, it does appear that trees are more able to reproduce vegetatively on better site types. This may be due to deeper, more fertile soils forming substantial roots thus giving fallen trees sufficient vigour to regrow. This observation cannot be substantiated without assessing what processes are taking place on very poor sites with large old trees. If the hypothesis is correct, however, it has implications for the type of management appropriate on different site types (which could be broadly split into National Vegetation Classifications W11 for moderate to poor soil nutrient regimes and W17 for very poor regimes):

Concern has been expressed about the ability of oak to regenerate in Atlantic oakwoods, particularly in a Scottish context, and the ability of oak to regenerate vegetatively has been recognised as one mechanism (e.g. Peterken and Worrell 2001). In unmanaged W11 stands with high densities of bracken and grasses such as *Hollcus mollis*, it is likely that oak and other species will maintain their presence in the long-term by vegetative means, rather than by regeneration from seed. It is possible that, in W17 stands, regeneration from seed will be more likely and the long-term prospects for oak will depend on a number of factors. At Coed Cymerau, outwith the fenced plot, there is no browsing pressure from deer and only light pressure from sheep and goats. In addition to this, there is more summer warmth than in the Scottish sites, conditions conducive for oak regeneration.

It is likely that tolerant understorey species, particularly rowan, will initially fill gaps created by death of individual oaks. The mechanism for regenerating larger gaps is likely to be through initial colonisation by birch and rowan with any recruitment of oak seedlings (given low enough browsing pressure) either taking place soon afterwards (as in group fells within Dalavich oakwoods and Glen Nant) or at a later stage under a young to mature stand of birch and rowan.

The vulnerability of stands which have been intensively coppiced in the past (i.e. their potential susceptibility to large scale mortality, lack of opportunities for large crowned trees to develop and limited creation of small scale gaps for recruitment of advanced regeneration) will be of particular concern to a number of "stakeholders". For example: where nature conservation interest is beginning to develop (e.g. initial colonisation of old growth lichen species in Barr Mor and Glen Beasdale) and where Atlantic oakwoods are an important landscape and recreation resource. In addition, there is increasing interest in utilisation of some of these less diverse stands for sustainable production of timber (e.g. Peterken and Worrell 2001).

The lack of continuity of low input traditional management in the old wood pasture stands is leading to a reduction in some biodiversity values as previously open grown trees are becoming overshaded or suppressed by younger trees developing as high forest.

Management recommendations

Avoid routine prescriptions - Treat each stand as an individual unit: consider how its structure has developed, whether it has been intensively managed and what interactions have taken place between management and site type.

Silvicultural operations should seek to minimise large scale disturbance, maintaining woodland conditions, targeting the safeguarding and development of key features (e.g. maintaining humid, sheltered conditions around water courses for Atlantic bryophytes, maintaining an open sheltered environment around trees with rich assemblages of old growth lichens).

Where deer/stock numbers are at a threshold for regeneration of oak, target control of browsing animals to those sites where oak is most likely to regenerate (e.g. protection of birch / rowan patches).

Identify those stands that have been managed intensively in the past (particularly those that have been planted). Consider the need for management intervention to break up uniform structure and "kick start" natural processes. Where large scale mortality is anticipated, action may be needed more urgently to make stands less vulnerable to sudden decline (i.e. more robust: thinning around x dominant stems / hectare to develop the potential for large old trees and create niches for understorey reinitiation).

In planted stands, assess the site type by looking at soils and vegetation. Consider how appropriate oak dominated woodland is and manage the stand accordingly. Two examples are provided:

1. Where the site type is base rich and appropriate species (e.g. ash, bird cherry) are absent and unlikely to colonise from adjacent stands, introduce a small number of plants of local origin to act as future seed sources.

2. Where oak has been planted on cold north facing slopes at high altitude and its presence is desirable as part of the future species composition, enrich natural regeneration of birch, rowan etc., with oak plants of local origin (from woodlands with more ancient and natural characteristics).

Assess the conservation value of stems carefully, do not assume that small trees are of lower value for biodiversity. In some stands, many of the older trees are sub-dominant and have well developed epiphytic communities, valuable dead wood and associated species of fungi and invertebrates.

Stands which have been less intensively managed, particularly those on richer site types, appear to be more self sustaining (e.g. capable of vegetative regeneration). Avoid the clearance of fallen stems which may respond in this way.

Bracken was cut in the past for bedding and thatching. It was also trampled by cattle. In many Atlantic oakwoods rank stands of bracken now exist and its control may be necessary to recruit tree seedlings into the canopy. The role of managed grazing may be a particularly useful form of management to achieve this and a number of other objectives.

Where it is an objective of management to develop a resource of timber, concentrate management on those woodlands that have a uniform structure and have been intensively managed in the past. Some timber production from more diverse stands may be appropriate, particularly where the removal of high forest trees from around pasture veterans is necessary.

Recommendations for further research and information transfer

There is the potential to commission a PhD to carry out further age structure studies. The objective would be to focus studies on identified trees which exhibit typical characteristics of past management; look at these trees in the context of structural development at the stand scale, studying all species within the stand. Kinlochmoidart is seen as a good potential site for further studies.

Develop techniques to read cores of other species (particularly birch).

All future cores to be related to individual trees (as in Coed Cymerau) rather than looked at collectively for each stand.

Undertake thinning trials in upland oakwoods which have been managed intensively in the past. Assess best thinning regimes to promote favourable condition. Assess the impact of each treatment on ecological diversity, reproductive capacity and timber quality. - Part of this work is to be undertaken under a Life 3 project: "Woodland Habitat Restoration: Core sites for a Forest Habitat Network". Models described in the Peterken and Worrell report will be adopted as two of the treatments.

