2.1 Natural disturbances

The character of natural woodland is determined by interactions between the growth and population dynamics of the constituent species, especially the trees, and their interactions with environmental forces, notably natural disturbances. The natural woods of many parts of the world were controlled by fires, some of which were fierce enough to destroy forests over many millions of hectares. The character of the forest at any particular place and time depended on the history of fire as much as on the growth of trees. If the last stand-destroying fire had passed through three years earlier, the natural forest would consist of blackened stumps and a vigorous growth of ground vegetation. If there had been no stand-destroying fires for the last 300 years then we might have found groves of majestic trees over a multilayered underwood, with accumulations of rotting wood on the ground and sparse ground vegetation. And, if the last fire had been 30 years previously, one might have encountered an even-aged thicket of young trees, with very little dead wood and no ground vegetation at all. All three conditions would be equally natural.

The natural regime of disturbances in British woods is difficult to determine, principally because the woods and the wider landscape are not natural. Nevertheless, as the people of south-east England were reminded on the night of 16 October 1987, British woods are disturbed by natural forces, and from such events it is possible to estimate the natural disturbance regime for British woods. Other sources are also useful, such as indications from pre-history of disturbances when the woods were still natural, and extrapolation from experiences in forests elsewhere in the North Temperate.

Over much of Britain, there seems little doubt that **wind** would be the main stand-destroying disturbance in natural woodland. The storm of 1987 blew down 15% of the timber volume in south-east England, which gives some indication of what is possible. However, storms of this magnitude are rare: the previous storm to achieve such an impact in the same region was in 1703. In most years, wind merely blows down a few trees and breaks a few branches, leaving the woods essentially undisturbed, save for some limited gap-formation.

The impact of the 1987 storm was irregular and patchy in several senses. Some woods within the storm track were levelled, but most were left with only a few gaps, or remained undisturbed. Gap-formation and stand destruction was concentrated in some districts, but very limited in others. Woods on scarp slopes facing the wind, and woods on wet ground were affected more than woods in sheltered situations, or on firmer soils. Older trees proved to be more vulnerable than young stands, but there were many exceptions to the rule. Beech and conifer plantations proved to be more wind-prone than other species and stand types. Experience from other storms, such as the 1968 hurricane across south-central Scotland, was much the same.

The other source of substantial, widespread disturbances is **drought**. This may seem paradoxical in a reputedly wet climate, but there is no doubt that the 1976 drought in southern England had a major impact on mature beech stands and on mature birch trees in mixed stands, especially those growing on thin or poorly-drained, heavy soils. Many trees were killed immediately, but others were so weakened that their growth was impaired for years, and mortality rates of survivors increased in later years.

Woods are also disturbed by **biotic factors**. The most obvious of these in recent times has been elm disease, which has largely converted woodland elms from canopy trees to populations of shrubs and saplings. Admittedly, the 1970s outbreak started in imported timber, but it spread naturally. In any case, elm disease flared up periodically in previous centuries from native sources, and the great 'elm decline' of prehistory now appears to be the result of massive infestation in original-natural woodland. Other biotic factors tend to be more insidious than dramatic. Fungi occasionally kill groups of mature trees in otherwise undisturbed woodland, and populations of grazing animals may fluctuate so much that sharp changes in the intensity of herbivory constitute a disturbance to woodland structure and regeneration.

Several other kinds of disturbance may have an impact on natural woodland in Britain:

- **Fire**. During droughts it is possible for dry birchwoods and oakwoods to burn, but most fires are set by people and burn in from heathland. The majority of mixed deciduous woodland does not burn under any circumstances. The only woodland type where natural fires may be a significant factor is pine woodland, but even here the incidence of lightning-set fires is rare. Prehistoric pinewoods burned irregularly, even in western Ireland, but this, too, may have been partly the work of people.

- **Ice storm and snow**. Heavy snow falls and glaze storms can be very destructive, especially the rare instances that occur when deciduous trees are in leaf. Their principal effect is to break crown branches, which has little long-term impact. Heavy spring snowfalls can facilitate layering by shade-bearing trees.

- **Landslip/Topography**. Trees growing on steep slopes grow most of their crown on the downslope side, and thus they tend to fall over prematurely. In this way woods on steep ground are chronically disturbed. Exceptionally, rockfalls, landslips and soil slumping around springs destroys canopy trees.

- **Flood and channel movement**. Today, floodplains support few woods, and flooding of most rivers is controlled. Under natural conditions, floodplains would be largely wooded, and liable to disturbance by floods and channel movement. It is possible that beavers once dammed smaller streams, thereby drowning patches of valley woodland. Channel movement would redistribute sediments and provide fresh deposits where new woodland could develop.

