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Coppice

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COPPICE

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Preface

There is a strong revival of interest in broadleaved woodland in lowland Britain which was reflected in the House of Lords Select Committee on 'The Scientific Aspects of Forestry', the Broadleaves in Britain Symposium, and the setting up, in 1982, by the Forestry Commission of a Broadleaves Policy Review Group. One of the first recommendations of this Group was that a publication on coppice should be produced. This traditional silvicultural system has had a profound influence on much broadleaved woodland and there is a need to consider how these woods can be maintained in the changing circumstances of the late 20th century. This booklet is intended to provide practical, managerial and silvicultural information for all those involved in coppice woodlands whether as owners, members of conservation trusts, local and national government officers or members of the public. Most of the material comes from a larger work on the silviculture of broadleaved woodland which is being written by one of the present authors, Dr. Julian Evans.

FRONT COVER
Bluebells under Sweet chestnut coppice in springtime. Steep, Hampshire *(11367)*

Introduction

When broadleaved trees are felled they will produce shoots from the cut stump. These are known as coppice shoots, and the stump from which they grow is called a stool.

The number and vigour of the coppice shoots varies with species and with age of the tree. Ash, hazel, hornbeam, lime, oak, Sweet chestnut and sycamore are the species that have been recently worked or are presently worked as pure coppice. Very often a limited number of trees are retained to grow over several rotations of coppice cutting to produce large timber, these trees are called standards and the system is called 'coppice with standards'. A few broadleaved species do not coppice vigorously or only have the capacity to do so when young and the stump is fairly small — beech, birch, cherry, and some poplars. Only two conifers produce coppice shoots, the Monkey puzzle and the Coast redwood, and neither are suitable for the commercial production of wood products by this method.

History

This ability of our native broadleaved trees to regenerate themselves from the cut stump has had a great influence on woodlands in Britain.

The practice of coppicing, on both short and long rotations, can be traced back to neolithic times (4000 B.C.), and evidence of use of coppice products for numerous rural needs can be found throughout the bronze age. The practice continued in Roman and Saxon periods; Rackham (1980) considered that by 1250 coppicing was widespread, and even in such large woodland areas as the Forest of Dean. In the 17th and 18th centuries coppice not only continued to supply building and fencing materials and domestic firewood but was increasingly in demand for charcoal, for iron and glass industries and, with oak, to provide bark for tanning.

In the middle of the last century the importance of coppicing began to decline as many of the traditional products were superseded. This decline accelerated after the First World War as rural electrification programmes and other more convenient energy sources finally supplanted firewood, so that by the mid-1950s regular coppicing, apart from that of Sweet chestnut, had become rare. This singular exception of Sweet chestnut, of which most coppice crops were planted between 1820 and 1870, developed because of the demands for long, straight, durable poles needed by the hop-growing industry. Though this demand declined at the beginning of the present century, a new and still continuing market developed for split chestnut for fence palings.

Why is coppice important?

Although active coppice management, apart from chestnut, has declined the total area of woodland that has been influenced by past coppicing is substantial. The total area of coppice in England by types and species is given in Table 1.

Landscape

The scenic impact of this total area of coppice is enhanced because coppice woodlands tend to be small and scattered and rotations short. Actively worked coppice with standards is aesthetically very attractive exhibiting a more diverse structure than most woodland.

Conservation

However, although the landscape effect of coppice is beneficial in providing some tree cover, the conservation values are even more important. These are:

a. The variety of habitat provided by different stages of worked coppice is highly beneficial, to flora and fauna. It ranges from the dense canopy and shaded ground of the older coppice ready for felling to the open ground after felling which encourages a resurgence of ground flora. This assumes of course that different parts of the wood are felled at different periods. Coppicing a whole wood in one operation only gives variety of habitat in time but not in space.

b. The relatively short rotations (15-20 years) mean that the period of complete canopy is short so allowing seeds of herbaceous and other ground flora to survive ready to

Table 1 Area of coppice in England by types and species **(hectares)**

	Sycamore	Ash	Sweet chestnut	Hornbeam	Hazel	Other species	Total
With standards	115	193	5,275	1,697	1,465	2,728	11,473
Coppice only	2,297	1,184	13,816	1,716	1,573	5,125	25,711
Total	2,412	1,377	19,091	3,413	3,038	7,853	37,184
Proportion of total coppice (%)	7	4	51	9	8	21	100

Source: Forestry Commission Census of Woodlands and Trees, 1979-1982 (1983) take advantage of the light following the next felling. The rich spring flora is most evident in the early years of the coppice cycle but declines after about 5-7 years.

c. Because coppice has been practised continuously for centuries in some woods there is a continuity of tree and ground flora types that has a strong link with the original flora on the site before man's influence made itself felt. As there are virtually no 'wildwoods' in Britain (woods that have not been actively influenced by man) these ancient coppices are particularly valuable scientific sites.