As a general principle, within published advice, ensure that the influence of woodland history on future stand management is given sufficient emphasis.

For demonstration purposes (to interpret the origin of inherited structures), reinstate active management in one or more Atlantic oak wood pastures, undertaking pollarding and managed grazing. Additionally, reinstate coppicing in an Atlantic oakwood that was originally planted.

Assess the soil moisture and soil nutrient status of other upland wood pastures to see if there is a connection between site type and past management.

Develop Francis Rose's New Index of Ecological Continuity and Sandy Coppins index for Atlantic Oakwoods to provide managers of Atlantic oakwoods with a guide (based on easily identifiable lichens) for assessing stand character and appropriate management (Peter Quelch suggested as the main author).

Include findings from this report in the Management of Upland Broadleaved woodlands Handbook.

References

Anderson, M. (1967) *A history of Scottish forestry*. Nelson, London and Edinburgh.

Backmeroff, C.E. and Peterken, G.F. (1988) *Coed Cymerau NNR Experimental plot - Tree monitoring in 1964 and 1988* Unpublished report to NCC

Bohan, R. (1997) *The Historical Ecology of The Woodlands of Ireland, Western Scotland and the Isle of Man.* PhD Thesis University of Dublin

Dye, J. Kirby, M. Gascoigne, M. Lawson, J. Kirby, J. and Read, J. (2001) *The Sunart Oakwoods, a report on their History and Archaeology.* The Sunart Oakwoods Research Group

Edwards, M.E. (1986) *Disturbance histories of four Snowdonian Woodlands and their relation to Atlantic Bryophyte Distributions* Biological Conservation **37** pp 301 - 320

Gwyn, D.Rh. (2001) *Cymerau Isaf Woodlands - Historical assessment* GAT project G1718 - report No. 426

Halliday, T.A. (1965) *A study of Coedydd Maentwrog, Merionethshire* Thesis University Coll. London

Lindsay, J.M. (1975) *The History of Oak Coppice in Scotland* Scottish Forestry **29** pp 87-93

Linnard, W. (2000) *Welsh Woods and Forests - a history* Gomer Press

Rose, F. (1993) *Ancient British Woodlands and their Epiphytes* British Wildlife **5**(2)

Murray, A. Driscoll, S.T. and Ballin-Smith, B. (1999) *Landscape around Castle Tioram - The Historical Evidence* - Glasgow University

Oliver, C.D. and Larson, B.C. (1996) *Forest Stand Dynamics* John Wiley and Sons

Oliver, D. (1992) *Coed Cymerau NNR Management plan* - unpublished NCC report

Peterken, G.F. (1996) *Natural Woodlands - Ecology and conservation in Northern Temperate Regions* Cambridge University Press

Peterken, G.F. and Worrell, R. (2001) *Conservation management of the Sunart Oakwoods SAC and the potential for supporting rural development* Report for Caledonian Partnership for the Life '97 project

Quelch, P. (2000) *Ancient Wood pasture in Scotland* Millennium Forests for Scotland

Rodwell, J.S. (1991). *British plant communities. 1. Woodlands and scrub.* Cambridge, Cambridge University Press.

Tittensor, R.M. (1970) *History of the Loch Lomond oakwoods.* Scottish Forestry **24** pp 100-18

Life '97 Age structure in Atlantic oakwoods - illustrations

Duntaynish


1. General view of plot – Duntaynish


2. This illustration shows old growth species *Lobaria scrobiculata* (with blue lobes) and *Loberia virens* (with green lobes) together with *Parmelia crinita* which also occurs in Barr Mor. – Duntaynish


3. This old trackway was possibly a route from a corn mill to loch side and may subsequently have been used to extract coppice material. – Duntaynish

4. Phoenix tree in Duntaynish.

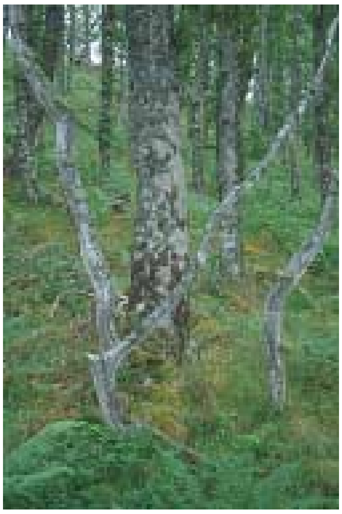
5. Peter Qulech showing the regeneration of a windblown oak (the original stem supports the root plate). – Duntaynish

6. Looking up into the Duntaynish plot.

 **7. Looking into the adjoining compartment. – Duntaynish**

Barr Mor

 **8. General view of plot. – Barr Mor.**

 **9. Naturally stored coppice with dead stems still evident at the base of the tree. – Barr Mor**.


10. Wall at the base of Barr Mor


11. A charcoal hearth or platform showing a supporting wall in the foreground. – Barr Mor


12. Looking down below the plot into diverse woodland. – Barr Mor


13. Looking up into the Barr Mor plot from the same location as plate 12 was taken.

Kinlochmoidart


14. One of several widely spaced coppice stems in Kinlochmoidart.

15. An example of a pollard at Kinlochmoidart.

16. A possible line of planted trees. – Kinlochmoidart

17. A fused coppice which has subsequently been pollarded – Kinlochmoidart

18. A birch showing ropey bark. – Kinlochmoidart

19. A charcoal hearth in Kinlochmoidart.

20. A sharpening stone – a common feature of charcoal hearths in the area. – Kinlochmoidart

Glen Beasdale

21. Glen Beasdasle plot.

22. Stored coppice at Glen Beasdale (outwith plot).


23. Naturally regenerated stem. – Geln Beasdale


24. Relatively old coppice stool. - Glen Beasdale

25. ***Lobaria pulmonaria*** **on open grown oak along the top of the bank. – Glen Beasdale**

