



Woodland biodiversity: Expanding our horizons



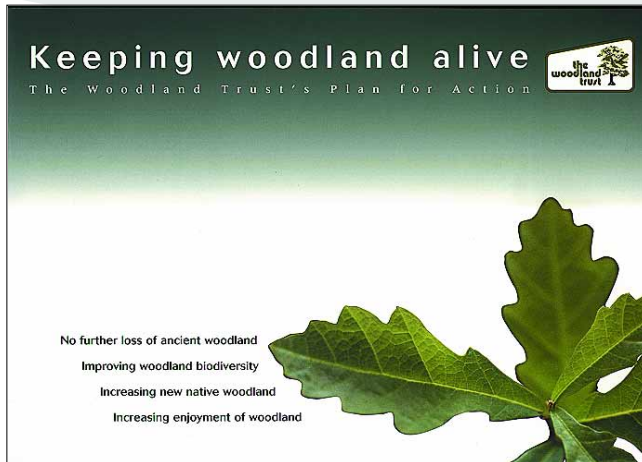
Contents



Photo: Richard Smithers

Introduction	3
Key features of woodland biodiversity	4
Ancient woodland	5
Old growth	7
Size	8
Core Area	10
Woodland adjacent to semi-natural habitats	12
Density of semi-natural habitats	13
Linkage of open ground habitats	14
Measures of woodland biodiversity potential	16
Corresponding strategies for improving biodiversity	17
Developing our plans and focusing our action	19
References	21

Introduction



In Keeping woodland alive - the Woodland Trust's Plan for Action, we set out the contemporary challenges facing woodland in the UK and identify priorities to guide our work over the coming years, including our wish to see the biodiversity of woods improved and restored. But what does this mean and how are we going to measure success?

In Seeing the woods for the trees - the Woodland Trust's approach to conservation, we state that we value all forms of life yet acknowledge that with so many species alive today our knowledge of the natural world will always be limited. We also recognise that species evolve in response to change. Monitoring total species abundance as a means of assessing improvements in woodland biodiversity is, therefore, impractical and to focus on any one species or group of species as a measure of overall biodiversity is likely to be misleading (Simberloff 1998, Harvey 1999).

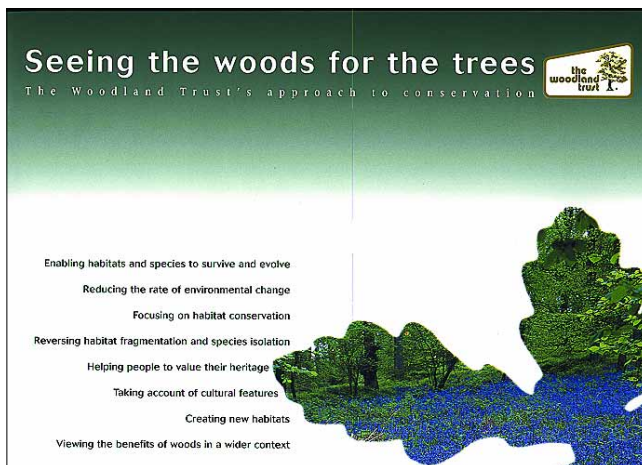
What is needed is a cost-effective means of measuring improvements in woodland

biodiversity and the relative merits of possible future activities relevant to:

- All habitats and species.
- Existing habitats and habitat creation.
- Landscapes and individual sites.

We are not alone in seeking a pragmatic solution. For example, the Joint Nature Conservation Committee is co-ordinating development of condition monitoring for SSSIs (for woodlands, see Kirby 1999).

As a first step we have identified those site features which are major determinants of value to woodland biodiversity. We have then sought to encompass them in the development of what we believe to be a series of simple yet meaningful measures. These are intended to direct broad action, they are not designed to answer all questions and there will still be a need to consider specifics and practicalities in reaching decisions, particularly at a site level.



Key features for woodland biodiversity

Below:
An "island" wood
Photo: Woodland Trust picture library



Increasingly intensive land use has led to massive loss of semi-natural habitats. Those that survive are becoming ever more isolated and effectively operate as islands. For example, 8 out of 10 woods on the *Ancient Woodland Inventory* in England and Wales are less than 20ha (Spencer & Kirby 1992). As a result, like other people (Diamond 1975; Kirby 1995, Peterken, Baldock & Hampson 1995; Ratcliffe, Peterken & Hampson 1998), we have turned to principles of island biogeographic theory (MacArthur & Wilson 1967) and landscape ecology (Forman & Godron 1986) to inform our thinking. With these in mind we have identified the following features as having greatest influence over the contribution sites make to woodland biodiversity:

- Ancient Woodland
- Old Growth
- Size
- Core Area
- Woodland edge adjacent to other semi-natural habitats
- Density of semi-natural habitats
- Linkage of open ground habitats

The attributes of each of these key features is considered in detail:

Ancient woodland

Ancient woodland is irreplaceable, having taken many centuries to evolve. It has been suggested that extinction prone species include most of those of original, natural conditions and that they are now found mainly in stable habitats (Terborgh 1974). If this is the case extinction prone species are more likely to occur in woodland than in any other habitat in the UK and particularly in ancient woodland, which is the most stable woodland type (Peterken, 1993). This assumption is supported by the UK Biodiversity Action Plan, which identifies that broadleaved woodland supports almost twice as many species of conservation concern as any other habitat, e.g. more than twice as many as chalk grassland and almost three times as many as lowland heathland. It has 78 globally threatened and rapidly declining species, and 46 species have been lost in the last 100 years, both higher than

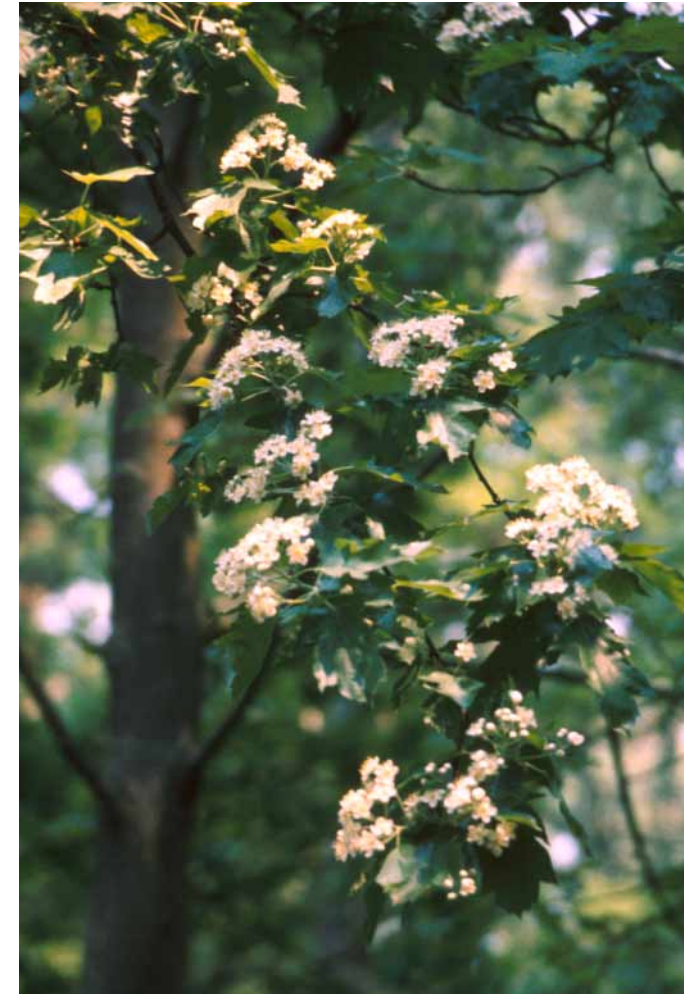
for any other habitat. (Biodiversity: The UK Steering Group 1995).