Wood production

Unfortunately conservation and landscape values do not bring a cash return to the owner. So the value of the wood produced by coppice is important.

Today the principal markets for coppice are:

a. pulpwood – with mills at Sittingbourne, Kent and Sudbrook, Gloucestershire;
b. turnery;
c. fencing – particularly Sweet chestnut which is used to make cleft pale fencing and fence posts;
d. firewood – the high cost of other fuels and the advent of the wood-burning stove has led to a strong demand for firewood.

Active working of coppice is associated with these products. Unfortunately with hazel, despite extensive areas of coppice, the species is ill-suited to these markets. Moreover, its traditional use for hurdles is labour intensive and it is uncompetitive with the softwood

Figure 1. Oak coppice thinned to convert it to high forest. *(D3886)*

Figure 2. Oak standards and hazel coppice. The stocking of standards is high, casting too much shade for vigorous hazel which here has not been coppiced for many years. *(A3984)*

panel fence. Nevertheless a small amount of hazel coppice is worked for hurdles, thatching spars, hedging stakes, bean poles and similar products (see page 16).

Woodland potential

The extensive area of coppice is a neglected resource which for many reasons has not been brought back into effective use. It is important to distinguish between neglected hazel coppice and mixed coppice of potentially valuable species. Hazel coppice, from which the standards have been removed and where hazel and other valueless species have prevented the growth of self sown more valuable species, has very little potential to develop into high forest. The mixed species coppice on the other hand has the capability of developing into high forest with the aid of some thinning. Many woods have developed in this way.

Coppice that is deliberately left beyond the usual rotation age of 15-20 years is termed stored coppice (see page 15). This leaves the options open for many years either to return to a further coppice crop by felling or to develop into high forest by thinning (Figure 1). If a coppiced woodland is left untended it will eventually develop into mature broadleaved forest (high forest) but the process will be a long one. However, almost every coppice includes some self sown seedlings of valuable trees such as oak, ash and sycamore and these will eventually dominate. These woods have produced a number of valuable sawlogs.

The conversion of coppice into high forest can be accelerated by timely cleaning, thinning and pruning. These operations are costly and require skilled work if they are to be effective. However, this expenditure is likely to be the only major investment needed to achieve a worthwhile broadleaved crop. Neglected coppice has considerable potential to develop into broadleaved forest.

Coppice management and working

State of the crop

Clearly a well stocked chestnut or mixed species coppice, when it reaches usable dimensions and provided a market is available, can be harvested and regenerated profitably. The same will apply to stored coppice. Hazel coppice with standards, if the standards are marketable, may provide enough return to cover the cost of hazel clearance and plant a replacement crop (Figure 2). Pure hazel or hazel from which the standards have long since been removed will require substantial investment to clear and replant.

Establishment and maintenance

A well stocked coppice crop at rotation age (Figure 3) will have dominated the site so that there is very little established ground vegetation. On felling, the stools regenerate rapidly

Figure 3. Chestnut coppice 15 years old, ready for cutting.

Figure 4. Chestnut coppice, one year old.

(Figure 4) and provided they are protected in the first season from damage by farm stock, deer and rabbits this coppice growth exceeds that of woody weeds (e.g. bramble, honeysuckle, willow, hawthorn) which have the disadvantage of having to start from seed. Herbaceous plant seeds also respond to the opening up caused by the felling and spectacular spring flowers can result; their effect on coppice regrowth is negligible. If the original coppice was not well stocked or contained a proportion of shrub species such as hawthorn or hazel then it will not give a satisfactory replacement crop without some replanting and subsequent tending. The extent to which this is worthwhile will depend on the circumstances of each wood. After the first year little or no further tending is needed in a well stocked coppice crop. Thinning of the coppice shoots is not necessary.

Coppice working

Area

Traditionally areas felled were small, geared to the ability of one or two men to cut and prepare the produce in a winter season. Today the same principle applies to chestnut coppice (Figure 5) though with other coppice types the limiting factor is more likely to be the size and shape of the woodland or of the crop type. Accessibility is of prime importance and stands alongside roads are likely to be more readily saleable than those involving a long haul over un-metalled tracks. Adequate stacking and loading space is essential and this should be close to a public road but must not impinge upon it.

