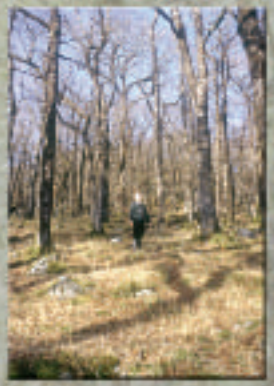
THINNING IN ATLANTIC OAKWOODS – ASSESSING OPTIONS AT THE STAND SCALE



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THINNING IN ATLANTIC OAKWOODS:
ASSESSING OPTIONS AT THE STAND SCALE

by

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A report commissioned by Highland Birchwoods

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Summary

- This report provides guidance to managers of mature oak coppice in Atlantic oakwoods; for the selection of stands and identification of trees for removal / retention in thinning operations. Information is applicable to Atlantic oakwoods where there is significant lower plant interest.

- The Peterken Worrell report (2001) provided a model for the management of existing mature high forest Atlantic oakwoods on Loch Sunart. This report develops that model, identifying opportunities at the stand scale for utilisation of oak timber and development of stand structure, in the context of maintenance or enhancement of biodiversity. Results are presented from a survey of biodiversity and timber values, and advice is provided for the selection of stands and individual trees, and the intensity and cycle of thinning together with choice of extraction technique.

- The surveys looked at the importance of trees for epiphytes, the potential of trees to become veterans, provision of shade for non-epiphytic bryophytes and timber quality.

- Results indicate that:

  - Timber is unlikely to be extracted on a commercial basis. However, it has the potential to support rural development through innovative application of locally grown wood.
  - 16% of trees had moderate to high timber quality, a further 19% of trees contained material suitable for flooring, craft use or cruck frames.
  - A uniform stand structure does not necessarily indicate low biodiversity values
  - In the majority of stands, some compromises are needed to remove sufficient trees to realise objectives. Trees shading bryophytes of moderate importance may be suitable candidates as their removal should only reduce the suitability of conditions for these lower plants, rather than removing interest directly.
  - Taking biological values into account, it was possible to remove 25% of standing basal area in 7 out of 12 plots surveyed but difficult to remove more than 10% in the remaining 5 plots.
  - Atlantic oakwood lower plants indicating ancient woodland need high humidity and varying degrees of shade. For rarer species, the balance between humidity and shade can be critical.
  - Wheeled vehicles should only be used to extract timber after extensive periods of dry weather.

- Thinning can be used to increase prospects for natural regeneration, increase tree species diversity, develop veterans (i.e. characterful trees with a range of niches for biodiversity / aesthetic value) and epiphytes, as well as produce timber and increase timber quality.

- Natural processes are changing the structure of Atlantic oakwoods. Changes are usually subtle and diversification of structure and species composition may take an extensive period. Conversely, storms can have a big impact which may occur over a larger scale than desirable in smaller woods.

- Stands suitable for thinning will have been coppiced or planted after the mid to late 19th century. Stands with high biodiversity values and frequent rock outcrops or steep sided ravines are unlikely to be suitable for thinning.

- Where there are signs of historic management such as wood pasture, judicious thinning around previously open grown trees may be appropriate to maintain the health of the tree and its epiphytes.

- Thinning intensities which remove around 25% of basal area will be necessary to have any appreciable effect on tree growth. The frequency of thinning will depend on objectives of management and response of retained trees.

- Criteria are included to select individual trees. The relative importance of lower plant species is specific to each woodland. Training locally employed native woodland advisors / project officers in lower plant identification is recommended together with employment of lower plant specialists where appropriate.

- Use of locally available low impact equipment is recommended to extract round logs or converted timber. Where material is extracted by a crofter or craftsman, the time required may not be as big a consideration as it would be to a timber contractor.

Contents

Introduction

Under the "LIFE '97 Restoration of Atlantic oakwoods" project, Peterken and Worrell (2001) (PW) looked at the conservation management and utilisation of Sunart oakwoods, many of which are designated as Special Areas of Conservation (SAC). They concentrated on the woodland and catchment scale, developing a strategic approach for management to achieve favourable condition whilst supporting rural development. This report was later developed into a "user guide" for oakwood managers and owners (Quelch 2002). The models have been adopted by the Sunart Oakwoods Initiative (SOI) and examples have been established for demonstration purposes.

One of the PW models, the Long-rotation High Forest Model (see appendix 1), provides guidance at the woodland scale for the diversification of mature oak woodland which was previously coppiced or planted. Whilst Peterken and Worrell were principally concerned with woodlands in SACs, this model is also of relevance to non-designated mature planted or coppiced oakwoods. The report also provided models for the management of a range of other woodland types, including developing native woodland on clear felled ancient woodland sites previously occupied by conifer plantations or new native woodland on previously unwooded sites. An appropriate model for this scenario is the standard rotation high forest model which is likely to become the focus of hardwood timber production in the future as such stands mature.

The PW report recommended production of a document to describe in detail the process of restructuring former coppice oakwoods for conservation benefit, and the timber outputs which are achievable. This report aims to address those issues by concentrating on the stand scale, providing managers with a checklist of considerations when determining how and where to thin and providing guidance for the assessment of stand qualities.

There are two main aspects:

1. Presentation of results of surveys of Atlantic oakwood stand qualities.

2. General recommendations for the selection of stands and trees for thinning and extraction techniques.

Figure 1: a mature oak stand which may have been planted – an appropriate structure to implement the Long-rotation High Forest Model.

Scope

This report provides guidance to managers of Atlantic oakwood for the implementation of the Long-rotation High Forest Model. Criteria are included to:

1. Assist with the preparation of management plans (particularly formulation of objectives and rationale).

2. Identify appropriate stands and facilitate the zoning of woodlands into the different PW models.

3. Identify trees for retention and removal to facilitate marking of selected stands.

Advice is most applicable for Atlantic oakwoods where there is significant lower plant interest. Some information will also be applicable to other oakwoods (e.g. general principles such as selecting sites which have previously been intensively worked and advice on extraction).

The survey

Background to the experiment and surveys

Stand management trials, co-funded by the European Community LIFE programme, are being established in Gleann Geal Atlantic oakwood, Ardtornish Estate (Lochaber, West Highlands of Scotland). The trials aim to assess:

1. The impact of different thinning intensities on lower plants.

2. The opportunities for production of oak timber.

3. The response of canopy trees to treatment.

4. The light requirements of native tree seedlings.

Prior to undertaking the thinning operations, three surveys have been completed to establish existing values, namely: bryophytes (by Ben Averis, consultant bryologist), lichens and veteran trees (by Peter Quelch, Forestry Commission Scotland's Biodiversity Advisor) and timber quality (by Gordon Gray Stephens, Scottish Native Woods, Argyll). This report presents results from those surveys, and provides an approach to synthesising the information obtained and discusses how compromises may be reached.

