3 Practical silvicultural management and wildlife

3.1 Natural versus managed forests

It almost goes without saying that the composition of your wood and the way in which it is, or has been managed, will determine its value for wildlife. There is currently great interest in converting and diversifying woods to create more 'nature-like' or 'close-to-nature' structures in the hope and expectation that they will deliver greater biodiversity benefits. We ask four questions here:

- What kind of natural forest structure would result in the absence of any management?
- To what extent are these structures emulated by different silvicultural management systems?
- Which structural types deliver the best 'value' in terms of their attractiveness to wildlife?
- What are the practical implications of a given silvicultural system for small woods?

In nature, as well as in managed forests, woods are constantly being shaped by natural processes and disturbances such as windthrow, fire, flooding, pests and diseases, and grazing by deer and other animals. These events continually create gaps in the canopy, allowing space for natural regeneration to occur and for the development, over time, of a multi-aged canopy mosaic at various scales and densities. In Britain the natural pattern of disturbance is generally small-scale, with mature trees or small groups succumbing from time to time to winter gales, old age or disease. But there is always the risk of larger-scale damage occurring infrequently at much longer intervals, as in the 1987 storm that devastated woods in South East England.

We are fortunate in Britain that our high annual rainfall militates against prolonged drought and forest fires experienced on a grand scale in the Mediterranean region or the conifer forests of Canada; and also that we have (so far) escaped major episodes of defoliation by insect pests like spruce budworms and mountain pine beetles in North America. In general, the rate of gap formation, based on observations in unmanaged temperate forests worldwide, would be expected to be of the order of 0.5–2.0% of the forest area annually, implying return intervals of 50–200 years between disturbances. The problem with small woods is that they are simply too size-limited to sustain a naturalistic disturbance regime – that is, a relatively small disturbance can wipe out a major portion of the wood, leading to an imbalance of age structures, while a major event could level an entire wood. This makes it critical to decide what your woodland does best in terms of its wildlife, and what sort of age-structure distribution to aim for.

Compared with a natural disturbance regime of 0.5–2.0% per annum, coppice rotations of 10–20 years turn over much faster, at rates of 5–10% per year. This creates a much younger and less complex age-structure than would be 'natural'. Growing trees on longer rotations, as in commercial broadleaved and conifer plantations, would appear at first sight to be much closer to the natural rate of turnover, e.g. 2% per year for conifers on 50 year rotations, or 1% per year for hundred-year rotations of oak or beech. But at this point the analogy breaks down, because in managed forests the fixed compartment layout implies that felling will be concentrated in large areas, at a predictable time and in predictable space. At the same time few trees will be allowed to grow on into veteran or 'old-growth' stages where timber production is the objective; and it is quite likely that replacement trees will be planted rather than naturally regenerated. In the Białowieza Forest reserve in eastern Poland, 38% of the trees are over 100 years old, many with diameters exceeding 200 cm at breast height, compared with only 18% (mostly broadleaves) of the trees recorded by the Forestry Commission in our most recent National Inventory of Woodlands and Trees. Studies of natural disturbance in old-growth forests in eastern North America indicate that in practice, some dominant trees may live for 300–500 years or even longer in places protected from disturbance, whereas areas subject to more frequent disturbance will typically result in shorter life-spans. The combination of different tree species mortalities and disturbance patterns adds complexity to the forest structure, which in turn determines the diversity of species which depend upon specific forest growth stages for their survival.

3.2 **Silvicultural systems**

Having pointed out some contrasts between managed and unmanaged forests, we can begin to explore to what degree different silvicultural management options can reproduce aspects of a so-called natural disturbance regime. To do this, we must first briefly consider the range of silvicultural systems and the forest structures that they create, recalling R S Troup's original (1928) definition of a silvicultural system as *the process by which forest crops are removed and replaced by new crops, resulting in woodlands of a distinctive form.* Julian Evans, in his book on '*Badgers, Beeches and Blisters*' (2006) also gives a useful introduction to the various types.

Perhaps the most distinctive types are wood-pasture (parkland-type) systems, where the trees are widely separated and there is enough light for grazing on a pasture beneath; and coppice, where the trees are regularly cut on short rotations, never achieving full height and re-growing after cutting from the base or from root suckers, rather than relying on natural regeneration from seed. We will return to coppice later, but first it is important to review some 'high forest' systems, where the trees are grown taller and for much longer in rotation, after which they are replaced by replanting or by natural regeneration from seed of the parent canopy. Figure 3.1 shows some contrasting profiles in even-aged and uneven-aged high forest systems.

The extreme case is 'clear cutting' (or clear-felling) that removes all trees in large clearings at the end of the rotation, usually followed by replanting, resulting in an even-aged crop. In large commercial forests this creates a coarse patchwork of compartments, often at different stages in the rotation, as the size of the felling coupes (clearings) can range from 1–5 ha in the lowlands to 20 ha or more in the uplands. But coppicing too is a form of clear cutting, although much less visually drastic as the felling units here are generally much smaller, say 0.25–0.5 ha clearances, so that more of them can be fitted into a small wood, giving a range of young age-classes. There should be no need to replant if the coppice recovers well. To fell on any larger scale in a small woodland will not only defeat the object of retaining some tree cover, but also drastically reduce the variety of niches available to wildlife.

Another approach, if you already own an even-aged conifer or broadleaved plantation, is to open the canopy gradually in defined areas, allowing in sufficient light to encourage natural regeneration or to carry out enrichment planting of native species. Woodlands managed in this way are essentially 'shelterwoods', relying on the presence of an overhead, if temporary canopy to provide the seed or shelter for the young crop during its initial establishment. The young trees will develop in much shadier conditions than in a clear-cutting or coppicing system, but several species can tolerate shaded conditions as young saplings such as yew, beech, hornbeam, field maple and sycamore. With less overhead or short-term canopy cover it is possible to grow species with intermediate light requirements, including ash, oak, lime, wild cherry, sweet chestnut, rowan and whitebeam. The two-storey system creates a greater horizontal and vertical structure.

One form of shelterwood is the 'uniform system', which requires a very rapid opening of the canopy to encourage seeding, followed by its complete removal over a short period.

