Notes on coppice

In Europe *active* coppices cover about 28 Mha, or 14.8% of the total forest area. Both France (7 Mha) and Italy (3 Mha) have substantial amounts of traditional coppice, but in many countries active coppicing is the tip of the iceberg - much neglected (stored) coppice was long ago converted or allowed to grow into high forest. There are still only about 50,000 ha of short-rotation coppice (mostly willow and poplar) grown for biomass in Europe: this compares with some 700,000ha devoted to other biomass systems. More significant is the 1.2 million hectares of eucalyptus coppice, mainly *E. globulus* and *E. camaldulensis*, grown in Portugal and Spain on rotations of 10-15 years for pulp, paper and fibreboard production.

The basic form – **simple coppice** – produces an even-aged crop, although the stools themselves may vary in age. In **coppice-with-standards** a more irregular structure is created, in which a portion of the standards is felled at the same time as a coppice cut, but the length standard tree rotation lengths may vary according to market requirements, with cohorts of new standards being identified at the same time. A third, but rapidly disappearing version of the coppice system is **selection coppice**, where two or three age classes of stems are rotated on the same coppice stool. This exists mainly in mountain beechwoods of the Italian Apennines and parts of the Pyrenees, often alongside conventional coppice-with-standards. At each harvest (c. 6-12 years) the oldest, dominant stems are cut for firewood and the others lightly thinned. This overcomes the weak tendency of beech to coppice, while retaining a light canopy cover after harvesting, protecting against soil erosion on steep mountain slopes,

Physiological responses to coppicing

The ability of trees to coppice or re-sprout is a response to wounding caused by natural agencies: snapping and uprooting in windstorms, fire, browsing by animals, drought, flooding, and disease pathogens. Coppicing activates the dormant buds present at the root collar, and on stools formed from previous cutting. These buds result from the periclinal cell division of the cambium and are connected to the vascular system; prior to cutting of the stem they remain dormant, growing outward from season to season beneath the bark with the cambium. Shoots may also arise from adventitious buds that form spontaneously on callus tissue at the cut surface after injury (as in European beech), or they develop from roots, producing suckers, as with aspen.

After cutting, the plant relies on starch reserves stored in the stool and root system for new stem growth; this survival mechanism ensures that there is enough photosynthetic capacity to keep the stool alive. Drastic reductions of carbohydrate resources caused by stem cutting and removal seems to force the plant into shoot production, with root development lagging behind; simultaneously, new fine roots must grow to supply these new shoots. In coppices of birch and eucalyptus, research has shown that the roots corresponded to the age of the stool – and although fine root biomass is shed after coppicing, the superstructure of the root system is retained. Chestnut roots, on the contrary, are always younger than the stool, suggesting that this species completely renews its root system at each rotation, while birch and eucalyptus keep the old root system. In beech and oak, there is evidence to suggest that the root system is totally regenerated after each cutting, and this may be true of many of our temperate species.

Coppice shoots grow more rapidly than seedlings, reaching the canopy faster, but as they are usually cut before flowering takes place, they have a reduced capacity for seed dispersal. This allows sprouting species to hold ground in the face of competition from non-sprouters, which would otherwise exhibit rapid growth rates and a high reproductive turnover. Repeated vegetative reproduction from stump sprouts or root suckers with very reduced flowering could eventually lead to genetic ‘fixing’ or ‘freezing’ of variation in coppices. The evidence for this is mixed, but if coppice stands have indeed become ‘fixed’ in the past, they may have limited capacity to adapt to accelerating rates of climate change, compared with sexually regenerating populations.

Cutting methods

Traditionally, coppicing was carried out using an axe or billhook, although nowadays chainsaws or tree harvesters are used. Reports of the effects of different cutting treatments are often contradictory because they may be influenced by, *inter alia*, the quality and height of the cut, the season of cutting, the tree species, its biological age and the site conditions. Most practical accounts suggest that low cuts on the coppice stool encourage new sprouts to develop at or below ground level, thus forming independent roots and creating more stable stems. Sprouts developing in close contact with the soil are also more likely to form an independent root system. Clean, sloping cuts may help to shed moisture and prevent rotting.