Felling

A sloping cut is traditional arising from the use of edge tools and though it will shed rainwater this is not a crucial factor in reducing the incidence of decay (Figure 6). Low cuts maximize the yield and may increase the tendency for coppice shoots to develop their own root system independent of the original stool. The bark on the stump below the cut should be left intact and undamaged. Use of chainsaws appears to reduce somewhat the number of coppice shoots on a stump compared with axe cutting, but there is no effect on height growth (Phillips, 1971) and either method is acceptable.

Timing

Traditionally, coppice is cut in the winter (October to March) for several reasons. Working is easier without the presence of foliage, there is a full season's growth for the new shoots, and, at least in the past, coppice workers have had other work to do in the summer. However, there are no overriding silvicultural reasons for winter working and coppice can be cut successfully at any time of the year except in late summer (August) when new shoots may not harden off before winter. The first cut of a newly established coppice should be made in March or early April so that the new shoots do not emerge until June when the risk of severe frost damage is slight.

Figure 5. Freshly felled cant of Sweet chestnut with a 'washmark' showing the boundary of cut.

Figure 6. A large coupe of Sweet chestnut coppice. Note sloping cut of stools in foreground.

Stools and stocking

Although coppice crops are worked on short rotations and therefore need to achieve full use of site potential in a short time, spacing of stools is not as close as initial spacing in conventional plantations because each stool produces many shoots which grow out from the base. Since thinning of coppice is rarely carried out the general rule is that the longer the rotation, and hence larger the roundwood desired, the fewer the number of stools per hectare. For example hazel worked on a 7-10 year rotation for bean sticks, thatching spars and hurdles has 1,500-2,000 stools per hectare, Sweet chestnut worked on a 15 year rotation for fence palings has 800-1,000 stools per ha and oak and ash worked on longer rotations have commonly 200-500 stools per ha.

In time some stools become very large and after several coppicings fewer may be needed to achieve full stocking (Figure 8). Conversely, at each coppicing due to natural decay, extraction damage and burning lop and top nearby, stools may die and a gap occur. These should be made good (gapping up) at the time by planting a large healthy tree 0.5-1.0 m tall with a good root system, or by layering one of the shoots from an adjacent stump left uncut for the purpose.

Fertilising

Cutting successive coppice may deplete a site of available nutrients, particularly of phosphate. However, so far there is little evidence to show that this has led to a decline in growth and few experiments have been done

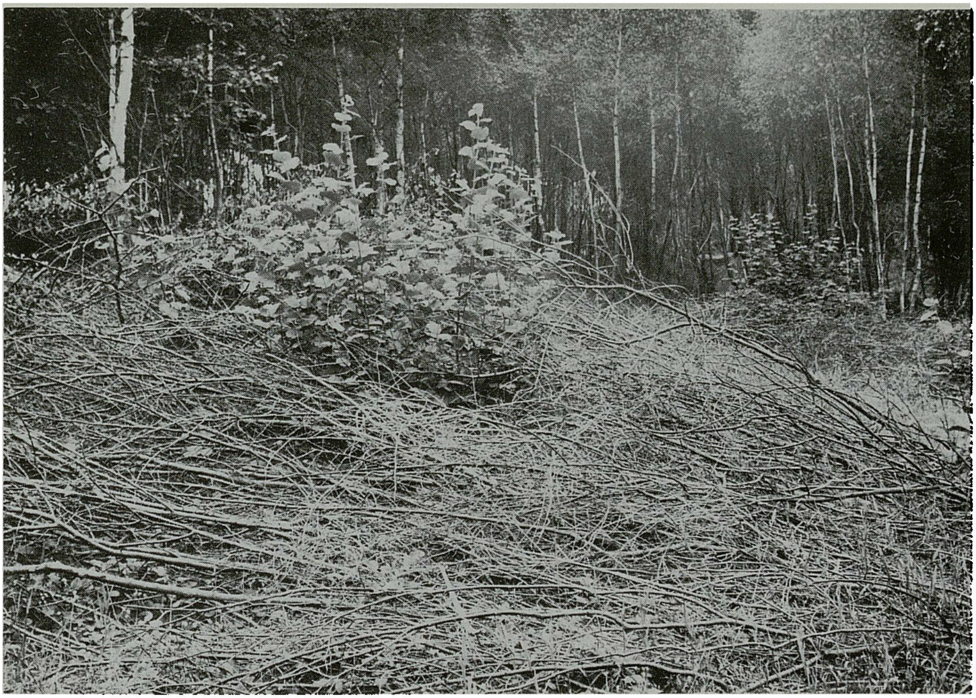

Figure 7. Brushwood covering hazel coppice to afford some protection from browsing.

which demonstrate that fertilising benefits the coppice crop. Application of fertiliser is only recommended after leaf analysis has indicated a possible nutrient deficiency.