The objective of the lichen / veteran and bryophyte surveys was foremost to ensure that no features of a high conservation status were directly removed (i.e. those that occur on the trees as epiphytes or features of the trees themselves) and that conditions will be maintained for high value lower plants benefiting from the shade and humidity provided by the tree in question. The second objective was to identify those criteria which can be assessed by non-specialists when marking stands for thinning.

The objective of the timber survey was to allow us to identify: a) the proportion of trees within a stand which are of potential value for timber production; b) the proportion of those trees which are also of value for biodiversity, and; c) the degree to which high value trees can be favoured in a thinning operation for development. The survey also identifies a range of end uses for the selected trees (see Table 1).

The findings of the three surveys are specific to the woodland where they were undertaken. However, information recorded in these surveys should provide a basis for generic guidance for managers of other Atlantic oakwoods as conditions within this woodland are broadly representative – many stands have been influenced by a period of intensive management for production of raw materials (e.g. charcoal and tanbark).

In Scottish Atlantic oakwoods, the period of industrial use was typically between 1730 and 1860 (it is unclear how old trees within these stands are but they appear to have last been managed during this period). Stand structure in the majority of Atlantic oakwoods is thought to be unnaturally uniform. Gleann Geal is similar to other woodlands in this area, in that there are many signs of stand enrichment with oak, and some whole stands appear to have been planted. Species composition is thought to be artificially dominated by sessile oak (*Quercus petraea*) with only minor components of downy birch *(Betula pubescens*) and rowan (*Sorbus aucuparia*).

Survey methodology

It should be noted that the following methodology was designed for research purposes and is too costly and time consuming for normal woodland management. A more practical approach to tree selection is described later in this report.

The trial consists of twelve 0.1 hectare plots. Selection criteria for the plot locations were:

- high forest;
- comparatively uniform stands;
- >50 trees/plot, and;
- lack of management within the last 50 years.

Trees within each plot have been numbered and their approximate position mapped. The surveys took place during August and September 2003.

Each surveyor was asked to classify the interest within these stands into three importance classes. The classes refer to the tree and its associated species / timber quality rather than individual species which may occur on the tree or within shade cast by it. Surveyors were asked to examine each tree, score it and, where appropriate, make notes on particular qualities. They were also asked to refine importance classes as the survey progressed and weigh up the level of interest within this woodland compared to other Atlantic oakwoods in the area.

Importance class one
Trees with the highest values (biological or timber) in the woodland. Given the importance of Atlantic oakwoods for lower plants, this class also includes trees supporting or providing shade to some nationally uncommon bryophyte and lichen species.

Importance class two
Trees supporting moderate value lower plants; not particularly uncommon in the western Highlands but rare in a European context. For veteran trees and timber trees, of moderate current value and moderate future potential.

Importance class three
Trees providing conditions for lower plants which are common in western oakwoods and those of low timber quality, little potential for future veterans.

Limiting trees
Trees limiting the development of class one or two timber trees were also recorded.

Survey results

Biological values

Despite the relatively uniform nature of stands surveyed, 39% of trees surveyed had class 2 biodiversity values and 16% had class one biodiversity values. Figure 2 shows the number of counts for biodiversity values (note that one tree may have more than one count – e.g. be of value for lichens and bryophytes).

The following observations were made:

- There does not appear to be a good relationship between those trees that are good substrates for lichens and those that are good for epiphytic bryophytes.
- Many of the trees that are good for lichens are also existing or potential veterans.
- There is not a clear relationship between standing basal area (used as a surrogate measure for light levels) and biodiversity richness.
- Bryophytes on the ground appear to be more influenced by the presence of suitable niches such as boulders and rock outcrops together with localised shade rather than general stand conditions.
- Lichens were frequently associated with trees on crags where management may not have been so intensive in the past. However, they were also encountered within uniform stands if sufficient light levels existed, so predicting where good lichen trees were likely to be was not straight forward and each tree had to be checked. This was also the case for epiphytic bryophytes.

