Boppard lecture notes - Ecosystem services

Peter Buckley & Radim Hédl

Ecosystem services of coppice

Provisioning: Production of timber, wood-fuel, biomass and non-wood forest products (NTFPs). Coppice can also be considered to be a provisioning service, in that resources are invested in this form of management to generate particular types of species assemblages for biodiversity (e.g. through agri-environment schemes and in support for protected areas and wildlife reserves.

Regulating: the high turnover of harvests means that accumulation of carbon tends to be lower under coppice (less than half that of close-to-nature forests), but still considerably more than in arable crops or pasture. The value of short-rotation (arable) coppice in this regard is that it will increase soil carbon stocks compared with the farmland it replaces. Coppices protect against **soil landslides** and **erosion** through root reinforcement and the risk of **rockfall**; recovery after cutting or damage can be rapid; on steep slopes selection coppices or standard trees give stability after harvests. Regular fuelwood removals reduce the risk of fire. Coppices also in a sense regulate biodiversity, by conserving specialist species of early growth phases. Pollination resources are increased by flowering in coupes and by some broadleaved species (e.g. *Robinia*).

Cultural/ non-material: coppices are valued aesthetically for their diversity of structure, the richness of their field layers, seedbank species, migrant warblers, butterflies and other abundant insect fauna. There is an abundance of historic evidence – heritage resulting from this form of management. Woodlands reduce the rate of, or eliminate the need for, cultivation, a significant cause of archaeological destruction. In the UK, woodland includes nearly 5,000 Scheduled Ancient Monuments, plus many areas managed for geological study. The social and environmental benefits of woodlands, including landscape and recreational value (the latter facilitating exercise, human health and longevity) may well exceed the value of production (woodfuel, etc), especially in the case of broadleaved coppice. Trees and woodlands are valuable for personal enlightenment and as places or catalysts for social activity and cohesion. Forests are increasingly acknowledged for their educational value. Trees have been perpetual motifs in fine art, and influenced many other art forms.

Supporting: like other forest systems, coppices aid soil formation and retention; nutrient and water cycling; as well as providing habitat for biodiversity.

Biodiversity is a key component of all of these vital services with all four categories, and is enshrined in the EU's Habitats and Birds Directives. The conversion of coppices to high forest (whether deliberately or by default) fundamentally alters the forest structure as well as the intensity, frequency and extent of management interventions. The impacts on biodiversity are especially great for species with a high turnover in forest gaps that have nowhere else to go in the immediate landscape, such as butterflies, reptiles, amphibians, epigenic invertebrates and corticolous bryophytes. 'Missing' ingredients associated with much longer rotations e.g. deadwood, saproxylics, microhabitats, 'habitat' trees, etc. could be added to enhance biodiversity still further. See the 'biodiversity considerations' outline below.

Some biodiversity considerations

1. Temporary (ephemeral) open space

Two-thirds of Priority Species, i.e. species given priority over planning and development under S.41 of the Natural Environmental and Rural Communities Act (2006) in England, and more widely within the UK Biodiversity Action Plan, are associated with glades and rides, with a further 12% with coppice and clear-fells. This means that nearly 80% of Priority Species in woodland are associated with either permanent or temporary open space.

Longer intervals of harvesting mean less temporary open space. Assuming a normal forest (i.e. an even distribution of age classes), temporary open space and young growth in coppice systems far exceeds the amounts available under conventional high forest silviculture. The area of young regrowth <5 years in coppice forest, depending on overhead cover by standard trees, can be three or four times that in broadleaved high forest run on long rotations. Crucially, the pre-canopy closure stage can occupy more than 10% of the forest area (up to 100% in short-rotation plantations). For example the UK Forestry Standard recommends a minimum of 10% open space for woods >10ha in extent; Harmer et al. (2010) suggest that any wood >5ha should have 10-20% of open and edge habitat – i.e. including together permanent and temporary open space. Simple coppice and CWS come close to this on temporary open space alone.