In England and Wales, ancient woods are defined as those where there has been continuous woodland cover since at least 1600 AD (Spencer & Kirby 1992). Before this planting was uncommon, so a wood present in 1600 AD was likely to have developed naturally. In Scotland, ancient woods are defined strictly as sites shown as semi-natural woodland on the 'Roy' maps (a military survey carried out in 1750 AD, which is the best source of historical map evidence) and as woodland on all subsequent maps (Scottish Natural Heritage 1997). However, they have been combined with long-established woods of semi-natural origin (originating from between 1750 and 1860) into a single category of ancient woodland to take account of uncertainties in compilation of the inventory.

Ancient woods include Ancient

Semi-Natural Woodland and plantations on Ancient Woodland Sites. Semi-natural stands in ancient woods are defined as those consisting predominantly of native trees and shrubs that have not obviously been planted but have arisen from natural regeneration or coppice regrowth. Plantations on Ancient Woodland Sites may be coniferous, broadleaved or mixed (Spencer & Kirby 1992).

Many species with poor powers of dispersal have now been identified as characteristic of ancient woodland. Some occur in almost no other habitat, particularly epiphytic lichens (Rose 1976, Rose 1992, Hodgetts 1992), saproxylic beetles (Harding & Rose 1986) and woodland flies (Marren 1990). A significant number of vascular plants are associated with ancient woodland to a lesser or greater degree (Peterken 1974, Peterken & Game 1984, Rose 1999, Peterken 2000), as are some mosses and liverworts



Key features for woodland biodiversity (continued)

Below:
Different epiphytic lichens act as ancient woodland indicators in different parts of the UK
Photo: Richard Smithers



(Ratcliffe 1968, Hodgetts 1992), slugs and snails (Boycott 1934), spiders, larger moths and butterflies (Marren 1990). The presence of various other species, including the dormouse (Bright 1996), can also be correlated more weakly with ancient woodland. In addition there are suggestions that some fungi may be specific to ancient woodland (Peterken, Baldock & Hampson 1995, Hodgetts 1996).

While plantations on Ancient Woodland Sites include stands planted so closely that any semi-natural understorey is suppressed, these woods often continue to support some species characteristic of ancient woodland, particularly along rides, ride margins and in glades as well as dormant within the seed bank (Radford 1998).

It has been suggested that many woodland species have a wider ecological amplitude in the uplands (Peterken 1996) and that the concept of ancient woodland

has less bearing on the value of woods to biodiversity as one travels north and west. It is undoubtedly true that some vascular plants indicative of ancient woodland in lowland England are not so restricted in the uplands. However, in other parts of the European north temperate zone as much as a third of the flora has been shown to have limited powers of dispersal and tends to be found mainly in ancient woods. Despite a lack of detailed studies, it therefore seems improbable that upland Britain will be wholly different and likely that a significant minority of vascular plants will be restricted to ancient woodland (Peterken, Baldock & Hampson 1995). Study of the distributions of epiphytic lichens has also shown that different ones can act as ancient woodland indicators in different parts of the UK (Hodgetts 1992) and the same may be true of other groups, which as yet have been studied less intensively.

Old growth

The term old growth is widely used elsewhere around the world, particularly in North America. Definitions are generally imprecise and refer to the number of trees over a certain size and the amount of standing and fallen deadwood (Peterken 1996). In the UK old growth has tended to be synonymous with the idea of virgin forest. As it is assumed that no woodland has escaped people's intervention and that the Wildwood had disappeared from England when the Domesday book was produced in 1086 (Rackham 1990), greater focus has been given to ancient woodland. A small proportion of ancient woods, however, retain old growth characteristics. In a UK context old growth has been defined as 'stands with more than 200 years' growth' (Peterken 1996) with a continuity of old trees reaching back into the past (Rose 1992). Indeed it is estimated by some that the UK may be home to most of Europe's ancient trees, excepting the olive and

plane trees of the Mediterranean region (Green 1991).

A substantial number of specialist woodland species are almost wholly confined to old growth stands, notably many saproxylic beetles and epiphytes e.g. more than 70 lichens (Rose 1992). Most of these species are rare, declining and have disjunct distributions (e.g. violet click beetle), which have been interpreted as relict populations of species dependant on dead wood or veteran trees in the original Wildwood and which have survived only where these habitats have been continuously present. As a result these species are particularly characteristic of ancient wood-pastures (Harding & Rose 1986) and it would appear that they have almost no ability to colonise new sites. However, the requirements of individual saproxylic invertebrates are known to be very specific (Warren & Key 1991), as are those of epiphytes (Rose 1976), implying a certain degree of mobility within woods as suitable habitats are only provided by a

small proportion of trees or deadwood at any one time.

An important feature of lichens restricted to old growth is that they are not usually confined to the oldest trees, although the presence of veteran trees is usually the feature most strongly associated with lichen-rich stands (Gustafsson *et al* 1992). Old trees are, therefore, an indicator of the continuity required by lichens which will colonise trees a lot younger than the age of the stand. The same may be true of invertebrates and fungi associated with old growth.

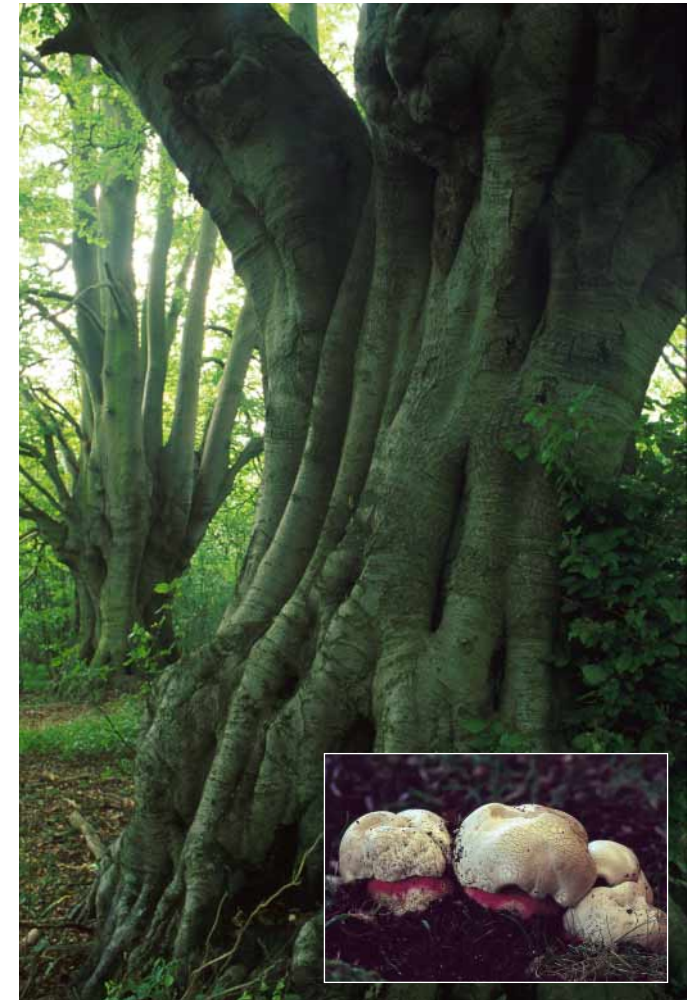
When old growth is clear felled all but the most specialist lichens may return after stands reach 200-300 years old where nearby old growth survives (Gustafsson *et al* 1992, Rose 1992). If scattered veteran trees are retained and woodland is allowed to regenerate lichens re-colonise much quicker but their recovery is seriously compromised if the nearest old growth stand is more than 2.5km away (Sanderson 1998).