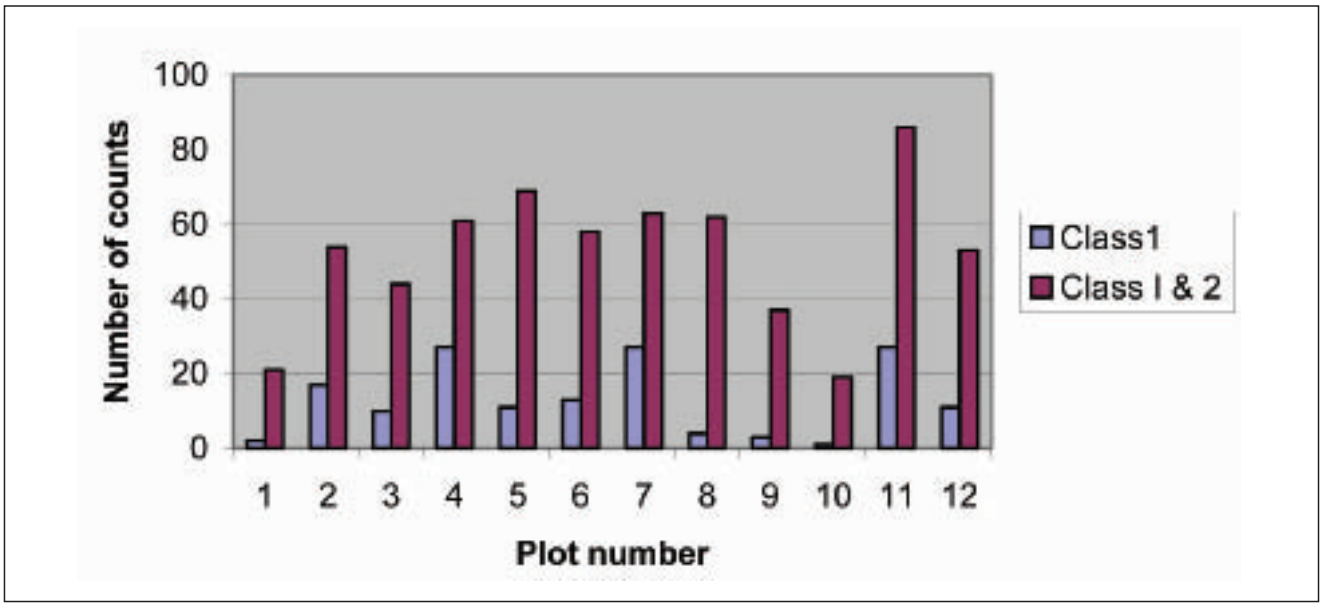
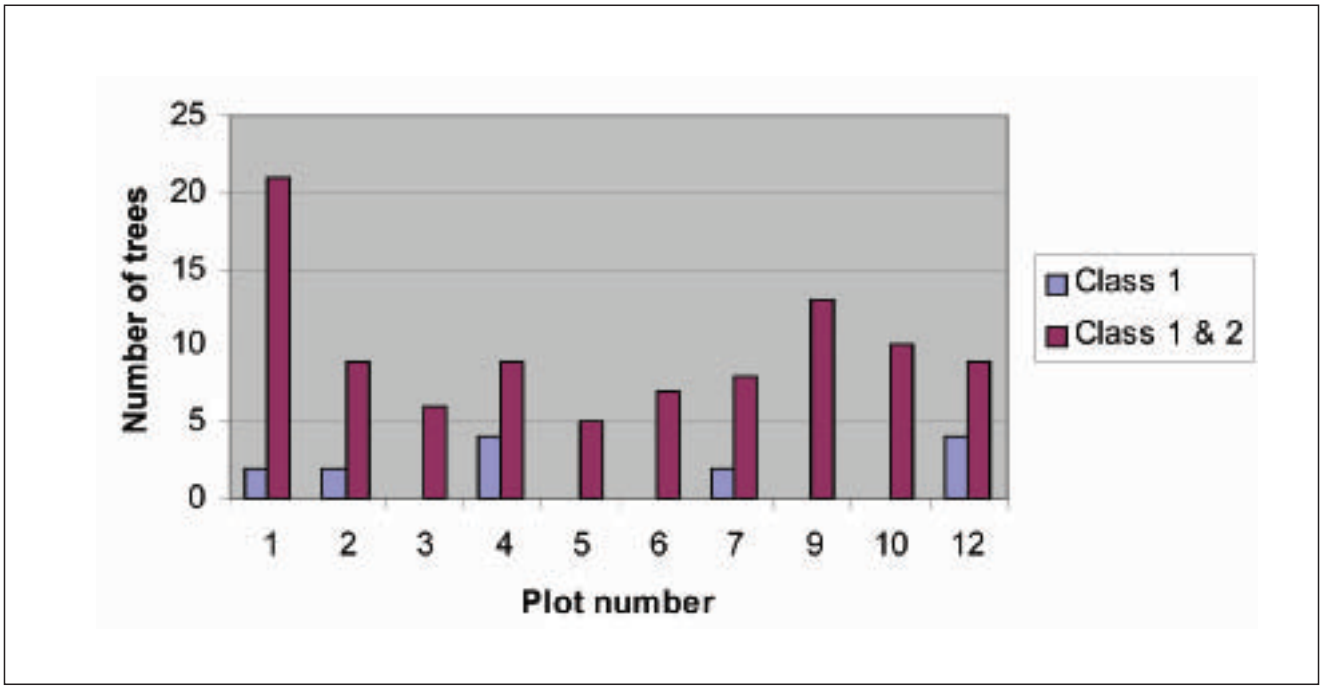


Figure 2: Count of biodiversity values.

Timber values

- A mean of 16% of trees per 0.1ha plot were in importance classes 1 or 2 for timber quality.
- The number of trees per plot with timber quality in class 1 or 2 was highly variable (maximum number of trees 21, minimum 5 with a standard deviation of 4.55).
- There was no relationship with timber quality and biodiversity values.
- The survey identified that many trees not in class 1 or 2 contain timber which could be used for short lengths for flooring or similar use, knees for boat repair, crucks for green oak buildings or features for craft use. Overall, 19% of trees out with classes 1 and 2 contained utilisable material.

Figure 3: Count of trees in timber quality classes 1 and 2 (NB data were not collected for plots 8 and 11).



Synthesis

Figure 4 shows the effect of combining the interests within each plot and the influence of one value on another. Trees which are shading bryophytes of moderate importance are likely to offer the best opportunities for compromise as, if felled and extracted, they would not be directly removing interest or altering the micro-climate of bryophytes with higher conservation status. The following assesses the effect of removing some trees in this category:

- If all biodiversity values are protected, 23% of trees with timber quality in class 1 and 2 could be felled. This would rise to 38% if those trees which also provide shade for class 2 bryophytes are felled.

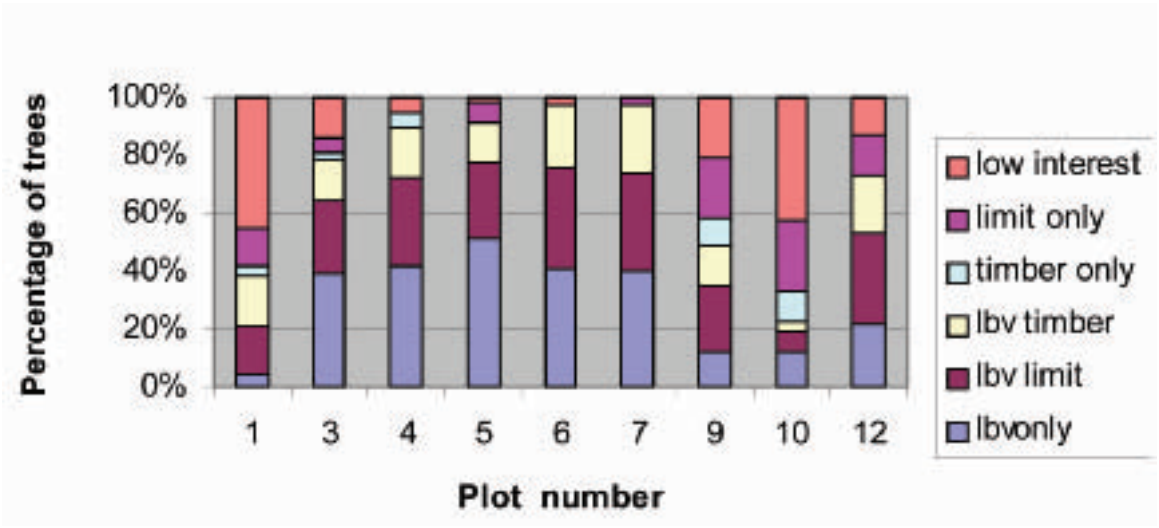
- A large number of trees were considered to limit the growth of timber class 1 and 2 trees. Figure 4 shows that many of these "limiting trees" also have biodiversity values (lbv) and opportunities to improve the future timber quality are limited (particularly in plots 3 to 7). Again, there are more opportunities to favour the development of timber trees if some trees shading class 2 bryophytes are removed.