Although it is difficult to estimate the precise influence that natural factors would have in natural woodland today, there seems to be little doubt that the principal disturbance would be wind, and that other sources of disturbance would be extremely rare or localised to particular topographical locations or woodland types. The sources of disturbance would interact, ie one disturbance would lead to another, eg gaps created by drought would increase the exposure of trees on the gap margin to wind. Whatever the source, the impact of a particular event would depend on the composition and age of the woodland and on the history of disturbances. Thus, for example, a particular storm will have little effect if a previous storm had recently toppled all the aged, infirm and unbalanced canopy trees. Whatever the source of disturbance, impacts are likely to be patchy and unpredictable.

In addition to these natural disturbances, modern woodland is subject to several kinds of **semi-natural disturbance**. Some of these are merely modified forms of natural disturbances resulting from the isolated condition of existing woods, eg altered wind disturbance due to long fetches across farmland. Others are biotic, resulting from the introduction of destructive species from abroad which, once introduced, spread naturally. The two most substantial recent examples are elm disease and grey squirrels, both of which have the capacity to reduce potentially tree-forming species to coppice or shrubs.

2.2 Structure, composition and processes in undisturbed old-growth

The structures associated with natural woodland are many and various. Even temperate deciduous forest spans a range from multi-stemmed wind- and ice-bitten scrub on mountain ridges to monumental stands 60m tall on deep, moist soils in protected sites in southern latitudes. Reviews can be found in Jones (1945), Martin (1992) and Peterken (1996).

Concentrating on the broad range of mesic mixed deciduous forest types, which broadly correspond with conditions in most of Britain, investigations of relict stands in Eastern North America and Continental Europe indicate that canopy trees generally live for 200-500 years, rarely beyond 700 years. The size of canopy dominants depends on the situation, but trees over 35m are exceptional. The width of trunks often reaches 100cm DBH, but occasionally goes larger, as in Bialowieza, where the maximum diameters are lime 200cm, oak 230cm, wych elm 150cm, and ash 130cm (Falinski 1986). The form of individual trees is generally slender, with narrow crowns.

In old-growth stands the density of trees usually falls within the range of 120-500 trees/ha, but this depends entirely on the minimum size included. More meaningful is basal area, which depends mainly on the large trees: in most old growth this ranges between 25 and 40 m^2/ha. Stand volume is mostly within the range 200-500 m^3/ha, though it can be much higher where conifers enter the mixture.

The volume of coarse woody debris (CWD) is generally high in natural old-growth, though the distribution is usually extremely irregular, with accumulations in valley bottoms and around blowdowns. Average volumes of 50-150 m^3/ha appear to be characteristic, depending on history of disturbances during the last 50 years or so. The distribution of CWD between the various components - snags, fallen wood, stumps, branchwood - varies according to the disturbance regime and the species involved. Living trees may also contain decay columns, and this is rarely included in estimates of CWD, though the volume is less than in wood-pastures.

Stand dynamics can be expressed as a Gap Creation Rate. However, gap creation often comes in pulses, ie there are years with substantial canopy losses, which recur at irregular intervals. Rare catastrophic disturbances destroy all or most of the stand in a single event, but thereafter gap creation is negligible as the stand regrows to maturity. The long-term average usually falls between 0.5% and 2% of the area each year, which implies an average canopy residence time for individual trees of about 100 years. Mortality rates of individual trees are usually around 1%/yr.

Regeneration in natural woodland is notoriously patchy in space and time. It is associated with older stands (advance regeneration), openings (gap phase regeneration), and the aftermath of larger disturbances. The composition of the regeneration is determined partly by the size of the opening: large gaps and major disturbances provide an opportunity for light-demanding species, whereas only shade-bearing species survive as advance regeneration. The individuals that grow into an opening may be a mix of advance regeneration, vegetative re-growth and new regeneration, so the actual composition of the new stand or group will generally be a mixture of species whose presence was determined by a range of circumstances.

Most natural broadleaved deciduous forest is mixed in composition, though near-monocultures of beech can develop in sub-montane regions, and small, single species patches of poplar, alder or willow are characteristic of wet and riparian forest. Elsewhere, several species usually occur together, though one species may dominate locally. After decades without substantial disturbances, shade-tolerant species such as beech, lime and elm increasingly dominate. Maximum diversity is associated with moderate levels of disturbance. Stand composition is rarely stable at the scale of groups, ie when a canopy tree of species A dies, its place in the canopy is likely to be taken by species B, or C. A measure of long-term, small-scale stability is achieved by long-lived individuals (oak, pine), species that usually regenerate vegetatively (lime), and shade-tolerant species that can regenerate in 'their own' gaps (beech). At larger scales (eg catchment), net composition is more stable, though it changes with long-term, post-glacial range expansions and contractions.