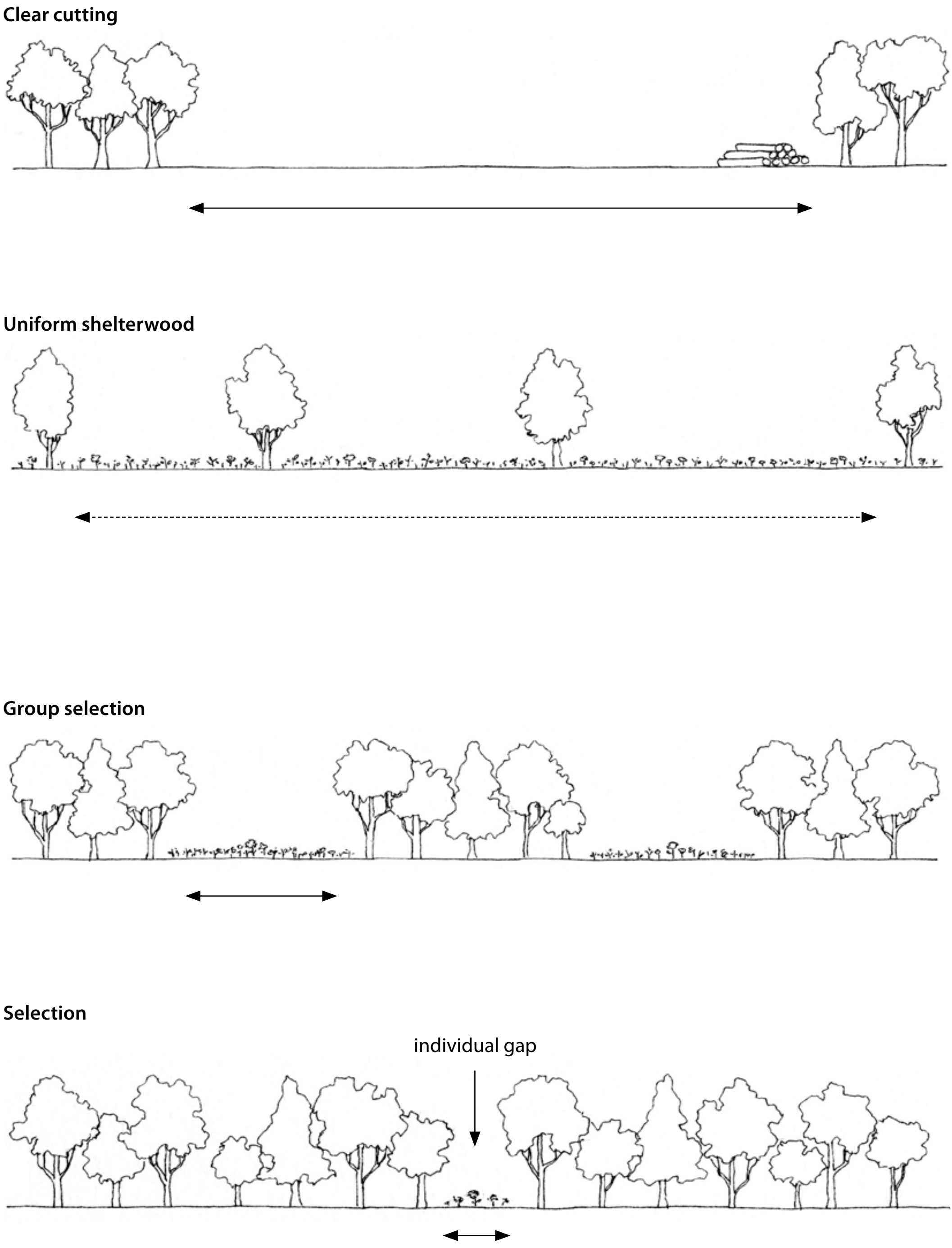


Figure 3.1 Contrasting silvicultural profiles, showing decreasing gap sizes created by harvesting from clear-cutting (top) to selection or continuous cover felling (bottom). [Felling coupe = ↔ ; the dashed line refers to a discontinuous coupe, leaving mother trees, in the case of the uniform shelterwood system].

This creates a sudden change in the woodland environment as the two-layered vertical structure converts rapidly into a uniform monolayer after perhaps 5–10 years, when the last of the mature trees are felled. Carried out on too large a scale, uniform shelterwoods are not so dissimilar to clear cutting, and therefore perhaps not appropriate for very small woods. There is also a very real risk of windthrow occurring during the rapid opening phase of the canopy, especially on thin soils. There are ways to get around this, by opening up the canopy in smaller-sized patches as strips, wedges, and groups, but they are beyond the scope of this book.

Two shelterwood types might be worth considering in small woodlands. The first is a 'group selection system', where the gaps created are much smaller than above, capable of accommodating several mature trees (say 5–10) in groups of 0.1–0.25 ha, i.e. areas of 30–50 metres or more across. Another type is an extreme shelterwood or 'selection system', in which the area of regeneration corresponds to the crown area of a mature tree that has just been felled. Within this gap the young seedlings regenerate, developing into thickets that are progressively thinned over time, until at maturity just one 'selected' tree remains standing, as before. With progressive felling over time, both systems produce intimately mixed age and size classes throughout every part of the stand, which contains seedlings, saplings, pole-stage trees, semi-mature and mature stems. Smaller gaps usually mean that only intermediate and shade-tolerant species (beech, Western hemlock, spruce and Douglas fir) can be grown, but in larger gaps (as in the group selection system) light demanders such as oak or Scots pine, as well as birches and willows, can thrive. Where the gap size is 0.25 ha or less, these shelterwoods are increasingly referred to as 'continuous cover systems'. A useful definition is

> *…. silvicultural systems which conserve the local forest canopy/environment during the regeneration phase. Coupe size is normally below 0.25 ha (50 x 50 m) in group systems; and in shelterwood – where used – is retained for longer than 10 years. The general aim of all systems within the concept is the encouragement of diversity of structure and uneven age/size on an intimate scale* (Hart, 1995).

The system is promoted in Britain by the Continuous Cover Forestry Group (www.ccfg.org.uk) which provides useful information and technical and professional advice.

Silviculture and biodiversity

At this point we can begin to compare the relative merits of different silvicultural management systems in relation to the diversity of structure, dynamics and composition we would expect to find in natural broadleaved forests within temperate regions (Table 3.1). Desirable features are listed in the left-hand column, bearing in mind that these relate to large areas of naturally-disturbed forests. An obvious main difference is that none of the main commercial management systems allow very old (veteran) trees to develop, hence denying a significant biodiversity niche for fungi, lichens, insects, hole-nesting birds and bats that all depend upon deadwood (see Sections 4.3 and 4.4). Exceptions are the rotting wood present in pollards in wood pastures, old coppice stools and sometimes old standard trees in neglected, coppice-with-standards woods. The gap size and turnover is also unnaturally faster in coppice rotations (although slower when standard trees are retained) and gaps are even bigger in clear-cut plantations. In terms of the amount of permanent open space, there is much debate about how much was present in the original forests of north west Europe, but the general consensus points to forests in Britain being relatively closed.