Protection

In general, coppice crops stay remarkably free from problems. Late spring frosts can be damaging, particularly to Sweet chestnut, but damage from snow or wind is very rare since coppice shoots or branches never reach very large size. Fires are rare owing to relatively little ground vegetation and the broadleaved nature of the crop.

Browsing by deer and rabbits can be serious but the rapid growth of coppice shoots limits damage very largely to the first growing season. Specific protection measures are rarely undertaken and when the crop is at its most susceptible there is usually much other herbacious vegetation as alternative browse. If browsing pressure is intense, heaping brushwood over stumps (Figure 7) gives some protection, but usually fencing and/or control of animal populations will also be necessary.

Costs and returns

Coppice is essentially a 'low cost : low return' silvicultural system.

After initial establishment the costs of maintaining productive coppices during successive rotations are small. At each felling a small amount of planting or layering in gaps may be needed along with attention to fencing where there is serious risk of browsing damage.

An existing well stocked coppice, be it

Figure 8. Mature lime coppice with 15-20 shoots per stool.

chestnut or mixed broadleaves will, after about 15 years, produce marketable roundwood that can be sold for pulpwood or firewood. Turnery may be a limited specialized outlet and, of course, Sweet chestnut has its own range of products.

In 1983 prices for pulpwood were about £13 per tonne at roadside equivalent to between £2 and £4 per tonne standing, depending on accessibility. Similar prices prevail for firewood. On this basis a mixed broadleaf coppice aged 15-20 years, which can be expected to contain some 30-60 tonnes per hectare (see page 13) would have a standing value of £60 to £200 at 1983 valuation.

Chestnut coppice is more profitable; total growing costs, including auction fees when felling, amount only to about £70 to £80 per hectare, while returns range from £300 to £1,200 per hectare (Evans, 1982).

Although the above figures indicate a 'profit' no account has been taken of the value of the land, which becomes important when comparing alternative land uses. However, coppice has a high conservation value which is difficult to measure in money terms. But clearly the possibility of a regular cash return, which coppice working affords, improves the prospect of retaining such woodland in our countryside and hence conserving wildlife values.

Growth and development

The growth and development of a coppice crop differs markedly from that of a plantation. The stools, supported by large root systems, produce numerous shoots leading to very high numbers per hectare (upward to 100,000), rapid site occupation, early canopy closure, and earlier culmination of maxium mean annual increment.

Number of shoots

The number of coppice shoots per stool varies with age and size of stool and cutting tool used (Phillips, 1971). A large number of shoots emerge in the first year, typically 50-150 per stool, but self-thinning takes place and each year some of the smaller shoots die so that by (say) 20 years there are 5-15 live stems (Figures 3 and 8). The final number of shoots surviving depends on species, spacing between stools and rotation length, e.g. mixed underwood worked on an 8 year rotation may have 10,000 to 20,000 shoots per ha when cut, while Sweet chestnut coppice at 16 years has about 5,000.

Growth pattern

Compared with a planted tree the initial growth of a coppice shoot is very vigorous and goes on growing throughout most of the first season. Oak will commonly reach 1 m and ash, sycamore and Sweet chestnut may grow as much as 1.5 – 2.5 m in their first year. Even greater height increment may occur in the second year but thereafter increment of most species is increasingly restricted to the early part of the growing season and becomes closer to that for a planted tree of the species. Rapid height growth and large numbers of shoots lead to canopy closure occurring in the second or third year for more vigorous species.

Yields

Yield data from coppice crops are far from comprehensive. Not enough data have been obtained to give an accurate picture of the range of yields by species on different sites nor to give reliable figures on the quantity of small diameter material under 5 cm in diameter. Recent work with Sweet chestnut in southern Britain has shown that variation in height growth is surprisingly small. Poor stocking, fewer than 500 stools/ha, is the main cause of low yields. However, according to Begley and Coates (1960), the mean annual increment over a coppice rotation, in terms of dry wood per hectare per annum measured to 5 cm diameter, is about 2½ tonnes per hectare for sycamore, birch, ash, lime, oak, alder and Sweet chestnut. Only poplar and willow exceed these figures at about 6 tonnes per hectare per annum. Moisture content is variable both between and within species but, with the exception of ash, moisture contents of 100 per cent of the dry weight are usual and poplar and lime as high as 190 and 160 per cent respectively. The dry weight yield of hazel, from which material down to 2 cm is used for hurdles and other products, is also about 2½ tonnes per hectare per annum. Yield of Sweet chestnut measured to include twigs is about 4 tonnes per hectare per annum (Begley, 1955).