The consequences of management neglect are seen in national survey data collected on wild bird populations or butterflies. Generalist bird species have remained fairly constant over the past 40 years, while specialist species (particularly those requiring young growth) have declined. In butterflies, all species show a decline.

2. Winners and losers of coppice management or neglect

Several studies have examined long-term species changes resulting from decades of abandonment or conversion of coppice stands. Most of these have recorded a decline in richness of shrubs and trees and understorey layers under increasing shade, a gradual tendency towards homogenisation in field layers with lowered β-diversity, but increases in shade-tolerant, vernal and eutrophic species. Basal areas of trees and shrubs have increased while there were losses of open space habitats, but increases in dead wood substrate. In many deciduous, temperate stands there was also evidence of increasing eutrophication and acidification, variously attributed to atmospheric deposition, biomass accumulation and increasing canopy cover. In some cases there were indications of deteriorating litter quality, especially on soils sensitive to acidification and under pure plantations of beech or oak. The interaction of these different processes makes it difficult to predict how particular species will respond at any individual site, but general trends can be described:

Winners and losers of coppice management or neglect

Coppice management	***Neglect/ high forest management***
+ open space/young growth	
+ seedbank replenishment	
+ heliophilous plants	-homogenised field layers
+ small mammals	- lowered β-diversity
+ reptiles and amphibians	- declining open space
+ migrant warblers	- declining litter quality
+ thermophilous lepidoptera	+ shade tolerant species
	+ leaf-mining Lepidoptera

+ saproxylic invertebrates
+ hole-nesting birds, bat roosts
+ fungi, mosses and lichens

Plants

Open-ground and seed-bank species: those with persistent seed include: *Digitalis purpurea, Urtica dioica, Juncus effusus, Hypericum perforatum, Euphorbia amygdaloides, Veronica montana, Scrophularia nodosa,Lysimachia nemorum, Poa trivialis, Agrostis stolonifera, Silene dioica*. Open-ground species: many grasses and tall herbs, e.g. *Anthoxanthum odoratum, Cirsium palustre, Epilobium spp., Stellaria holostea, Prunella vulgaris, Viola riviniana*, plus several umbellifers and composite species.

Lengthened rotations may have long-term consequences for many light-demanding plants and those that rely on persistent seedbanks, which tend to decline in density and species richness in aging or converted coppices. These losses could accumulate over time (Van Calster et al., 2008b) unless reactivated periodically through heavy thinning, ride management, fire or rare windthrow events. The species concerned may disappear or persist only in small and more vulnerable populations along edges and glades.

Butterflies

Most woodland butterflies rely on sheltered, sunlit rides and glades, with a plentiful supply of larval food plants, and an abundant supply of flowers for nectaring. The warm microclimates within early- to mid-successional stages of coppice regrowth are literally hotspots for butterflies and many other insect species, which also tend to be rich in nectar sources. In the Alsacian Hardt of the Upper Rhine Rift Valley, openness and nectar abundance were the best predictors of butterfly species richness and diversity, followed closely by host plant cover (Fartmann *et al*., 2013). Many of these species are rare or declining in Northern Europe, with the exception of speckled wood (*Pararge aegeria*) which is increasing its range. Some can tolerate shadier conditions, including speckled wood and white admiral (*Limentis camilla*).

A similar trend is observed in English woodlands. Since 1990 butterfly numbers have fallen by 51%, reaching an historic low in 2012, although statistical analysis suggest no change since 2009. Long term decline is thought to be due to lack of woodland management and loss of open spaces in woods. Species in severe decline include brown argus, common blue, gatekeeper, holly blue, marbled white, meadow brown, peacock, small heath, small copper, small tortoiseshell and wall brown.