Management continually opens up the forest, creating a relatively high proportion of (temporary) open space in all systems, most notably in clear-cutting, coppice and wood-pasture systems. In some ways this can be regarded as an advantage over the natural state, as open-ground species such as some small mammals, birds and butterflies can also thrive in this environment.

Table 3.1
Contrasts in structure, dynamics and composition between natural, temperate broadleaved forest and different types of managed wood. Features that are emphasised or reduced in managed woods, compared with natural woodland, are shown as positive or negative symbols; or (o) if no change. Uniform shelterwoods are omitted, but would show some affinity with clear-cutting (modified from Peterken, 1996).

Feature	Natural woodland	Shelterwoods		Clear-cutting	Coppice	Wood pasture
		Group selection	Selection			
Maximum tree age (years)	300–500	–	–	– –	– – –*	(o)
Average final tree age (years)	c.200	–	–	– –	– – –*	
Tree species diversity	mixed	–	–	– – –	(o)	– –
Gap size	mainly small	(o)	(o)	+ + +	+ +	n/a
Gap creation rate/year	1%	(o)	(o)	(o)	+ + +*	n/a
Permanent open space	little	+	+	+ +	+ +	+ + +
Structural diversity (stand level)	high	(o)	–	– – –	– –	–
Structural diversity (whole forest)	patchy	(o)	–	+ +	+ +	+ +
Dead wood	abundant	–	–	–	– – –*	–

* modified in the case of coppice-with-standards

Structural diversity – the variation in horizontal and vertical structure present either at the scale of the stand, or the whole wood – is very different in most of the managed systems from what we would expect in a natural wood. Because of the relatively large size of the felling coupe in clear-cutting and coppice systems, they are less spatially diverse *within* the felling coupes, which therefore tend to be even-aged. But at a landscape, whole-wood scale this creates big contrasts *between* adjacent areas of felling young, intermediate and older growth stages. If your wood is part of a larger woodland area, the age structure within your section, though not covering all ages, may be very different from that in neighbouring woods, making an overall patchwork of management styles and growth stages. You should consider this wider context when drawing up management plans to promote biodiversity.

You may have noticed in Table 3.1 that the silvicultural systems containing features most closely corresponding to the natural state are intimate shelterwoods, using the group selection and selection systems. These both produce a patchy and highly diverse canopy structure, usually containing more than one tree species, grown on long rotations. Furthermore, the small coupe size means that several units at different growth stages can be fitted into a small wood. However, we should be cautious before recommending them as the 'best' systems to promote biodiversity in every case. There is little evidence-based research in this area – ecological comparisons of different silvicultural systems are rare and usually too small-scale to satisfy strict experimental criteria. The situation becomes more complicated when more and more species groups are taken into consideration – insects, birds, mammals, fungi, etc. It will also depend on the inherent species-richness of your wood, and on whether it contains any species of particular conservation importance that have specific habitat requirements. For the remainder of this chapter we will consider some important biodiversity features associated with different silvicultural systems.

Non-intervention: the ultimate management solution?

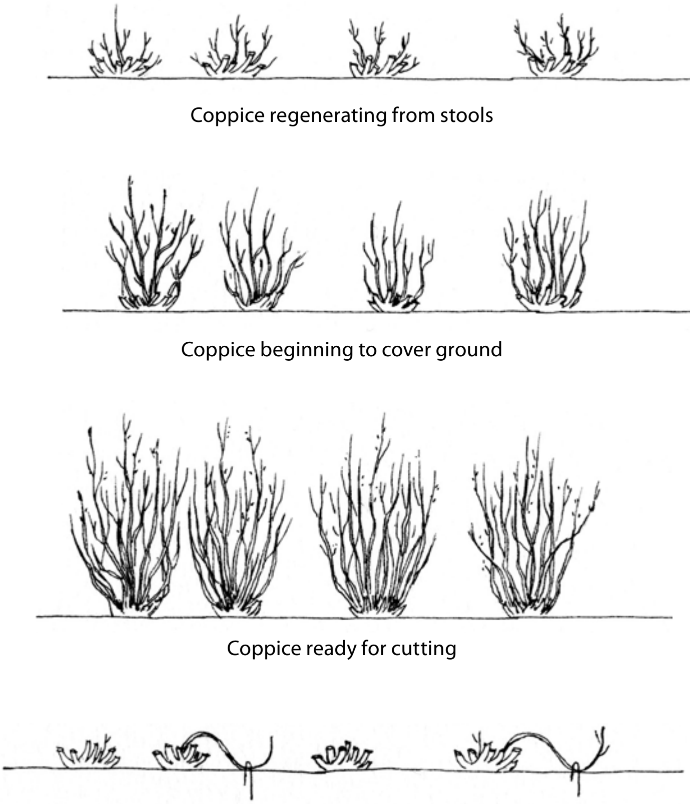
Suppose for a moment that you decide to not to carry out any management in your woodland – what would happen? There is a good chance that parts of your ownership – even all of it – will be even-aged, whether as coppice stands or conifer or broadleaved plantations. In this case, the structure will gradually diversify over time as subordinate trees are suppressed by their dominant neighbours – i.e. the same trees that would normally be removed in thinning operations or cut back during coppicing – creating a deadwood resource. At the same time, gaps will begin to appear in the canopy through natural disturbances – wind, squirrel damage, etc., creating more deadwood. Eventually these gaps will increase in size until the point is reached where enough light filters through the ageing canopy to allow tree seedlings and a shrub layer to develop from sources dispersed from within or outside the wood. This is the beginning of an embryonic uneven-aged structure, with old trees, deadwood, young regeneration and thickets represented, but it may take 50–100 years to reach this stage, depending on the starting point.

A means of increasing biodiversity, the *laissez-faire* option sounds attractive, but first there are a few drawbacks to consider. All even-aged stands pass through a long dark phase after first canopy closure, especially if left unthinned, when light levels fall typically to 1–5% of those in the open. This will eliminate species such as butterflies requiring open conditions and birds requiring scrub, unless they can survive in other parts of the wood where management is maintaining young growth. Secondly, health and safety issues may arise if you have to deal with hazardous trees and dead snags as the wood self-thins and ages. Lastly, you could be very unlucky if whole areas are flattened by a severe storm, creating uniformity all over again: this would not be the case if a range of age-classes and species is maintained, as young growth has a smaller 'sail area' and is less susceptible to storm damage. Having said this, some non-intervention areas in parts of the wood will be very valuable for species requiring old-growth conditions.

3.3 Coppice

Coppicing – a likely evolutionary response to the wounding of trees by browsing animals, uprooting by storms or fire – arises from the activation of dormant buds at the base of the stem, or from the formation of buds on callus tissue at the cut surface (as in beech). With repeated cutting at the base of the stem, coppice stools are formed from which the new stems arise. New shoots also arise from root suckers in poplar, aspen, wild cherry, elm and alder. These can produce clonal masses that may come to dominate large parts of a wood. Most other broadleaved species, such as oak, hornbeam and sweet chestnut withstand repeated coppicing well; but ash, birch, sycamore and beech are usually less long-lived as coppice.