26. Charcoal hearth in Glen Beasdale.

27. Group dieback of oak in the vicinity of Glen Beadale.

Coed Cymerau

28. Mid plot. – Coed Cymerau


29. Wall along the top of the bank. - Coed Cymerau


30. Woodland developed along the top of the bank since the 1960's. - Coed Cymerau

31. Understorey in the middle of the plot. - Coed Cymerau

32. Dead trees at the base of the bank. - Coed Cymerau

33. Remains of a fallen dead birch. - Coed Cymerau

34. Oak saplings in a gap created by senescent birch trees. - Coed Cymerau

Figure 3 Histogram of oak age classes - Duntaynish

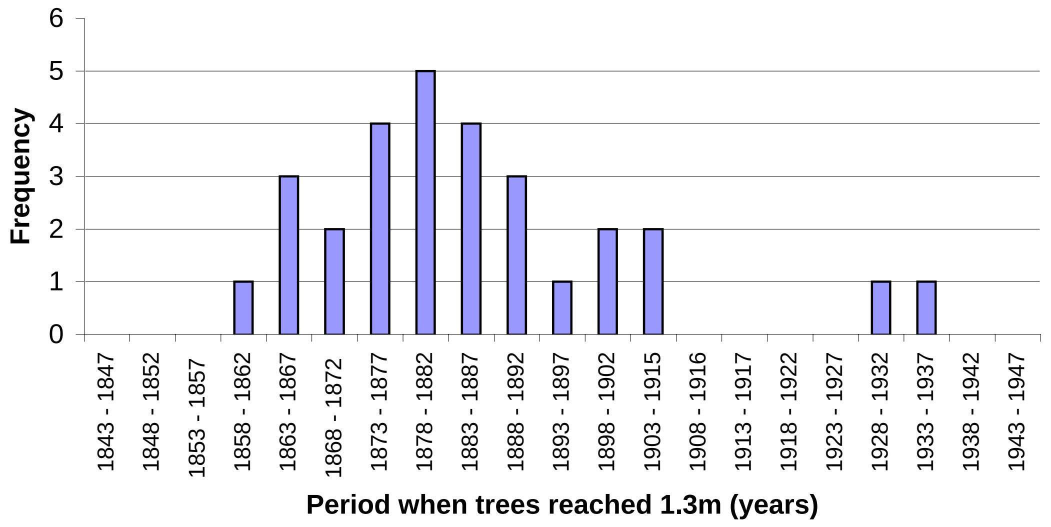


Figure 4 Histogram of Oak DBH Classes from Duntaynish