The overall structure of natural forests can be described in terms of silvicultural systems (Jones 1945). Almost all are high forest, not coppice. Where large disturbances are frequent and/or recent even-aged stands and two-storied high forest are common. In relatively undisturbed locations, a group selection structure is widespread. Coppice-like stands develop in severe environments. Parkland structures occur on forest margins where fire once swept in from nearby grassland and scrub.

Permanent open spaces are rare in most remnant natural forests. They persist on large cliffs, screes, boulders and outcrops, but otherwise are mainly associated with rivers and wetlands. Temporary open spaces persist after disturbances on fertile ground, where herbaceous growth not only inhibits tree establishment, but also attracts herbivores. Likewise, tracts of bracken or patches of dense underwood can inhibit regeneration after a disturbance, and thus maintain an opening in the canopy. Temporary open spaces exhibit a collective permanence, in that most forests contain recently-formed gaps somewhere.

2.3 Natural woodland in Britain

Does this generalised description fit natural woodland in Britain? In the absence of original-natural stands we cannot be sure, yet it is worth attempting to define the general characteristics of British natural woodland as a basis for predicting the likely long-term outcome of maintaining minimum intervention reserves. Evidence is available from pollen and other sub-fossil remains, near-natural stands, and the impact of natural disturbances on managed woods. Three types are considered (i) floodplain woodland, (ii) Boreal forest and (iii) the rest.

The principal disturbance factor in British woods is likely to be wind with limited effects due to drought and biotic factors. On steep slopes, topographic factors may over-ride these. Most forests would be mature or old-growth, regenerated as small- and medium-sized gaps. Large-scale disturbances would be infrequent, so large-scale even-aged stands would be rare.

Growth would probably be limited on heavy and poorly-drained soils. Small-scale gap dynamics would favour shade-tolerant tree species. Permanent open spaces would be limited to the wettest ground, large cliffs and screes, and perhaps to very poor soils. Most stands would conform to high forest, but limited areas on both very fertile and very poor ground would be maintained as wood-pasture by large herbivores (section 3.3). In southern Britain, small-leaved lime and large-leaved lime would be dominant (Birks *et al* 1975, Greig 1982), but in the west and north elm, oak and alder would be prominent.

The larger floodplains would be predominantly wooded, but much larger areas of open ground would persist as mires and grazed grassland. Channel mobility would ensure a limited presence of poplar-willow woodland on shoals, but most of the floodplain would be occupied by mixed woodland dominated variously by pedunculate oak, ash, suckering elms and alder, with alder dominant in depressions. Such woodland would be more vulnerable to wind than woodland on higher ground, and also perhaps more heavily grazed, so light-demanding trees would be well represented.

Boreal and treeline woodland is strongly associated with poor and dry soils. It is likely to be subjected to wind, fire and drought, generating structures with strong, large-scale, even-aged elements and an approximation to two-storied high forest. The likely dominants are Scots pine, birch, aspen, rowan and, on wet sites, alder. Boreal forest would be mixed on a landscape scale with mixed deciduous woodland, the latter tending to occupy fertile ground and lower, south-facing slopes. Mires and long-lasting open spaces would be frequent.

2.4 Wildlife and natural features in natural woodland

The wildlife of natural woodland is astonishingly diverse. The work of Falinski (1986) and others in Bialowieza National Park, Poland, has demonstrated that even compartment-scale segments of natural lowland forest contain 2000 species of flowering plants, ferns, bryophytes, lichens and fungi. The fauna is likely to be a great deal richer.

The species-groups of natural forest which have been most reduced by the transformation to cultural landscapes are:

- Large mammals and birds. These require very large territories and home ranges. Fragmented remnants of natural forest may harbour small populations, but the population size may be too small to be sustained. In practice, most remnants of natural forest lack the large carnivores and herbivores.

- Saproxylic species. These depend on dead wood and mature structures. The prominent components are fungi, timber-utilising invertebrates, hole-nesting birds and epiphytic lichens, but they would also include large mammals that used hollow trees as dens. Such species have been much reduced in managed woodland, and many now survive as small relict populations in ancient woods.

- Forest interior species. These preferentially inhabit closed forest far from large gaps and forest edges. They have been recognised particularly amongst birds, which find some protection from predation in forest interiors. Such species retreat disproportionately upon forest fragmentation.

- Wetland species. In most natural lowland forests undulations on the land surface allowed a mosaic of wet and dry patches to persist. Windthrow generated pit-and-mound microtopography. Managed forests that are drained and harvested have fewer wet hollows and generate few windthrow pits.

Other groups of natural forest species have evidently prospered with forest fragmentation and management. Open space and young-growth species are restricted in natural forests, but they expand rapidly after substantial disturbances, and have become widespread in managed forest and unploughed deforested landscapes.

