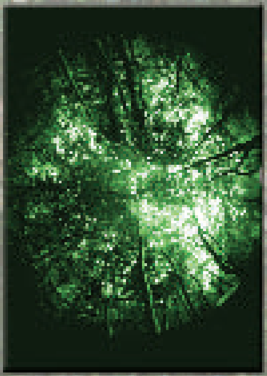
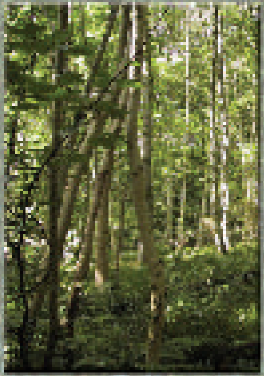
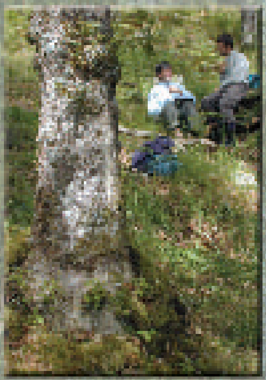
STAND DYNAMICS IN *TILIO-ACERION* WOODLANDS OF THE CLYDE VALLEY

BY RICHARD THOMPSON AND ANDREW PEACE

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by

Richard Thompson* and Andrew Peace*

A report commissioned by Highland Birchwoods

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Summary

- A considerable amount of recent management activity has been undertaken in the Clyde Valley with financial support from LIFE Nature under the Core Sites for a Forest Habitat Network project. One of the main activities was to reduce the amount of non-native trees.

- Forest Research was commissioned by LIFE Nature to assess the impact of this management and its effect on the regeneration of native tree species. The impact of herbivores was also assessed.

- It became apparent, as the study progressed, that a major influencing factor over the existing condition of the Clyde Valley woods and their response to management, was woodland history. A desk-based study (part funded by SNH and LIFE Nature) was undertaken by Stirling University's AHRC Centre for Environmental History to assess mapped and documentary evidence and to summarise the history of the woods concerned in this project. This history report (Sansum *et al*, 2005) was commissioned through the Core Forest Sites LIFE project, however, general recommendations derived from an assessment of the history study are provided here.

- Three woods were looked at in detail: Lower Nethan, Upper Nethan (both Scottish Wildlife Trust reserves and Special Areas of Conservation – SACs) and Jock's Gill (a SAC managed by SNH). They showed contrasting woodland composition, structure and regeneration potential. The Centre for Environmental History report (Sansum *et al*, 2005) shows that each wood also had a contrasting history of management: The stand assessed in Lower Nethan went through a phase as an orchard, Jock's Gill was at one time associated with an extensive designed landscape and subsequently inter-planted with conifers. Upper Nethan appears to have been coppiced from at least the 18th century and has been through phases as sparse, open woodland, until recently, grazed by cattle.

- Forest Research looked at tree regeneration and vegetation composition in 86 4x4m quadrats. Light levels were also recorded. In Lower Nethan, pre and post thinning, stand composition and basal area measurements were recorded.

- In Lower Nethan, data for a class of "good" ash regeneration were analysed and a positive relationship was established for diffuse light levels and amount of standing deadwood (principally elm). "Good" ash regeneration was also related to the presence of certain species of flora.

- There was a weak relationship between light levels and standing (live) basal area but, as a guide, a maximum of $30m^2$/ha is suggested as a threshold to initially secure advanced regeneration (greater levels of light being necessary to recruit saplings into the canopy).

- Pre thinning canopy cover of sycamore in Lower Nethan was 49%. This allowed a diverse flora (containing many woodland specialist species), and advanced regeneration of a range of native tree species to exist. Post thinning proportion of sycamore was 39%. An upper limit of 40% sycamore canopy cover (as assessed over the whole woodland) is suggested in terms of Favourable Condition.

- Browsing impact was variable between sites but was only considered to be a problem on one site (roe deer suppressing coppice shoots and heavily browsing sensitive species such as bramble). *Tilio-Acerion* woods are generally considered to be more tolerant of browsing than less productive woodland types because of available alternative forage.

- The Upland Mixed Ashwoods Habitat Action Plan was assessed in terms of its relevance to management of Clyde Valley woods. Actions were generally applicable although achieving unfavourable improving condition rather than favourable condition was thought to be more realistic in the defined time frame. There is a danger that Habitat Action Plan targets will be treated as prescriptions in individual stands. This could lead to loss of woodland condition (e.g. substantial reduction of canopy cover where sycamore is dominant). The critical issue is setting of objectives and limits for condition monitoring and establishing realistic timeframes.

- Most if not all of the woodlands in the Clyde Valley are in a period of transition from past intensive management (ending during the two world wars) and a regime, predominantly, of minimum intervention. Woodland dynamics are in a transitional phase which is heavily influenced by “introductions” of Dutch elm disease and colonisation by sycamore, beech and grey squirrels.

- The woodland history report (Sansum *et al*, 2005) provides very useful information about past management and how this has affected current structure and species composition. This has facilitated a much clearer understanding of the processes taking place, the time scale over which current conditions have developed and the need for management intervention.

- The history report (Sansum *et al*, 2005) also contains a lot of information about the use of woods and wood products for local purposes and latterly, for industry. This would seem to be an excellent educational resource, connecting local children with their ancestors’ life styles and encouraging them to see neighbouring woodlands in a new and positive context.

- The former distribution of semi-natural woodland in the Clyde Valley, from the 18th century onwards, can be determined from old maps. As many of these areas are now associated with hedgerows and old orchards (i.e. features which may have retained relict woodland communities) this would seem to be a good basis for initial planning of the future Forest Habitat Network.

Contents

Introduction

The majority of the ash-elm woodlands of the middle Clyde Valley catchment have been designated as Sites of Special Scientific Interest due to their importance for nature conservation. Many are also Special Areas of Conservation (SAC) due to their status as EU priority habitats, falling into the *Tilio – Acerion* ravine forest type. This collection of woods forms the most extensive example of ash-elm woodlands in Scotland (Peterken 2000).

These woods are very diverse, being botanically rich, topographically variable and structurally dynamic. They typically contain large volumes of deadwood, largely due to Dutch elm disease but also to unstable mature trees on steep slopes. However, this instability usually means that there are few very old trees. The National Vegetation Classification (NVC) (Rodwell 1991) ranges from W8 (elm-ash-hazel) on moist base rich sites and W9 (elm-ash-rowan) on drier base rich sites to W11 (oak-hazel) and W17 (oak-birch) on acidic soils (typically as an upper fringe above more base rich soils on the valley sides – e.g. Cleghorn Glen). In some areas (notably, Upper Nethan), localised stands of slope alderwood occur. These are best classified as Peterken stand type 7D.

The Clyde Valley landscape has been heavily influenced by man for centuries. Historical records suggest that use of the woods was diverse in the past and included non-woodland components such as orchards and designed landscapes with exotic species introduced as a result of enrichment planting. Today, the woods described within this study occur within a mosaic of intensive agriculture and urban settlements.

Background to the project

The SAC woods in this complex were included in the LIFE Nature project "Core Sites for a Forest Habitat Network" and this research was included in the project to provide guidance on management practices and their impact on woodland condition.

One of the aims of the Clyde Valley element of the LIFE project has been to reduce the abundance of exotic broadleaved trees to encourage regeneration and recruitment of native trees. This work has been undertaken with a long-term view and guidance is needed on the planning and monitoring of subsequent management in these stands.

The original remit of Forest Research's LIFE funded activities in the Clyde Valley was:

The project will look at the impact of removal of broadleaved exotics and thinning of native stands on woodland structure and composition and the subsequent impact on regeneration of native species. It will consider the intensity and timeframe of exotic removal and the effect on levels of light, native tree regeneration and vegetation competition. It will determine appropriate silvicultural regimes to favour the establishment of native species and identify the impact of browsing by deer and rabbits on regeneration.

Subsequent investigations of woodland dynamics made it clear that the past management of these sites has had a profound impact on their current ecology. A woodland history study by the Centre for Environmental History was therefore commissioned through SNH and funded by LIFE Nature to inform this report and improve our understanding about the role of Clyde Valley woodlands in the past. The history study forms a separate Highland Birchwoods report (Sansum *et al*, 2005).

Aims

The aims of Forest Research's work under this project are:

- to assess the influence of exotic tree removal/reduction on the regeneration of native tree species
- to assess whether certain vegetation communities are precursor indicators of suitable conditions for natural regeneration of native species
- to see how woodland history influences stand structure, species composition and regeneration mechanisms
- to provide recommendations for stand management in terms of timing and intensity of operations
- to provide recommendations for different management approaches according to the history and current structure
- to review the relevant woodland habitat action plan in relation to the Clyde Valley
- to assess what constitutes Favourable Condition for *Tilio-Acerion* habitat in relation to sycamore canopy cover.

Site Descriptions

Sections of three woodlands were studied in detail. These were Lower Nethan, Upper Nethan and Jock's Gill. The first two sites are managed by Scottish Wildlife Trust and the third by SNH. The following provide general descriptions of each site (adapted from the Clyde Valley LIFE web site) followed by specific descriptions of the transect locations.

Lower Nethan (Crossford, Lanarkshire)

OS Landranger Sheet Number:	72
National Grid Reference at site centre:	NS 818 465
National Grid Reference at Access point:	NS 824 470
Area:	43.2 hectares / 106.8 acres

A carboniferous limestone gorge containing semi-natural deciduous woodland with an complex structure and a rich ground flora. Herb-rich meadows and deciduous scrub form an integral part of the site. Several rare plant species have been recorded, including wood fescue and bird's nest orchid.

The site has a rich invertebrate fauna which includes a number of uncommon beetles (Coleoptera) - one of which is nationally rare and, associated with leaf litter, fungi and dead and decaying wood. This wood also contains rare species of saproxylic diptera (two species are Red Databank - Bratton 1991).

Transect locations

Two transects were located in the south-east section of the main block (see figure 1). Whilst this is a steep slope, it is relatively moderate terrain compared to the steeply incised gorge immediately to the north. The site has been worked in the recent past (1914 – see woodland history report) and has a canopy dominated by sycamore, with increasing amounts of dead elm to the north.

This wood was thinned in 2003/4 and timber extracted by horse.