In its basic form, coppice is grown as an even-aged crop, known as simple coppice which is a form of 'low forest', never obtaining its maximum height (Figure 3.2). From a biodiversity viewpoint, its underlying problem is that it produces almost uniformly young growth and a homogeneous vertical structure: hence there are no trees in older age classes and often little deadwood (except that present in old coppice stools). This uniformity is further emphasised if, as in many stands, your wood has been neglected for 50 years or more, or the coppice is dominated by a single species such as sweet chestnut. This can be partially remedied if the coppice is grown in two- or multi-layered systems with mature standard trees (the latter often self-seeded or planted) in a coppice-with-standards system. These standard trees provide an additional range of age-classes, and ideally should themselves be uneven-aged in order to maximise structural benefits.



Coppice cut and layered to produce new stools

Figure 3.2 Simple coppice system, producing uniformly young, even-aged growth on rotations of usually less than 30 years (after Ovington, 1965).

Traditionally, standard trees were grown on multiples of the coppice rotation, usually up to 4–5r (where r = a coppice rotation), the numbers roughly halving with each progressive age cohort. Their density was a compromise between the productivity of the two components of the crop: in the pre-War era a 50:50 cover of each component, coppice and standards, was considered a normal stocking for working coppices, with a minimum of 25 standards per hectare. In practice many neglected small woods now contain high densities of veteran standard trees that were never thinned and have now effectively shaded out the coppice layer, while in other cases the coppice itself has grown into an even-aged high forest. Both states create the shady conditions that have led to widely-publicised losses of specialist species associated with young growth, including migrant warblers, nightjars, dormice and fritillary butterflies.

If your wood contains significant areas of coppice, there are a number of remedial actions that you can undertake that will diversify the coppice area and increase its attractiveness to wildlife. At the level of the whole wood, options which you might consider are:

- In simple coppice such as sweet chestnut, introduce some standard trees, up to densities of 25 per hectare, to vary the canopy structure. When they grow into mature oaks they could occupy 20–40% of the overhead cover, but for sites where there are scarce butterfly species, a lower cover density of 20% or less may be appropriate. Standards can be promoted by singling some coppice stools for native species (i.e. reducing them to one stem), or by planting and natural regeneration. Species with relatively open canopies, such as oak, ash and birch, will allow more light through.

- Avoid a monoculture: increase the proportion of other site-native trees and shrubs, which may need to be introduced if natural regeneration sources are too far distant. In chestnut coppice, stools can be 'thinned' using brushwood killers, stump removal or premature cutting to prevent rapid re-growth. If the stand is to be promoted to high forest, felling and 'singling' stools can be used to create space for other species already present, or group felling and restocking practised. The overall diversity of different species groups using the canopy should increase in proportion to the greater variety of host species and the more diverse canopy structure.
- Intervene to favour species other than the dominant one, be it hazel, sweet chestnut or hornbeam, by selective thinning after coppicing and before canopy closure. Allow the species composition to diversify naturally over time through natural regeneration.
- You may not be able to cope with coppicing more than one part of the wood on a strict rotational basis. In the most difficult and inaccessible areas, therefore, consider allowing some areas to revert to high forest, where it will self-thin and begin to follow a natural dynamic.
- Retain all old or veteran trees (including standards, if present) in order to boost the deadwood supply and to encourage hole-nesting birds and bats.

At the level of the felling unit, compartment or cant:

- Vary the coppice coupe size, with some larger areas of 0.5–1 ha if your wood will accommodate them, to encourage woodland birds and small mammals.
- Maintain wide rides and glades (see Section 4.1) to provide open conditions and links between cut areas for species that require more light.
- Revert to a continuous-cover or group selection felling regime in the less economically viable parcels, or non-intervention as above.

Woodland owner coppicing hazel in winter.

Restoring neglected coppice

If your coppice area has been neglected, and you have reason to believe that there are species in your wood, or nearby, that might benefit from access to young growth stages, you could consider trying to reinstate the coppice cycle.

Cutting affects the hormonal balance of the tree, promoting the breaking of dormant lateral buds that were formed at the base of the young shoots while they were developing. Provided cutting is repeated at regular intervals, these buds will continually re-form and the stools will remain viable for many cycles. In ancient woods, large ash, hazel and lime stools are frequently hundreds of years old, and in some rarer cases are thought to be over a thousand years. A proportion, however, will die of natural causes at each cutting (5–10%

Coppice management myths

Coppice management is fairly straightforward – regular cutting results in fresh re-growth. No thinning is usually necessary, as competition between shoots on the same coppice stool rapidly reduces their number to a few dominant shoots. Being an ancient tradition, several theories have grown up around the silviculture and management of coppicing that have yet to be rigorously tested. Harmer and Howe (2003) and Harmer (2004) have examined evidence for the effectiveness of different cutting treatments using practical investigations and literature accounts:

Quality of cut – sloping cuts are often advocated, preferably south-facing in order to dry quickly and to prevent rot. While it is possible that cutting on the slant increases the area of the wound and the chance of callus bud formation, there is little convincing evidence that sloping cuts on coppice stools produce better results than flat ones. An early experiment on chestnut with different billhook, bow-saw or chainsaw cuts also failed to show differences in subsequent height growth.

Position of cut – low cuts are considered best, presumably because the developing shoots are then encouraged to develop their own root systems. Higher cuts tend to produce more shoots in some experiments, although these stems may then be less stable compared with those arising from low cuts, and there is some evidence that they may be more prone to butt rot.

Season of coppicing – the conventional view is that coppice is best cut during the dormant period, between late autumn and early spring, as there will be less bark tearing, stump mortality and frost damage to developing shoots. Such timing also avoids the peak of the bird nesting period from April to July. However, experimental coppicing out of season, in late summer and early autumn, has shown little difference in shoot numbers and height growth after a few years growth, compared with conventional 'in season' cutting. Some authorities claim that summer-cut coppice poles are more prone to deterioration and decay than winter-cut material.