Birds

In general, bird species numbers tend to increase with increasing age structure (Donald *et al*., 1998), provided that a variety of age-structures are maintained. Although canopies developing into and beyond the pole stage are generally less attractive, standard trees in coppice provide a niche for canopy-feeding and hole-nesting species. For many songbirds, the shrub layers of up to 6m are important for nesting and feeding. The shading out of low shrub cover resulting from abandonment of coppice management and succession to high forest, or its removal through intensive animal browsing, directly affects woodland birds by reducing their food items such as invertebrates and fruits, depleting nesting sites and exposing them to predators.

A long-term study in Bradfield Woods, Suffolk, illustrates the importance of pre-canopy closure for songbirds foraging and nesting within regrowth aged 5-10 years, at roughly 4-6m. In this case an increase in the deer populations between 1987 and 2003 reduced the shrub layers markedly, resulting in lower abundance in the latter recording period.

A number of woodland specialists (lesser spotted woodpecker, lesser redpoll, spotted flycatcher, tree pipit, wood warbler, crossbill and marsh tit) have declined by over 70% relative to 1970 levels, with willow tit and capercaillie down by more than 90%. By contrast, populations of four other woodland specialists (blackcap, great spotted woodpecker, green woodpecker and nuthatch) more than doubled over the same period. Populations of some woodland generalist species (blackbird, bullfinch, dunnock, song thrush and tawny owl) have declined relative to 1970; tawny owl and bullfinch by almost 50% but great tit and long-tailed tit numbers have increased by more than 60% since 1970.

Mammals

Open conditions and early regrowth, dispersed over the woodland as a whole, provide good habitat for colonising voles, mice and shrews up to the point of canopy closure. Numbers of wood mice, shrews and voles are often inversely correlated with stand age in Mediterranean, temperate and even boreal woodlands. Short-rotation coppices of willow and poplar can also provide suitable conditions for small mammal generalists even in agricultural surroundings, as long as weedy herbaceous layers are retained at ground level. In denser scrub, the ability to travel through interlocking branches above ground is a well-developed specialism in dormice.

3. Management

Deer damage

Expanding deer populations pose a threat to young coppice. The European population of roe deer is now an estimated 9.8 million; Germany has almost a quarter of the total. The increase, 1960 – 2005, was estimated to be 240%. Areas of range expansion shown in green; red areas denote contraction. For red deer, the European population stands at c. 2.5 million (UK 400,000); Spain has about a third of the total. The increase in population, 1960 – 2005, is estimated at about 400% (Deinet *et al*, 2013).

Deer populations may benefit from the mosaic of conditions provided by worked coppice stands, with open areas providing good feeding conditions, while adjacent dense pole stands provide cover for lying up. However increased browsing by wild deer threatens not only the coppice re-growth, but also the woodland ground flora, tree seedlings, shrubs and climbers. Young coppice shoots are particularly susceptible to damage from browsing, barking and rubbing. The effect on bird populations through the removal of shrub layers has been mentioned.

Specialist species

Relatively few ‘coppice species’ rarities, occur among the Natura 2000 species; most are present in non-forest situations or in forest habitats not specifically resulting from coppice management. Conservation management may be carried out expressly to support a single species or group of species, e.g. the Scarce Fritillary *Euphydryas maturna,* Eastern Eggar moth (*Eriogaster catax*) and many other Lepidoptera which are not necessarily on the Annex II list, iconic species such as the hazel grouse *Bonasa bonasia,* some Warbler (*Sylvia*) species and mammals such as the dormouse *(Muscardinus avellanarius*) and bat *(Rhinolophus)* spp. Besides these, vascular plants responding to ‘light forests’ are important pollination sources and may be valued aesthetically.

Wider biodiversity considerations

Coppicing does not cover the full range of forest biodiversity: as we have seen it favours light-demanding understory vascular plants, ruderals and competitive and thermophilic animal species, providing pollination sources and food for invertebrates and mammals. Many other species benefit from high forest management or neglect: bryophytes, lichens, fungi, saproxylic beetles and some carabids – also wood pasture. The general sensitivity to shelterwood management roughly follows the order: herbaceous plants < soil macrofungi < ground dwelling arthropods < land snails < saproxylic fungi < hole nesting birds and saproxylic insects < epiphytic lichens and bryophytes < epixylic bryophytes (from Brunet et al., 2010).