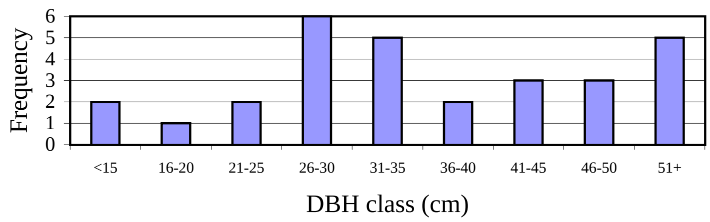


Figure 5 Taynish Oak - Age vs. DBH Plot

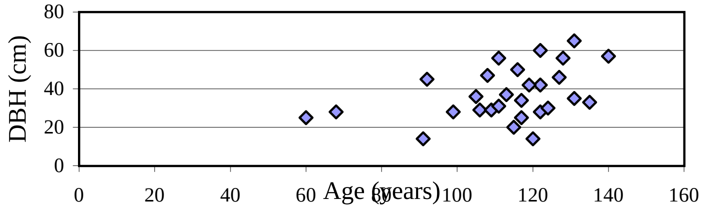


Figure 6 Histogram of oak age classes - Barr Mor

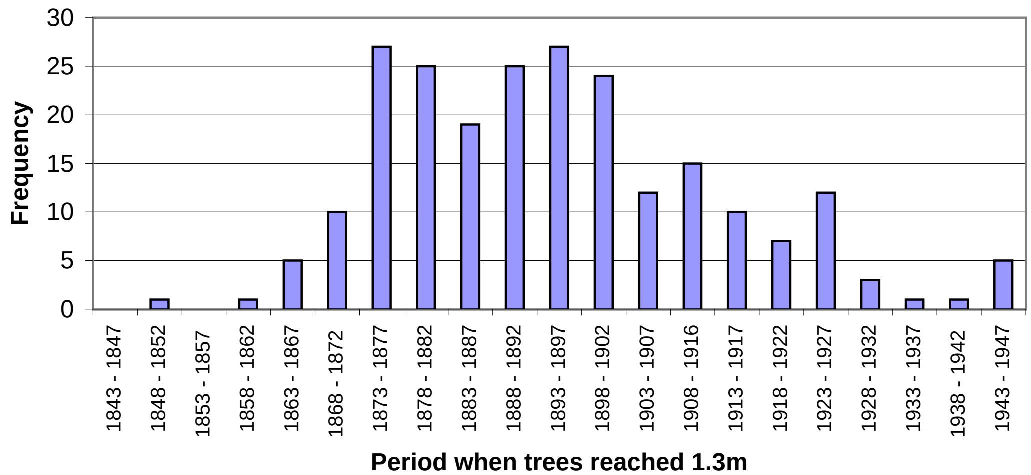


Figure 7 Histogram of oak DBH classes

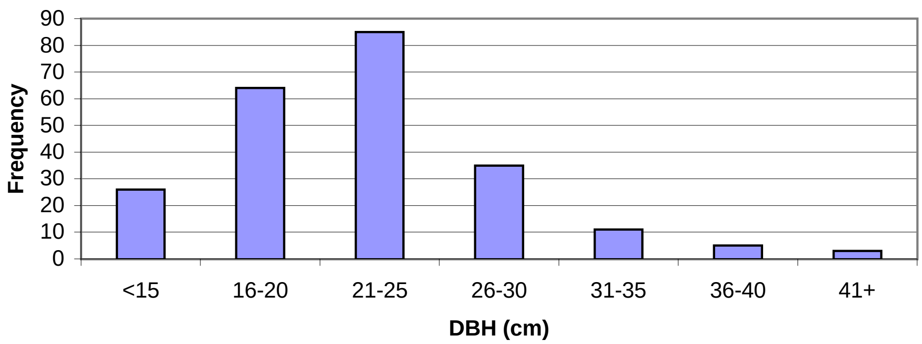


Figure 8 Oak - Age vs. DBH plot - Taynish 15.2

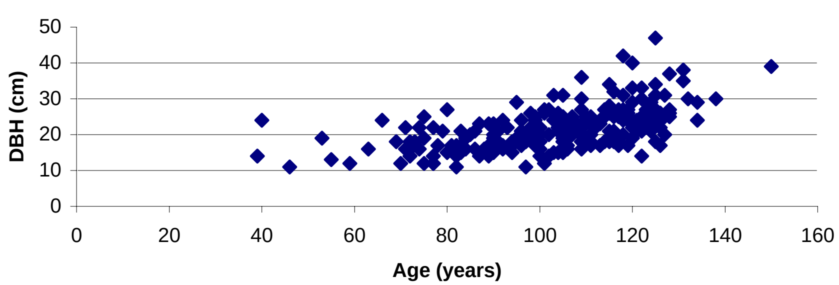


Figure 9 Histogram of age classes - Kinlochmoidart

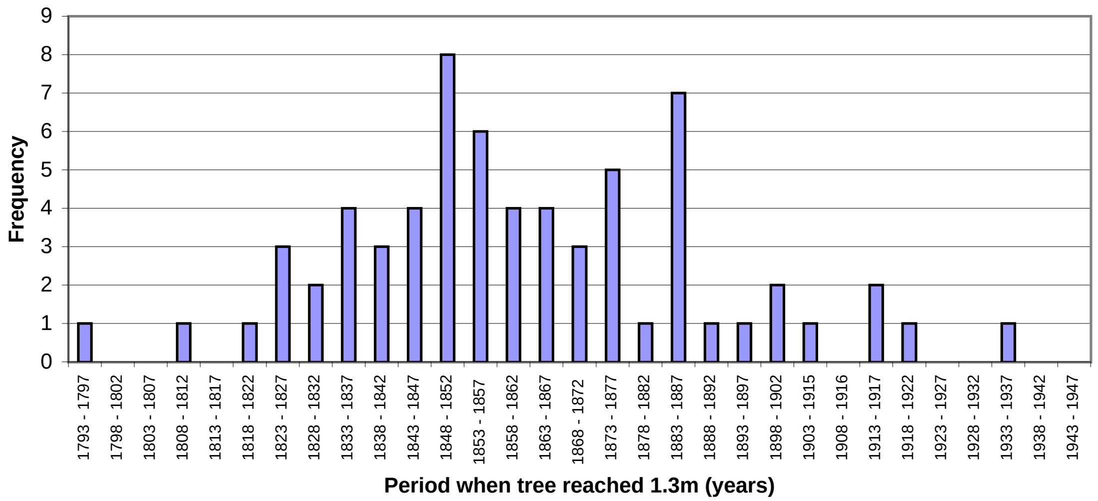


Figure 10 Histogram of Oak DBH Classes from Moidart

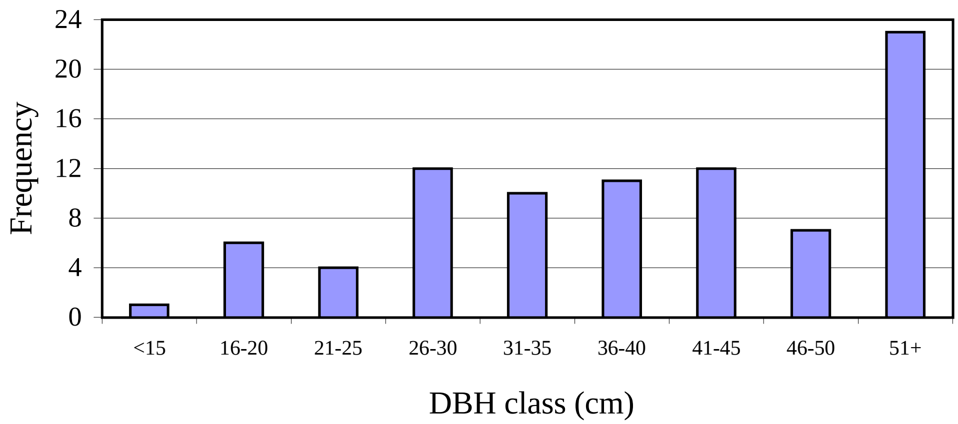
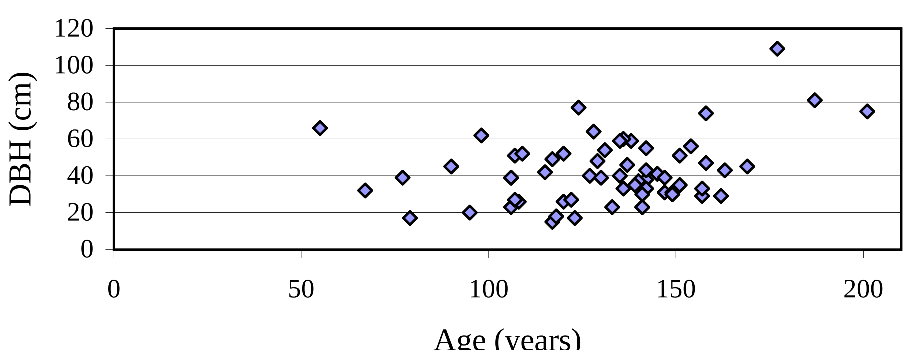