- The development of some class 1 or 2 veteran and lichen trees was also limited by trees shading class 2 bryophytes.

In some cases, to realise objectives of thinning, some trees with moderate value epiphytes may need to be felled. Criteria to identify where removal of a tree will minimise impact are provided later in this report.

In plots with medium biodiversity values, finding sufficient trees to remove 25% of standing basal area was possible if some trees shading bryophytes of moderate importance were identified for removal. Two plots had sufficiently low biological values to make removal of 25-30% of standing basal area straightforward. We found that it would be difficult to remove more than 10% of standing basal area in plots with high biological values.

Figure 4: Synthesis of biodiversity values and timber quality



Explination of Figure 4.

- *"low interest"* indicates trees within plots which were assigned less than importance class 2 for all criteria.
- *"limit only"* are trees which are limiting the development of trees in timber quality classes 1 or 2.
- *"timber only"* are trees with timber quality classes 1 or 2 but no other interest.
- *"ibv timber"* are trees with biodiversity values and timber quality in class 1 or 2.
- *"ibv limit "* are trees with biodiversity values in class 1 or 2 which are also limiting the development of timber quality trees – class 1 or 2.
- *"ibv only"* are trees with biodiversity values in classes 1 or 2 and low timber quality, no potential to improve timber quality.

Key observations from surveyors

The following are key findings from the surveyors' reports. Some of the comments are quoted directly whilst others are summaries of more detailed information.

Timber quality – Gordon Gray Stephens

- The economics of timber production suggest that the small quantities of largely low grade timber being produced at Gleann Geal would be unlikely to be extracted on a commercial basis. However, supply of locally produced material may be put to good use by the local community and help to stimulate rural development.

- The activities of woodland groups and initiatives such as Argyll Green Woodworkers, Scottish Native Woods and Highland Birchwoods have demonstrated that there is the potential to add value to low grade hardwoods in the Highlands.

- Experience indicates that wheeled vehicles should only be used in western oakwoods when there has been a prolonged dry period. Use of vehicles during or immediately after wet periods can cause considerable difficulties.

There is a good fit between the timing of this trial and the development of a woodland group in Morvern. To foster wood skills and crafts among the local community, use of some of the material from the thinning trials is suggested for one of the following projects:

1. A cruck-framed building constructed as a community facility

2. A project centred around the reconstruction of a west coast birlinn could be achieved on a number of levels from construction of an individual boat to the development of a birlinn centre.

3. Distribution of small quantities of processed oak to local craftspeople and woodworkers with a reward for the best innovative use of the material.

[In recent years, the Sunart Oakwoods Initiative (SOI) has encouraged woodland-related community activity and rural development around Loch Sunart, initially focusing on the north side of the loch. In 2003, the Initiative was extended into Morvern. The Morvern Woodlands Project is funding native woodland restoration and access improvements, and developing community involvement in the woodlands of Morvern, through training, employment and events, delivered under the umbrella of the SOI.]

Table 1: Timber grading.

End use	Characteristics	Comments
Planking / beam	Minimum 2.5m straight stem without major visible defects. Minimum dbh of 45cms.	Sought after timber: most western oakwoods contain a very small number & Gleann Geal is no exception.
Small beam	Minimum 3m straight stem without major visible defects. Minimum dbh of 30cms.	Small beams are a valuable structural timber, fit for most domestic buildings.
Craft use/flooring	Small straight lengths & pippy trunks.	Previous work by Highland Birchwoods included acquisition of a mobile double slabber mill. This allowed 4 foot sections to be converted into flooring. Craft workers can find a good use for timber with "defects" .
Use in green oak buildings	Sound timbers with swept or "bent" stems or major branches can be used as cruck blades, collars and braces.	In addition to the beams and small beams certain "bent". This is a small, but growing market with good potential to add value.
Wooden Boat repair	90 degree bends from major branches and v forks.	Knees for wooden boats are a major market in America, and one which has not been exploited (to the surveyor's knowledge) in Scotland.

Bryophytes – Ben Averis

- The two most frequently encountered bryophytes of higher conservation status in this survey (*Adelanthus decipiens* and *Plagiochila atlantica*) are in Scotland strongly associated with native deciduous woodland with a long-recorded history of canopy cover ('Ancient' woodland). They are most common on SE-facing slopes and appear to demand a delicate balance of high atmospheric humidity and moderate amounts of light and warmth. This balance is likely to be upset by felling, especially as this would immediately let in much light on southerly aspects.
- The shade cast by trees to the S-SW of *Plagiochila atlantica* appears to be important in shading the liverwort from the strongest sun in the middle of the day and the afternoon, when conditions can be driest after morning dew has evaporated.
- Bryophytes of moderate importance require shaded, humid woodland. They are not particularly uncommon in the western Highlands but are important species in a European contex.

Table 2: Importance classes for bryophytes in Gleann Geal.
(NB the status of all species below is likely to be higher in woods further east and south of the study area)

Status	Species
High	*Adelanthus decipiens, Aphanolejeunea microscopica, Harpalejeunea molleri, Plagiochila atlantica* and *P. exigua.*
Moderate	*Bazzania trilobata, Hylocomium umbratum, Lejeunea patens, Mylia taylorii, Plagiochila killarniensis, Plagiochila punctata, Plagiochila spinulosa, Ptilium cristacastrensis, Saccogyna viticulosa, Scapania gracilis* and *Sphagnum quinquefarium.* *Hymenophyllum wilsonii* (Wilson's Filmy fern) is included as an 'honorary' bryophyte.

Lichens and veterans – Peter Quelch

- Any guidance on recognition of lichens to indicate habitat richness for thinning, should be restricted to the larger, more easily recognisable species. Rare crustose and scriptose lichens are difficult to identify on oak and are more typically found on smooth barked species within oakwoods (e.g. rowan) or in ash and hazel woods.

- Different tree species often support completely *different lichen flora*; additionally these flora *change as the trees mature*. Lichens do not grow at random on any trees but in distinct communities which vary according mainly to bark acidity. The most acidic trees are pine, birch and alder. By contrast ash, sallow and hazel are much less acidic and have a richer flora of lichens containing more ancient woodland indicator species. Young oak are acidic but become less so as they mature.