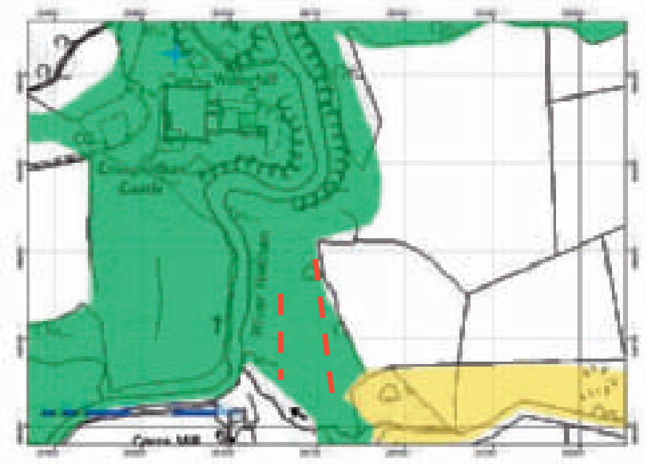


Figure 1: Lower Nethan Transects NS 817 461

Upper Nethan (North west of Blackwood, Lanarkshire)

OS Landranger Sheet Number:	72
National Grid Reference at site centre:	NS 803 447
National Grid Reference at Access point:	no public access
Area:	82.9 hectares / 199 acres

A riverine/gorge deciduous woodland on boulder clay and carboniferous limestone and calciferous sandstone outcrops. Wet, base-enriched mid and lower valley sides support slope alderwood, an unusual and restricted habitat. The level ground in the gorge bottom exhibits base-rich alderwoods which are also an unusual woodland habitat type in the district. The drier slopes of the gorge support ash-elm woodland and there are areas where oak is a dominant component. Secondary birch-dominated deciduous woodland is a feature of disturbed areas. Clearings with herb-rich permanent grassland are also present. The woodland had a diverse flora including unusual and locally uncommon species such as broad-leaved helleborine, wood melick and pendulous sedge. This is also the only known locality in Lanarkshire for great horsetail. The wet riverbanks also support a varied flora which includes alternate-leaved golden-saxifrage.

Cattle grazed the wood up until 1988 when SWT erected a stock fence.

Transect locations

One transect is located in an almost pure stand of ash, on a moderately steep slope, approximately half way between the upper boundary and the steeper banks above the river. The second is located on the upper slope, slightly to the north-west. This is in a stand dominated by alder with some birch and ash. Most of the trees on both areas have been coppiced, many of the stools are substantial. There are some maiden stems of ash in the transect 1 area.

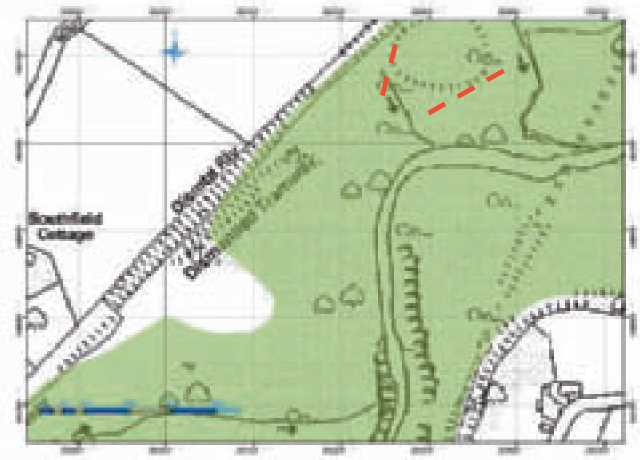


Figure 2: Upper Nethan Transects NS 803 451

Jocks Gill Wood (West of Carluke, Lanarkshire)

OS Landranger Sheet Number:	72
National Grid Reference at site centre:	NS 820 500
National Grid Reference at Access point:	no public access
Area:	55.6 hectares / 137.5 acres

A branched valley of considerable variety in topography, geology and woodland structure, dominated mainly by mixed deciduous woodland. A number of uncommon plants occur both in the woodland, peripheral scrub and invading coarse grassland, including birds-nest orchid and broad helleborine. One of the largest remaining areas of semi-natural gorge woodland in the Clyde Valley.

Transect locations

This wood contains one long transect running along the lower slope and floodplain. It begins in a relatively open woodland with patches of blackthorn and a small section of open fen, then enters high forest composed of a variety of species, predominantly native, with occasional sycamore and beech. Within this section there are a number of mature birch and goat willow.

Sycamore was felled to waste within this wood in 2003/4.

Figure 3: Jock's Gill Transect NS 823 502

Methodology

An initial survey was undertaken in the three woods described, using the following methodology:

Quadrats (4x4m) were established along pre-determined transects (with 14m between plot centres). The aim was to establish at least 20 and not more than 30 quadrats at each site. Each plot peg was marked with the number of the quadrat.

Within 4x4m quadrats the following assessments were made:

- percentage cover and mean height of all ground flora species.
- the number of seedlings/saplings of each species.
- the minimum height and mean height of all seedlings in each quadrat.
- the height of the five leading seedling/sapling stems/quadrat, noting the species of each.
- average length of leading shoot of the 5 leading seedlings/saplings (measured at the end of the growing season or last years growth).
- level of browsing (high, medium or low together with an indication of what is doing the browsing). hemispherical photographs taken in the growing season using standard protocol.

No distinction was made between seedlings and saplings and this report uses “seedlings” to describe all regeneration <7cm and up to 3m high.

In addition to the data collected within the 4x4m quadrats, one soil pit was dug for each vegetation type (pits were included for noticeable increases in plants indicating changing moisture status - e.g. meadowsweet). A separate record of the vegetation community and indication of the abundance was made where the soil pit was dug.

Post thinning assessment – Lower Nethan

A thinning operation was carried out through LIFE Nature funding as part of the Core Forest Sites project. The aim of this work was to reduce the number of non-native trees (in this case sycamore) and encourage natural regeneration of native tree species.

After the thinning operation, the quadrats described above were relocated and assessments 1-6 above were repeated.

In addition, the residual basal area was calculated by measuring the diameter at breast height of all trees within a 12m radius plot (centred on each quadrat). Stumps of recently felled trees were also measured and their underbark diameter was converted to a theoretical diameter at breast height using the following formula:

$$dbh = 1.6 + (0.7 \times SD)$$

Where

dbh = overbark dbh in centimetres

SD = underbark stump diameter in centimetres

This allowed an estimate of original basal area. The species of each tree or stump was recorded together with a record of whether it was live or dead (for stumps, assumed alive or dead when felled).

Results

Two of the woods surveyed (Jock's Gill and Lower Nethan) had a substantial amount of regeneration. However, few seedlings were recorded in either transect in Upper Nethan (see figure 4).

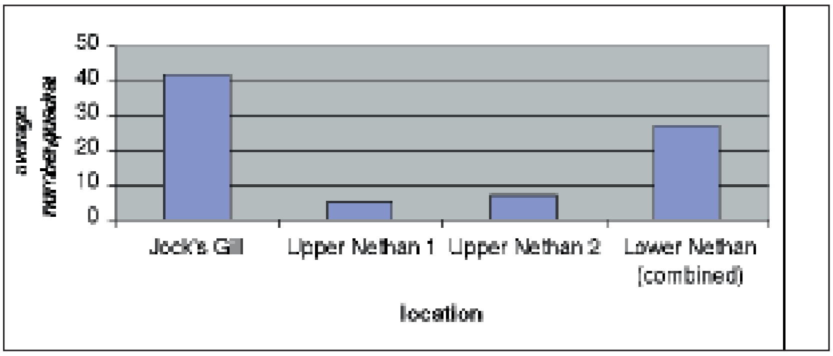


Figure 4: Average number of seedlings per quadrat

Lower Nethan

Figure 5 shows the proportion and species of tree regeneration in Lower Nethan quadrats. Data were combined for both transects as there was little difference between transects in terms of seedling numbers/species per quadrat.