Long-term productivity

In principle coppice can be worked indefinitely but two factors, site exhaustion and stool mortality, could lead to declining yields with time.

Although the regular removal of produce from a site may cause net loss of nutrients over time there is no recorded evidence of yield decline though, according to Rackham (1967), the reason for the lengthening of coppice rotations in the late middle ages may have been due to declining fertility. However, even in the most intensive forms of coppicing (osier growing) and possibly due to high site fertility, continuous annual cropping can be maintained for at least 30 years without needing to fertilise (Stott, 1956).

More important as a potential cause of yield decline is stump death. Provided shoots emerge there is no evidence that the vigour of shoot growth is affected by stump size or age and the term 'tired coppice' is quite misleading. Indeed, some stumps are known to have produced vigorous coppice over many hundreds of years. However, stump mortality does significantly reduce yield per hectare by lowering stocking, and replacement should be carried out. In Sweet chestnut coppice typically 5 per cent of stumps die at each cutting, but in lime the figure is only 1-2 per cent.

Figure 9. Coppice with standards. Oak standards over mixed coppice of ash, hazel, lime and birch.

Coppice with standards

Coppice with standards is a two-storey forest where among the coppice (underwood) some trees (standards) are grown on for larger size timber (Figure 9). This silvicultural system was very widely used and indeed was the legally required way of managing coppice woods from the time of Henry VIII (Stewart, 1982) when a stocking of at least 30 standards per hectare had to be left.

Too great a number of standards overshades and depresses growth of the coppice (Figure 2). Generally between 30 and 100 per hectare are retained depending on tree size. Standards may be even-aged but are more commonly made up of several age classes, with each age class approximately equally represented. Standards should be evenly spaced and a typical overstorey structure is shown in Table 2.

At the end of each coppice rotation mature standards are felled, intermediate aged ones thinned, and new ones planted or recruited from natural regeneration or occasionally by retaining a coppice shoot to grow on to large size (storing coppice). The length of time a standard is retained will depend on desired log size and species growth rate; oak is generally retained for 5-6 coppice cycles (100-130 years) and ash for 3-5 cycles (60-100 years).

Standards may be the same as, or different from, the coppice species, with the obvious exception of hazel which grows to a maximum height of 12 m and remains bushy. Ideally standards should cast only light shade, have strong apical dominance, a deep root system

Table 2 Traditional stocking for standards

	Age class/coppice rotation			
	1	2 – 3	3 – 4	4 – 6
Name of 'standard'	Teller	2nd Class	1st Class	Veteran
No. of stems per hectare	50	30	13	7
Percentage of area occupied	10	10	10	10

and thick bark. In practice the only unacceptable species for a standard is beech because of the very dense shade it casts. Standards develop large open crowns, exhibit rapid diameter growth similar to that under free growth conditions (Jobling and Pearce, 1977) and reach timber size in about 3-6 coppice rotations. On some species, notably oak, standards often develop vigorous epicormic branches and unless these are pruned off or controlled in some other way high quality timber cannot be produced.

Stored coppice

Stored coppice is a stand of trees derived from shoots grown on past the normal coppice rotation, often with the intention of converting to high forest (Figure 1). Many western oak woods are in this condition following cessation of regular coppicing for tan bark and/or firewood at the beginning of the 20th century. Storing coppice is a means of obtaining timber size material but the quality may be inferior owing to (1) the tendency of decay and stain to invade the base of trees developing from stools, though this will usually not extend beyond wood present at the time of wounding and (2) the curved or swept butt. Storing coppice does not permanently consign the stand to high forest status and coppicing can usually be revived even after 100 years of neglect (Rackham, 1980).

Short rotation coppice

Short rotation coppice is loosely defined as coppice worked on a cycle of less than 10 years. Several broadleaved crops are worked in this way and are conveniently divided into two groups: rural crafts and fuelwood. Both groups are of only minor significance; the rural crafts because the scale of working is small, and the short rotation coppice for fuelwood because it involves techniques that have not been fully tested in practice.

Rural crafts

In the past much underwood has been cut on short rotations to yield sticks and small poles for many different rural uses. For convenience five kinds of crops are considered: mixed underwood, hazel coppice, short rotation Sweet chestnut, osier beds, pollarded trees.