Protection of coppice stools – if deer or rabbits are a problem in your wood, they will certainly target any young coppice re-growth: some protection will be needed for 2–3 years to prevent the stools from being repeatedly stripped and possibly killed. Conservationists often advocate barricading the coppice stools with brash piles, sometimes topped with bramble and rose briar, or 'dead hedges' consisting of brash interwoven between upright stakes. However, brash piles seem to be particularly ineffective in preventing damage, unless a robust dead hedge surround is constructed: ultimately fencing or culling may be required.

mortality may be typical for mature stools (Evans, 1984; Harmer and Howe, 2003)) but they can be replaced, through planting, natural regeneration or layering. In neglected stands, the dormant basal buds become progressively embedded in bark as the stem diameter increases, gradually reducing their ability to re-shoot over time. The critical interval varies considerably between species and site factors, such as shading and site fertility, may also play a part. While there is no doubt that the vigour of reshooting declines and the mortality of stumps increases with increasing stool age and size, there is no compelling quantitative or predictive evidence for different species. Many conservation authorities argue that after 50 years it is not worth re-coppicing neglected stands, but this judgement is often based more on the consideration that the open character of coppice and some of its associated wildlife may have been lost, rather than its inherent re-coppicing ability.

Even if the coppice has reverted to high forest, some species, such as hornbeam, sweet chestnut, field maple, lime and ash, may recover from cutting well, but expect poor results with subjects such as beech and birch. You can experiment by cutting a small group of stools at an edge, where there is plenty of light. One technique to try is selective coppicing – that is, removing the largest coppice stems, but leaving one or two subordinate stems to maintain supplies of carbohydrate to the stool during its recovery. If sufficient new shoots develop, the remaining subordinate stems can be removed after two to three years and the rotation re-established. Even if recovery is poor, there are some advantages in this as sparse stool densities will provide additional structural diversity and encourage natural regeneration of other species through seeding. Similar approaches are used for restoring ancient pollards in wood-pasture (see Section 4.3).

Creating new coppice stools and pollards

Creating new coppice stools and pollards is a much easier task than restoring ancient ones. Most native broadleaves will form stools if cut as early as the first growing season, but for good coppicing species such as ash, hazel and oak, the cut can be deferred for up to 20 years. A serviceable rule of thumb states that the first cut should be made at half the eventual coppice age, but in the case of beech and birch, the earlier the cut, the more likely there will be successful re-growth. New pollards can also be successfully created on young trees up to 15 cm in diameter and up to 15 years old. These are best situated in open positions along the edge of the wood, or along a ride. For species like ash and beech, Read (2000) recommends making the initial cut above the eventual pollard height of 2–3 m, leaving some lower branches intact while new re-growth takes place on the bole, then finally removing these lower branches, leaving stubs where new shoots will arise.

3.4 Even-aged plantations

Nearly 70% of the woodland area in Britain consists of recent plantations, and more than half of these are coniferous, with a much higher proportion of conifers in Wales and Scotland than in England. If you have inherited a plantation, the chances are that whole sections or compartments will be even-aged: all trees were planted (or rarely naturally regenerated) at the same time and progressively thinned with the intention of clear felling and replacing the stand at the end of the rotation. The overriding advantage of the system is that uniform crops are produced, with economies of scale achieved through planting, thinning and felling large areas of similar crops. However, as we have seen, the prospects for wildlife are poor because of the uniformity of these often monospecific, mono-layered and even-aged canopies. In mid-rotation in particular, little light penetrates through managed plantation canopies and, except at edges and rides, there will be an almost complete lack of understorey trees and shrubs, and sometimes very little ground flora. Non-native conifer plantations of spruce, Western hemlock and Douglas fir cast an all-year-round shade and can quickly impoverish spring flowers such as bluebells and wood anemones.

Woodland owner discusses management options for a PAWS woodland with a Forestry Commission advisor.

Restoring conifer plantations on ancient woodland sites

Many plantations have been sited on upland grazing or ex-arable land, so it will take a very long time before they begin to develop recognisable woodland communities. However, the policy of 'improving' existing woods that prevailed for 50 years from the 1930s to the mid-1980s, resulted in about 40% of ancient woods, over 220,00 ha, being felled and replanted with more productive, even-aged conifer or broadleaved tree crops. Through forest policy initiatives and grant-aid, many of these plantations on ancient woodland sites (PAWS) are now being restored or reverted to their former semi-natural state: the best techniques for doing this are still being worked out.

The first step, if you own a plantation, is to check whether indeed it is a PAWS candidate. There is plenty of guidance published by the Forestry Commission and Woodland Trust on how to survey and restore PAWS sites (Thompson *et al.* 2003; The Woodland Trust, 2005) but it is worth first checking the Ancient Woodland Inventory maps to see if your wood is listed (or indeed whether parts are semi-natural, ancient woodland). These maps are available from Natural England, the Countryside Council for Wales and Scottish Natural Heritage, and are available on-line, for example on the Governments's MAGIC website (www.magic.gov.uk). The Inventory originally covered only woods of 2 ha or larger, but in some counties re-surveying has recently increased the resolution down to 0.25 ha.

If your wood is ancient, it should be possible to confirm this by searching for remnant features of the original wood, including the following:

- Deadwood: the presence of felled trees, branch debris, stumps and coppice stools from the previous woodland cover.
- Archaeological features such as wood banks, saw-pits, drainage grips, charcoal hearths, pollards and stubs.
- Native woodland species that are not part of the plantation crop, including shrubs and ground flora, and buried seed in the soil.

In the last case, there may be scattered native tree survivors that have become engulfed by the plantation canopy including former coppice and veterans, but which may be salvageable. In windthrown gaps willows, birches and ash will often have self-seeded and there may be lingering patches of hazel, holly, hawthorn and other shrubs present in the understorey. Perhaps the best indicators of woodland origin are the so-called group of ancient woodland indicator plants, mainly ground flora species that are poor colonisers and are therefore largely restricted to these sites (see Section 2.1). Lists of these indicators are available from the literature (e.g. Rose, 2006) and local wildlife trusts, and include species like bluebell, wood anemone, ramsons and yellow archangel (see also Table 2.1). Remember that one bluebell does not make an ancient woodland – rather it requires a number of indicator species, occurring consistently within a stand, to confirm the diagnosis.