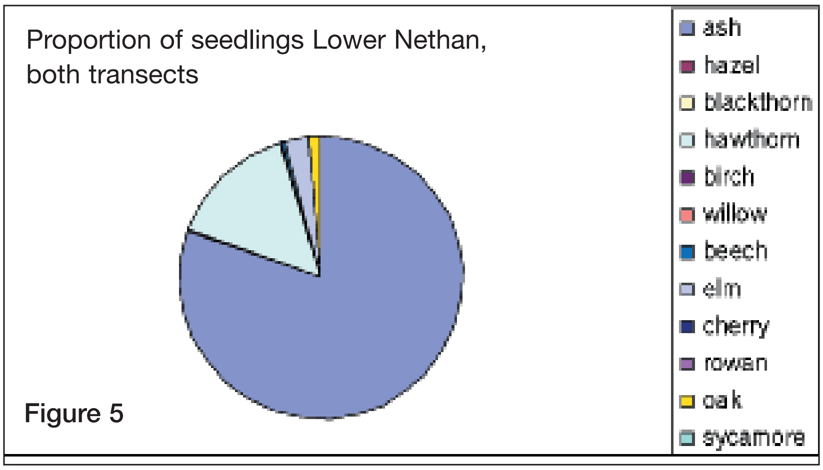


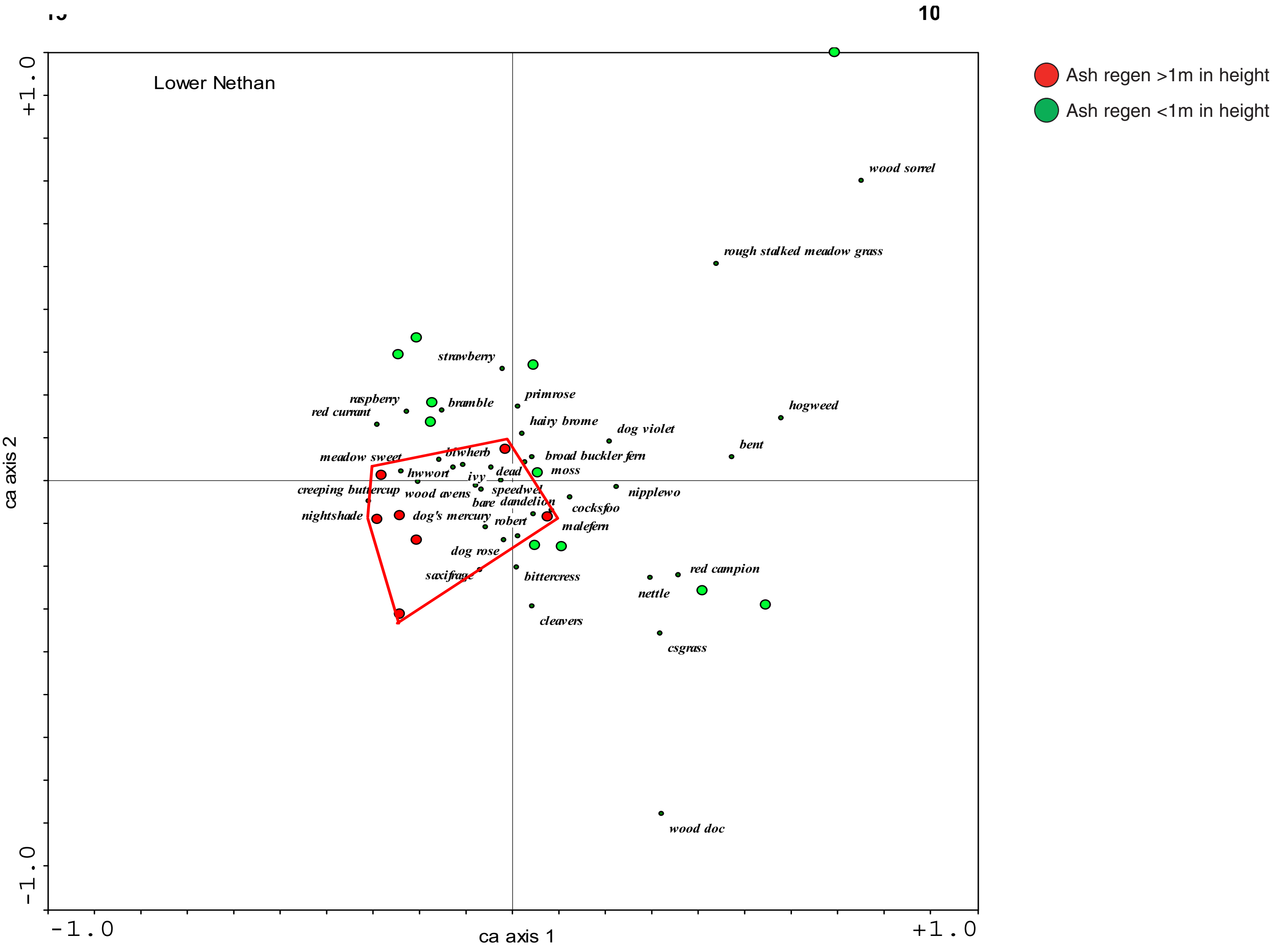
Figure 5

The effect of light, deadwood and vegetation community were computed for seedling abundance and height. When all size classes and species were assessed, no meaningful results were obtained. The summarised data set contained a wide range of seedling parameters including a number of species with differing shade tolerance and a wide range of seedling numbers and heights. There was a relationship between seedling height and seedling abundance and therefore there parameters could not be considered independently.

A sub-set of data were therefore used to reassess the impact of the variables described (i.e. light, deadwood and vegetation community). Quadrats were selected where they contained 10 or more ash seedlings over 1m height. The rationale for selecting this sub-set is that ash is the main target canopy species and if they reach 1m in height, this indicates that conditions are conducive for recruitment. This sub-set is referred to as "good" regeneration. "Poor" regeneration refers to quadrats which had more than 10 ash seedlings that were less than 1m in height (see table 1).

Figure 6 shows that there is a grouping of quadrats with good regeneration in terms of which species of ground flora they typically occur with. It is possible that the seedlings themselves may have altered conditions and affected the composition of ground flora. When average "Hill-Ellenberg" values for reaction and nitrogen (R+N – i.e. soil nutrient requirements) are calculated for each species, the average value for good ash regeneration is slightly higher than that for areas with "poor" regeneration. It is not straight forward to assess this directly as some of the species in the "poor" areas have high R+N values but only grow in very open conditions and may themselves have created unfavourable competition for ash regeneration (e.g. cock's foot and cleavers).

Figure 6: Ordination of "good" (red) and "poor" (green) regeneration classes in relation to ground flora species – Lower Nethan



Good ash	**Poor ash**
broadleaved willow herb	wild strawberry
hedge woundwort	primrose
creeping buttercup	raspberry
wood avens	bramble
dog's mercury	hairy Brome
dandelion	dog violet
ivy	broad buckler fern
wood speedwell	cocksfoot
dog rose	common bent
o-l- golden saxifrage	nipplewort
herb robert	red campion
enchanters nightshade	male fern
meadowsweet	cleavers
	creeping soft grass
	hogweed
	wood sorrel
	nettle
	rough stalked meadow grass

Table 1: Lower Nethan - ground flora species in relation to "Good" and "Poor" regeneration classes

The sub-set was also used to assess the influence of light. Table 2 shows that there is a relationship with higher light levels and the occurrence of "good" regeneration.

Similarly, there is a relationship with good regeneration and the basal area of standing deadwood (the majority being dead elm). See table 3. This may be due simply to increased light levels provided by the loss of canopy cover. However, there may be more complex processes taking place (e.g. mycorrhizal associations benefiting from dead elm roots).

Regeneration class	Mean light level (diffuse light)
Good	0.1614
Poor	0.1135

P=0.002

Table 2: Ash regeneration class in relation to available diffuse light levels

Regeneration class	Mean standing deadwood basal area (m^2/ha)
Good	11.56
Poor	7.52

P= 0.061

Table 3: Ash regeneration class in relation to basal area of standing deadwood

There is a slight relationship between regeneration and basal area (of live trees only). However, in absolute terms, this is not convincing and side light from outwith the 12m radius basal area plot is likely to be critical to the height and abundance of regeneration within the plot (see table 4).

It was not possible to identify meaningful differences between soil samples using visual assessments. In all cases, the soil type was a brown earth, humus was mull and soil texture was silty-clay-loam. Any future analysis of soil properties within this woodland type will use instrumentation to obtain more accurate results.

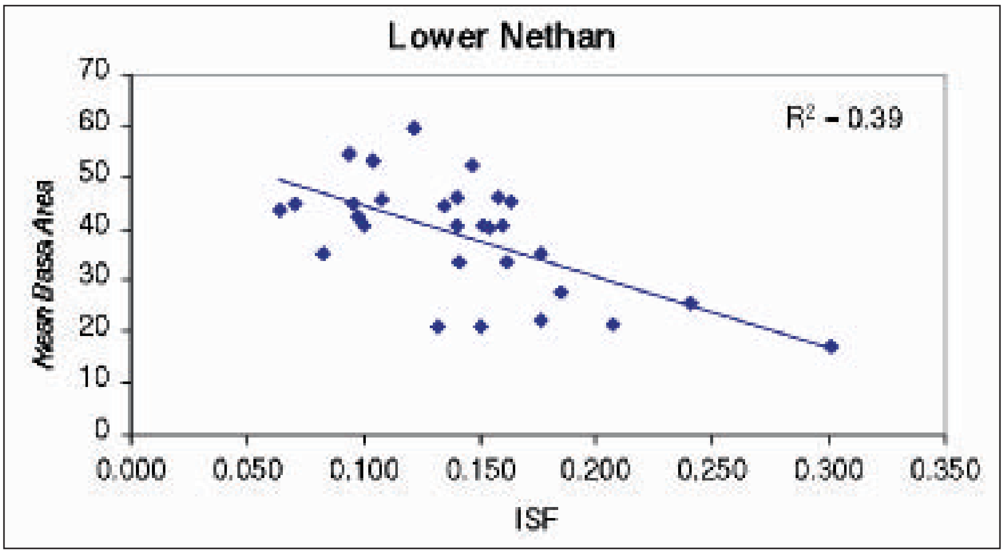
Regeneration class	Mean standing basal area (m^2/ha)
Good	40.62
Poor	35.45

P=0.161

Table 4: Ash regeneration class in relation to original (pre-thinning) basal area of live trees

There is a relationship between diffuse light and basal area (see figure 7). This is not very convincing and, as discussed in relation to table 3, it is thought that 12m radius basal area plots are unlikely to capture the influence of side light which appears to be very important for these valley side woods. However, working from data in tables 1 and 3, we suggest that an approximate target basal area of 30m^2/ha should be aimed for when attempting to initially secure advanced regeneration. A more open canopy would be necessary for saplings to be subsequently recruited into the canopy.

Figure 7: Relationship between original basal area and ISF (diffuse light) – Lower Nethan



Lower Nethan: post thinning survey

The following figures (8-10) show original and residual basal area for the area thinned in Lower Nethan. Sycamore accounted for 86% of felled basal area. However, this only reduced the proportion of sycamore in the wood by 10% (from 49% to 39%) with proportionate increases in ash, oak and elm.

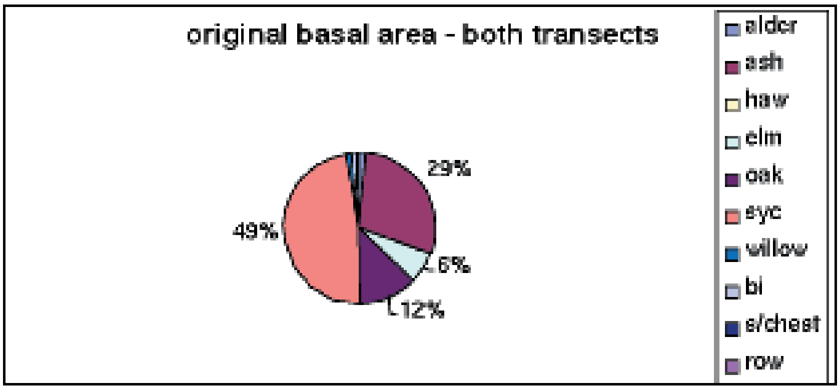


Figure 8

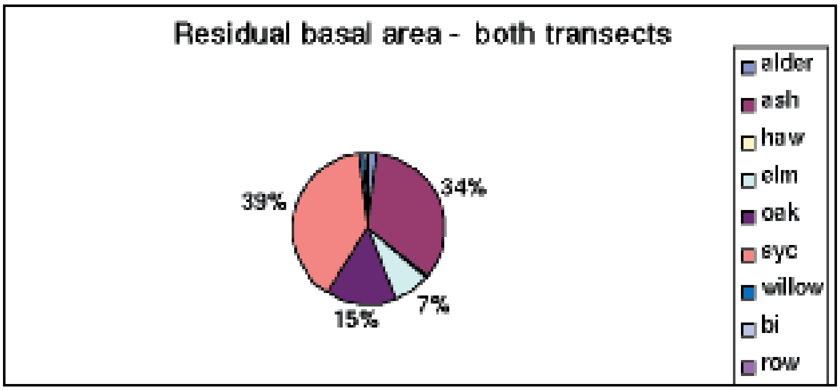


Figure 9

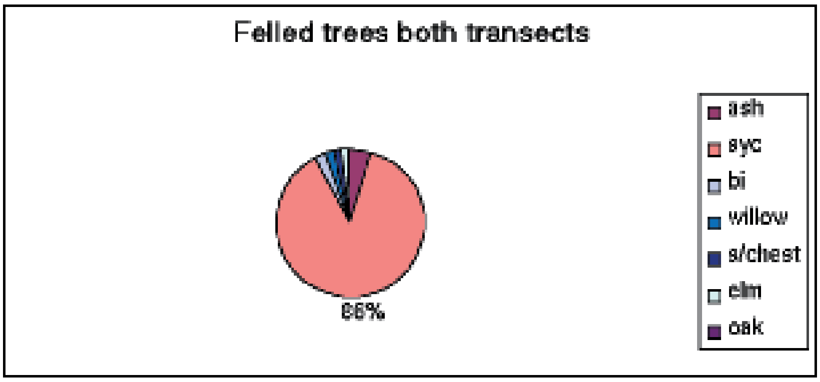


Figure 10

Jock's Gill

Figure 11 shows the proportion and species of tree regeneration in Jock's Gill quadrats.