- The term ***veteranicity*** was adopted to show the potential for the tree to become a veteran oak of the future. Class 1 was probably large already with an open grown crown and a well lit trunk (which is also likely to increase its lichen substrate quality). Other features of veteranicity were: existing or incipient rot holes; forks; burrs; buttress swellings; and large coppice stool formation. Hence, sometimes a small group of stems was chosen to become a big coppice stool group of stems for the future. These were left unthinned especially if they were fairly open grown, with each having good crowns.

The ***colonisation and succession*** of lichens is akin to a gradual colonisation and succession of higher plant species over time on a bare soil site, which we are more familiar with. The young tree is colonised by certain common crustose species (e.g. *Lecanora chlarotera*) when it is young. These species are fast colonisers and therefore of no use as ancient woodland indicators. With continuing succession, more interesting species may colonise (e.g. *Thelotrema lepadinum* – a fairly easily recognised crustose species with characteristic "volcanoes". This species is only found in ancient woodlands and was fairly abundant in the Gleann Geal plots). This is followed by a successional stage when big foliose lichens, particularly *Parmelia*s, dominate - the Gleann Geal plots are more or less at that stage. When the trees mature enough for *Frullania tamarisci* (a purple leafy liverwort) to become established, larger foliose lichens move in on top of that liverwort and then lungworts and *Sticta* dominate. Smaller foliose lichens like the *Pannaria*s come in at that stage but never seem to dominate, though *Degelia* can reach large sizes but mainly on ash. Rare lichens like the *Pseudocyphellaria*s seem to be at the top of that pyramid of succession. [This species was encountered in the woodland surveyed but outwith the plots].

General recommendations for thinning in Atlantic oakwoods

Why thin?

There are several reasons why an owner / manager may wish to thin stands within Atlantic oakwoods:

- To prepare a stand for natural regeneration and increase the abundance and diversity of vascular plants. Dense stands which have been subject to intensive grazing may be in a poor condition for acorns to germinate and advanced regeneration to establish. Wavy hair-grass (*Deschampsia flexuosa*) is often dominant, with little accumulation of leaf litter; acorns are more vulnerable to predation and, in dry years, to desiccation. A light thinning combined with reduction of grazing animals, leads to increased light levels, and the development of small herbs and dwarf shrubs together with deeper litter layers.

  In addition, crowns of dominant oak should be more capable of bearing seed if given room to expand. These conditions should allow for more successful germination and establishment of oak advanced regeneration. Recruitment of that regeneration into the canopy would of course require development of larger canopy gaps subsequently.

- Species other than oak were often removed in intensively worked coppices. Therefore, today, there is only a scarce representation of species such as birch, rowan, holly and ash, which would naturally occur more frequently. Where tree species other than oak occur, thinning may be targeted to give these trees more growing space and to develop crowns for future seed production.

- All stands have a variety of tree sizes and forms. It may be desirable to develop a number of stems in each stand to provide candidates for future veteran trees (see the later sections on selection criteria to identify candidates).

- Stands with very low light levels (i.e. where standing basal area is >38-40m^2/ha) may have a sparse representation of old growth lichens or other epiphytes such as polypody ferns (*Polypodium* species). Where this is the case and important bryophytes will not suffer from increases in illumination, light thinning may be appropriate to increase lichen and fern abundance, provided sufficient humidity can be retained.

- The traditional reason for thinning is to develop timber quality and provide early supplies of timber. Demand for locally grown hardwood timber is increasing and its utilisation is seen as a potential vehicle for rural development in more remote communities.

Potential problems with thinning

- *Loss of shade and humidity*:
  In general, most lichen species prefer humid, dapple shade conditions. Stands with a large number of stems per hectare appear to be too dark for an abundant lichen flora to develop. Analysis of data from the experiment at Gleann Geal is required to provide clearer guidance. Some lichen species (e.g. *Dimerella lutea* and *Stictas*) are understood to prefer more shaded conditions (Averis and Coppins, 1998).

  Bryophyte species generally prefer more shaded conditions to lichens but similar levels of humidity. As stated by Averis in the survey for this report, some of the rarer bryophytes prefer very humid and moderately lit conditions found under medium density tree canopies on south facing slopes. It is thought that only a small reduction in the tree canopy could cause humidity levels to drop too low for particularly rare species to persist.

- *Loss of ecological continuity*:
  Rare woodland lichens and bryophytes require continued woodland cover to provide the conditions describe above. Any large scale disturbance which removes whole patches of old growth species (i.e. ancient woodland indicators) either directly through felling and extraction of groups of host trees or indirectly through loss of appropriate micro-climate conditions, will be very slow to recolonise due to poor dispersal abilities of species concerned and, for epiphytic species, the need for succession.

- *Windthrow*:
  As discussed below, windthrow is the most likely natural disturbance mechanism for Atlantic oakwoods. However, this is unlikely to be seen as a benefit from thinning unless it occurs sporadically.

- *Loss of "wilderness" value:*
  Due to the long period without management, these woodlands are considered by many members of the public to be 'natural' in their species composition and structure. Obvious signs of recent management are likely to reduce the aesthetic appeal of these woodlands in the short-term although development of large characterful trees and installation of multi-purpose paths (for public access and extraction) are likely to result in net public benefits in the longer term.

- *Extraction:*
  A lot of thought needs to be given to extraction routes, timing and choice of equipment to ensure that soil disturbance does not become a problem (see the section on extraction and conversion below).

Figure 5: This stand has been thinned within the last thirty years. It now shows much greater potential for timber production than elsewhere within the wood. A stand thinned for a variety of objectives would exhibit greater diversity in terms of tree size and form.

The role of natural processes

Stands which have arisen from intensive management will eventually begin to diversify through natural processes. For example, self-thinning is occurring in many of the plots in Gleann Geal: coppice stools are self singling and suppressed maiden trees are dying. Over the long term, this may lead to promotion of the more dominant stems. However, self thinning tends to lead to a uniform distribution of dominant trees and suppression of light demanding species. Occasionally, natural processes can cause larger scale disturbance over much shorter time spans. Storms can have a major impact, snapping and blowing down canopy trees to provide high volumes of large diameter deadwood and increased light levels for lichens, vascular plants and natural regeneration. However, examples of these events are rare and relying on such processes to diversify stands in small woodlands is a risky strategy.