Mixed underwood

If left undisturbed and protected from browsing almost any area of land in Britain below 300 m altitude will, in a few years, be found carrying a dense thicket often of many woody species. This is usually most profuse on recently cleared woodland, but in the lowlands generally a feature of young plantations is unwanted woody growth which often has to be cleared from the stands to release the planted trees. Such woody growth when 4-6 m tall can yield many small roundwood products – hurdles, bean and pea sticks, hedging stakes,

Figure 10. Mixed underwood of birch, hazel and sallow being cut on an 8 year rotation for bean sticks, hedging stakes, etc.

turnery material, etc. This may be obtained casually as a by-product of cleaning operations or areas of underwood can be worked on a regular cycle often of about 8 years (Figure 10).

Although traditionally winter work, cutting may be done at any time of the year. It is done by hand and a skilled operator selects, cuts and sorts the material for many different end-uses, in the course of working.

Hazel coppice

In the past hazel was a valuable shrub in temperate regions providing firewood, food and satisfying numerous rural needs for long, flexible, small diameter sticks for wattle and daub plaster work, thatching, hurdles, garden fencing, barrel hoops, etc. Although now out-of-print, a full account of the hazel coppice industry in the 1950s has been written (Anon., 1956).

Since 1956 the area of worked hazel coppice has declined from about 60,000 ha to no more than 3,000 ha. A large area of unworked hazel exists and if markets reappear such crops can be brought back into production provided the last coppicing was less than 40 years before; stools neglected longer than this rapidly die.

Hazel is usually grown as coppice with standards and is ideally worked on 7-9 year rotations yielding shoots 4-5 m long. Cutting may be carried out at any time but winter working, when the wood is drier, is preferable for hurdle making. Regrowth of coppice after cutting is profuse but not especially vigorous and must be protected from browsing.

Growth rate of hazel is similar to that of young coppice of oak or lime but declines rapidly after 15 years. On fertile sites and with a stocking of 1,500 stools per hectare yields of oven dry wood are about 25 tonnes at 10 years and 45 tonnes at 15 years. Hazel coppice is likely to continue as a minor underwood crop owing to the steady demand for hurdles (Figures 11 and 12), for garden fencing and for thatching spars. About 5,000 houses are thatched each year and on average 3,000 spars are used per house. This requirement for 15 million spars (1 m long) can be provided from about 1,500 ha of hazel.

Short rotation Sweet chestnut

A minor but specialized market exists for walking sticks cut from Sweet chestnut as only this species is acceptable for sticks used in hospital practice (British Standard BS 5181, 1975). The market requires material in clean 1.2 m lengths with a base diameter ranging from 2.4 to 3.2 cm depending on grade of stick. Crops are normally worked on a 3 year rotation, though 2 years is sufficient if summers are sunny and warm.

Osier beds

Although not traditionally considered as forestry, growing willows for osier wands for basketry is a long practised system of short rotation coppice – see Stott (1956) for a general account. Cultivars of two willows, *Salix triandra* and *S. viminalis*, are used. A bed is established on deep ploughed and well

Figure 11. Hurdle making. Cleaving rods with the billhook.

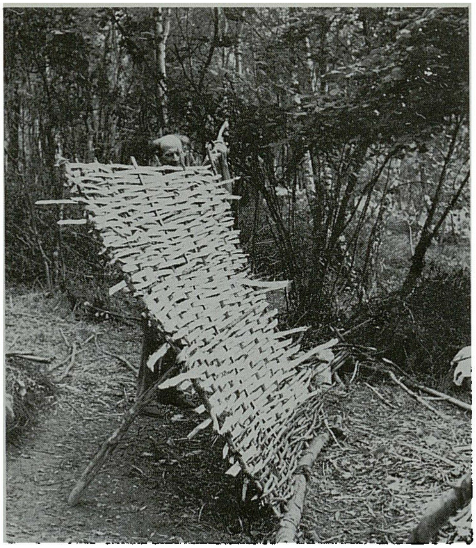

Figure 12. Hurdle making. Weaving a cleft rod.

harrowed ground using sets 30 cm long and spaced at 30 × 60 cm to give a stocking of 55,000 per hectare. Each year the slender shoots, 2-3 m tall, are cut between November and March. Differences in processing the long flexible withies give the range of colours from white to brown. In Britain only about 150 ha is under osier cultivation and is almost entirely restricted to the moist, rich alluvial soils in parts of the Somerset levels.

Pollarded trees

Pollarding is the same as coppicing in all respects except the new shoots emerge on the top of a short trunk 1.5 – 3 m high rather than at or near ground level. The shoots at this height escape browsing, especially by cattle and deer, and in the past pollarding was a widespread alternative to coppice and accounts for the multi-stemmed habit of many older trees, e.g. in the New Forest.