Alan Rayner has advised 'that the fungal ecology of unmanaged woodland will differ substantially from that of managed woodland, and in my own experience the difference in fungal flora between adjacent stands of managed and relatively unmanaged/ancient woodland can be startling. This difference may principally arise because disturbance increases the incidence of opportunist fungi, whose mycelia grow and fruit readily, compared to more specialised forms with persistent mycelia that reproduce more slowly or sporadically. Consequently, fruit body production can often be prolific in managed woodland, but species diversity is low, with what are normally regarded as "common" species predominating, whereas unmanaged woodland supports a higher diversity of more unusual species whose fruit bodies are less easy to find at any one time. Another important consideration is the arguably greater scale-heterogeneity of niches (from tiny twigs to large tree trunks) for fungi in unmanaged woodland.

3. Issues relating to naturalness of reserves

3.1 How natural are non-intervention woods?

We can designate woodlands as non-intervention reserves and strive to keep them free of direct human influences, but how natural are the resulting stands? At least five kinds of human influence can never be totally excluded, (i) the residual effects of past human activity on the site, (ii) permanent changes in the balance of nature, (iii) diffuse, widespread environmental change generated by people, (iv) continued interaction with the surroundings, and (v) the long-term effects of ecological isolation. In these circumstances reserves can never be completely natural.

3.1.1 Residual historical influences on the site

Field ecologists know that tree shapes generated by past management can be detected long after that management has ceased. This is particularly true of multi-stemmed trees grown from former coppice stools, old pollards and wide-crowned trees that grew up in open conditions. Since oak, beech, ash and other long-lived trees were well represented as coppice, standards and pollards, these features will be particularly enduring. At Lady Park Wood, for example, the standard oaks and coppice origins of many lime and beech are still clearly visible 130 years since the last coppicing. The number of trunks on a former stool is progressively reduced, and the lower branches of former wide-crowned trees die as adjacent trees grow up, so the stand increasingly takes on the form of high forest, but 200-300 years may have to elapse before structural signs of former management are erased.

The physical modification of land form by past management will be even more enduring. Woods are full of tracks, pits, small quarries, charcoal hearths, cultivation remains and ponds, and most are surrounded by boundary banks or walls. It would be possible in some instances to erase these features and restore the original land form, but this would be expensive, disturbing, and destroy valuable historical features. In effect, these features are permanent.

3.1.2 Permanent changes in the balance of nature

The most profound effects of people on a reserve are possibly the least obvious. Settlement and forest clearance over the millennia was accompanied by the reduction and then extinction of large carnivores and herbivores. In Britain we have lost the wolf and other large carnivores, so that today there is no natural check on the populations of deer. Forest cattle have been reduced to vestiges confined to parkland, such as the herd of white cattle at Chillingham Park. Wild boar were also eliminated, though they are now making a determined comeback in some southern counties. The interactions of these beasts in lowland mixed deciduous forest can be observed in Bialowieza National Park, but even here the imbalances are profound and deer numbers are rising inexorably. With these species gone from Britain, we can only estimate their impact on natural woodland indirectly.

This issue is further considered in 3.3 below.

3.1.3 Diffuse changes in the environment caused by people

Every forest is affected by widescale environmental changes caused by people. These range from worldwide climatic changes, acid rain and enhanced nitrate deposition to regional-scale effects, such as land drainage. For this reason alone, no wood can be totally natural. The scale and character of the impacts are difficult to assess, and they certainly vary regionally. In Europe, substantial long-term changes in ground vegetation are consistent with increased soil acidity and nitrate concentrations. Pollution has been blamed for widespread deterioration in the health of forest trees. The date of flowering or leafing of some plants has been brought forward during the last century (Sparks 1999). One might predict, for example, an increase in the frequency of fertile seed set in *Tilia cordata* (where the lack of cumulative warmth of summers inhibits fertilisation, Pigott and Huntley 1978-82), or the northwards expansion of *Campanula trachelium* (which reaches its northern limit in the English midlands), but so far responses of this sort have not been reported.

3.1.4 Continued interaction with the surroundings

Any natural woodland that develops in a woodland reserve will be surrounded by a managed environment, either managed woodland or unwooded ground from which trees have been cleared. It is important to understand how the surroundings can affect the reserve, and what impact the reserve can have on the surroundings.

a. Species changes within reserves

Isolated woodland reserves are infiltrated by species from the matrix, where non-woodland habitats, plantations and secondary woods include numerous species which naturally have no place in original-natural woodland. In theory, this can result in increased predation of species within the woodland, but perhaps the most significant effect in Britain is the possible invasion of woodland by non-native species. Today, any wood set aside as a natural woodland reserve is liable to be colonised by sycamore, rhododendron or some other naturalised species.