If you have found these features in your wood, the next stage is to plan a restoration strategy. Essentially, this involves thinning the plantation canopy with a view to eventually – perhaps in the very long-term – replacing it with native species, if possible using plant materials already present on site. To make a start, conventional advice is to thin selectively around native trees where they survive (including old pollards and coppice stools), as well as where 'hotspots' of remnants and regeneration occur, such as along rides and streamsides (Figure 3.3). Once this holding operation has been achieved, the next question is whether, and how quickly to convert the plantation to a more semi-natural state. As every wood is different, there are no hard and fast rules, but points to consider are:

- How much of the original plantation to retain. Generally speaking, retained areas of mature canopy, even non-native conifers, can benefit species that thrive in shade or use the canopy for protection. If reserved in non-intervention areas, they will also provide an accumulating source of deadwood. Furthermore, there is little point in prioritising conversion treatments in parts of the wood conspicuously lacking in remnant features: partial restoration of the most promising areas may be the best solution.
- Similarly, numbers of native trees surviving amongst the canopy may be too sparse to provide sufficient natural regeneration, even after thinning of the main crop. Some lowland conifer plantations contain only 10–100 individuals per hectare of these survivors, with few viable native saplings and seedlings present on the ground. Such areas can either be left to diversify naturally, or thinned heavily in stages for eventual underplanting (enrichment planting) with native species.
- Heavy thinning of the canopy risks windthrow, both to the plantation crop and any native remnants that have suddenly been exposed. It should be avoided on exposed sites or where the soils are shallow or prone to waterlogging: spruces, Douglas fir and Western hemlock maybe particularly susceptible on such sites.
- Thinning may also stimulate heavy weed growth which can swamp young regeneration and in turn encourage heavy browsing if deer and rabbits are abundant. Conversely, prolific regeneration of the non-native canopy species (e.g. pine, spruce, fir, Western hemlock and sycamore) can occur and may need to be controlled. Thinning intensity will clearly influence the response of competitors such as bramble, bracken and grasses. Some experiments have shown that after very heavy (80%) thinning of Corsican pine

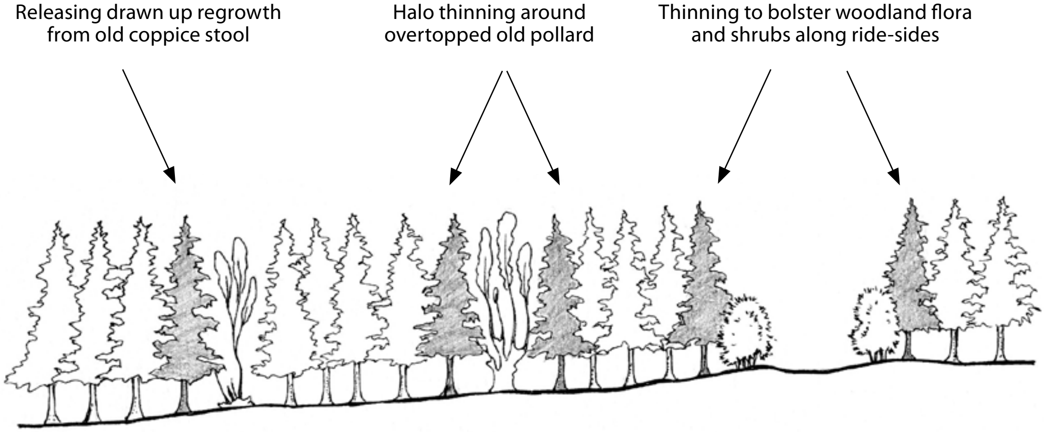


Figure 3.3 Recovering semi-natural features from a PAWS woodland site by carefully targeting removals of the plantation trees (shown shaded), (after Woodland Trust, 2005).

on lowland sites, bramble thickets approaching to a metre tall developed after four years compared with less than half a metre in light (20%) thinning. Nevertheless light thinning did not allow tree seedlings to establish any better, indicating that gradual removal of the crop, often advocated, may not necessarily be more effective than rapid clearance (Harmer and Kiewitt, 2006).

3.5 Converting conifer and broadleaf plantations to uneven-aged systems

At this point we can consider different silvicultural systems which may be used to restore even-aged woodlands, both on PAWS sites, and in more recent woodland. The flow diagram (Figure 3.4) presents a choice between gradual, phased removal of the existing canopy versus very heavy thinning and rapid removal. Phased removals have the attraction of avoiding severe disruption to any wildlife present such as bats and dormice, fungi and insects requiring deadwood substrate under shady, moist conditions, as well avoiding damage to young regeneration and ground vegetation. The most appropriate techniques here are to develop shelterwoods based on selection and group selection silviculture – i.e. continuous cover systems. On the other hand, if thinning the crop is likely to cause windthrow, or access is difficult and browsing pressure is likely to be a problem, rapid conversion using clear felling may be more feasible, followed by fencing and replanting. If windthrow is not an issue, a uniform shelterwood system can be used, supplementing any young regeneration by underplanting with native trees and shrubs where necessary.

Rapid conversion using the uniform system normally involves the removal of up to a third of the mature canopy cover, leaving a shelterwood of 75–120 trees per hectare if light-demanding trees are to be regenerated or planted, or more dense (150–200 trees per hectare) for shade-bearers. To avoid heavy weed growth suppressing seedlings, regeneration or replanting should be as rapid as possible – perhaps 5–10 years under Scots pine, but up to 20–30 years for oak and beech, with progressive removal of the canopy (Figure 3.5).