Today pollarding is restricted mainly to riverside willows, mostly *Salix alba*, though a similar operation is sometimes applied to trees to improve their production of side shelter by stimulating new branches all along the bole, e.g. poplars around hop fields (Figure 13). Of course, identical effects are often seen in towns when crowns of street or garden trees are severely reduced or completely removed.

If new pollards are planned they should be kept as low as possible (boles rarely need to be more than 2 m high) to ease the strenuous work involved. For willow a stout, straight, live branch is inserted into the riverbank and left to root and become established. After 2 – 3 years the top is cut off (polled) at 2 m above ground. Shoots arise profusely the following spring. As with coppice these will grow to utilizable size in 5-10 years. Poles can be regularly harvested in this way for at least 100 years.

Fuelwood

In many countries wood remains the most important fuel but in Britain, with reserves of coal, oil and natural gas, it provides less than one per cent of our energy. Most is used in wood-burning stoves or boilers for estate or domestic purposes with wood supplies coming from thinnings, residues from felling or slabwood from sawmills. However, there are two related developments which may increase the use of wood for fuel and lead to tree planting for this purpose (Crowther and Patch, 1980).

1. *Firewood coppices.* Rising fuel costs, ideas of self-sufficiency, and unavailability of gas and electricity grid supply in some remote places are renewing interest in working existing and establishing new coppices for firewood.
2. *Energy crops.* Owing to the finite size and eventual exhaustion of fossil fuels consideration is being given to alternative, especially renewable, energy sources: growing woody material on very short rotation coppice systems is one possibility.

Firewood coppices

Growing one's own energy is an attractive prospect and planting trees is one obvious way. However, wood is not necessarily an easy or cheap alternative to other fuels and several factors must be considered.

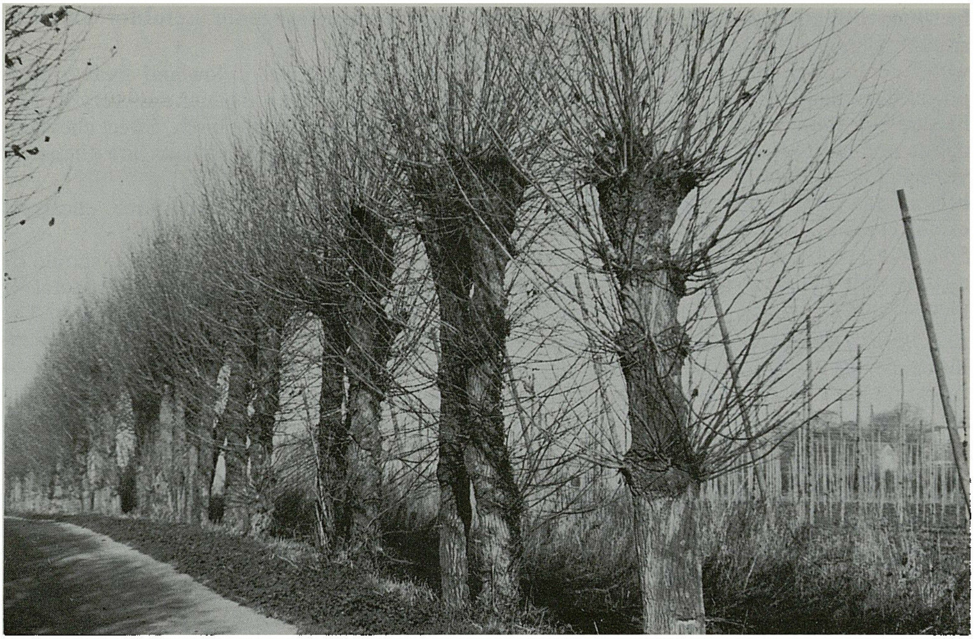

Figure 13. Pollarded poplar used as shelter around a hop field.

Quantity of fuel needed. Heating a three-bedroom house consumes about 130 GJ of energy per year which equates with the following amounts of fuel:

36,100 kwh of electricity
1,230 therms of gas
2.7 tonnes of domestic heating oil
4.3 tonnes of coal
8 tonnes of air dry wood
7 tonnes of oven dry wood

Stacking space for drying wood. Burning wood which has a high moisture content is inefficient yielding little heat and causing tar deposits in the stove and flue. The moisture content needs to be less than 20 per cent, thus no freshly felled or green timber should ever be burnt; even the moisture content of ash is over 30 per cent when felled.