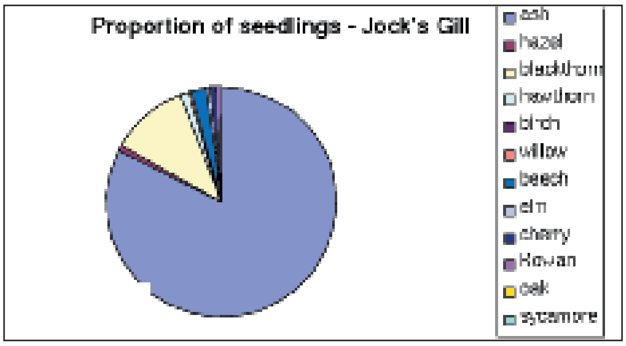


Figure 11

The same parameters as above were used to select sub-sets of "good" and "poor" ash regeneration for Jock's Gill. Figure 12 shows a much less clearly defined relationship between vegetation communities and "good" regeneration. This site is very complex in terms of a mosaic of site types, canopy species composition and structure. Therefore, less clear results than Lower Nethan were expected. However, casual observations on site suggest that there are indicators of unsuitable ground for ash regeneration (e.g. abundant opposite-leaved golden saxifrage appears to indicate that ground is too wet for ash).

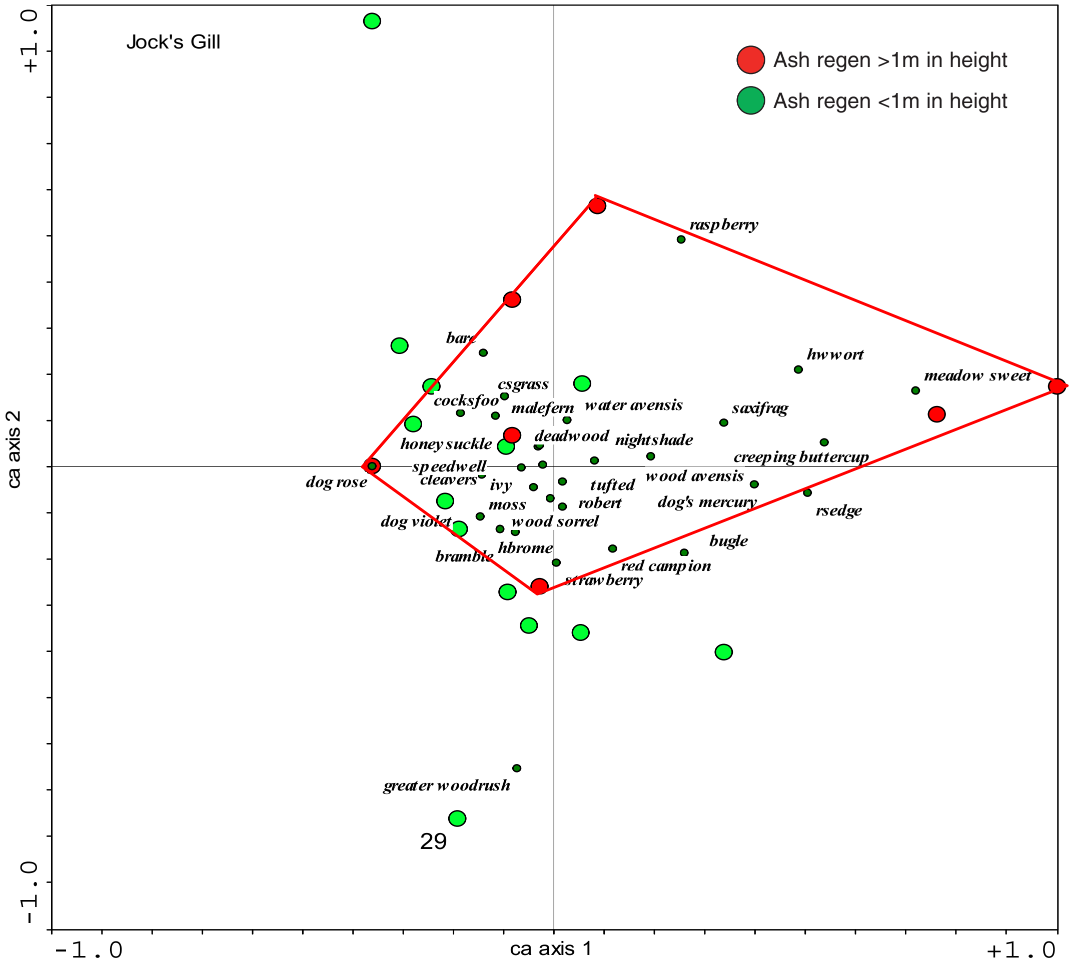


Figure 12: Ordination of "good" (red) and "poor" (green) regeneration classes in relation to ground flora species – Jock's Gill

Data for basal area and deadwood were not collected (there were no groups of dead elm as in Lower Nethan). However, data for light were compared with "good" and "poor" regeneration. Again, there is a poor relationship, with lighter quadrats occurring where there is poorer regeneration (see Table 5). The transect in Jock's Gill runs through several unwooded patches and it is suspected that the lack of regeneration within these areas is due to vegetation competition (one area for example is dominated by a deep sward of meadow sweet and hedge woundwort).

Upper Nethan

It was not possible to use "good" and "poor" classes described above as there were no ash seedlings above 1m in height. However, the most interesting results from Upper Nethan concern the relationship between canopy and species of regeneration. As described, transect 1 is dominate by an ash canopy and transect 2, by an alder canopy. It is interesting to note that only one ash seedling was recorded in transect 1 whereas, the regeneration that did occur in transect 2 was dominated by ash (here light levels were too low under the alder to permit regeneration to exceed 54cm (see figure 13 and 14).

Regeneration class	Mean light level (diffuse light)
Good	0.1284
Poor	0.1503

P=0.912

Table 5: Relationship between regeneration class and diffuse light.

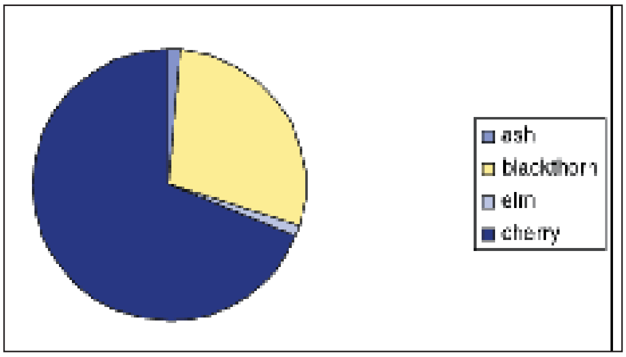
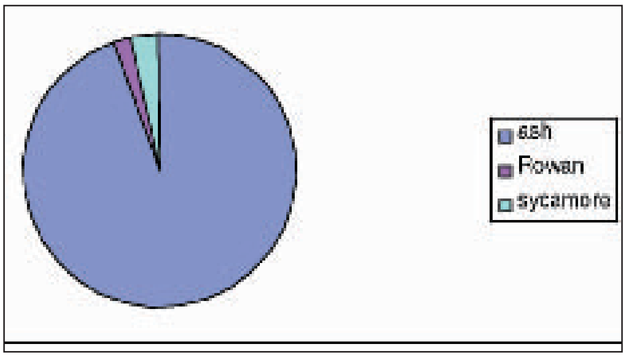


Figure 13: Proportion of seedlings - Upper Nethan Transect 1

Figure 14: Proportion of seedlings - Upper Nethan Transect 2



Discussion

Silvicultural and ecological considerations

The following discusses ecological processes taking place in the three study woods:

Lower Nethan

Within the stand assessed, there is good structural diversity and a substantial amount of advanced regeneration. However, this is distributed very patchily throughout the stand, related to some extent to light and dead elm but it is also suspected that soil moisture may be an important variable. It is unfortunate that soil differences were not apparent.

Browsing (by roe deer) does not appear to be having a significant impact here. Observations of differences within the fenced deer exclosures should confirm this.

It is probable that, since the time elm died to the time of data collection, remaining live trees have responded to fill some of the canopy gaps and increased in basal area. Although seedlings exceed 1m in the “good” class, their growth rate may have declined as the canopy cover has increased. In subsequent assessments, it should be possible to see how seedlings within the gaps created by dead elm have responded to additional light created by the recent thinning operation.

The thinning should allow some of the advanced regeneration to recruit into the canopy and will help to adjust the long-term balance between native and naturalised species. The “bank” of advanced regeneration includes wych elm seedlings. This species occupies approximately 7% of the overstorey (as assessed by residual basal area) and continues to produce seed.

Standing deadwood provides a wide range of important niches such as hollows and clefts. These will rot quickly if trees are felled. Fallen deadwood is of value, but for a different suite of species. It would not offer as good a range of habitat niches for diptera for example (per.com. J Humphrey). There is little published information on the relative value of dead elm and other species but, as reported by Rotheray, (1997), sycamore and beech are known to support important numbers of saproxylic diptera.

The method for killing trees standing will alter their suitability for deadwood fauna. Ring-barking is not suitable as the tree rots from the outside and heart rot (an important niche for many species concerned) does not develop. It is preferable to chemically kill the tree. The best forms of decay will develop by putting the tree under stress, (e.g. knocking off large branches). This stimulates latent pathogenic fungi which can ultimately kill the tree. It is accepted that this sort of management is unlikely to be practical in most circumstances within the Clyde Valley.