Figure 11 Moidart Oak - Age vs. DBH Plot



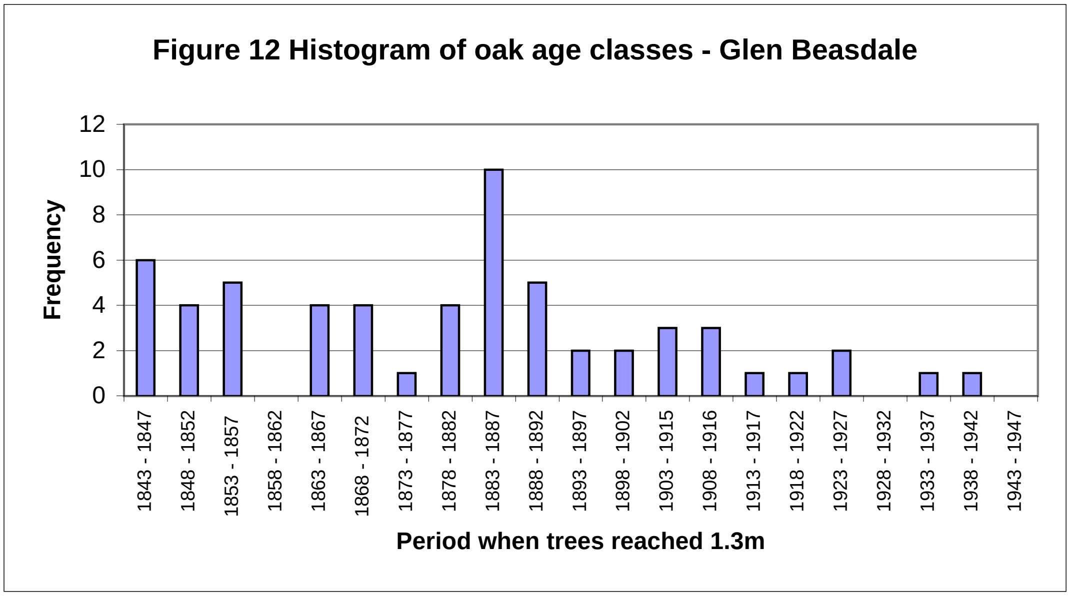


Figure 12 Histogram of oak age classes - Glen Beasdale
Frequency
12
10
8
6
4
2
0
1843 - 1847
1848 - 1852
1853 - 1857
1858 - 1862
1863 - 1867
1868 - 1872
1873 - 1877
1878 - 1882
1883 - 1887
1888 - 1892
1893 - 1897
1898 - 1902
1903 - 1915
1908 - 1916
1913 - 1917
1918 - 1922
1923 - 1927
1928 - 1932
1933 - 1937
1938 - 1942
1943 - 1947
Period when trees reached 1.3m

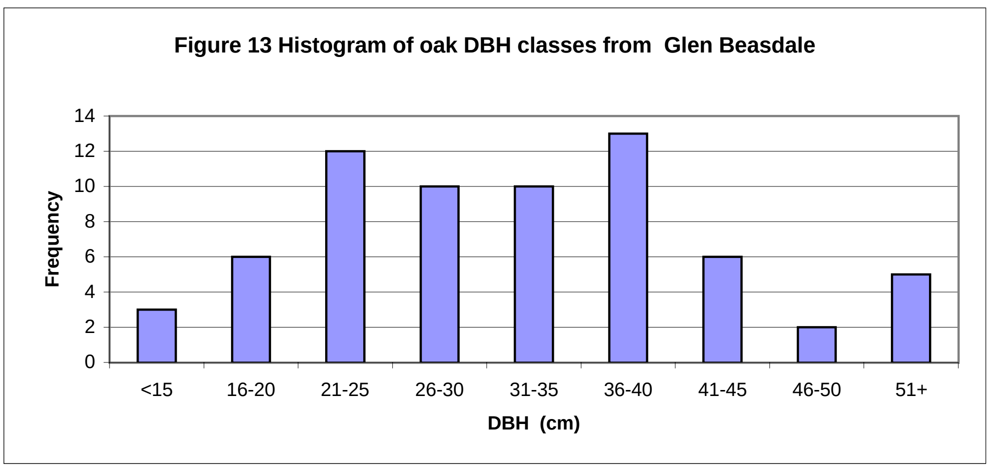


Figure 13 Histogram of oak DBH classes from Glen Beasdale
Frequency
14
12
10
8
6
4
2
0
<15
16-20
21-25
26-30
31-35
36-40
41-45
46-50
51+
DBH (cm)