Below:
The UK may be home to most of Europe's ancient trees

Photo: G.L.Jones

Inset:
Devil's Bolete - a fungus associated with ancient trees

Photo: Martyn Ainsworth



Key features for woodland biodiversity (continued)

Left:
Size matters!
Photo: Niall Benvie



Size

As the size of islands increases so does the number of species that they support. On average a ten-fold increase in size leads to a doubling of species number (*MacArthur & Wilson 1967*). With increasingly intensive agriculture and habitat fragmentation, woods in the UK operate as island habitats and their species number has been shown to increase with size in the same way (*Game & Peterken 1984*). Also related to size is the concept of minimum dynamic area, MDA, (*Pickett & Thomson 1978*). The MDA is "the smallest area with a natural disturbance regime, which maintains internal recolonisation sources and hence minimises extinction" i.e. the smallest area required for a species or habitat to

sustain itself independently without intervention. Each species has its own peculiar requirements so MDA varies between species. The MDA for most species in the UK is unknown but some area requirements in relation to woodland species have been estimated:

Capercaillie need 500ha of open pine habitat (*Ratcliffe 1999*). Pine marten need 230ha of continuous woodland for a pair to establish a breeding territory (*Balharry 1993*). Dormouse need woods exceeding 50ha to sustain healthy populations (*Bright 1996*). In a lowland arable landscape in eastern England it has been found that for all but the commonest woodland birds, the probabilities of breeding do not approach 100 per cent until woodland size reaches about 10ha or more, such as

about 25ha for marsh tits, and nuthatches are rarely encountered even in woods of 100ha or more (*Hinsley et al 1994*). However, the idea of a minimum area requirement may be misleading as the simple presence of a species does not necessarily indicate a viable population. The concept of a minimum viable population (*Shaffer 1981; Gilpin & Soule 1986; Soule 1987*) is more useful, especially for species with poor dispersal abilities in a fragmented landscape where the arrival of immigrants may be infrequent.

It seems reasonable to suppose that the MDA of a habitat may in part be defined by the area requirements of its keystone species (*Simberloff 1998*). These are defined as species that have impacts on others far beyond what might be

expected from consideration of their abundance or biomass. For example, ectomycorrhizal fungi associated with the roots of trees are extremely efficient in obtaining minerals from soils within which non-mycorrhizal roots would grow very poorly (*Cooke 1977*) and as such are keystone species. It follows that given we know so little about so many species any increase in area is likely to accommodate the MDA of more species and thereby give greater chance of achieving the MDA of the habitat as a whole.

Below:
Dormouse need woods exceeding 50ha to sustain healthy populations
Photo: Kenneth Watkins OBE



Key features for woodland biodiversity (continued)

Below:
Penetrative edge effects from intensive land use are of greatest concern
Photo: David Lund



Core Area

Although size is important, potential confusion arises because it has also been shown that given the same total area the species abundance of woodland herbs increases with the number of separate individual woods (Game & Peterken 1984, Peterken & Francis 1999). This is due to the probability of different sites having different soils supporting different plant communities. Nevertheless, larger areas contribute more to biodiversity, as this finding does not take account of the needs of other groups of organisms which rely on larger areas of woodland, or the potential for future extinction. The concept of Core Area (Laurance & Yensen 1991 & Laurance 1991) is particularly helpful to understanding the latter point. Habitat fragmentation leads

to an increase in the habitat edge to area ratio. Consequently, plant and animal populations are not only sub-divided, they are increasingly exposed to environmental impacts from outside the site. These may take many forms. Increasing wind speed, air temperature and loss of humidity (McCollin 1998) typify microclimate gradients. In the UK environmental impacts associated with intensive land use are undoubtedly of greatest concern e.g. pollution and pesticide drift. There is no significant reduction in drift of pesticides into woodland as compared with open arable landscapes (Davis *et al* 1993). Serious acute effects on plants, fungi and invertebrates occur at least 10 metres away and can occur at a distance of more than 100 metres dependant on the chemical being used and the method of

application (Cooke 1993).

The Core Area of a woodland cannot simply be defined by its woodland edge to area ratio. It is also a product of its shape, size, and distance to which edge effects penetrate. If a wood's total area and length of woodland edge are known then a shape index (Paton 1975) can be calculated, describing its deviation from a circle, and together with an estimate of the distance to which edge effects penetrate can be used to determine the Core Area (Laurance & Yensen 1991). Figure 1 shows two woods of equal size with markedly different Core Areas.

Use of the Core Area model has focused on tropical forest fragments. For example, it has been used in northeastern Queensland to demonstrate the minimum size of forest

fragments, depending on shape, required to ensure that more than 50% remains unaffected by external impacts (Laurance 1991). Further research is required in the UK to establish how far detrimental edge effects penetrate a range of different woodland types in different situations to enable Core Areas to be accurately calculated. As a rough rule of thumb it is known that changes in microclimate extend up to three times the canopy height in from forest edges and that such gradients show a reasonable degree of consistency between studies carried out in different climatic regions (McCollin 1998). This means that a majority of ancient woods in England and Wales may not have a significant Core Area, given that 44% of them are between 2-5ha (Spencer & Kirby 1991) and there is likely to be a substantial number less than 2ha

which are not included in the inventory currently.

A simple illustration of the Core Area concept is the observation from a lowland arable landscape in eastern England that wrens are less likely to be present in long, narrow woods than in circular ones probably due to increased exposure, especially in windy weather (Hinsley *et al* 1994).

It should also be borne in mind that the smaller the Core Area the greater the chance of less mobile species wandering out into hostile territory and succumbing to adverse conditions created by man or natural predation. Circumstantial evidence suggests that this is a significant selection pressure which has led to further recent reductions in the dispersal ability of some species. For example, in South East

England the pearl-bordered fritillary appears far more sedentary in coppice woods, which are invariably surrounded by intensive land use, than in other regions where it occupies different habitats which cover a wider area (Barnett & Warren 1995).

It has been noted that many invertebrates associated with herbaceous woodland plants may benefit from woodland fragmentation, temporarily and locally as the length of woodland edge will be increased and enhanced light penetration may lead to population increases in important herbaceous foodplants (Kirby 1994). However, where woods are bounded by intensive land use, clearly this does not undermine the idea that Core Area is important for sustaining their long term value to biodiversity.

Below top:
Figure 1 Two woods of equal size with markedly different Core Areas;
2.2 hectares and 7 hectares

Below bottom:
Wrens are less likely to inhabit long narrow woods
Photo: RSPB Images



Key features for woodland biodiversity (continued)

Right:
Transitional habitats are now rare, especially in the lowlands
Photo: Mike Lewis

Below:
Hedges often provide the only link between woods
Photo: Woodland Trust picture library



Woodland edge adjacent to other semi-natural habitats

Intensive land use has increasingly led to the establishment of abrupt woodland boundaries. Transitional habitats, which survived at least to some degree until only 20-30 years ago, from woodland through scrub to other semi-natural habitats, including flower-rich grassland or heathland, are now rare, especially in the lowlands. Even hedges, which in many cases provide the only link between semi-natural habitats, continue to be destroyed or lost through mismanagement at an alarming rate. Over 110,000km of hedgerows were lost between 1984-1993 with over 61 per cent of this loss taking place after 1990 (CPRE 1999).