Upper Nethan

There is very limited tree regeneration in Upper Nethan. This is not currently a major consideration in much of the wood as stems are relatively young and, in most areas, there is a full canopy. However, as this stand matures and canopy gaps naturally occur, or if gaps are created to encourage regeneration, browsing levels should be reduced. Out of the three woods surveyed, this wood clearly had the highest browsing levels (identified by heavily browsed bramble and some browsing to coppice shoots of several species including unpalatable alder – see Thompson *et al* 2004). The fenced exclosure may be useful in the future to show what impact deer are having on regeneration.

There is some rationale for intervening to encourage regeneration at an earlier stage, to provide greater continuity of habitat for fauna dependant on trees of a particular stage of maturity (e.g. saproxylic invertebrates, bats, epiphytic lichens). As there has been limited recording of these groups in Upper Nethan, this need cannot be clearly identified at this stage. However, if there was such a paucity of regeneration in Lower Nethan (where there are good records of fauna dependant on mature and senescing trees), the case for intervening to encourage regeneration would be more obvious.

It is understood from the management plan that this wood was grazed by cattle for at least 25 years prior to 1988. There is probably a legacy of this in the vegetation structure (which is less diverse with a higher proportion of grass in the sward than in the other two study woods) and in the shrub layer which is represented largely by hawthorn (a species more tolerant of cattle grazing - H. Armstrong In Prep). Cattle have almost certainly had a positive effect at the top of the slope through maintenance (and possibly, over the longer-term, creation) of a meadow.

The lack of diversity in the canopy tree species and clear demarcation between species groups (i.e. distinct areas of ash next to areas dominated by alder) suggest that some management has taken place to influence this (possibly some enrichment of target species and removal of less desirable species, or indeed targeted removal of species such as oak). It is interesting to note that this apparently artificial species composition at a stand scale is associated with poor regeneration. Whilst this is confused by heavier browsing levels than elsewhere, a greater diversity of tree species (native and naturalised) in the canopy seems to permit a range of niches for successful tree regeneration.

It is interesting to consider what this wood will look like in 50 to 100 years time. Although ash coppice and maiden stems are not particularly dense, some self-thinning will take place and dominant trees will assert themselves more clearly. Many of the hawthorn shrubs appear to be old and some of these may die within the next 50 years. There are some blackthorn seedlings and it is possible that a future shrub layer is composed largely of this species. As trees mature some will become unstable (Peterken describes typical valley-side trees developing eccentric crowns with the weight on the lower side, leading to eventual instability). What happens in gaps created by windblow will depend on the amount of herbivore impact and condition of vegetation. It is possible that shade tolerant regeneration (e.g. ash or sycamore – there are some sycamore seed sources elsewhere in the wood) may exist and be ready to occupy the space in the canopy. Alternatively, windblown trees may themselves continue to grow, horizontal branches responding to light to grow vertically. If grazing levels are any higher than at present, the wood will become more open in time and may, perhaps go through a phase where a mantel of thorny scrub develops and facilitates the regeneration of high forest trees (as described by Vera - 2000). This can be seen happening at the top of the bank where hawthorn are colonising the edges of the old meadow, some of which have protected ash saplings which are now growing up through the shrub layer.

Some recent management was carried out either end of the section of Upper Nethan where the FR transects were located. In the alder wood, selective coppicing was undertaken, felling all stems on 20% of coppice stools. There are still fairly low light levels on coppiced stumps and it is questionable whether coppice regrowth will be able to survive in these conditions. This work will, however, allow remaining alder stems to become more substantial and may provide enough light for ash seedlings to establish given sufficiently low pressure from roe deer.

Jock's Gill

Whilst there is a substantial amount of regeneration in this wood, much of it appears to be very old (most seedlings have moss plumes growing up their stems) and it is questionable how long seedlings can survive under these low light levels. However, this is not a problem in Jock's Gill as there are generally several canopy strata. It appears as though there was some disturbance to the canopy 20-30 years ago (perhaps an older age class of birch dying out) which allowed ash saplings to recruit into the lower canopy. There is a cohort of birch which is estimated to be around 60-70 years old. As this senesces, there will be further opportunities for advanced regeneration to enter the canopy. Gaps created by sycamore and beech, felled through LIFE funding, will provide additional opportunities.

As with Lower Nethan, there are only limited signs of herbivore impact within this wood. Basal shoots remain unbrowsed and there are grazing sensitive species (e.g. honeysuckle) well within reach of roe deer.

The main issue in Jock's Gill in future management will be the control (or acceptance) of beech regeneration. There are occasional beech seedlings within the surveyed area and several mature beech have been retained.

There seems little doubt that ash will persist in the future species composition. However, it is unlikely that birch will. This is thought to date back to a clearfell around 1940 (see woodland history interpretation below). It is possible that limited intervention in the future will also reduce or eliminate the presence of willow (currently frequently encountered in the canopy).

The effects of woodland type

It is interesting to consider the influence of past woodland management over current structure and composition in *Tilio – Acerion* woods compared to that in other woodland types. In the past, the Clyde Valley woods were used for a variety of purposes and a range of species were exploited. This is in contrast to the western oakwoods which were typically simplified in their species composition to maximise the amount of oak. Despite the mix of species, regular coppice cycles would have produced a very artificial woodland structure and it is the ecological characteristics of the Clyde Valley woods (see box below), rather than management history, which has led generally to a more complex woodland structure than can be found in ex- coppices in upland oakwoods.

Comparison of ecological conditions between *Tilio-Acerion* woods in the Clyde Valley and Quercus with *Ilex* and *Blechnum* woods of the West Highlands.

- Clyde Valley woods contain native and non-native species which are moderately shade tolerant and can quickly occupy any canopy gaps.
- They also have small scale variation in micro-site type (e.g. soil moisture and nutrient regime).
- Small gaps have been created by Dutch elm disease and, on steep streamside banks, landslips are not uncommon.
- Due to rich soil nutrients, NVC W8 and W9 woods are very productive in terms of biomass and this high level of available forage reduces the impact of browsing on tree seedlings.
- This situation contrasts with upland oakwoods where most tree species are light demanding, site types are relatively homogenous and suitable sized canopy gaps for successful tree regeneration rarely occur.
- NVC W17 and 11 site types are generally less productive and the impact of herbivores is often more severe on tree regeneration due to the limited availability of alternative forage.

These differences mean that *Tilio-Acerion* woodlands can acquire a complex structure over a relatively short period of time, whereas past activities in upland oakwoods tend to leave a much more obvious legacy in terms of woodland structure.

Summary of the woodland history study and implications for management

It is easy to assume that riverine woodlands are the closest type that we have to natural woodland, being relatively inaccessible and subject to shifting river patterns, landslips etc. However, the history report (Sansum *et al*, 2005) quickly eliminates this view for the Clyde Valley and highlights the immense amount of activity which has taken place in and around these woods since at least the 11th century. Indeed, Lanarkshire is recognised for being an area of good woodland practice historically and for sophisticated use of its woods by the 17th century.

The woods have played a vital part in people's lives. In medieval times they were important components of hunting "forests" but also provided essential materials for local people (e.g. for houses), as well as providing important grazing and shelter for livestock and game. Later they became globally significant, providing numerous products for the industrial revolution and allowing coal mines to operate during the wars. The same can be said of many woods throughout the UK although, in a Scottish context, this level of intense activity from such an early period may be unusual. The proximity to large populations and rich coal seams has made the location of these woods strategically important and meant that, relative to their size, they have had a big influence over cultural and industrial development.

Will the location of these woods have such an influence over their structure in the future? Competition from imports has affected the Clyde Valley timber trade since the mid 19th century. In the short-term, it is unlikely that many wood products will be made from Clyde Valley timber on a commercial basis. However, it has been predicted that the cost of transport will increase significantly over the next few decades and that the global economy could be destabilised by climate change. In these circumstances, it is possible that we may turn to these woods to supply raw materials once again. Possible uses could be sawn hardwood timber from high forest stands or products from coppice material such as fence panels. It is doubtful that these woods would be used for fuel on anything other than a small local scale as future urban wood fuel systems are likely to utilise materials from 20th century conifer plantations. Any utilisation of wood products will need to be considered in the context of Special Areas of Conservation but it is clear from the woodland history study (Sansum *et al*, 2005) that these woods are extremely robust and able to cope with significant amounts of change.

Woodland history findings discussed in relation to field evidence for the research sites

Lower Nethan

It is surprising to see the evidence on the First Edition Ordnance Survey map and hard to imagine that the majority of this area was an orchard in 1858, although clues exists at the top of the slope (i.e. an old pear tree). Woodland over the majority of this bank has a diverse structure with a wide range of tree species and, in several places, well-developed regeneration. The ground flora is diverse and includes species listed as possible ancient woodland indicators by Peterken (2000) (i.e. water avens, yellow pimpernel and dog’s mercury). However, there is some question as to whether species confined to ancient woodlands in the Clyde Valley are merely restricted to these habitats due to different edaphic conditions on adjacent sites. In this case, the area which used to be an orchard is of a similar site type to that supporting the adjacent ASNW. It is also possible that management of the orchard was less intense than described for elsewhere (e.g. planting crops of rye under the fruit trees) and that semi-natural vegetation may have persisted.

The period as an orchard seems to be very short lived as evidence from the 1816 maps suggests no trees and nearly 100 years later in 1914 there are reports of coffin boards being felled from the site. Assuming that it would take at least 50 years for hardwood trees to reach an adequate diameter for sawlog production, this would mean that the orchard must have regenerated (or been planted) with high forest species no later than the mid 1860s. Certainly the OS revisions of 1898 and 1913 depict mixed woodland.

Upper Nethan

There is evidence for the existence of this wood on the Roy maps (1747-55), including the area where the FR transects are located. Woodland cover appears to have become more sparse on the 1773 map although the same extent as the Roy map is shown on the 1816 map. There was a lot of coal mining activity all around Upper Nethan and this increased after 1853 when a substantial viaduct was built probably to access coal seams on the eastern side of the river.

The 1858 map shows scattered tree cover, indicating clumps of woodland and open space. Certainly, coppice stools in parts of Upper Nethan (particularly in the slope alderwood) are substantial and may well date back to at least this period or earlier. There are records of birch and alder being felled for gunpowder production in 1859 and it is conceivable that this could have taken place here to create the scattered open canopy seen on the 1858 map (surveyed 1858-9). The current delineation of species groups appears to be artificial in that there are clear boundaries between alder dominated areas and ash dominated areas, with little apparent difference in vegetation communities on the margins. It is possible that some enrichment planting took place to consolidate the groups.