Minimum intervention woodland reserves in larger woods can function as refuges for deer, especially where the surrounding plantations are evergreen coniferous, ie, dark enough to reduce herbage. This seems to be the case in Lady Park Wood, where the surrounding Highmeadow Woods are a mosaic of conifer and broadleaves of all ages. On the other hand, the reverse seems equally possible in different circumstances, ie given a choice of worked coppice in the surroundings, the minimum intervention reserve may be unattractive to deer.

b. Edge effects

Edge effects may be extremely important in small woods, but the depth of 'edge' varies according to the factor being measured. Values given in a recent review (Murcia 1995), show that physical factors, such as increased air temperature and light intensity, are detectable up to 50m into a wood. Stand characteristics were more variable: for example, the higher basal area on a wood edge penetrated only 15m, whereas increased vulnerability to windthrow extended 150m. Biological responses were also wide: enhanced seed dispersal extended 10m, whereas increased nest predation extended up to 600m.

Since British woods have been managed for so long (and have therefore long had internal edges), species which are extremely sensitive to edge effects will presumably have vanished long ago. The general edge effect can thus be set fairly low in the range, say 50m.

c. Altered incidence of disturbances

Isolation prevents natural disturbances from propagating through woodland, and thereby reduces the frequency of disturbances. This is most obvious for fires, but it can also be a factor for disease. In British conditions, only the Boreal pine woods are likely to be affected by a modification of a natural fire regime. The spread of disease and other biotic factors does not seem to be inhibited by isolation, as recent experience with Dutch elm disease and grey squirrels shows.

Marginal trees in isolated woods appear to be more vulnerable to wind. However, the trees on the very edge are generally wind-firm, so the trees that are most likely to be blown down are those standing one or two trees in from edges, where eddies are set up and trees lack a strong wind-firm structure. Isolation in relation to wind can also occur when plantations on the margin of a reserve are felled, leaving the reserve suddenly exposed.

d. Altered hydrology and river forms

Ancient woods in gently undulating lowlands are commonly situated on higher ground, separated from rivers and streams, where drainage is mainly outwards from the wood. Such woods have a relatively self-contained hydrology, though drainage in the surrounding fields could presumably affect the rate of run-off.

In the uplands, ancient woods generally occupy the steeper slopes, but may extend on to floodplains of very narrow headwaters. Springs commonly issue within the wood, and small streams flow through the wood. Land use upstream and upslope will influence flow rate and water quality, but this will affect only a very small proportion of the wood. More significant, perhaps, is the ability of watercourses to carry species and seed into the wood from upstream habitats.

3.1.5 The long-term effects of ecological isolation

Even where it is part of a larger woodland, any natural woodland reserve will be isolated to some extent by its distinct structure and dynamics, and this may influence the composition of the stand and the diversity and behaviour of species. Some examples:

- **Failure of beech to spread to its natural potential range**. The post-glacial migration of beech was slow, and by the time it arrived in Britain the original-natural woods had been substantially cleared, especially on the chalklands of south-east England. This and beech's antipathy to coppicing may have prevented it spreading to its potential natural range. Latterly, beech has been planted in north and west Britain beyond its acknowledged native range, and has become thoroughly naturalised. The modern native range of beech has thereby become a matter of debate.

- **Immobility of invertebrates**. Invertebrate populations confined within isolated woods may have developed a more sedentary character than they would have had when woodland covered the landscape. The more mobile individuals tended to move into hostile territory outside woodland, so a higher proportion of sedentary individuals survive to reproduce. This effect has been demonstrated for both ground beetles and butterflies, but it may well have been general.

- **Relaxation**. In theory, the number of species in an isolated reserve will have been steadily reduced since the wood became isolated. This is because small populations are at risk of extinction from localised or temporary changes in habitat conditions, and a proportion of such species will be unable to re-colonise from nearby woods. In practice, this effect is difficult to demonstrate and probably affects only small, very isolated woods.

3.2 Pasturage in natural woodland

The assumption that natural woodland generally took the form of high forest with a more-or-less closed canopy has been challenged on the grounds that populations of large herbivores would have exerted so strong an influence on forest structure that truly natural woodland would have taken the form of wood-pasture, ie groups of trees and individual trees with spreading crowns in a matrix of grazed herbage. Proponents of this view consider that the loss of the Pleistocene megafauna was the work of people, and that the old-growth and so-called virgin high forest stands we now see have developed only in this modified environment. They point to the fact that oaks were prominent in the original-natural forests, a condition that would only be possible if much regeneration took place in open, grassy circumstances. They also note that epiphytic lichens reach optimum growth in the semi-open conditions of wood-pastures, not the shade of high forest.