The level of intervention in the context of historic management

Intensive oak coppicing regimes during the 18th and 19th centuries were of small extent and duration compared to woodlands further east (Smout, 1997) and therefore species could survive and move back into adjacent areas more successfully. Lower plants probably survived more intensively worked areas with refugia in gullies, on rock outcrops and on veteran trees on adjacent boundaries or in adjoining wood pasture. They have achieved their current condition due to a long period free from disturbance combined with suitable climatic conditions. Therefore, despite some evidence that patches may have been worked intensively for a short period, returning to any form of patch clearance in ancient woodlands larger than that needed to allow regeneration would be inappropriate.

Selecting stands for thinning

Stands most likely to be suitable for thinning are those which have been coppiced intensively or those planted and subsequently unmanaged. These may be large relatively uniform areas or, more typically on broken ground in the west, smaller components within a range of different stand types (see Figure 6).

In most cases, a number of objectives will exist for each stand but the balance between them will need to be prioritised. This will be influenced by characteristics such as; stand origin, the density of trees, topography within the stand and position in the woodland (e.g. lower top height of trees at higher elevation). For example, improvement of a stand for future timber production is likely to be targeted towards stands with heavy stocking and limited biodiversity values; and creating gaps for regeneration is likely to be most appropriate in stands of lower basal area and limited lower plant interest. (Two plots matching this description occur in Gleann Geal - the limited lower plant interest is thought to be due to lower humidity) .

The following describes broad habitat indicators where anything more than very localised thinning is unlikely to be appropriate:

Although intensive management had largely stopped on the west coast of Scotland by 1860s – 1880s, sections of some more accessible stands may have been opportunistically worked for firewood, fence posts etc. Where this took place longer than 50 years ago, lichen communities have often responded to increases in light and any subsequent thinning may be difficult to achieve without directly removing trees with a high abundance of important epiphytes.

Some topographic features within Atlantic oakwoods are likely to contain flora more sensitive to disturbance and are therefore best avoided in thinning operations unless specialist advice indicates that species would benefit. Rock outcrops and steep stream side banks are typical examples. These create conditions suitable for lower plants due to shelter and humidity and often to the lack of access for large-scale disturbance in the past. Ground water seepage from rocky slopes often causes soil base enrichment which provides conditions for small components of upland mixed ashwood.

Areas of former wood pasture often contain large open grown trees showing evidence of pollarding. Such areas can also contain remains of dwellings and shelter for livestock, together with sunken trackways and field boundaries. Former wood pastures are likely to be rich in biodiversity and contain important heritage features, therefore thinning is unlikely to be appropriate. However, gaps may have been enriched with planting or naturally regenerated into a thicket. Some judicious thinning around veteran trees may be appropriate here to improve light levels for lichens and the health of veteran tree crowns. In such cases specialist advice should be sought.

If the stand(s) has been surveyed by a lichenologist, their species list can be compared with indices of ecological continuity (Coppins and Coppins, 2002) to determine the level of disturbance that the site has experienced. Thinning will be inappropriate where the relevant index indicates an important site.

Thinning intensity and cycle

Removal of 10% of standing basal area is only likely to produce subtle changes (e.g. enough to increase light levels for lichens in heavily stocked stands). For most objectives, removal of 20-25% of standing basal area is likely to be required to make any significant difference to the growing condition of trees retained, be it for future timber production or development of potential veteran trees.

A thinning cycle of anything less than 10 years is likely to be too short given the age of trees and their potential to respond. Cycles in excess of 20 years may prove to be appropriate. The word cycle is perhaps misleading, indicating that a similar volume may be removed in subsequent operations. In the case of Atlantic oakwoods, future operations are likely to be clearly targeted to improving the condition of identified timber and veteran trees, removing a proportion of remaining timber trees or creating gaps for recruitment of regeneration.

Figure 6: a stand with uniform structure which indicates that thinning may be suitable (photo: Peter Quelch).

Identifying the value of individual trees

Objectives

The purpose of thinning is the first consideration. The following describes how differing objectives affect the choice of trees to mark for felling:

Regeneration

If the aim is to create gaps for regeneration, then removal of some bigger crowned dominant trees may be appropriate. Otherwise, it will be necessary to take a number of neighbouring trees (co-dominants and sub-dominants) to create sufficient light and freedom from other canopy interactions (e.g. canopy throughfall of defoliating invertebrates – Harding, 2002). Given the level of biological interest in the Gleann Geal plots, some reduction in suitable micro-climate conditions for ground-dwelling bryophytes of moderate importance and, possibly, removal of a proportion of trees with moderate value epiphytes, is likely to be necessary to achieve sufficiently low canopy cover for recruitment of oak seedlings. (See sections on selection for criteria to select appropriate trees).

Timber production

The aim of a thinning operation for timber production should not be to purely harvest stems of the best form, but to leave a proportion of these (for future production and to ensure that a full range of genotypes are maintained) and take some poorer formed trees which are limiting the development of the future timber resource. It will rarely be necessary to remove suppressed trees as these will be having little effect on the growth and form of trees retained for development (the exception will be where they are causing an obstruction to felling of more dominant stems). The initial stocking density and range of size classes will influence whether a crown thinning or intermediate thinning is undertaken (crown thinning concentrates on removing co-dominant trees in the canopy and intermediate takes some co-dominant and some sub-dominant trees).

Improving conditions for veteran trees and poorly represented tree species

It is usually obvious which trees are acting as direct competitors. Veterans and minor tree species are often sub-dominant and suppressed. Consideration should be given to the potential for these trees to respond to the removal of competitors and likely life span of the trees concerned, particularly where the tree to be removed may have other biological values. Where veteran trees are dominant, removal of competitors will generally be positive but care should be taken with existing veterans which have adapted to a closed high forest structure, not to create too large a gap around the crown otherwise their condition may deteriorate (Read, 2000).

Lichens

In general, increases in light in previously unmanaged ex-coppice or plantation stands are likely to be beneficial for epiphytic lichens, as long as a suitable level of humidity can be maintained. However, the degree to which this is the case varies between species. A field guide for lichen identification is planned and it is recommended that information on light requirements is included for each of the species described.

Creation of deadwood

Where objectives other than timber production are involved, substantial amounts of deadwood may be created by thinning. This is still likely to be the case where timber production is a main goal unless extraction is very straightforward and low value material such as firewood can be extracted economically. In such circumstances, positive steps will need to be taken to retain sufficient proportions of felled timber for deadwood (Peterken and Worrell (2001) indicate that around 40m3/ha is appropriate).