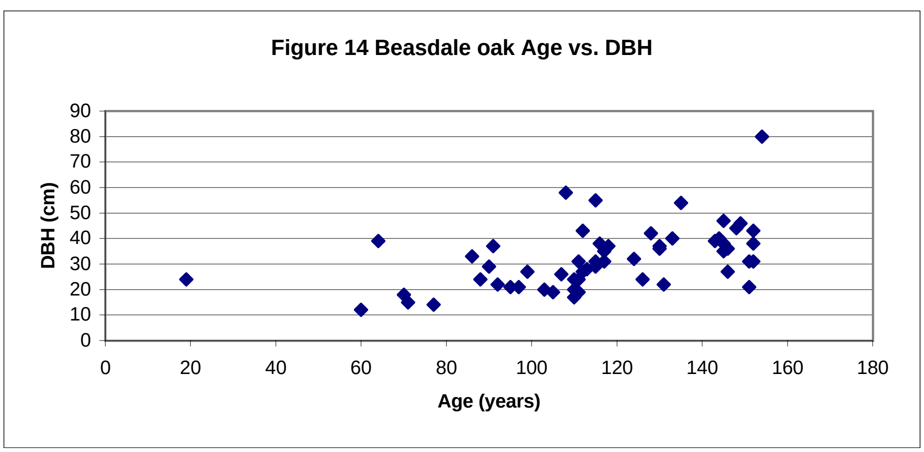


Figure 14 Beasdale oak Age vs. DBH
DBH (cm)
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
180
Age (years)