Evidence against the proposition is, however, available. Thus, the species of open space habitats are generally poorly represented in pollen diagrams before the Neolithic clearances. It is difficult to reconcile the abundance of *Tilia* and *Ulmus* in the pre-Neolithic forests with the suggestion that the forests were heavily grazed. Bialowieza National Park, on mesic soils in lowland Poland, which retains both large carnivores and large herbivores in a large, near-natural forest, has few openings and takes the form of high forest. In eastern North America, the pre-European forests on prairie margins and major valleys appear to have been kept open by Indian cultivation and hunting practices, whereas the forests in the hills appear to have been dense high forest.

The debate remains unresolved. It seems quite likely that large herbivores might have maintained open-structured forest in some places, such as alluvial ground, where competition from vigorous herbage reinforced by preferred grazing might have strongly inhibited tree regeneration. One can imagine forest on thin, dry soils on scarp margins remaining open if tree growth is slow and viewpoints are favoured by deer and cattle on the move. Ancient woods often contain natural glades associated with dense bracken and mires. The importance of natural wood-pasture may be obscured if, as seems possible, the ground which tended to generate such structures was disproportionately converted to farmland. However, as a general condition of all natural woodland, wood-pasture seems an unlikely model. This report takes the view that the high forest model should remain the 'default' assumption, but allows that wood-pasture variants of near-natural woodland should be recognised.

3.3 Varieties of naturalness

It is easy to assume that primaeval forest could eventually be restored or recreated in a non-intervention reserve, but forests were being modified 5000 years ago, some species have been lost, the landscape is pervaded by non-native species, and the climate continues to change. We must recognise that the natural woodlands that largely covered the landscape over 5000 years ago may be impossible to re-create, and that any natural woodland that may develop in reserves will be qualitatively different.

In order to accommodate this issue, several kinds of naturalness can be recognised, all based on composition (Peterken 1996). They are exemplified by stand composition in ancient woodland on poorly-drained, alkaline clay loam in midland England (Table 3.3).

- **Original-naturalness**. The last forest not significantly affected by people. These are the so-called Atlantic period forests, that in midland England were usually dominated by lime. Unmodified portions of this forest survived until much later, but all surviving forest appears to have been managed and modified by early historical times.

- **Present-naturalness**. The natural forest that we would have inherited if people had never influenced the forests. This assumes that the original-natural forests would have continued to change in response to climatic changes, long-term soil maturation and the continued migration of species. There seems no reason to doubt that the original stand constituents would have survived in midland England, but beech and hornbeam would probably have colonised the region.

- **Past-naturalness (or inherited-naturalness)**. The components of the existing forest which have been inherited directly from the original-natural forest. In midland England, lime has been largely eliminated from ancient woods, leaving the characteristic mixture in the form of oak standards over mixed coppice of hazel, maple, ash and elm.

- **Potential-naturalness**. The forest that would develop if human influence were removed completely and the resultant succession were to take place infinitely quickly. This is a hypothetical condition that expresses the current potential of the species now on the site. In midland England it is possible that oak will fail to survive, but almost inevitable that sycamore will be present and that it will persist. Lime, beech and hornbeam, which remain uncommon in the midlands ancient woods, cannot form part of this 'instantaneous' succession.

- **Future-naturalness**. The forest that would eventually develop from existing forests if human influence were removed. This would take centuries to develop, but in midland England it is assumed that lime would not recolonise, and that beech, hornbeam and sycamore would eventually spread and maintain themselves. There is also the possibility that other species would enter the system.

The general point is that in the chosen example the five varieties of naturalness would have different compositions. When we consider natural or near-natural woodland, it is desirable that we specify which variety of naturalness we mean. If the objective is to restore near-natural woodland, the particular type of naturalness specified determines policy on species re-introduction, the control of naturalised species, and whether any effort is to be made to maintain declining native species.

Table 3.3. Composition of woodlands with different qualities of naturalness on poorly-drained, alkaline clay loam in midland England. Relative abundance is indicated by the number of +.

	Original	Present	Past	Potential	Future
LIME *Tilia cordata*	+++	++			
OAK *Quercus robur*	++	+	++		
ASH *Fraxinus excelsior*	+	++	+++	+++	+++
MAPLE *Acer campestre*	+	++	+++	++	++
ELM *Ulmus glabra*	++	++	+	+	+
HAZEL *Corylus avellana*	+++	+++	+++	++	++
BEECH *Fagus sylvatica*		+			++
HORNBEAM *Carpinus betulus*		+			+
SYCAMORE *Acer pseudoplatanus*				++	++
Unknown species					??

In practice, it is probably sufficient to simplify to three types of naturalness, recognising that potential-natural is hypothetical, and that present-natural did not happen. These can be labelled:

- **Original-naturalness**, which can be reconstructed from pollen diagrams.