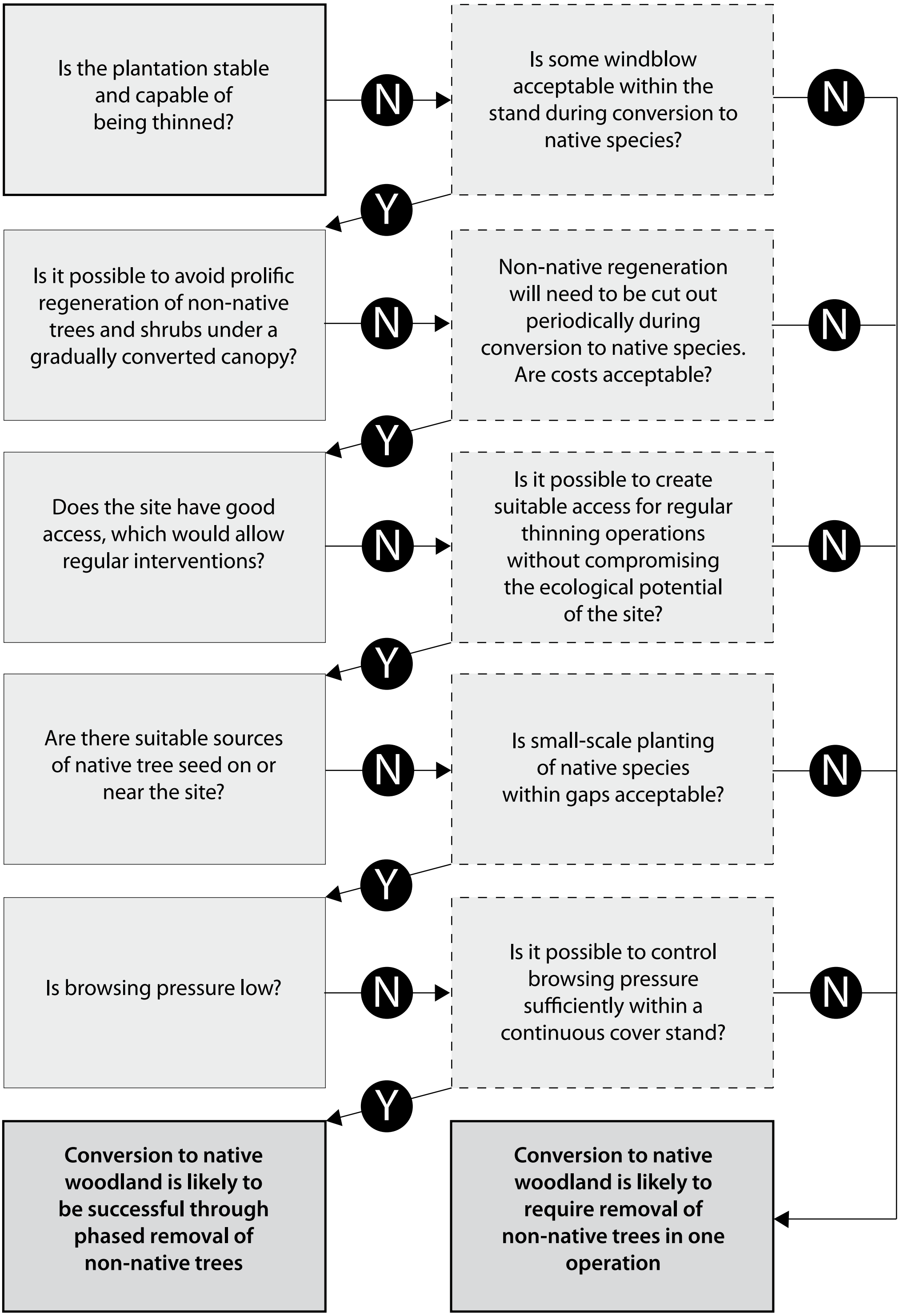


Figure 3.4 Decision pathways for restoring PAWS woodland using phased or rapid removal of the original crop (from Thompson *et al.*, 2003).

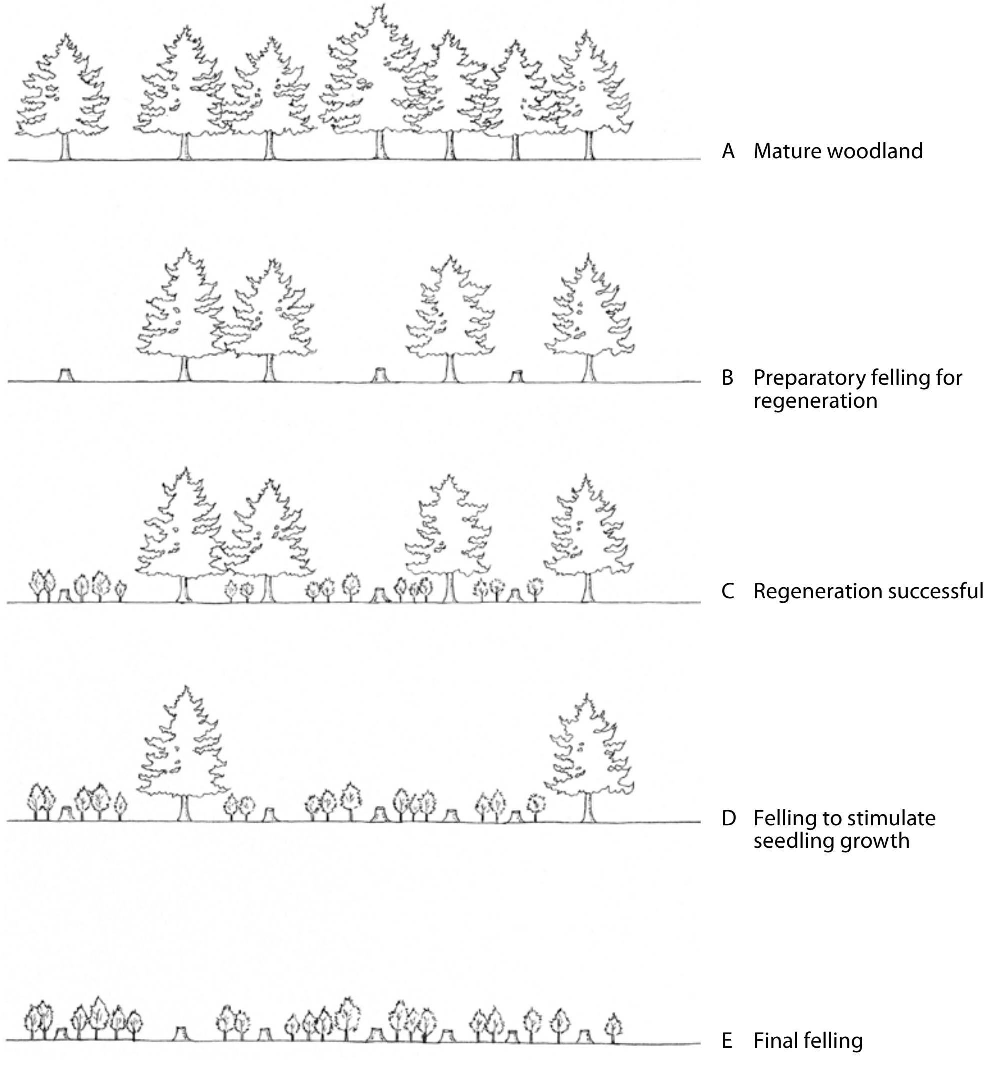
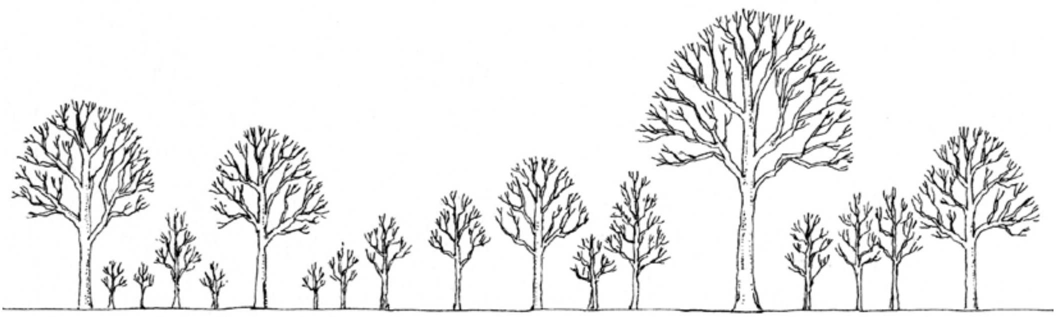


Figure 3.5 Uniform shelterwood system, showing the sequence of canopy removal while regenerating or replanting a young replacement wood with native species (after Ovington, 1965).