No evidence for the coal bing was seen on the line of the transect. Several soil pits were dug and these all showed characteristic brown earths. However, the railway line and an old trackway run just above the transects and it is easy to imagine that this area was subject to a lot of disturbance in the mid 19th century. Wartime fellings are suggested in the management plan (with evidence on the 1946 aerial photograph) and this was corroborated by ring counts of recently felled trees (an average of c.60+ years was recorded).

Cattle were present in this wood until the late 1980s. There is an area of thorn scrub colonising an open meadow above the existing wood. This appears to be functioning in a similar way to that described by Vera (2000) (i.e. a “mantle” of thorny species is facilitating the colonisation of high forest trees). This system relies on large herbivores to create the open meadows/pastures which then gradually colonise with grazing resistant species. It is tempting to think that this process of colonisation from a previously open area (whether through felling or over-grazing) has taken place within the last 100 years further down the bank in the area where the transects are. However, mapped evidence and the presence of large coppiced stools suggests that this is not the case. The presence of hawthorn and blackthorn in the understorey may be due to their resistance to cattle grazing rather than as indicators of a recently colonised wood. Other species of tree regeneration may either be absent due to vegetation competition (the vegetation under ash being very luxuriant and dominated by grasses and species such as dog’s mercury and hedge woundwort) or to relatively high levels of roe deer browsing.

Compared to other woods in the Clyde Valley, Upper Nethan has a uniform age structure and species composition. Livestock grazing appears to have had a significant effect as indicated by the ground flora, shrub layer and meadow. This wood appears to have had a greater continuity of management and therefore, perhaps, reflects more accurately past stand management than the other two study woods which have been through substantial changes in use and subsequent re-colonisation by native and naturalised tree and shrub species.

Jock's Gill

There is evidence on the Roy maps (1747-55), for woodland cover over the entire length of the transect. The 1816 map shows a similar process of woodland clearance and diversification as appears on the 1816 map for Lower Nethan. This time, however, it appears to have been mainly for the enhancement of the designed landscape rather than for horticultural and agricultural production, although orchards are depicted on a 1766 map of Hallcraig to the east of Mauldslie.

The area of woodland which encompasses quadrats 11-30 appears to lie in open ground along-side a narrow strip of coppice on the burn side. By 1858, this area appears to have been inter-planted with conifers. Later maps (1898 and 1913) also show a mixed woodland. The area to the east of this (encompassing quadrats 1-10) appeared in 1816, to be located in a very formal landscape designed setting. By 1858 this area is shown as open ground with small areas of formal planting to the east. With the exception of some mature beech trees on the upper margins of this wood, there are no signs of the designed landscape today. Part of the transect appears to have been crossed by a tramway (an axle from a tram cart lies adjacent to the transect) from the brick works (opened in 1880), substantial remains of which can be seen on the southern side of the stream. Associated disturbance from this activity could have promoted the development of a thicket of blackthorn (perhaps the same as recorded on the 1914 map – see the history report (Sansum *et al*, 2005))

Records of an estate sale in 1933 record "magnificent timber" including beech, larch and spruce. Assuming that felling took place shortly after the sale (say 1935-45) this would make oldest trees in the present stand around 60 to 70 years. Casual observations suggest that this is about right as there are many substantial birch trees which are beginning to senesce. The abundance of mature birch fits well with a clearfell which included a high proportion of conifers as the ground available for regeneration would have been well suited for birch regeneration (as can be seen in recently felled conifer stands today given a sufficient seed source).

Today, Jock's Gill has a diverse and complex structure, far removed from the designed landscape with which it was once associated.

Application of the Upland Mixed Ashwoods Habitat Action Plan

The following gives relevant extracts from the Upland Mixed Ashwoods HAP and discusses implications for the Clyde Valley woods. Whilst the woods fall to some extent between this HAP and that for Lowland Mixed Broadleaves, as there are broad similarities between the plans and the later has not yet been published, this analysis has used the Upland Mixed Ashwoods plan. Sections in italics are quoted directly from the HAP.

Current factors affecting the habitat

1. *Invasion by sycamore, beech and other species which are generally not native to these woods in most of Britain, leading to changes in the composition of the woods. Dutch elm disease has changed the structure and composition of many woods since the early 1970s, and recurrences may still be affecting them. Canopies opened by disease may be subject to higher rates of windthrow, and invasion of the gaps by unrepresentative species becomes more likely.*

This is obviously a major factor for the Clyde Valley. However, beech regeneration does not seem to be so prevalent in this woodland type as it does in adjacent acidic site types (see 6). Dutch elm disease does not appear to lead to windthrow and, for the areas surveyed, gaps created by the disease are colonised by native species. However, it is recognised that sycamore regeneration is an issue in other Clyde Valley woods at this time.

The effects of sycamore are discussed by Peterken (2000) and issues relating to its effect on Favourable Condition are discussed in the following section.

2. *Replacement of native trees with planted conifers was a major threat until the early 1980s. Large scale felling and modification of the composition of the woodland by intensive planting of inappropriate broadleaved species may reduce the diversity of the woodland.*

This is not a major factor in the Clyde Valley, PAWS being found mainly in Hamilton High Parks.

3. *…the removal of trees in field boundaries and small patches of ash-rich scrub in fields*

Because of the mosaic of urban landuse and agriculture, there are perhaps more opportunities for abandonment of small areas of land and colonisation than in a uniform intensively farmed landscape.

Although the precise details of CAP reform and what constitutes Good Agricultural and Environmental Condition have not been finalised, it appears that regulations will allow some colonisation of scrub in fields adjacent to native woodland.

4. *Locally nutrient enrichment leading to changes in soils and ground flora may occur from spray drift or runoff from adjacent agricultural land.*

This is likely to be an issue locally and may form a useful focus for initial woodland expansion to create buffer zones.

5. Cessation of traditional management practices such as coppicing may in some areas lead to a reduction in structural diversity within the woods.

In fact, this has led to an increase in structural diversity within the stand but in the long-term, there will be a reduction of structural diversity at the landscape scale. This would be a bigger concern if the main species groups of interest needed young growth and open conditions to flourish (e.g. if dormice were found this far north or the valley was important for pearl bordered fritillary butterfly). However, many of the species of interest require mature, structurally complex stands with deadwood (e.g. saproxylic coleoptera and diptera) and are likely to benefit from a minimum intervention approach, provided that there are sufficient nectar sources in the immediate vicinities of the woodland (see 3 above).

Ground flora may have benefited from coppicing although very rich assemblages currently occur under a high forest structure. Peterken (2000) suggests recommencing coppicing in one Clyde Valley woodland as a demonstration. This would allow some assessment of the relative benefits in terms of biodiversity to be made and would link in well with interpretation of woodland history.

The effects of livestock grazing on woodland biodiversity are not clear. It is probable that the cessation of cattle grazing in Upper Nethan would have led to a reduction in structural diversity at the woodland scale if the Scottish Wildlife Trust were not controlling vegetation manually to increase species diversity in the meadow area. However, at a stand scale, structural diversity is greater in the other two study woods where managed grazing does not appear to have been a factor in the recent past. If a more in depth woodland history study is undertaken, it would be very interesting to look into the type of grazing management practised in these woods historically.

6. Climate change, potentially resulting in changes in the vegetation communities.

The most frequently referred to consequence of climate change is an increase in the amount of beech. This is due to warmer summers allowing greater amounts of viable seed to be produced. According to the Monarch project, for the HIGH scenario, the predicted areas of increased favourability in Scotland are restricted to the east and west coast by 2050 (see figure 15). However, these areas lie in such close proximity to the Clyde Valley that increased favourability for beech is likely to take place here as well.

As discussed, beech regeneration typically occurs abundantly on more acidic site types. It is found sporadically on *Tilio-Acerion* sites though and should be anticipated as a factor in the future achievement of favourable condition.

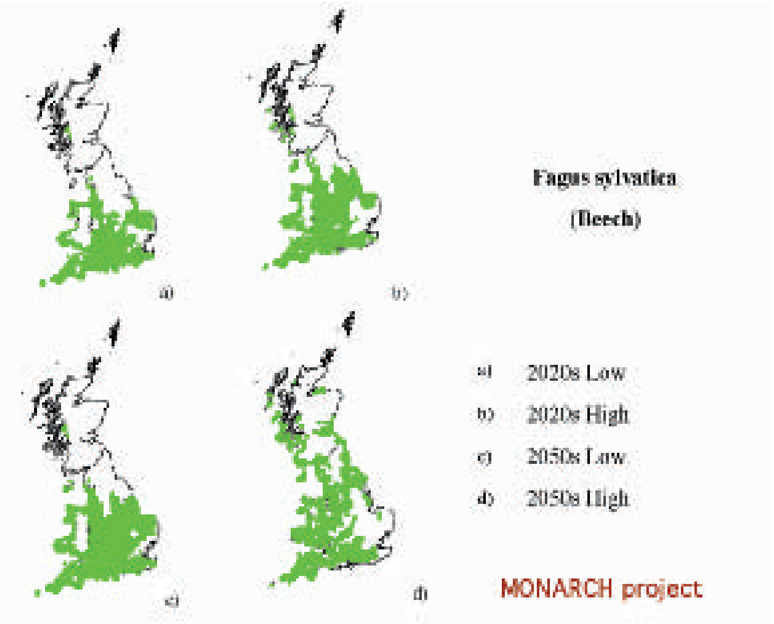


Figure 15

As discussed by Peterken (2000), *Tilio-Acerion* woodlands in continental Europe survive in a matrix of beech-dominated forests due to their ravine conditions which favour the growth of elm, ash, lime, hazel and maples. If a minimum intervention approach is taken, it is possible that, beech may become more dominant on areas of moderate topography and *Tilio-Acerion* may become restricted to steeper riversides.

Targets

7. *Initiate by 2004 measures intended to achieve favourable condition in 100% of upland mixed ashwoods within the SSSI/ASSIs and Special Areas of Conservation*

8. *Achieve favourable condition over 70% of the designated sites by 2010.*

This form of wording has been modified in the two draft woodland HAPs which succeeded this set of plans (i.e. upland birchwoods and lowland mixed broadleaves). Targets are now more realistic, aiming for unfavourable-recovering where favourable condition cannot be achieved in the short-term.