Where other semi-natural habitats do occur adjacent to woodland they have a valuable role to play in fulfilling the needs of many species which require different habitats in close proximity. This may

reduce the need to manage open ground habitats within woods. Saproxyllic invertebrates are a good example, as they need the juxtaposition of old trees and deadwood to breed and open habitats in which to nectar (Key & Ball 1993). For other woodland species with less specific requirements, e.g. badgers (Neal 1986), other semi-natural habitats adjacent to woodland may also play a valuable role in increasing the area of suitable available habitat and thereby sustaining viable populations which the woodland alone could not otherwise support. Depending on their size and shape, adjoining semi-natural habitats may also increase the Core Area of woodland unaffected by detrimental impacts from intensive land use and link woods enabling species to migrate and operate over still larger areas.

Density of semi-natural habitats

According to island biogeography, the chances of a species finding a new island decreases as the distance it needs to travel increases. However, its chances of survival once it arrives depend on the likelihood of it finding the right habitat. The theory predicts that in general this will be greater on islands that are bigger or have been around for longer (MacArthur & Wilson 1967). There has been much refinement and development of the theory over the years, with thoughts varying from the idea of large "core" populations unaffected by "satellite" populations (Hanski & Gilpin 1991) to models in which all populations can become extinct and be affected by neighbouring populations (Levins 1970). However, it is still regarded that in general, extinction rates decrease with increasing area of habitable sites and that colonisation rates decrease with increasing isolation (Elmes, Welch & Carey 1992).

While some woodland species are able to move around in a patchy landscape over a large area, e.g. sparrowhawk (Smart & Andrews 1985), many characteristic species of ancient woodland are poor colonisers and may only spread readily into adjacent areas, e.g. wood anemone (Peterken 2000). There are species, however, intermediate between these two extremes. In general red squirrels are not thought to disperse more than 1km in fragmented landscapes (Rushton, Lurz & South 1998). In eastern England, the likelihood of treecreepers being present in woodland has been shown to decrease as the distance to the nearest wood increases (Hinsley et al 1994). The same study has also concluded that the amount of woodland within 0.5km of a wood is important for long-tailed tits and within 1km for chaffinches and great-spotted woodpeckers.

It follows that, as the proportion of semi-natural habitat within any given area

of countryside around a woodland increases, more species will be able to operate over a wider area and use other semi-natural habitats as stepping stones between woods. As most woods in the UK may be smaller than their MDA and, therefore, too small to be self-sustaining, the density of semi-natural habitat in the surrounding countryside may thus be a vital factor in determining whether or not a site's value to biodiversity is sustainable in the long term. As a counterpoint it has been suggested that isolation is not altogether a bad thing, as those species most capable of migrating are likely to be generalists with the competitive potential to displace sensitive, specialist species with poor powers of dispersal (Simberloff & Cox 1987). While this may be true of remote islands it is less likely to be true of remnant patches of semi-natural habitat in the UK (Dawson 1994), as mobile species are already able to move between them.

Below:
Wood anemone may only spread readily into adjacent areas

Photo: Archie Miles



Key features for woodland biodiversity (continued)

Below:
Was the original Wildwood wall to wall trees?
Photo: Keith Huggett



Linkage of open ground habitats

There is debate over the nature of the original Wildwood. It has long been conceived as wall to wall trees with squirrels able to make arboreal journeys from Land's End to John O'Groats. This appears to be backed by the pollen record, although many assumptions are made in determining weighting given to the abundance of different species. However, this image is increasingly questioned. If this was the case where did all the open ground species present today survive? Some have suggested that as the climate has cooled since about 6,000 years ago open ground habitats, established as a result of forest clearance, created much warmer semi-natural habitats which acted as a

refuge for species which would otherwise have disappeared (Elmes, Welch & Carey 1992). Others make the case that it is unlikely that traditional management has been around long enough or has been sufficiently constant for species to have evolved to be dependant on it. They suggest that the simpler explanation is that some woodland management has by chance perpetuated temporary or permanent open ground habitats, which were present in the original Wildwood (Hamblen & Speight 1995, Vera 1998). The suggestion that large herbivores, such as Aurochs, were not adapted to live off the sparse vegetation of a woodland floor reinforces this idea (Tubbs 1996). It has also been supported by recent conjecture about savannah in Mediterranean

Europe and the observation that there is a thin but continuous pollen record of insect-pollinated plants typical of open ground habitats. Such plants produce relatively little pollen compared with wind-pollinated species and the fact that their pollen has been recorded at all leads one naturally to the conclusion that there was more to the Wildwood than just forest (Rackham 1998).

Whatever the truth it is undeniable that over the millennia open space habitats flourished at the expense of woodland and that traditional woodland management (i.e. coppice, coppice-with-standards and wood-pasture) sustained temporary or permanent open ground habitats within woods.

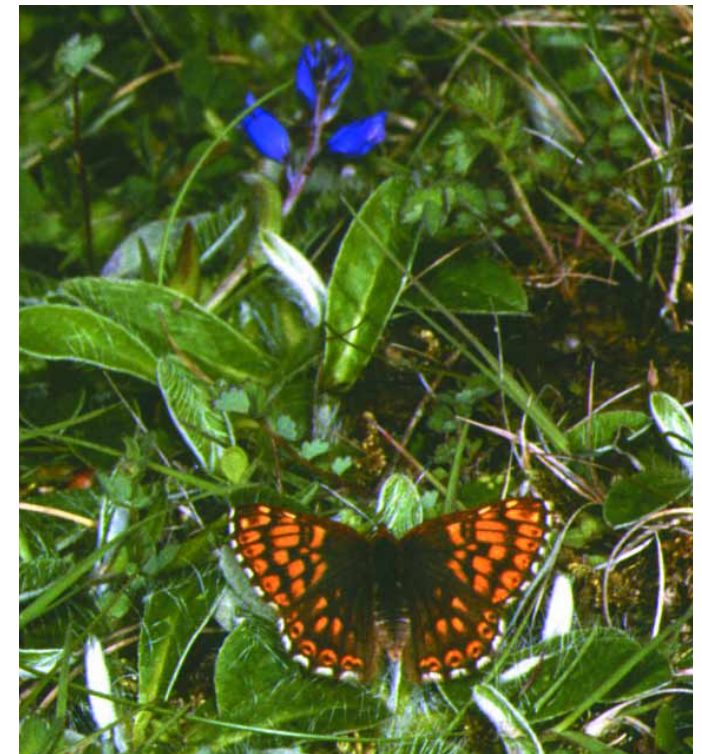
Perhaps it is not surprising, therefore, that the majority of species with very specific

habitat requirements not associated with old growth are instead reliant on temporary and permanent semi-natural open ground (Peterken 1996). It is debatable whether these are strictly woodland species. For example, the pearl-bordered fritillary may be confined largely to coppice woods in South East England but in the South West and North, Wales and parts of Scotland it is a species of well-drained grassland, bracken and scrub habitats (Barnett & Warren 1995). However, loss of other semi-natural habitats means that much woodland management for conservation has focused on the maintenance and creation of such habitats within woodland (e.g. Fuller & Warren 1993, Fuller & Warren 1993a).

Some people suggest open ground habitats

should be easier to re-create and less internationally rare than semi-natural woodland, which should be valued for the length of time it has taken to evolve (Hamblen & Speight 1995). However, it should be borne in mind that woods can act as a barrier to dispersal of open ground species, e.g. certain butterflies will not fly over it (Mungira & Thomas 1992). Others have suggested that this is because they provide a cue which enables non-dispersing species to remain within a fairly discrete area (Elmes, Welch & Carey 1992). Either way linkage of open ground is important, within woods or between areas adjacent to woods, to sustain its contribution to biodiversity.