Figure 15 Histogram of oak age clases - Coed Cymerau

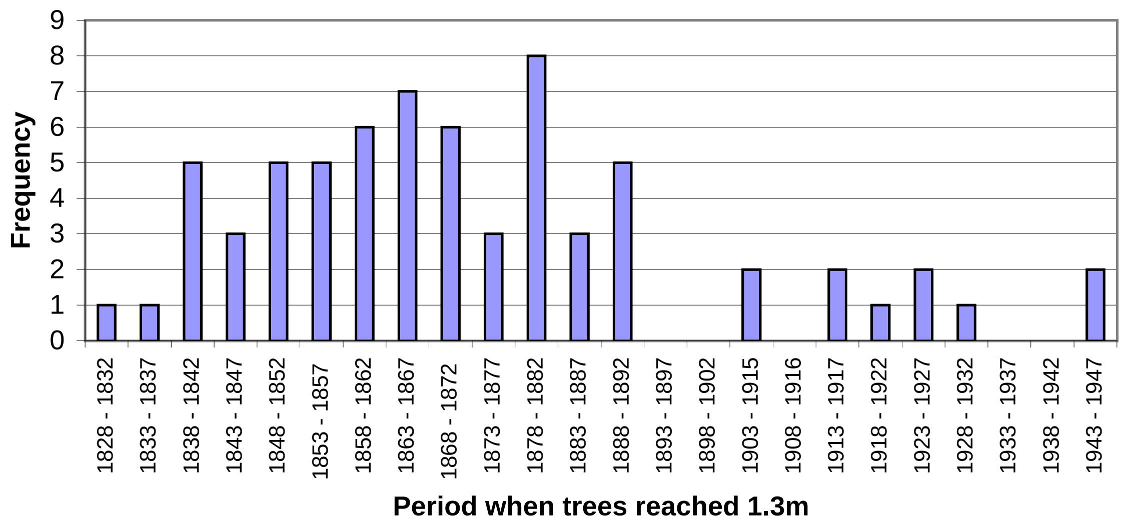


Figure 16 Histogram of Oak DBH Classes from Coed Cymerau

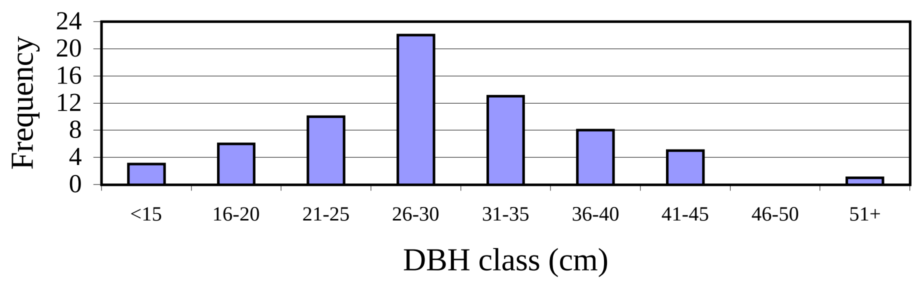


Figure 17 Coed Cymerau Oak - Age vs. DBH Plot

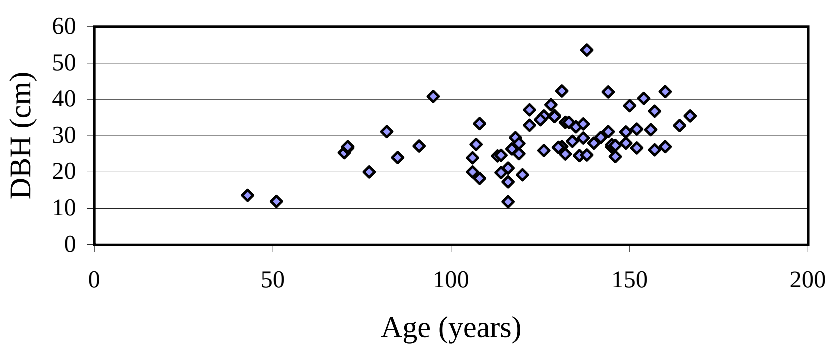
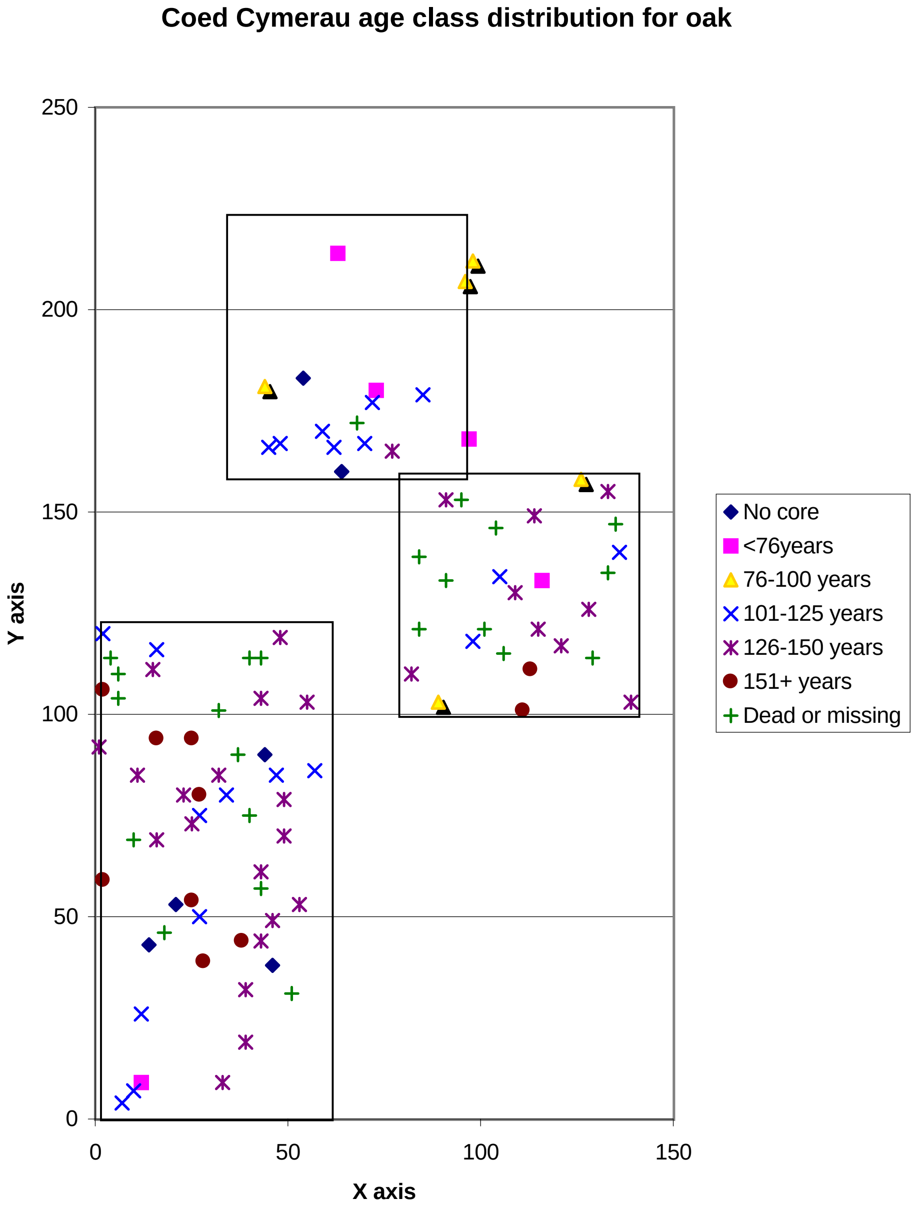
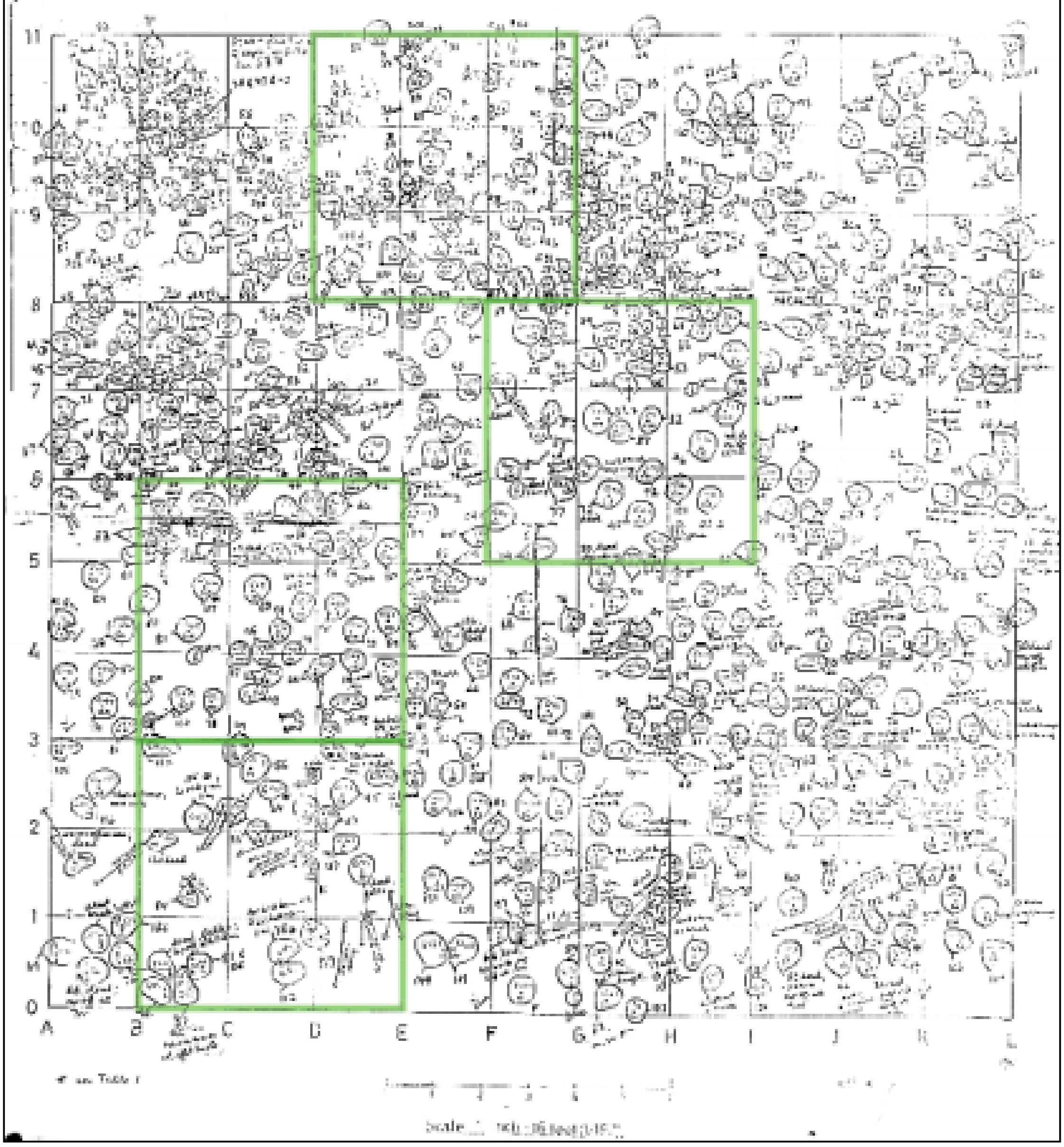