If some trees are allowed grow to large diameters, e.g. for more than 150 years, they will increasingly provide microhabitats in the form of cavities, dendrothelms, bark cracks and fungal sporophores that are missing in younger stands. Veteran trees of >50-70 cm dbh eventually develop into 'habitat trees'. Threshold levels of deadwood >20-50m3/ha. However, much silvicultural activity tends to remove senescent trees. Wood-pasture *par excellence* provides veteran trees and a range of saproxylic species, but it is a system only likely to be practiced for conservation motives.

Silvicultural systems that might deliver a wider range of niches, including open space and young growth, are irregular and strip shelterwoods, wood pastures and coppice-with-standards. In the latter, conventional forestry allows tends to assume standard trees will grow to only c.100 years, dictated by the underwood cycle, and cover 40-50% of the area. These standards, on longer rotations, could supply some veteran trees and dead wood. Under this system the number of standards in each age class should be approximately half that in the younger age class. For conservation of butterflies, much lower cover of 10-15% is advocated.

Management strategies

There is a tension between coppice that produces woodfuel and biomass, with modern pressures to thin, convert and manage for timber in European forests, while at the same time satisfying the deadwood quotas required for certification (Fuller, 2013). High forest cycles with conventional silvicultural thinning are mostly too long to promote early successional species, but felling larger groups, variable density thinning, a reduction in standard tree densities (often too high) and an enlargement of the ride system can be more successful. If trees are grown on very long rotations, through to understorey initiation and beyond, the increased structure may again become suitable for scrub and edge species to colonise. Strategies which might maintain young growth are:

- group felling
- variable density thinning
- reducing densities of standard trees
- extending, widening and scalloping rides
- NOT
- individual tree selection
- continuous cover forestry and close-to-nature forestry
- singling of coppice stools (conversion to high forest)

In the end, a mix of age classes is most likely to deliver a fuller range of biodiversity. Mason and Zapponi (2015) recommend segregating the age-classes. Unharvested 'tree islands', or *'îlots de sénescence'*, are connected by a network of 'deadwood corridors' within a general productive forest matrix. Harvests t 1-3 could be phases within the coppice cycle. The

'Forest Biodiversity Artery' (FBA) is embedded in the productive matrix of different age-classes

A regional landscape approach, ensuring that suitable young growth habitat is available, may help with planning conservation efforts, rather than focusing piecemeal on individual sites. At this landscape level, species sensitivities to habitat loss and fragmentation need to be taken into account, in parallel with initiatives for forest restoration. Metapopulations of species which are of conservation concern might be more efficiently maintained by targeting the coppicing effort within their centralized zone of distribution, rather than at the periphery; but, at the same time, avoiding the risk of concentrating the effort in too few locations. Generalist species of young woodland might be encouraged by increasing connectivity between patches, including the strategic placement of short-rotation coppice in the wider landscape. Ultimately, however, the outcome will be driven by markets and the extent to which society values the unique properties of coppice communities. The emergence of new markets such as biofuels might provide part of the solution to abandoned coppices; otherwise the costs of conservation coppicing may prove too high.

Table 1: Silvicultural management and temporary open space

age (years)	growth phase	short-rotation coppice	simple coppice[1]	coppice with standards[1]	high forest[2]
< 5	open space – stand initiation	100	17	12	4
6-30	young growth – stem exclusion	0	83	62	21
31-100	thicket to mature stages	0	0	20	58
>100	understorey re-initiation stage	0	0	6	17

[1] based on coppice rotations of 30 years; standards occupying 30% of the area
[2] based on rotations of 125 years