Below:
Woods can block some butterflies from dispersing
Photo: Woodland Trust picture library



Measures of woodland biodiversity potential

Inset:
The Wye Valley has a high density of ancient woodland

Photo: Archie Miles

Below:
Cumulative Core Area takes account of all semi-natural habitats

Photo: Woodland Trust picture library



The overarching conclusion when all the key features identified are considered together is that the contribution that sites make to woodland biodiversity increases as their temporal and spatial continuity increases.

In this context the following measures, which can be used at a landscape or site scale, encompass the key features of woods for biodiversity:

- Density of ancient woodland cover
- Percentage of ancient woodland which is semi-natural
- Cumulative Core Area of semi-natural habitats
- Area of old growth

Density of ancient woodland cover

This measure takes into account the importance of ancient woodland and reflects its extent as a percentage of land area.

Percentage of ancient woodland which is semi-natural

There is a need to temper the previous measure by ascertaining the proportion

of ancient woodland under consideration that is semi-natural. In effect this will highlight the extent to which the habitat has undergone gross change as a result of re-planting or invasion by species not native to the site e.g. exotic conifers and rhododendron.

Cumulative Core Area of semi-natural habitats

This measure is determined by calculating the cumulative area of all semi-natural habitats (including planted Ancient Woodland Sites) within the area being considered and the combined length of their boundaries with intensive land use. A shape index (*Paton 1975*) can then be used to define mathematically the degree to which together they deviate from a circle. In turn, this figure can be used to work out the cumulative Core Area (*Laurance & Yensen 1991*) by making an assumption, subject to further research, that detrimental edge effects penetrate a distance of 100m.

By accommodating all semi-natural habitats in the calculation, the measure encompasses all the remaining key features

identified as being of greatest importance to biodiversity, with the exception of old growth; size, Core Area, woodland edge contiguous with other semi-natural habitats, density of semi-natural habitats and linkage of open ground habitats. In doing so it assumes that for woodland biodiversity the most significant edge effects are associated with intensive land use rather than with open ground in general. This also ensures consistency with the basic assumption which underpins the Core Area Model (*Laurance & Yensen 1991*) that edge effects are equal on all sides. As a measure it effectively summarises the overall degree to which semi-natural habitats are fragmented. It is important to note that the use of this measure means woodland creation would not be prioritised at the expense of other existing semi-natural habitats.

Area of old growth

This measure seeks to identify all areas of old growth and takes into account its importance, which is otherwise not adequately represented by the other measures.

Corresponding strategies for improving biodiversity

Nature conservation in the UK has taken a site-centred, species-orientated approach. Legislation has focused on the designation of special areas and on species protection (e.g. *the Wildlife & Countryside Act 1981; the Countryside & Rights of Way Bill 2000*), while nature reserve selection strategies have tended to focus on identifying a representative sample of sites (e.g. *Ratcliffe 1977; Goodfellow & Peterken 1981*). Conservation management, in turn, has placed great store by the perpetuation or restoration of traditional management practices. One of the effects of developing the measures, based on the key features of sites to woodland biodiversity identified, is to give greater focus to what can be achieved in the surrounding countryside.

Density of ancient woodland

There is a need to be realistic. Resources for conservation are always likely to be limited and semi-natural habitats may never take up more than 20 per cent of the UK's land area. If woodland biodiversity is to be improved then it will

be important to focus on action where there is greatest potential for biodiversity gain. While there are no actions that can increase the density of ancient woodland cover this measure can be used in targeting action to a particular geographic location or in prioritising sites.

Percentage of ancient woodland which is semi-natural

Restoring planted Ancient Woodland Sites is the only means by which the area of Ancient Semi-Natural Woodland can be increased. It is estimated that 38 per cent of ancient woods in England and Wales have been converted to plantations since the 1930s (*Spencer & Kirby 1992*). Where exotic conifers and rhododendron significantly impact on the sites' ancient semi-natural character, or have the potential to do so, restoration can be achieved by removing them and reinstating site-native trees and shrubs, preferably by natural regeneration (*Radford 1998*). It should be accepted, however, that the resultant stand-types may not necessarily reflect the woods' former historic composition.

Cumulative Core Area of semi-natural habitats

Increasing the cumulative Core Area of semi-natural habitats within a geographical area or site can be achieved by targeting the creation of new native woodland or other semi-natural habitats. For example, taking the idealised example shown in Figure 2, the net result of planting the area linking the two ancient woods in Figure 3 is that the cumulative Core Area remains the same, whereas in Figure 4 it is significantly increased even though exactly the same area of planting has been undertaken.

In pursuing such a strategy we need to acknowledge that it is inevitable that we cannot pass on the landscape pattern we see today, nor can we simply replace lost woods, if we are to sustain the widest possible biodiversity. However, since many of the woods that have been cleared would have been located next to the remaining ancient woodland, past landscapes may to some degree be restored.

Below:
Restoring planted Ancient Woodland Sites is a priority
Photo: Archie Miles



Corresponding strategies for improving biodiversity

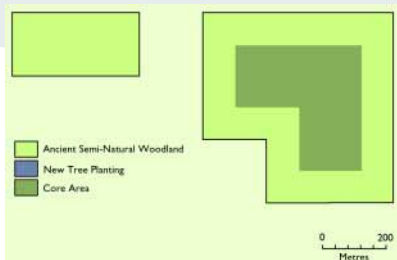


Figure 2 Area of small ancient wood: 8ha
Area of large ancient wood: 32ha
Cumulative Core Area: 12ha



Figure 3 Area of new planting: 4 ha
Cumulative Core Area: 12 ha



Figure 4 Area of new planting: 4 ha
Cumulative Core Area: 16 ha

Reservations have previously been expressed about applying island biogeographic theory to habitat creation (Margules, Higgs & Raffe 1982; Hill *et al* 1992; Dawson 1994; Simberloff 1998). It is acknowledged that it is likely to take a very long time for habitats to mature to the point where they are suitable for colonisation by some species, particularly given gross changes to soils, and for species with poor powers of dispersal to spread. Indeed it can be argued that linkage may actually promote predation, invasion and competitive displacement by more mobile species (Laurance & Yensen 1991), though it seems unlikely that their existing ability to disperse readily between habitat islands in a UK context would be significantly further enhanced by habitat creation. In any case, by focusing on increasing Core Area it should be noted that the emphasis is on enhancing the sustainability of habitats rather than on linkage. However, if action is targeted to a

particular region then inevitably as the cumulative Core Area of semi-natural habitats is increased greater connectivity will result. This will either arise from creating extensions to existing semi-natural habitats, stepping stones or corridors, which are of sufficient dimensions to contribute to Core Area.

Area of old growth

While there is no quick way to develop old growth stands this measure can be used to target: regeneration of agricultural landscapes with veteran trees to wooded conditions where close to existing old growth stands; creation of new woods adjacent to old growth stands; management systems which perpetuate old growth characteristics in existing old growth stands and all nearby woods.

The net result of the measures is that site-centred woodland management, which seeks to promote the biodiversity of existing semi-natural woodland, may be

viewed as a lower priority than the strategies outlined above in sustaining woodland biodiversity in a fragmented and hostile landscape. This is not to say that perpetuating traditional management practices is unimportant where they have continued without a significant break. However, this may only be true at a minority of sites.

It may be noteworthy that the measures can be re-interpreted to be equally relevant to other habitats. For example, measures for use in relation to improving heathland biodiversity at a landscape scale might be the density of heathland cover (including sites capable of restoration), the percentage of heathland which is not degraded, and Core Area of semi-natural habitats.

Developing our plans and focusing our action

In the context of *Keeping woodland alive* and *Seeing the woods for the trees*, the Woodland Trust will use these measures to monitor progress in improving woodland biodiversity potential and to help inform the development of policies, strategies and implementation.