- **Inherited-naturalness**, which are the component species (and genotypes) of semi-natural woodland that are deemed to be within their native geographical and edaphic range.

- **Future-naturalness**, which labels the unpredictable future of woods which are henceforward allowed to develop as naturally as possible, free from any controls on composition.

3.4 Types of near-natural woodland

If we accept (i) that the influence of people can never be completely excluded from woodland, and that the 'best' one can achieve in a reserve is 'near-natural' woodland: that (ii) there are various qualities of naturalness, and (iii) that ambiguity remains about the true structure of natural woodland, then there is a case for recognising several types of near-natural woodland for the purposes of establishing minimum intervention reserves. Table 3.4 summarises the main types.

Table 3.4. The main types of natural woodland on which minimum intervention reserves might be based

	High forest model	Wood-pasture model
Original-natural	Ia Reconstruction of virgin forest, based on relict original-natural stands or re-introduction of lost species, whilst controlling the impact of deer and other herbivores to levels that permit natural regeneration in gaps.	Ib Reconstruction of virgin forest, based on relict original-natural stands or reintroduction of lost species, in the presence of large herbivores which can maintain permanent open space habitats.
Inherited-natural	IIa Free development of ancient woodland, whilst maintaining the locally native species currently on site; excluding established and colonising non-native species; and controlling deer and other herbivores are levels that permit natural regeneration in gaps.	IIb Free development of ancient wood-pasture, whilst maintaining locally native species currently on site; excluding established and colonising non-native species; and maintaining large herbivore populations that allow intermittent and patchy natural regeneration.
Future-natural	IIIa Free development of ancient or secondary woodland, controlling only the populations of deer, etc to levels that allow natural regeneration in gaps.	IIIb Zero control of tree regeneration and herbivores in any kind of woodland.

These types represent reference points. Intermediate conditions can be identified. In most existing minimum intervention reserves, the general intentions conform most closely to type IIa, but in wood-pastures like the New Forest unenclosed woods conform to type IIb. The Broadbalk and Geescroft Wildernesses at Rothampstead correspond to type IIIa.

3.5 The place of people in nature

One of the oldest debates concerns the relationship between people and nature. Simplifying enormously, two views are expressed: (i) that people are part of nature, and (ii) that nature is everything else except people. To a substantial extent this is a problem of definition. 'Natural' is a word that has carried a wide range of meanings, including both the notion of inevitable development (including the transformation of landscapes by farming), and the notion that natural should be defined as that which is not human or affected by people.

The position adopted here is that natural should mean 'without significant human influence'. This is chosen because it is difficult to see what the word could mean if significant human influence is allowed within the definition, and because it provides a clear antithesis as a basis for understanding how people relate to the rest of the world. This does not deny that people have long influenced their surroundings, nor does it imply that woodland reserves influenced by people are undesirable. It simply sets up a definition that is useful.

3.6 Effects of natural woodland reserves on their surroundings

Just as a minimum intervention reserve can be affected by its surroundings (3.1.4), so the reserve may have an impact on its surroundings, both damaging and beneficial.

Natural stands with large amounts of rotting wood and an abundance of decay species are not always welcome as neighbours by timber growers. In British conditions the high fuel load represented by large volumes of coarse woody debris is rarely a threat to adjacent plantations, even in Boreal pine woods, though natural woods might be more attractive to picnickers and their fires. In Continental Europe, *Ips typographicus* infestations can spread from unsalvaged blowdowns into surrounding stands.

Minimum intervention reserves may benefit nature conservation in surroundings woods by acting as sources for the repopulation of wider environment. Supporting evidence comes from the surroundings of the New Forest and Windsor Great Park. These are top locations for saproxylic invertebrates in Britain, but these species are evidently found in the surrounding countryside more often than in similar countryside lacking nearby source populations. However, it is also plausible that the richness of the New Forest and Windsor Great Park is in part due to them being part of a broader landscape in which old trees are, and have always been, relatively common.

4. Selecting minimum intervention reserves

The selection of minimum intervention reserves should be a mixture of 'top-down' and 'bottom-up' approaches. Whilst there is a strong case for including those sites that already happen to be *de facto* minimum intervention reserves, the selection of sites will have stronger support if it has a clear foundation. This section therefore considers the basis for determining the overall population of reserves and the criteria for selecting individual sites, but the actual selection and justification of particular sites has been completed by the parallel report by Ed Mountford (*English Nature Research Report*, 385).