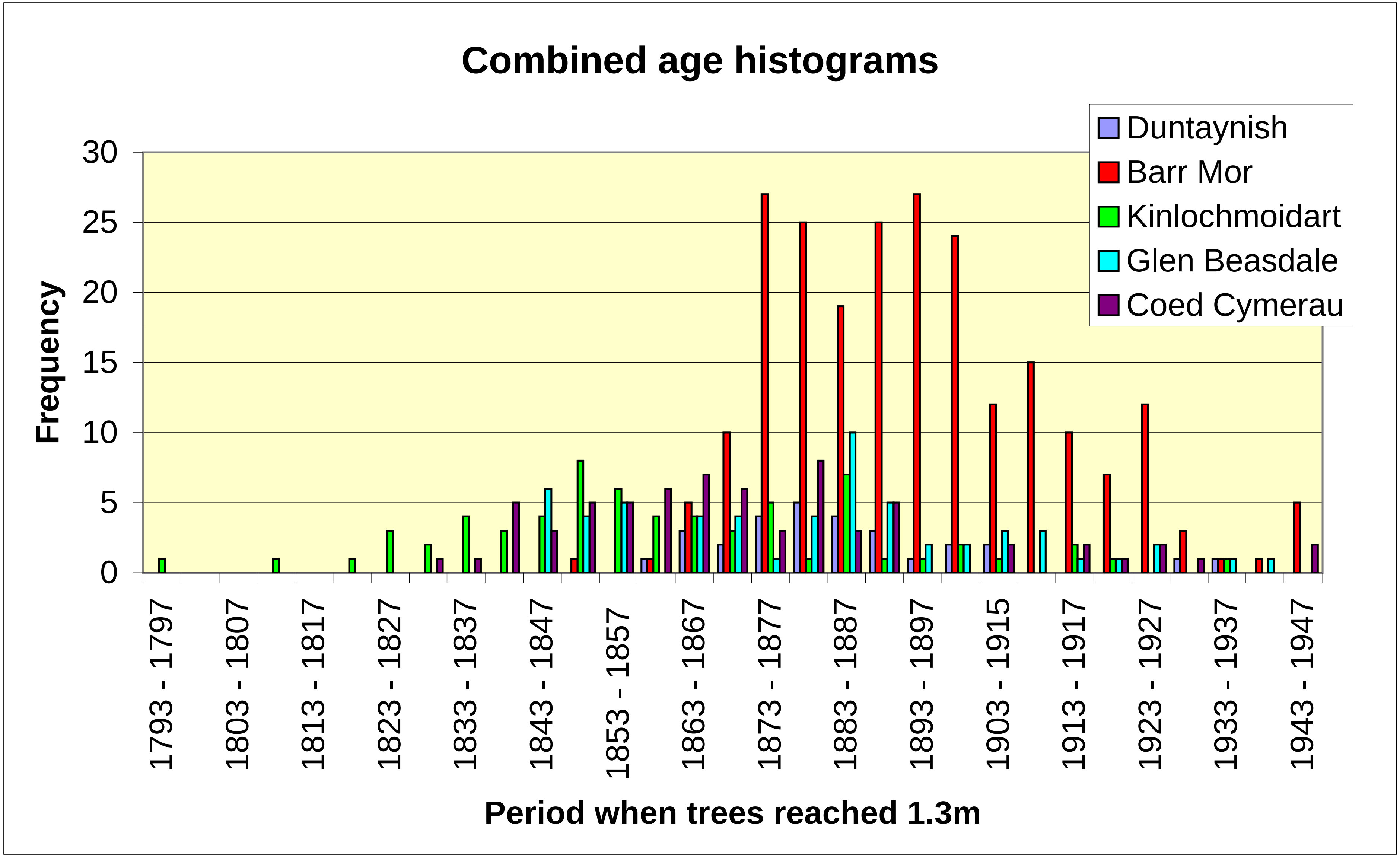
Figure 18



Coed Cymerau age class distribution for oak
250
200
150
100
50
0
0
50
100
150
Y axis
X axis
No core
<76years
76-100 years
101-125 years
126-150 years
151+ years
Dead or missing

Figure 19 COED CYMERAU – EXPERIMENTAL PLOT (Taken from Backmeroff and Peterken 1988)




Combined age histograms
Duntaynish
Barr Mor
Kinlochmoidart
Glen Beasdale
Coed Cymerau
Frequency
0
5
10
15
20
25
30
1793 - 1797
1803 - 1807
1813 - 1817
1823 - 1827
1833 - 1837
1843 - 1847
1853 - 1857
1863 - 1867
1873 - 1877
1883 - 1887
1893 - 1897
1903 - 1915
1913 - 1917
1923 - 1927
1933 - 1937
1943 - 1947
Period when trees reached 1.3m