Baseline profile of the Woodland Trust's sites

At a site scale it will be possible to determine numerical values for each of the measures but there is no intent to produce a cumulative score for individual sites, as there is insufficient scientific evidence to adequately weight the importance of these attributes one against another. This profile will provide a baseline against which any increment in the value of our sites to biodiversity can be monitored.

Opportunity mapping

Nationally the measures will be used to identify priority areas of the country and to target action for woodland biodiversity within them. It should be noted that there are some similarities to English Nature's approach to work on Prime Biodiversity Areas (Phillips 1996, Jefferson et al 1998).

In practice this will mean using the Ancient Woodland Inventory to focus initially on areas of the country where there is a high density of ancient woodland (Figure 5).

Within priority areas identified, restoration of planted Ancient Woodland Sites will be the focus for action where the percentage of ancient woodland that is semi-natural is low. An example of such an area, taken from English Nature's Ancient Woodland Inventory, is shown in Figure 6. (overleaf)

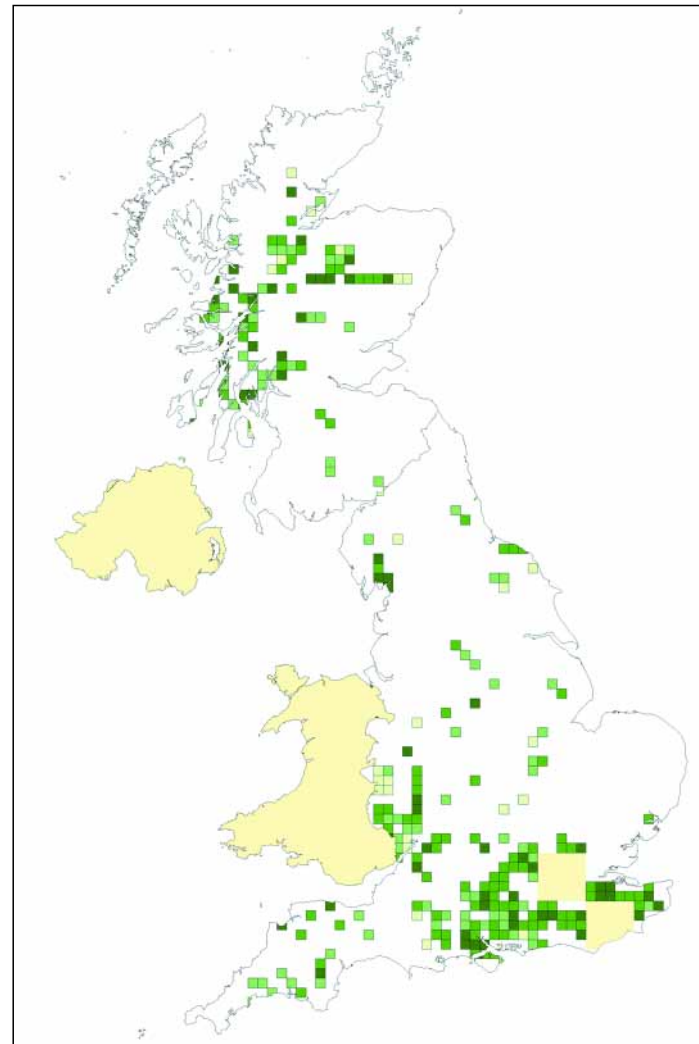
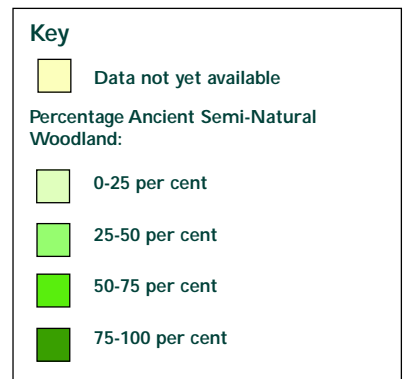


Figure 5: 10km grid squares in England and Scotland where ancient woodland exceeds 5 per cent land cover
Data: © Scottish Natural Heritage & English Nature



Developing our plans and focusing our action

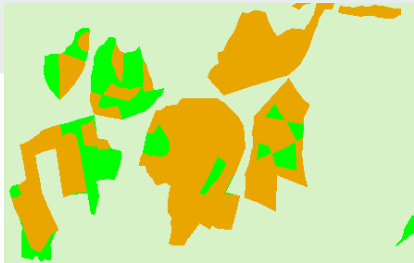


Figure 6 An area where restoration of planted Ancient Woodland Sites is a priority



Figure 7 An area where habitat creation is a priority

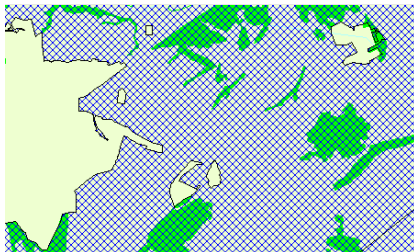


Figure 8 An area where the cumulative Core Area of semi-natural habitats is high

Habitat creation will be targeted where the cumulative Core Area of semi-natural habitats is low in spite of the high density of ancient woodland. A relevant example area is shown in Figure 7 but in Figure 8 the presence of other habitats designated as a Site of Special Scientific Interest as well as ancient woodland means that the cumulative Core Area of semi-natural habitats is already high.

In addition identification of old growth stands will be used to target action to conserve and extend this habitat wherever it occurs across the country as a whole (Figure 9).

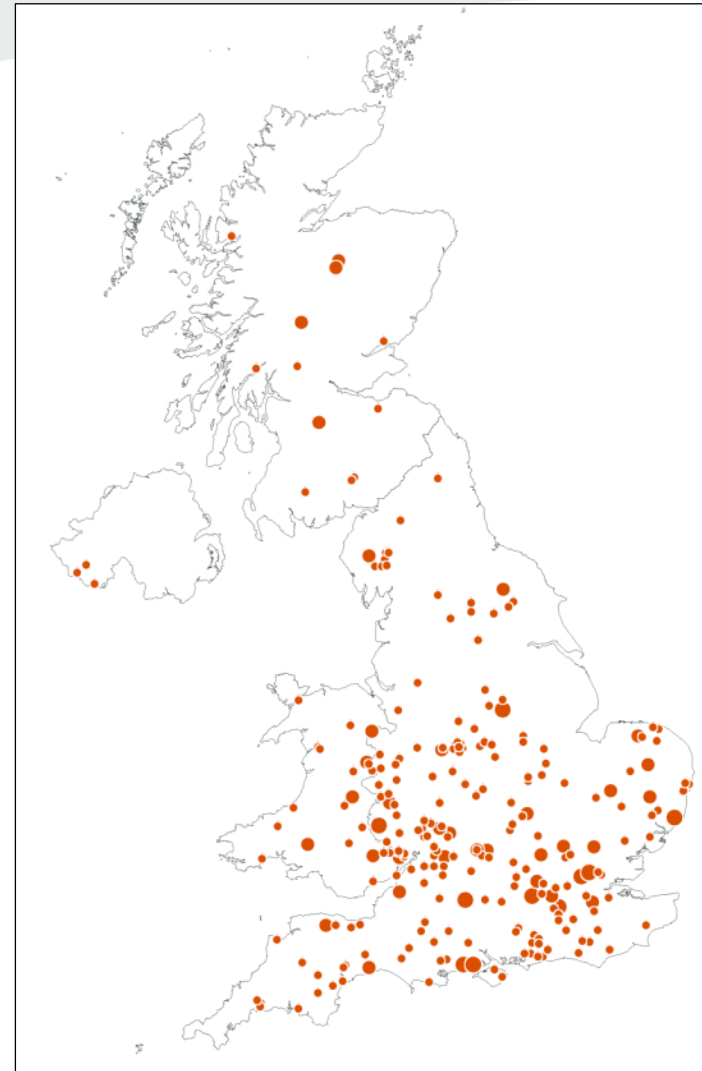
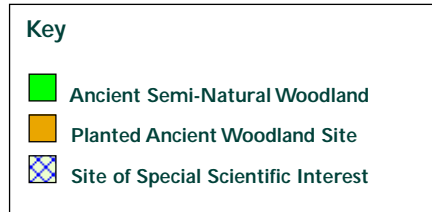
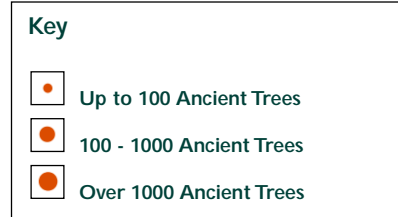