French researchers found no difference in sprouting recovery between axe and chainsaw cuts in holm oak, whereas the traditional ‘saut du piquet’ technique, involving cutting stems at 50 cm above stool height and splitting them off the stool, ostensibly to reduce sprout competition, actually increased stool mortality and reduced sprouting. A German study found that mechanised felling using a tree harvester, versus high or low chainsaw cuts, made little difference to stool mortality or sprouting recovery in mature sessile oak, but low cuts (at c.11-12 cm above ground) did cause more dominant shoots to develop from below the root collar. In contrast, others have reported that sprouting in 6-year old chestnut was positively related to higher stool cutting positions, in agreement with other studies on a range of species. It may be that more starch reserves and dormant buds become available with higher cuts, but the new stems may then be more vulnerable to breakage and windthrow, particularly when they are grown on old stools. The Great Storm of 1987 created a lot of windblown and broken coppice, particularly in overmature chestnut.

Season of coppicing

Researchers have found that cutting in March and November produced consistently better sprout regrowth compared with either harvesting during a cold period in January or cutting within the growing season (May and July), even though stool mortality was not affected. One study showed that shoot regrowth, after cutting eight-year maiden saplings of ash, oak and sycamore at different periods in January, April and June showed only marginal differences after six years.

Resprouting ability

At each harvest a proportion of coppice stools die (typically 5-10% per cut, but potentially more in over-mature stands) and need to be replaced by planting, natural regeneration or layering. Larger stools and those with fewer neighbours tend to show better recovery than smaller stools with weak sprouting. Shading, for example by standard trees, may reduce resprouting in coppice.

Coppices can be rejuvenated by re-cutting, long after abandonment, although this may not be commercially viable if re-sprouting is reduced after such prolonged periods. In some Mediterranean stands of over-mature holm oak coppice, cutting led to senescence and death of the whole tree, while in the Czech Republic the probability of resprouting in 97-year-old sessile oak was less than 50% in stem diameters >35 cm dbh. In SW Germany, 80-100 year sessile oak suffered only 16% stool mortality after felling, again with slight increases in mortality in larger stem sizes. Another account found a 60% probability of re-sprouting in large-diameter stools (>70 cm dbh), also of sessile oak which had been coppiced 100 years previously. Virtually all contemporary lime stools and most hornbeam stools in the same stand re-sprouted successfully. A Swiss report also found that re-coppicing a 60 year-old sweet chestnut stand resulted in only 4% stool mortality. This variation seen in the ability of different species to recover from delayed re-coppicing may be due to differences in allocation of resources between roots and shoots, or the ability of some species to produce root suckers as well as coppice shoots. Another possible explanation is that axillary buds become progressively embedded as the stem increases in diameter: thus their ability to re-shoot gradually declines or becomes less vigorous with time since last coppiced.

Coppice with standards

An English statute of 1544 stipulated a minimum of 12 standards per acre (30 per hectare) to be grown above the coppice. Mature trees were needed for timber-framed buildings from the 14th and 15th centuries and earlier, using durable trees such as oak. These were not massive trees, typically being grown for up to three times the (usually short) coppice rotation, and were rarely older than 100yrs. Very large timber was not essential for most building purposes in the Middle Ages - sawing technology was still in its infancy and hundreds of small diameter oaks, as roughly-squared whole trees, were used in walls, floors and rafters. Standard trees were technically uneven-aged, and were rotated on a multiple of the coppice rotation beneath, usually up to 4r (where r = a coppice rotation), the numbers roughly halving with each progressive cohort

Large numbers of standards would have suppressed the growth of underwood by their canopy. Their density was always a compromise between the productivity of the two components of the crop: a 50:50 mixture of standards and coppice cover was considered normal stocking for ‘working’ coppice-with-standards systems in England, and post-war census criteria specified a minimum of 25 standards ha^{-1} to qualify. In modern conservation coppice a cover of not more than 30% for standards is often recommended: for butterflies it is even less, with 10% cover being recommended by Butterfly Conservation. In Dallington the figure is c.25%.