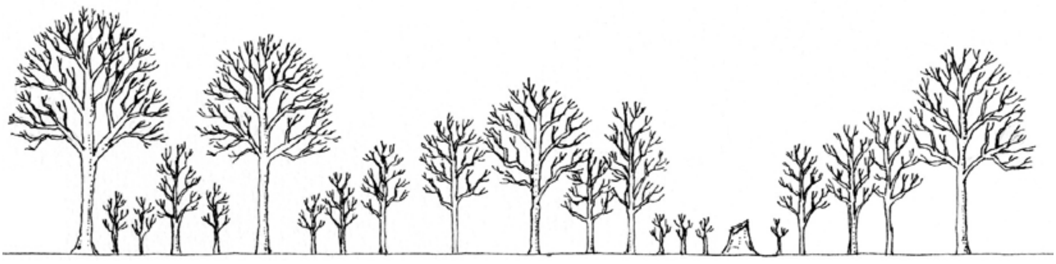
Continuous cover forestry regimes are becoming more popular in Britain. About 30,000 ha (3–4%) of the Forestry Commission estate are now earmarked as non-clear felling systems, and in Wales the National Assembly has recommended that at least 50% of state-owned woodlands should be managed as continuous cover. For woodland owners considering certification, the UK Woodland Assurance Scheme recommends that in windfirm (conifer) plantations "*lower impact silvicultural systems shall be increasingly favoured where they are suited to the site and species*" unless "*there is evidence that clear-felling provides habitat that has a high value for biodiversity*" (UKWAS, 2008).

However, there are a number of practical and ecological drawbacks of continuous cover forestry which need to be carefully weighed beforehand. To develop an intimate mixture of trees sizes requires careful management and stocktaking, and very long timescales to achieve the desirable uneven-aged structure (Figure 3.6). The inherent lack of uniformity means that forest operations are scattered over a wide scale so that felling and extraction difficulties around young regeneration are acute. Control of browsing is difficult, as there is good protection and cover for deer, etc. The windthrow risk is high, except on well-drained soils because the small openings made in the canopy by felling are proportionately larger than in conventional, low-thinning operations.

Technical guides are available on how to set about the conversion (e.g. Kerr, 2008), but the overall aim is to produce a skewed distribution of size classes with small-sized individuals the most frequent, grading through progressively larger size classes to a few dominant, mature individuals. The details are rather too complicated to go into here and the reader is directed to the excellent technical guides produced by the Forestry Commission and the Continuous Cover Forestry Group. In terms of the timescale, to convert a 10 ha wood from even-aged to continuous cover might take 80 years, assuming it is regenerated in small groups of 0.15 ha. Regenerating 10% of the area would therefore mean felling seven such groups at eight year intervals (Harris, 2009). Many woods smaller than this will not be able to support a full range of size classes, or if this were attempted there would be only very limited patches of each cohort, perhaps too small a habitat for certain species specialising in a particular growth stage. There would be few light-demanding species able to take advantage, unless a good ride network or open space is also present. One approach would be to work with neighbouring woodland owners to achieve this type of structure over a larger area, with economies of scale in harvesting.



A Before felling mature tree



B After felling mature tree

Figure 3.6 Continuous cover silviculture using the selection system, in which individual trees or very small groups are felled at maturity, creating small gaps for regeneration (after Ovington, 1965).

3.6 The harvesting commitment of different silvicultural options in small woods

The choice of silvicultural system and the size of the felling unit or coupe adopted both have profound implications for small woodlands. If a small-group felling system over extended rotations is adopted with the goal of creating an uneven-aged tree population, including large, old trees, the annual commitment will not be great and the intervals between interventions will be long. In contrast, maintaining a regular coppicing cycle is a heavy commitment because of the short rotation, even though this may be desirable in the interests of promoting certain woodland birds or butterflies.

Table 3.2 summarises the situation for a small woodland of 5 ha, managed under different systems. If the felling unit is 0.25 ha, this will allow 20 such units to be fitted in. The example shows that cutting hazel coppice on a seven year rotation would require the clearance of up to three 0.25 ha units per year in order to promote the full age range of 0–7 years throughout the wood. If the coppice is hornbeam, sweet chestnut or ash, the rotation could well be 20–30 years, which obviously decreases the frequency of cutting. This also has the effect of staggering the age interval between different cohorts, a situation that might no longer suit a relatively immobile species needing to colonise freshly cut areas that are immediately adjacent.

In theory, high forest systems require fewer management interventions because they operate on much longer rotations than coppice. For a group selection system with a turnover of 80–100 years, the felling interval compared with coppice increases to 4–5 years in this example, depending on the size of the felling unit. This has a number of attractions as there would be a greater range of age-classes, giving a structure that is closer to the natural state (as we saw at the beginning of this chapter), while requiring less frequent management on the whole. At the same time as felling the prescribed area, other operations might be necessary in other parts of the wood, such as planting areas that do not regenerate satisfactorily or thinning the older units with a view to selecting a good final timber crop. These longer rotations are not compatible with the specialist species of young coppice, although using group selection in this case would still produce considerable areas of young growth. In this example, almost a fifth of the woodland area would still be relatively open, in the pre-canopy closure stage, while at the same time significantly increasing the opportunities for species requiring mature growth stages.

A final option shown in Table 3.2 is the continuous cover system. There is no requirement here to set a felling unit size, as individual and small groups of trees are felled throughout the whole wood, traditionally at intervals of 6–10 years, during which any necessary thinning operations are also carried out. The aim is to select the best trees for sawlogs, which can extend rotations for 125 years or longer, although the criterion is the size (diameter) of the tree rather than its age.

Table 3.2
Management commitments resulting from a) the choice of silvicultural system, and b) the size of the felling unit in a small wood of 5 ha.

Silvicultural system	Rotation length (yr)	Felling unit size (ha)	No. of working units	Felled units per year	Mean annual cut (ha)	Cutting interval
Coppice, short rotation	7			2.86	0.71	every year
Coppice, medium rotation	20–30	0.25	20	0.7–1.0	0.17–0.25	1–1.4 years
Group selection	80–100			0.2–0.25	0.05–0.06	4–5 years
Continuous cover	125	-	-	-	-	6–10 years

There are of course many alternative strategies that a woodland owner can adopt other than those presented above. If the commitment is too great, you can simply confine operations to parts of the wood where access and extraction are easiest, allowing the remainder to develop into mature woodland with minimum or irregular interventions. If you have neighbours, you may be able to agree a management regime for the whole wood that optimises its potential for wildlife, for example by coordinating coppicing efforts to maintain adjacent areas of young growth, or consolidating non-intervention stands in other parts. Much will depend on the wildlife survey (Chapter 2) and an appraisal of the potential of the wood to serve particular species groups.