Figure 9 Concentrations of ancient trees in the UK.
Preliminary data: Ancient Tree Forum



References

Balharry, D. (1993)

Factors affecting the distribution and population density of pine martens (*Martes martes*) in Scotland.
Unpublished Ph.D. thesis, University of Aberdeen.

Barnett, L.K. & Warren, M.S.

Species Action Plan - Pearl-bordered Fritillary.
Butterfly Conservation, Wareham.

Biodiversity: The UK Steering Group Report. (1995)

Volume 1: Meeting the Rio Challenge.
HMSO.

Boycott, A.E. (1934)

The habitat of land Mollusca in Britain.
Journal of Ecology Vol.22, pp.1-38.

Bright, P.W. (1996)

Status and woodland requirements of the dormouse in England.
Peterborough: English Nature (Research Report No. 166)

Cooke, A.S. (1993)

The environmental effects of pesticide drift.
Peterborough: English Nature.

Cooke, R. (1977)

Fungi, man and his environment.
Longman Group Limited, London.

CPRE (1999)

Hedging your Bets: Is hedgerow legislation gambling with our heritage?

Davis, B.N.K., Brown, M.J., Frost, A.J., Plant, R.A., & Yates, T.J. (1993)

Effects of hedges on spray drift.
In: Davis, B.N.K., ed. (1993) Environmental impact of pesticide drift.
Huntingdon: Institute of Terrestrial Ecology, NERC contract report to Nature Conservancy Council and Department of the Environment.

Dawson, D. (1994)

Are habitat corridors conduits for animals and plants in a fragmented landscape?
Peterborough: English Nature (Research Report No. 94).

Diamond, J.M. (1975)

The Island Dilemma: Lessons of Modern Biogeographic Studies for the Design of Nature Reserves.
Biological Conservation Vol. 7, pp. 129-146.

Elmes, G.R., Welch, R.C., Carey, P.D. (1992)

Metapopulation dynamics in patchy habitats.
In: Hill, M.O. (1992) The role of corridors, stepping stones and islands for species conservation in a changing climate.
Peterborough: English Nature (Research Report No. 75)

Forman, R. & Godron, M. (1986)

Landscape Ecology.
John Wiley & Sons.

Fuller, R.J. & Warren, M.S. (1993)

Coppiced woodlands; their management for wildlife. (Second Edition)
Joint Nature Conservation Committee.

Fuller, R.J. & Warren, M.S. (1993a)

Woodland rides and glades: their management for wildlife.
Joint Nature Conservation Committee.

Game, M. & Peterken, G.F. (1984)

Nature Reserve Selection Strategies in the Woodlands of Central Lincolnshire, England.
Biological Conservation Vol. 29, pp. 157-181.

Gilpin, M.E. & Soule, M.E. (1986)

Minimum viable populations: processes of species extinction.
In: M.E. Soule ed. (1986) Conservation of Biology and the Science of Scarcity and Diversity.
Sinauer, Sunderland, Mass. pp. 19-34.

Goodfellow, S. & Peterken, G.F. (1981)

A method for survey and assessment of woodlands for nature conservation using maps and species lists; the example of Norfolk woodlands.
Biological Conservation Vol. 21, pp. 177-95.

Green, E.E. (1991)

Simply fungi.
In: Read, H.J., ed. (1991) Pollard and Veteran Tree Management.
Corporation of London.

Gustafsson, L., Friskesjo, A., Ingelög, T., Petterson, B. & Thor, G. (1992)

Factors of importance to some lichen species of deciduous broadleaved woods in southern Sweden.
Lichenologist Vol. 24, pp. 255-266.

Hambler, C. & Speight, M.R. (1995)

Biodiversity Conservation in Britain: Science replacing Tradition.
British Wildlife Vol. 6, pp. 137-147.

Hanski, I. & Gilpin, M. (1991)

Metapopulation dynamics: brief history and conceptual domain. In: Hanski, I. & Gilpin, M., eds. (1991) Metapopulation dynamics: empirical and theoretical investigations.
London: Academic Press pp. 17-38.

Harding, P.T. & Rose, F. (1986)

Pasture-Woodlands in Lowland Britain.
Institute of Terrestrial Ecology, Abbots Ripton.

Harvey, J. (1999)

Who's listening? Building on Biodiversity Programmes: Where Next?
Lancaster: British Association of Nature Conservationists/National Trust Conference - Nature in Transition.

Hill, M.O. et al, (1992)

The role of corridors, stepping stones and islands for species conservation in a changing climate.
Peterborough: English Nature (Research Report No. 75).

References

Hinsley, S.A., Bellamy, P.E., Newton, I., Sparks, T.H. (1994)

Factors influencing the presence of individual breeding bird species in woodland fragments. *Peterborough: English Nature (Research Report No. 99).*

Hodgetts, N.G. (1992)

Guidelines for selection of biological SSSIs: non-vascular plants. *Joint Nature Conservation Committee.*

Hodgetts, N.G. (1996)

The conservation of lower plants in woodland. *Joint Nature Conservation Committee.*

Jefferson, R.G., Robertson, H.J., Wilkinson, M.A., Polley, M., Reid, C., Mitchell-Jones, A., Michael, N. & Cooke, R. (1998)

Prime Biodiversity Areas: definition, identification and conservation uses. *Peterborough: English Nature (Research Report No. 290).*

Key, R.S. & Ball, S.G. (1993)

Positive management for saproxylic invertebrates.

In: Kirby, K.J. & Drake, C.M., eds. (1993) Dead wood matters: the ecology and conservation of saproxylic invertebrates in Britain. *Peterborough: English Nature (Science Report No. 7).*

Kirby, K.J. (1995)

Rebuilding the English Countryside: Habitat fragmentation and wildlife corridors as issues in practical conservation. *Peterborough: English Nature (Science Report No 10).*

Kirby, K.J. (1999)

Woodland feature monitoring on SSSIs using the Common Standards approach. *Joint Nature Conservation Committee Draft Guidance.*

Kirby, P. (1994)

Habitat fragmentation species at risk - invertebrate group identification. *Peterborough: English Nature (Research Report No. 89).*

Laurance, W.F. & Yensen, E. (1991)

Predicting the Impacts of Edge Effects in Fragmented Habitats. *Biological Conservation Vol. 55, pp. 77-92.*

Laurance, W.F. (1991)

Edge Effects in Tropical forest Fragments: Application of a Model for the Design of Nature Reserves. *Biological Conservation Vol. 57, pp. 205-219.*

Levins, R. (1970)

Extinction. In Gerstenhaber, M., ed. (1970) Some mathematical problems in biology *Providence, R.I.: American Mathematical Society pp. 77-107.*

Mac Arthur, R.H. & Wilson, E.O. (1967)

The Theory of Island Biogeography. *Princeton, New Jersey: Princeton University Press.*