Selection is based on representation, ie on ensuring that the minimum intervention reserves as a set include the full range of variation within British woodlands, in so far as all the nuances can be accommodated within a limited number of sites (4.1). The selection of particular examples to represent parts of the range of variation is based on site quality judged against criteria explained in section 4.2. The focus of selection is ancient semi-natural woodland (4.1.1.), but minimum intervention reserves in other types are also justified (4.3). The selection assumes that the scale of minimum intervention reserves will be tens or hundreds of hectares, and that the number of reserves will be around 50 (4.1.5), but there is a case for proposing much larger (and presumably far fewer) reserves (4.4).

4.1 Overall selection

The total population of minimum intervention reserves should be determined primarily by scientific requirements and limited by a realistic assessment of resources (section 2). Conservation and cultural benefits from minimum intervention reserves can be satisfied in managed woods, so these are not the limiting factors in site selection. Unfortunately, both scientific requirements and available resources are difficult to determine with precision.

4.1.1 Distribution of reserves between major woodland categories

Given that the core purpose is to understand natural woodland states and processes for their intrinsic interest and for comparisons with managed woodland and other land, there is a logical emphasis on the most natural woodlands, ie the ancient, semi-natural woods. These are the woods with the most natural composition and the most continuity of woodland conditions. They form valid controls or reference points for comparison with managed woods of all kinds, and with formerly-wooded land now used as farmland, etc. The composition of most ancient semi-natural woodland probably falls closer to inherited-natural than original-natural (section 3.4), and those which have been colonised by non-native species are on the way to becoming future-natural, but a significant minority can still be regarded as close to original-natural, and these form the core reference points.

In order to accommodate the uncertainties about natural woodland pasturage and the structure of natural woodland (3.2) and to minimise the risk to wood-pasture species from any change to a high forest structure, there is a case for recognising parallel sets of high forest and wood-pasture reserves. Grazing and browsing intensity would be controlled at low levels in the former, and the outcome would probably take the form of high forest. In the latter, pasturage would be maintained with deer, domestic stock, or both, and the outcome would probably be open stands. In both the degree of direct intervention by people in the structure and composition of the vegetation would be minimal. Given the over-riding nature conservation need to maintain native woodland species in the sites they now occupy, wood-pasture reserves would generally be selected from existing wood-pastures.

The emphasis in selection should be on original-natural and inherited-natural stands in ancient woods, but there is some value in including other types of woodland, which fall broadly within the future-natural category. Three types should be considered:

- broadleaved, deciduous stands in which naturalised trees are allowed free reign, eg sycamore, and beech in the north and west;

- non-intervention on 'bare ground', where the succession to woodland can be studied;

- plantations, ie old-growth conifers, where we can see just how natural these can become.

The core set of minimum intervention reserves would be the ancient semi-natural woodland managed on the high forest model. The wood-pasture set of reserves and the other types listed above are best regarded as supplements to the core set. All would merit designation as "minimum intervention reserves", provided the distinctions are recognised.

4.1.2 Representation of semi-natural types

The overall selection of sites should represent the full natural range of variation in ancient semi-natural woodland, which is best determined by reference to a general ecological classification of woodland. The total selection might simply include each type pro rata by area, so that common woodland types are far better represented than rare woodland types, and ordinary examples of each type are included in preference to unusual examples. This, however, may not be optimal: for example, extremes, such as treeline stands, are just as necessary as ordinary stands in representing the range of conditions, if not the range of types.

4.1.3 How many sites would be useful?

The four recent woodland classifications broadly agree that native woodland can be usefully partitioned into about 30-60 units (Table 4.1.3a). The National Vegetation Classification is accepted as standard, but it departs from the group in the sense that representation can be considered at either community (18 types) or sub-community (57 types) level. It also splits wet woodland into seven types, some of which cover only a small area, but lumps most lowland mixed deciduous woodland into two types, which make up more than half the existing ancient semi-natural woodland.

Table 4.1.3a. Recent classifications of British native woodland

Classification	Number of units	Basis	Coverage
Rackham (1980)	30	Native trees and shrubs	Eastern England, principally ancient woods.
Peterken (1981) STAND TYPES	39 stand types or 59 sub-types	Native trees and shrubs, combined with site characteristics.	GB ancient semi-natural woods. Six secondary types also recognised.
Bunce (1982) ITE	32	All vascular plants	GB semi-natural woods, most being ancient
Rodwell (1991) NATIONAL VEGETATION CLASSIFICATION	18 communities or 57 sub-communities	All vascular plants and bryophytes	GB woods, both ancient and secondary. Includes some plantation types. Also recognised juniper woods and six scrub types.

A more practicable basis would be to adopt the eight woodland types recognised by the Forestry Authority (1994) (Table 4.1.3b), which aggregate the NVC woodland types and the stand types of Peterken (1981). This simplified classification was deemed to be an appropriate level of detail for advice on woodland management, and it has since been adopted with some modifications as a basis for Habitat Action Plans.