Theoretically, standard oak stems were kept clean by the coppice branching underneath them, up to a height of 5-6m; but they were still very short-boled and branched excessively above coppice height. 6-7m beams were possible, but 10m beams were almost impossible to find. After each coppice cut the increased light levels usually triggered epicormic growth on the remaining boles, forming knots and low-quality timber. The success of plantations, which rapidly replaced coppice-with-standards, is the close spacing of timber trees which forces them into apical dominance with only minimal side-branching.

Biodiversity issues in coppice

From a conservation point of view, a strong case for continuing to coppice is the vibrant plant communities that develop immediately after cutting, comprising the ephemeral spring flora (often arising from the seedbank) together with perennial, shade-tolerant species more typical of closed woodlands. The light, warmth and shelter of newly-cut compartments also encourages many early-successional communities of woodland birds, butterflies and other thermophilic invertebrates and pollinators, small mammals (like the dormouse) and basking reptiles. Coppicing may be continued specifically to promote the habitat of iconic species - populations of butterflies such as the chequered skipper, pearl-bordered fritillary, nightingale and other migrant songbirds which nest and forage in scrub (whitethroat, willow warbler, chiffchaff, garden warbler, blackcap).

Conversely, coppices are regarded as poor habitats for late successional species because of their perceived lack of dead wood. However, they are capable of maintaining saproxylic niches in microhabitats such as cavities, dendrothelms and mould in old coppice stools, and in stubs, pollards or standard trees. In Belgium, old restored coppices have been shown to support saproxylic species and to have the potential to allow re-colonisation. These experimental sites, which had very few old standard trees, were found to have fairly rich populations of saproxylic beetles - which presumably had survived in old coppice stools, because otherwise, being poor dispersers, they would have taken far too long to colonise and build up their numbers. In the medium term at least, restored coppices may favour species with a preference for sun-exposed wood.

Standard trees in coppice can provide microhabitats and deadwood, but traditionally they were felled at relatively young biological ages, typically 100 years or less; much longer would be needed to achieve their full biodiversity potential. Some authors consider that leaving intervals without harvesting for 50 years could never achieve tree-bearing microhabitat densities approaching those of old-growth forests; double this period was more likely to achieve this target. Large diameters of deadwood, favoured by many saproxylic beetles, can coexist within relatively open and sunny conditions in coppices and wood-pastures. Long standard tree rotations of 125 years have been recommended for conservation reasons, covering 20-25% of the area, but if not constrained by marketing incentives, there is no reason why they should not be left indefinitely. In Italy, where there are still markets for older trees within coppice, the 'single tree orientated silviculture' method is advocated, in which low densities of target trees among the coppice are selected (e.g. 100 ha^{-1}) and thereafter favoured by frequent thinning of their immediate neighbours, until they become valuable timber trees. This system produces a varied horizontal and vertical canopy structure comprising isolated trees, thinned stools and unmanaged coppice, although the crop trees will still be harvested when biologically young, at merchantable size. Another silvicultural technique is to manage groups of standards as mini-high forests within the coppice area.

Amounts of deadwood are commonly used as an indicator of 'health' of European forest ecosystems. A threshold of the order of >20-50m^3 ha^{-1} has been suggested as necessary to support a high diversity of saproxylic organisms, although much higher levels have been recommended by other authorities. This theshold might be achieved in neglected coppice, but not young, working coppices. The most recent UK Woodland Assurance Scheme guidance recommends accumulating standing and fallen deadwood, in equal proportions, to a minimum of 20 m^3/ha or 5-10% of the average stand volume across the whole woodland area, including some large sizes of >20cm in diameter.

Reference: Buckley P, Mills J (2015) Coppice silviculture: from the Mesolithic to the 21st century. In: Kirby K J, Watkins C (eds) *Europe's changing woods and forest: from wildwood to managed landscapes.* CABI International, Wallingford, UK, pp 77-92.

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