Summary of criteria for tree retention / selection

Veteran trees
(NB the criteria below are not mutually inclusive)

- open grown
- well lit around the trunk (or the potential to create sufficient light)
- good epiphytes (ferns and bracket fungi as well as lichens and bryophytes)
- large stem diameter
- existing or incipient rot holes
- fused stems (see figure 7)
- forks
- burrs
- buttress swellings
- large coppice stool formation
- large diameter dead branches
- trunk hollowing
- water pockets
- fallen trees which are growing up again from the main stem or root (known as phoenix trees)

Figure 7: Fused coppice stem – candidate for a future veteran tree (photo: Peter Quelch).

Lichens

In order to identify whether the lichen community on a particular tree should be retained, the interest within each woodland should be calibrated. Some species are obviously of high importance (e.g. *Lobaria amplisima*) or low importance (e.g. *Parmelia saxatilis*). However, it may be difficult to assess the value of a number of other species and the following criteria should be used to weigh up their status in the woodland concerned:

- *National and international status*:
  Reference can be made to Woods and Coppins (2003) to determine the conservation status of different species. The majority of species which constitute class 1 trees in this study, are classified as species for which Britain has international responsibility. Particular rarities such as the *Pseudocyphellaria*s have additional status as Near Threatened, and Nationally Scarce.

- *Abundance:*
  If the lichen species is well represented in the stand and the tree in question only has a very low abundance, this will reduce its relative importance.

- *Scarcity within the woodland:*
  If a species is generally considered to be of low to moderate importance but it only occurs on a very small number of trees within the woodland, retention of the trees concerned should be considered to maintain the full suite of species.

Figure 8: Large patch of the lichen *Lobaria virens* making this tree an obvious candidate for retention (photo: Peter Quelch).

- *The community of species:*
  Whilst individual species may be relatively common, if a community of lichens (e.g. the *Parmelietum laevigatae)* is particularly well developed on a tree within a stand with an otherwise poor representation, the tree may be considered an important example to be retained.

Weighing up these criteria will require training, experience and advice from specialists (see later).

Figure 9: A typical boulder important for Atlantic bryophytes.

Bryophytes

A similar approach to the one described above for lichens can be adopted for bryophytes. In addition, for non-epiphytic bryophytes, it is possible to identify a range of habitat types with which they are often associated:

- *Rock outcrops and boulders:*
  On steep surfaces, small oceanic liverworts can survive because larger, competitive bryophytes are unable to get a "foothold" (Averis and Coppins (1998) and see Figs 9 and 10).

- *Steep-sided ravines:*
  The atmosphere is very humid and a good diversity of rock habitats are present (Averis and Coppins 1998). Trees on the edge of such ravines influence the level of humidity – a belt of unthinned trees should be retained.

Figure 10: Close up of a section of the boulder showing *Plagiochila Atlantica* (centre) a class 1 bryophyte in Gleann Geal.

Timber trees

Criteria are summarised in table 3.

Importance class	Features
1	Dominant, balanced & good crown, straight main stem with timber volume, minimal deadwood.
1-2	Dominant tree with good crown, straight main stem with some small branches allowable, small quantities of deadwood allowed.
2	Co-dominant tree with two of the following: moderate crown, straight stem, small quantities of deadwood.
2-3	Sub-dominant tree with two of the following: moderate crown, straight stem, moderate amounts of deadwood.

Table 3: Importance classes for timber quality.

Selecting trees in practice

Unless surveys are undertaken by lower plant specialists and all interest is clearly identified on the ground, each potential candidate tree for removal will need to be checked for epiphytic interest, the qualities of the tree itself and the value of shade cast by it.

Many oakwood managers have a good working knowledge of lower plants and identification of the more obvious species may be relatively straight-forward. Where this knowledge is not available and specialists are not taken on to carry out a full survey, it is suggested that some training is undertaken. To avoid the need for a large number of people to be trained and to allow consolidation of training, it is recommended that individuals likely to be involved in the marking of a number of woods (e.g. woodland initiative project officers) are trained. A two-day course on Atlantic oakwood bryophytes and another on the Lobarion lichen community and associated species should provide oakwood managers with sufficient knowledge to identify the more conspicuous species.

It is worth approaching specialists even if a professional survey is not planned as many woodlands have been surveyed in the past and there may be existing knowledge about the location of rare species or reassurance that interest is very limited. At the least, some input from specialists is recommended to indicate the relative value of different species for the woodland in question. Scottish Natural Heritage or Forestry Commission offices should be able to provide details of lower plant surveyors.

Marking trees for thinning is a complex process of decision making, even in a conifer plantation. An initial period of familiarisation is normally required when beginning to mark each new stand. As discussed previously, the characteristics of the stand will influence the balance between different objectives for thinning. This will in turn affect what type of tree is selected for removal (e.g. dominants may need to be removed to create sufficient gaps for regeneration). The approach suggested is to temporarily mark those trees which should ideally be removed, then assess them for biodiversity values. It is often possible to select an alternative tree and assess the relative interest between the two. The intensity of thinning will again be tied to objectives and characteristics of the stand. It will be helpful to know the standing basal area and set a target for removal to assess whether the correct intensity has been reached (Hamilton and Christie, 1971).

A major consideration when selecting a tree for removal is the ease with which it can be felled. Damage to crowns of adjacent trees is inevitable when felling dominants and co-dominants but if a tree is likely to get hung up and a winch isn't available during felling operations, this should not be selected on safety grounds.

Extraction and conversion

This should be a primary consideration where timber production is a key objective. Where tracks c.2m wide exist, equipment such as all terrain cycles (quads) with specialist attachments or mini-forwarders may be appropriate. However, away from tracks, wheeled vehicles can cause a lot of disturbance in wet conditions and are not suitable where there are sections of side slope or frequent boulders. Horses may be appropriate for extraction across minor side slopes but, again, they are likely to cause disturbance in wet conditions. Where volumes are very low, a range of more labour intensive equipment may be appropriate, particularly where the operator is a crofter or craft worker for whom timber extraction only represents a small proportion of his or her working time and the capital outlay on more sophisticated equipment is not possible. Examples of this type of equipment would include chainsaw winches with skid cones and chainsaw mills for converting logs into boards, posts and beams at stump. Extraction of low volumes over uneven terrain may be possible using simple equipment such as the iron horse.

Routes should be continually assessed during extraction and operations ceased if the weather deteriorates. Where possible, a number of routes should be used for more flexible options such as the horse or iron horse to reduce the concentration of ground disturbance. If logs can be extracted prior to conversion, a mobile bandmill will be appropriate where sufficient volumes of suitable material can be collected. In more remote Atlantic oakwoods, transport and accommodation costs will need to be considered if hiring one of these saws from another area.