The main issue here is the percentage of non-native trees. To take the composition target for Lower Nethan condition monitoring assessment as an example, a maximum percentage of 30% cover of sycamore is included. This seems a sensible approach at the woodland scale, allowing some areas to be more heavily dominated by sycamore as long as the overall proportion is below 30%.

Box 1

Lower Nethan Condition monitoring target for composition:
Site non-natives within any one layer are acceptable at no more than 10% cover, with the exception of sycamore (*Acer pseudoplatanus*) within areas of calcareous ash (*Fraxinus excelsior*) gorge woodland (NVC: W8), where it is acceptable at levels of up to 30%.

Figure 9 shows the residual basal area for Lower Nethan (i.e. that retained after thinning). If we accept that there is an approximate correlation with basal area and percentage cover, then it can be seen that post thinning, sycamore made up 39% for this section of the wood (the most heavily sycamore dominated section). If we look at this section in isolation, the proportion of non-site native species is moving in the right direction. However, as an individual wood, this section would be considered to be in unfavourable recovering condition.

For the example above, taking the HAP target as it currently stands, there is a temptation to prescribe further reduction of sycamore to achieve favourable condition by 2010. In real terms, this would be to the detriment of good conditions within the wood. Sycamore does not appear to be causing any significant problems in terms of impact on ground flora (this is very diverse and contains many woodland specialist species associated with *Tilio-Acerion* woodland) and native tree species are regenerating well under its canopy (see Waters and Savill 1992 for a discussion on alternation between sycamore and ash). Landscape impacts would be unacceptable if sycamore was removed at a greater rate than has already been undertaken as this part of the wood is very prominent from Craignethan Castle. In other woods where advanced regeneration is not so prevalent, sudden reductions in canopy cover are likely to lead to excessive competition from vegetation.

The critical issue here is the setting of objectives, limits and timescales. If these are realistic and appropriate to maintain or improve woodland conditions then the HAP process should be achieved in time. Conditions should not be "improved" too quickly through artificial means if natural processes will achieve desired results in due time (and if this is the preferred course of action) or if more subtle forms of management will eventually achieve desired conditions.

9. *Complete restoration to site-native species of 1,200 ha of former upland mixed ashwood which has been converted to non-native plantation on Ancient Woodland Sites by 2010.*

10. *Complete restoration to site-native species over a further 1,200 ha of former upland mixed ashwood which has been converted to non-native plantation on Ancient Woodland Sites by 2015.*

In strict HAP definition terms, restoration only applies when non-native species occupy more than 50% of the canopy. In the majority of cases, restoration refers to plantations on ancient woodland sites - PAWS. However, sites heavily dominated by naturally regenerated non-native species are also applicable. The restoration milestone in terms of canopy cover of non-native trees is less than 50%. Targets are due to be revised in 2005 and it is likely that they will promote management to <u>begin</u> a <u>gradual</u> process of restoration over a larger number of woods, rather than to complete it over a restricted area.

As discussed in 2 above, there are few classic "PAWS" in the Clyde Valley. Restoration is only likely to be applicable in a small number of cases as the proportion of non-native trees in ancient woods is rarely above 50% at the woodland scale. Where restoration is applicable, the proportion of non-native trees should ideally be reduced gradually, focusing on the condition of other components of the woodland ecosystem (e.g. maintaining habitat suitability for saproxylic diptera) rather than simply aiming for a particular canopy composition.

Research and monitoring

11. *Support research on the history and past management of upland mixed ashwoods, including an investigation of the dynamics and management of sycamore and beech in this habitat, to improve our understanding of their development, present condition, distribution and future management. (Action: CCW, EHS, EN, FA, SNH)*

This action point was the catalyst for the present study. Further work is needed on the dynamics of this woodland type and the role of sycamore. Follow up surveys in Lower Nethan should provide useful information. However, additional experimental/monitoring resource is needed to cover a range of sites and management scenarios.

The woodland history study (Sansum *et al*, 2005) was very much a cursory assessment of the three woods selected for this project. Due to time limitations, it was not possible to make full use of archival sources. A full archival research study would probably reveal a great deal more detail about woodland use and management in the Clyde valley in general, but may also cast more light on the SAC woods.

Favourable Condition and sycamore

Binggeli (1992) suggests that sycamore was introduced to England in 1578 and that it was probably introduced to Scotland slightly before that. Planting of sycamore remained relatively rare until the late 18th century when it became a fashionable tree in amenity plantings often in mixture with other exotics or as parkland trees. It is suggested that this practice encouraged its spread. The first record of the Gaelic name for sycamore (Plinntriinn) was recorded in 1772. There is some evidence from pollen analysis that sycamore has only been abundant in the last 150 years.

There are many references to sycamore regenerating prolifically and invading ancient and semi-natural woodlands. However, Elton (1958) thought that if “left to itself the sycamore would probably settle down eventually to a normal ecological balance in our deciduous woods” and added that “although Britain is slightly north-west of its natural limits in Europe, the sycamore can reasonably be regarded as filling a more normal niche in our woods than some other invaders” (Elton 1958). Gilbert (1989) suggested that sycamore, with ash, “are likely to occupy the niche recently left vacant by elm”.

Sycamore occupies a similar ecological niche to ash but with some important exceptions. Two of the most important being water tolerance (ash is able to cope with a greater amount of water logging) and light (sycamore casting much more shade than ash) (Binggeli 1992). However, the amount of shade cast by elm is likely to be closer to that of sycamore than ash (data was not available to substantiate this).

Appendix 1 shows a condition table for *Tilio-Acerion* woodland in the UK. The composition attribute is of most relevance here. This states that the existing proportion of native species must not be reduced and that 90% or greater must be made up of native or naturalised species. The position on sycamore acceptability appears to be left to the local officer to determine an appropriate level. As discussed above (under upland mixed ashwoods HAP analysis point 8 (Box 1), a 30% threshold for sycamore cover was set for condition monitoring in Lower Nethan. As a diverse woodland flora and advanced regeneration of native tree species persisted under 49% canopy cover of sycamore prior to thinning operations in Lower Nethan, an upper limit of 40% is suggested. This amount may be applicable for other SAC woods in the Clyde Valley although the characteristics of each wood should be assessed independently before targets are set. For example, in areas where there is slower nutrient cycling, the humus type may be a moder like mull rather than a mull. In these conditions, greater amounts of leaf litter accumulate, with potential consequences for woodland flora.

As alternation possibly occurs between sycamore and ash (sycamore regenerating poorly under its own canopy – Waters and Savill 1992), a long-term view should be taken where sycamore is locally dominant in the canopy. However, if this is the case over a large proportion of the woodland, then some management intervention may help to retain a balance of species (e.g. chemical killing some mature sycamore where advanced regeneration of native species exists).

The transects in Lower Nethan should provide some useful information in the next 10-20 years about the nature of sycamore invasion and the consequences it has for biodiversity. As we are in a period so recently affected by Dutch elm disease and stand structure is still heavily influenced by wartime fellings, it is difficult to be certain about the long-term role of sycamore and whether, as suggested by Elton, it will eventually exist in balance with other species. In the meantime, outwith non-intervention areas, it would seem prudent to include an upper limit for sycamore cover under the composition attribute when condition monitoring.

Clearly, the traditional nature conservation view of sycamore cannot be accommodated in the Clyde Valley. It is a well established tree and trying to eliminate it would lead to excessive costs, many practical difficulties and, in many cases, drastic reductions in canopy cover (hence unfavourable declining condition). Sycamore's values are recognised today: for example, it supports a substantial bio-mass of insect, has good bark characteristics for epiphytic lichens (given sufficiently low pollution levels in the future) and is an important tree for saproxylic diptera). It is a recognised component of *Tilio-Acerion* woodlands elsewhere: for example, in Denmark the definition of Favourable Conservation Status includes the presence of sycamore.

To reiterate George Peterken's suggestion in his report for the Clyde Valley (Peterken 2000), it would be of value to maintain some ancient semi-natural woods where sycamore and beech are minimised. These would act as a control to assess the impact of naturalised species. However, if this is pursued, sites would need to be selected with care to minimise practical difficulties and costs and a long-term commitment would be implicit.

Recommendations

Recommendations from woodland history findings

- An understanding of past management/ uses of woodland helps us to appreciate why neighbouring woods or stands within a woodland differ in structure and species composition. In the absence of this information, it is possible that differences may be attributed to changes in site type (i.e. soil nutrients, soil moisture and climate). In such circumstances, management proposals might be based on false a premise (e.g. attempting to get oak regeneration or replanting oak where it has previously been planted on a site more suited naturally to growing ash).

- Some knowledge of the past landuse allows us to more easily recognise features of value and manage a site in such a way that will retain or enhance that feature. For example, protecting sites of industrial archaeology or reinstating cattle grazing in recently abandoned wood pasture where features such as veteran trees and species rich grassland remain.

- In the past, the woods of the Clyde Valley were central to people's lives, providing building materials, agricultural implements and fuel for local people and pit-props, gunpowder and bobbins for industry. They were also important for livestock grazing. This historic connection with people and woods would seem to provide an excellent educational opportunity and would fit well with the history section of the National Curriculum.

- If funding is available, some form of educational resource should be created to demonstrate this and inspire local children to value their woods. The resource could be in the form of an audio-visual presentation or, ideally, employment of a local woodland enthusiast, to undertake a woodland history "roadshow" of local schools.

- The impact of past management on the condition and structure of the Clyde valley woods has yet to be fully investigated. A more detailed study would allow us to reconstruct past management events in these woods and relate these to their past and present condition. This would not only help us to understand the woods today and place current and future management in context, but also to further our understanding of Scottish woodland history. It would also be instructive to compare findings with other types of woodland such as upland oak coppice.

- Local utilisation of wood products should be encouraged to provide a link with the past and demonstrate the direct value of the woodlands for local people as well as the international benefits in biodiversity terms. Due to extraction difficulties, there is limited scope for this but some small-scale working and sale of local wood products (e.g. bird tables etc promoted in garden centres with a "Clyde Valley timber" label) would be a clear demonstration that these woods are of benefit to local communities.

- The three woods studied in this report have all been through a lot of changes to their structure and have experienced intensive management. They are now in a period of transition to a more balanced structural and species composition. All study sites experienced substantial disturbance during the two world wars: an absence of regeneration or insufficient volumes of deadwood should not always be seen as problems which need to be overcome in the short-term as many stands in the Clyde Valley are in a relatively early stage of development.

- Given the limited amount of time since past disturbance, it is difficult to see what impact recent "introductions" are having (e.g. sycamore, grey squirrels, Dutch elm disease and climate change). Their affect on a stable system is likely to be very different.