Margules, C., Higgs, A.J., Rafe, R.W. (1982)

Modern Biogeographic Theory: Are there any lessons for Nature Reserve Design? *Biological Conservation Vol. 24, pp. 115-128.*

Marren, P. (1990)

Woodland heritage - (Britain's ancient woodlands). *David & Charles, Devon.*

McCollin, D. (1998)

Forest edges and habitat selection in birds: a functional approach. *Ecography Vol. 21, pp. 247-260. Copenhagen.*

Munguira, M.L. & Thomas, J.A. (1992)

Use of road verges by butterfly and burnet populations and the effect of roads on adult dispersal and mortality. *Journal of Applied Ecology Vol. 29, pp. 316-329.*

Neal, E. (1986)

The Natural History of Badgers. *London & Sydney: Croom Helm mammal series.*

Paton, D.R. (1975)

A diversity index for quantifying habitat edge. *Wildlife Society Bulletin Vol. 3, pp. 171-3.*

Peterken, G.F. (1974)

A method of assessing woodland flora for conservation using indicator species. *Biological Conservation Vol. 6, pp. 239-245.*

Peterken, G.F. & Game, M. (1984)

Historical factors affecting the number and distribution of vascular plant species in the woodlands of central Lincolnshire. *Journal of Ecology Vol. 72, pp. 155-182.*

Peterken, G.F. (1993)

Woodland Conservation and Management. (Second Edition). *London: Chapman and Hall.*

Peterken, G.F., Baldock, D. & Hampson, A. (1995)

A forest habitat network for Scotland. Scottish Natural Heritage. *Research, Survey & Monitoring Report Series No. 44.*

Peterken, G.F. (1996)

Natural woodland. *Cambridge University Press.*

Peterken, G.F. & Francis, J.L. (1999)

Open spaces as habitats for vascular ground flora in the woods of central Lincolnshire, UK. *Biological Conservation Vol. 91, pp. 55-72.*

Peterken, G.F. (2000)

Identifying ancient woodland using vascular plant indicators. *British Wildlife Vol. 11, pp. 153-159.*

References

Phillips, M.R. (1996)

A method for identifying Prime Biodiversity Areas in a Natural Area in West Sussex. *Peterborough: English Nature (Research Report No. 180).*

Pickett, S.T.A. & Thomson, J.N. (1978)

Patch dynamics and the design of nature reserves. *Biological Conservation Vol.13, pp. 27-37.*

Rackham, O. (1990)

Trees & Woodland in the British Landscape. (Second Edition). *J.M. Dent & Sons Ltd.*

Rackham, O. (1998)

Savanna in Europe. In: Kirby, K.J. & Watkins, C., eds. (1998) *The Ecological History of European Forests. CAB International.*

Radford, E. (1998)

The restoration of replanted Ancient Woodland. *Peterborough:English Nature (Research Report No. 269).*

Ratcliffe, D.A. (1968)

An ecological account of Atlantic bryophytes in the British Isles. *New Phytologist Vol 67, pp. 365-439.*

Ratcliffe, D.A. (1977)

A nature conservation review. *Cambridge University Press.*

Ratcliffe, P.R., Peterken, G.F. &

Hampson, A. (1998)

A forest habitat network for the Cairngorms. *Scottish Natural Heritage (Research, Survey & Monitoring Report Series No. 114).*

Ratcliffe, P.R. (1999)

Capercaillie Conference. *Battleby: Biodiversity Group.*

Rose, F. (1976)

Lichenological indicators of age and environmental continuity in woodlands. In: Brown, D.H., Hawkesworth, D.L, and Bailey, R.H., eds. (1976) *Lichenology: progress and problems. Academic Press: London and New York. pp. 279-306.*

Rose, F. (1992)

Temperate forest management: its effects on bryophyte and lichen floras and habitats. In: Bates, J.W. & Farmer, A.M., eds. (1992) *Bryophytes and Lichens in a Changing Environment. Oxford University Press.*

Rose, F. (1999)

Indicators of ancient woodland - the use of vascular plants in evaluating ancient woods for nature conservation. *British Wildlife Vol. 10, pp. 241-251.*

Rushton, S.P., Lurz, P.W.W., & South, A.B. (1998)

Modelling the distribution of red squirrels on the Isle of Wight: an isolated and threatened island population of extreme conservation significance. *Report to English Nature.*

Sanderson, N.A. (1998)

New Forest Epiphytic Lichen Database. *Hampshire Wildlife Trust.*

Scottish Natural Heritage (1997)

Advisory Note 95.

Shaffer, M.L. (1981)

Minimum population sizes for species conservation. *Bioscience Vol. 31, pp. 131-134.*

Simberloff, D.S. (1998)

Flagships, Umbrellas, and Keystones: Is Single-species Management Passé in the Landscape Era? *Biological Conservation Vol. 83, pp. 247-257.*

Simberloff, D.S. & Cox, J. (1987)

Consequences and costs of conservation corridors. *Conservation Biology Vol. 1, pp. 63-71.*

Smart, N., Andrews, J. (1985)

Birds & Broadleaves Handbook. *RSPB.*

Soule, M.E. (1987)

Viable populations for conservation. *Cambridge University Press.*

Spencer, J.W. & Kirby, K.J. (1992)

An Inventory of Ancient Woodland for England and Wales. *Biological Conservation Vol. 62, pp. 77-93.*

Terborgh, J. (1974)

Preservation of natural diversity: the problem of extinction prone species. *Bioscience Vol. 24, pp. 715-722.*

Tubbs, C.R. (1996)

Wilderness or Cultural Landscapes: Conflicting Conservation Philosophies? *British Wildlife Vol. 7, pp. 290-296.*

Vera, F. (1998)

Large Herbivores and the Management of Natural Landscapes – Oak and Hazel as Metaphors for Diversity. *Planta Europa pp. 293-300.*

Warren, M.S. & Key, R.S. (1991)

Woodlands: past, present and potential for insects. In: Collins, N.M. and Thomas, J.A., eds. (1991) *The Conservation of Insects and their Habitats. Academic Press, London.*



Woodland biodiversity: Expanding our horizons

The Woodland Trust was founded in 1972 and is the UK's leading conservation organisation dedicated solely to the protection of native woodland. The Trust achieves its aims through a combination of acquiring woodland and sites for planting and through advocacy of the importance of protecting ancient woodland, enhancing its biodiversity, expanding native woodland cover and increasing public enjoyment of woodland.

The Trust relies on the generosity of the public, industry, commerce and agencies to carry out its work. To find out how you can help, and about membership details, please contact one of the addresses opposite.

The Woodland Trust
Autumn Park, Grantham
Lincolnshire NG31 6LL
Telephone: 01476 581111 Fax: 01476 590808
Website: www.woodland-trust.org.uk
E-mail: enquiries@woodland-trust.org.uk

Registered charity number 294344
Registered in England number 1982873
Registered Office: Autumn Park, Grantham, Lincolnshire NG31 6LL
Copyright © 2000 The Woodland Trust
The Woodland Trust logo is a trademark of the Woodland Trust
Printed on recycled paper  1471 06/00

The Woodland Trust Scotland
Glenruthven Mill, Abbey Road
Auchterarder, Perthshire PH3 1DP
Telephone: 01764 662554 Fax: 01764 662553

The Woodland Trust Northern Ireland
1, May Avenue, Bangor, County Down BT20 4JT
Telephone: 02891 275787 Fax: 02891 275942

Coed Cadw
The Woodland Trust Wales
Pantyrnonen, Pencarreg, Llanybydder
Carmarthenshire SA40 9CQ
Tel/Fax: 01570 480888