Unless static winching onto a hard trackway can be used, it is not realistic to undertake extraction without some impact on the ground. Limited soil disturbance (e.g. cutting shallow channels through the humus layer and the first 2 or 3 cm of the A horizon) should heal within 2 to 3 growing seasons. Where possible, consideration should be given to constructing narrow all terrain cycle tracks which can be used for future extraction, recreation routes and extraction of deer carcasses. The route and specification of these would need to be agreed with Forestry Commission woodland officers (and Scottish Natural Heritage if the woodland is designated).

Conclusions

It is possible to put the Long-rotation High Forest Model into practice with careful selection of stands and individual trees together with a considered and flexible approach to timber extraction. The following should ensure that structural diversity increases at the woodland scale in line with the indicators of favourable status outlined in the model: protecting and enhancing directly observed biodiversity values; protection of habitats indicating richer biodiversity; and selection of stands according to their access for timber extraction.

Creating gaps for regeneration may not be an issue, i.e. an open canopy may exist already due to trees dying and past grazing levels limiting regeneration. Alternatively, there may be opportunities to expand the existing woodland, encouraging regeneration at the woods margins. In both cases, some management will often be required to achieve this (e.g. bracken and herbivore control). There will be other cases where it is desirable to diversify the age structure and creation of canopy gaps is necessary to achieve this in the short to medium-term (e.g. in an isolated woodland or a series of woods dominated by one age class, with a closed canopy and no opportunities for expansion onto adjacent ground). In Atlantic woods with lower plant interest, some thought will be needed to determine where such gaps are created. Ideally, stands with a low basal area and little lower plant interest should be selected. Where such conditions don't occur, compromises will need to be made and relative values of trees assessed as discussed in the selection sections. In all cases, grazing pressure should be sufficiently low to allow advanced regeneration to exist under a canopy before gaps are created.

Volumes of high quality timber were low in the woods surveyed but innovative use of small dimension stock by local craftsmen or niche markets for cruck frames or boat repairs increases the potential for Atlantic oakwoods to promote rural development.

If all but the most common lower plants are protected from any impacts of thinning, it becomes difficult to thin at a sufficiently high intensity to make any difference to the growing conditions of retained trees. Moderate value bryophytes on the ground (i.e. those that are relatively frequently encountered in western oakwoods but are uncommon nationally) offer the opportunity for compromise as felling trees that shade them will not directly remove interest and such species are typically less exacting than rarer species, and hence are more capable of withstanding changes to their micro-climate. Criteria within this report should help to identify which trees with moderate value epiphytes can be removed without significantly reducing biodiversity values at the stand scale.

Where oakwood managers lack knowledge of lower plant identification, short courses are recommended for lichens and bryophytes of Atlantic oakwoods. Specialists should be approached for any existing knowledge of the woodland concerned and commissioned to do a survey where particular rarities are suspected.

Thinning has the potential to develop a woodland towards favourable condition, particularly for recruitment of regeneration, lichens, veteran trees and increased volumes of deadwood. If carried out in the wrong place, too intensively or without regard to the biodiversity values, it also has the potential to break long periods of ecological continuity and

Conclusions cont.

create an unfavourable micro-climate for some lower plants.

Choice of extraction equipment, routes and timing are primary considerations to avoid unacceptable levels of ground disturbance.

More information is needed to predict the impact of thinning in mature Atlantic oakwoods on lower plants. The experiment established at Gleann Geal should allow us to assess the response of a range of species to very light and moderate thinning intensities. It is recommended that future guidance on lichen identification includes details of light requirements so that managers can predict the impact of thinning. A field guide to the identification of Atlantic oakwood liverworts is also recommended.

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Appendix 1:

Long-rotation High Forest Model (Extract from Peterken and Worrell (2001) p.32).

This model would apply to woods where an existing mature structure is to be maintained, but from which a limited harvest of timber would be extracted. The basis would be rotations of 150-200 years, combined with small-scale felling and restocking by natural regeneration, planting, or both. Felling at this rate would allow 0.5-0.67% of the canopy to be renewed each year, but felling and restocking would in practice take place in episodes of, say, 10.0-13.4% restocking at intervals of 20 years. It would probably be practicable to use some of the ground in such woods as pasture. Favourable status would be maintained if:

- Mature and maturing stand structures to be maintained over at least 70% of the area. 'Maturing' in this instance would be 50 years growth or more, the age at which an oak plantation would be expected to develop an underwood, or the age at which a semi-natural oak-birch stand would start to appear mature and diverse. The criterion implies that up to 30% of an existing mature oak wood can be felled and restocked in the next 50 years.
- Rotation of canopy oaks to be at least 150 years. This allows much longer rotations, but ensures that the stand remains generally mature.
- Fell and restock patches to be a range of sizes up to 2 ha. This mimics natural disturbance patterns and allows openings large enough to allow oak to grow into the canopy without permitting large clear-fell coupes. Most gaps would be no more than the spread of 2-3 mature trees.
- Thinning no more than 30% crown thin in any one operation. This leaves a mature stand that would rapidly fill most canopy gaps by crown expansion.
- At least 50% of the site to remain unthinned during the last 10 years. This avoids disturbing at least half the site until the rest of the wood has recovered from the last operation.
- Canopy trees retained indefinitely to be at least 5 per ha. These provide a minimum density of large old trees.
- Deadwood volume to be at least 40 m^3/ha. This is slightly above the values generally obtained in managed semi-natural stands.
- Shrub layer covers at least 10% of area in stands over 50 years old. It can hardly be higher if it is to apply to strongly acid oak-birch woods.
- Regeneration predominantly natural by seedling regeneration or vegetative regrowth. In the event of regeneration failure, planting confined to oak at low density on less than 50% of available ground.
- Grazing and browsing to be reduced to allow regeneration for at least one period of 15 years in every 100 years over 50-75% of site. This allows a pulse of regeneration over a majority in gaps and as advanced regeneration in shade within the lifespan of canopy trees.
- Glades and other open space habitats (temporary and permanent) to occupy at least 10% of site. Gaps created by windthrow or silvicultural operations would count as open space habitats.

This model would maintain existing mature stands, and should be particularly suitable for mature oak woods. It perpetuates mature stands, but also diversifies the structure and helps to generate younger age-classes. It also enables timber to be utilised. The disadvantage is that stand structures and ground conditions that have been undisturbed by felling within recent decades would be disturbed, and that some habitat trees for epiphytes would be removed. Care would therefore be required to ensure that extracted trees are not only utilisable, but do not currently support rare epiphytes.

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