- To a greater or lesser extent, these woods now exhibit rich floristic and structural diversity. This indicates that they are relatively robust and should be able to cope with well planned and sensitively executed management intervention, where it is necessary or desirable.

- Jock's Gill went through a phase where it was enriched with conifers and exotic broadleaves. A comparison of its biodiversity with a wood which has not been through a similar phase would inform those undertaking PAWS restoration today.

- The history study identified several areas within the Clyde Valley which were semi-natural woodlands within the last 300 years and have subsequently been cleared for agriculture. Identification of these areas throughout the Clyde Valley would seem to be a good basis for beginning to plan a Forest Habitat Network, particularly where old woodland sites include niches which may contain relict woodland communities (e.g. old hedge rows and orchards).

- The description of the view from Craignethan Castle in the history report is very evocative and wording from the report could form a key part of an interpretation panel describing the past use of the woods and their current value. Some of the following wording (quoted from the history report (Sansum *et al*, 2005)) could be included:

> *In the 1890s McMichael described the scene in the Lower Nethan Gorge thus:*
>
> *"The view downwards [from Craignethan] is of a grand woodland character, but the level ground and gentle slopes near the river form cultivated fields of an irregular shape, interspersed with hedgerow trees and copses, the enclosures seeming to have been individually cleared out of the forest which surrounds them, and which occupies in unbroken masses the steeper declivities and unbroken banks.*
>
> *"… the development of the area since the 18th century and accompanying population expansion (the population of Lesmahagow parish more than doubled between 1801 and 1831: NSAS) undoubtedly drove inroads into the woods and encouraged the development of this pattern."*

Silvicultural recommendations

- Most if not all of the Clyde valley woods are in a period of transition – some check on sycamore's development would be prudent, whilst applying a general policy of acceptance.

- Favourable condition and a relatively high proportion of sycamore are not incompatible (40% canopy cover, assessed over the whole woodland is a suggested upper limit for one of the woodlands in this study although this should be reviewed as more is learned about the specific impacts of sycamore in this locality).

- If practical and safe to do so, keep dead trees of elm and other species standing for as long as possible. Where the intention is to create deadwood artificially, this is best done by injuring standing trees (e.g. knocking large limbs off).

- Options to control non-native trees should be considered carefully. From a socio-economic view point, it may be desirable to use local contractors to extract material and utilise it locally. However, the costs involved and potential extraction disturbance, may prohibit this option. Alternatively, trees could be felled to waste. Where this is undertaken, we would recommend leaving trees in the length as this will provide good quality fallen deadwood for invertebrates (P. Kirby 1992) and reduce costs. It may not be possible to do this where woodland owners prefer a tidy appearance or where trees are felled adjacent to paths. Whilst killing the tree standing will provide standing deadwood and should be easier to undertake than felling, there is a risk of stimulating seed production as the tree is put under stress (personal communication, C. Edwards) and there are public liability implications. If this is carried out, chemical killing is preferable to ring-barking as it is more likely to create suitable deadwood.

- In many cases, minimum intervention will be appropriate. However, active management should not be ruled out, particularly where there is easy access and a market for produce. Some structural diversity at the landscape scale would be desirable, although it is hoped that young growth will be plentiful as the Forest Habitat Network is established and agricultural margins are less clearly defined as a result of CAP reform.

- If coppice regrowth is the purpose of future operations, felling small coupes is recommended as opposed to selective coppicing. This should provide sufficient light for vigorous regrowth.

- Signs of grazing/browsing impact should be assessed to see whether control of herbivores is necessary prior to any silvicultural operations to encourage regeneration. In the majority of woods in the Clyde Valley, herbivore impacts appear to be very low.

- It would be interesting to establish one area as a working coppice so that raw materials are available to stimulate local crafts and an assessment can be made of the relative biodiversity of this system compared to high forest. Obviously, the wood to be coppiced would have to be selected with care to ensure that the impact on woodland condition was acceptable.

- The application of managed grazing should be considered (where this is practical) to maintain valued open habitats.

Conclusions

The experiments established by Forest Research can only provide baseline information at this stage. The quadrats in Lower Nethan should provide useful information in 5-10 years time and demonstrate the consequences of thinning in order to reduce the percentage of sycamore and encourage native species regeneration.

Many of the Clyde Valley woods will, in practice, be managed under a minimum intervention regime. Some woods will largely take care of themselves but, for SACs it may be necessary to reduce the percentage of naturalised species where this exceeds c. 40% when assessed over the whole wood. If natural regeneration, understorey shrubs and grazing sensitive species are not present in the minimum quantities identified in the management plan, some control of herbivores may also be necessary.

HAP targets should guide the direction of management and should not be seen as prescriptions. Timeframes to achieve Favourable Condition should be considered in relation to the objectives and targets set for condition monitoring.

It is difficult to appreciate the processes currently influencing woodland structure and species composition without having an understanding of the history of a site and, ideally, specific history relating to a particular stand.

The history report (Sansum *et al*, 2005) has shown that the three study woods had contrasting management histories. It also suggests that they have been subject to long-term management from at least the 11th century and have undergone a variety of phases of use and management. Each wood was very important to the cultural identity of the three local areas and there is great scope for interpretation and use of this information to encourage local children's enthusiasm for history and for woodland.

Patterns of historic woodland distribution can be derived from old maps and could form an initial basis for Forest Habitat Network planning.

The study woods have recovered well from sustained and intensive use. They are still in a transition phase (in terms of their structure and species composition) towards a more natural state (if managed under a minimum intervention regime). However, this pattern of development is confused by "introductions" such as grey squirrels, elm disease, together with increasing proportions of naturalised species such as sycamore and beech.

Natural regeneration should not be assessed without considering the whole structure of the stand. Its absence may not be critical where there are a number of canopy layers or canopy trees are not approaching maturity and the continuity of mature trees is not critical at the stand scale.

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Appendix 1: Condition Table for *Tilio-Acerion* woodlands

Condition table for *Tilio-Acerion* ravine woodland in the UK
(NVC W8, W9 part, Annex I habitat)

From MacAllister *et al* (2001): Table 4-1

Attribute	Measures	Targets	Comments
1. Area	Extent/location of stands	• No loss of ancient semi-natural stands • At least current area of recent semi-natural stands maintained, although their location may alter • At least the area of ancient woodland retained	• Stand loss due to natural processes eg in minimum intervention stands may be acceptable • Stand destruction may occur if the understory and ground flora are irretrievably damaged even if the the canopy remains intact • Loss = 0.5 ha or 0.5% of the stand area, whichever is the smaller • 20% canpy cover is conventionally taken as the lower limit for an area to be considered as woodland • Area and location of stands may be assessed remotely or by site visit
2. Natural processes and structural development	Age/size class variation within and between stands; presence of open space and old trees; dead wood lying on the ground; standing dead trees	• At least the current level of structural diversity maintained • Understory (2-5m) present over at least 20% of total stand area (except in parkland) • A minimum of 3 fallen lying tree >20cm diameter per ha and 4 trees per ha allowed to die standing • Canopy cover present over 30-90% of stand area (except in parkland stands) • Age class structure appropriate to the site, its history and management • Ground flora present over at least 50% of area	• Any changes leading to exceedance of these limits due to natural processes are likely to be acceptable • There is generally a good structural variety in these stands although veteran trees may be under-represented because of past treatment and the unstable nature of some sites • The ground flora may appear sparse in places late it the season where colonies of *Allium* have died back. Its composition may be variable (see attribute 5) • In coppiced stands a lower canopy cover (of standards) can be accepted, as will also be the case in parkland • See JNCC guidance note for the sorts of age structure likely to be appropriate for different types of management regime • Assess this attribute by field survey
3. Regeneration potential	Successful establishment of young stems in gaps or on the edge of a stand	• Signs of seedlings growing through to saplings to young trees at sufficient densitty to maintain canopy density over a 10 yr period (or equivalent regrowth from coppice stumps) • No more that 20% of area regenerated by planting • All planting material of locally native stock • No planting in sites where it has not occurred in the last 15 years	• A proportion of gaps at any one time may develop into permanent open space; equally some current permanent open space/glades may in time regenerate to closed canopy • Regeneration may often occur on the edges of woods rather than in gaps within it • The density of regeneration considered sufficient is clearly less in parklnad sites than in high forest; in coppice most of the regeneration will be as stump regrowth. See JNCC Guidance Note on likely desirable levels of regeneration • The minimum level of regeneration to be acceptable from a nature conservation viewopiont is likely to be much less than that needed where wood production is also an objective • Assess this attribute by walking through the wood in spring/summer
4. Composition	Cover of native versus non-native species (all layers). Death, destruction or replacement of native woodland species through effects of non-native fauna or external unnatural factors	• At least the current level of site-native species maintained • At least 90% of cover in any one layer of site-native or acceptable naturalised species • Death, detruction or replacement of native woodland species through effects of introduced fauna or other external unnatural factors not more than 10% by number or area in a five year period	• In sites where there might be uncertainty as to what counts as stie-native or as an acceptable naturalised species this must be made clear (eg the position of sycamore) • Where cover in any one layer is less than 100% then the 90% target applies to the area actually covered by that layer • Factors leading to the death or replacement of woodland species could include pollution, including eutrophication from adjacent farmland; new diseases (Dutch elm disease where it has not already struck) • Damage to species by non-native species that does not lead to their death or replacement by non-woodland species (eg damage from squirrels to trees that nonetheless survive) Is not necessarily unnacceptable in nature conservation terms • Excessive browsing/grazing by even native ungulates may be considered an unnatural external factor wher it leads to undesirable shifts in the composition/structure of the stand, although this may be picked up by attribute 2 or 5 anyway • Assess this attribute by a walk through the site
5. Species, habitats, structures characteristic of the site	Ground flora type. Distinctive and desirable elements for a given site eg lime, locally uncommon species such as *Convallaria majalis;* veteran trees or rich lichen/invertebrate assemblages. Patches of assiciated habitats and transitions eg to alder wood, yew groves, species-rich grassland	• 80% of ground flora cover referable to relevant NVC community (usually W8, W9) • Distinctive elements maintained at current levels and in current locations (where appropriate) • Patches and transitions maintained in extent and where appropriate location	• Changes leading to these targets not being met may be acceptable where this is due to natural processes • Distinctive elements and patches should be marked on maps for ease of checking in the field wherever possible • If there are species groups/assemblages that cannot be assessed directly on a general site visit then surrogate features should be given where possible eg dead wood concentrations for associated invertebrates

NOTES

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HIGHLAND BIRCHWOODS
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