The simplest way to reduce the moisture content of wood is to cut it into lengths suitable for burning, split it and then stack it in a dry place with good air circulation, e.g. a lean-to shed beside a house. The actual amount of space needed per tonne of air-dry wood (17-18 per cent moisture content) will depend on wood density. Less dense woods, such as poplar, willow and most conifers with a specific gravity of about 0.35, will occupy about 2¼ cubic metres of space per tonne, dense woods such as oak with a specific gravity of about 0.5 will occupy 1½ cubic metres of space per tonne. Air-drying wood takes time and *at least* 6 months should be allowed between felling and burning and for some species such as elm a year's drying is necessary.

Land needed. If it is intended to work existing broadleaved woodland, which will almost always be of a native or long naturalized species (oak, ash, Common alder, hornbeam, Sweet chestnut, lime, sycamore, birch), it can be assumed that on a 10 year cutting cycle an annual increment of 2-3 tonnes of air-dry wood per hectare will be achieved. Thus to produce annually 8 tonnes of air-dry wood 3-4 hectares of coppice woodland is needed with about one-third of a hectare being cut each year. Better productivities, up to 6 tonnes per hectare per year, may be obtained with some exotic species of willow, alder, poplar, Southern beech and eucalypts, but in almost all cases this will mean establishing a new coppice.

Establishing a new coppice. Site conditions will influence the choice of tree species but for fuelwood production achieving rapid growth is essential. Although experience with the more rapidly growing exotic broadleaved species as coppice crops is limited in Britain, there is evidence of their ability to coppice and to produce substantially greater yields than the more common broadleaved species. For those who are prepared to take the risks involved in trying new techniques the table below suggests species for firewood coppices.

The much commoner broadleaved species mentioned earlier can also be used and though slower growing are more useful for conservation purposes.

On heathland sites in lowland areas cultivation and fertilisers are beneficial; very limited experience suggests that birch, Sweet chestnut, Southern beech and eucalypts are the most likely candidates.

On moist upland sites only birch, eucalypts or sycamore should be tried.

Removal of competing vegetation should be undertaken, preferably with either a total or spot herbicide treatment before planting. The method of weed control to be used after planting will influence the spacing adopted and must be decided before planting commences.

Healthy plants, well furnished with roots, and 0.5-1 m in height should be planted into clear ground at a 2.5 or 3 m square spacing. The ground should be weed free so that early growth is assured. Control of competing weeds should be maintained to ensure continued vigorous growth of the trees until vegetation is suppressed after the first cutting cycle. Newly planted trees are vulnerable to damage from farm stock, rabbits, hares and deer; fencing or individual tree protection may be necessary.

Table 3 Choice of species for firewood coppices

Site	Name	Species or variety
Stream and pond sites	Willow	*Salix alba* and cultivars *Salix fragilis*
Moist but well drained	Alder	*Alnus cordata* (especially where soils are neutral or alkaline)
	Poplar	*Populus nigra* *P. x euramericana* cultivars *P. trichocarpa* 'Fritzi Pauley' *P. trichocarpa* 'Scott Pauley'
Well drained fertile lowland sites. Avoid frost hollows.	Eucalyptus	*E. gunnii, E. glaucescens, E. nitida*
	Southern beech	*Nothofagus procera* in the west *N. obliqua* in low rainfall areas (but not East Anglia)

Figure 14. Poplar coppice, one year old.

When to cut coppice. When establishing a firewood coppice newly planted trees should not be cut until there is material suitable for the fire. Depending on species and site this may be between 7 and 10 years by which time trees should have developed a reasonable basal stump. Coppice regrowth from the stump will usually be more vigorous than the original seedling crop.

The interval between cutting firewood coppice crops, the coppice rotation, will be 6-10 years and should be fixed to yield material convenient for manual handling and conversion, typically stems 7-8 m tall and 10 cm in diameter. Production of suitable poles will be achieved a year or two earlier if the number of shoots on each stool is reduced to about five in the second year after cutting. This concentrates growth on a small number of shoots. Regular coppicing in this way can be carried on indefinitely and yield per unit area maintained provided any dead stumps are replaced by new plants or by layering.

Energy crops

In many countries trials are under way to assess the potential of tree crops as a large renewable energy source. The need for fully mechanized harvesting, producing woodchips, repeated cuttings and obtaining maximum yields using all the above ground woody material has led to research into measuring productivities of vigorously coppicing broadleaves, planted at close spacing (0.3-1.5 m) to give stockings of 4,000-100,000 stems per hectare, cut on cycles of 1-5 years. Several trials have been established in Britain and include alders, birches, eucalypts, poplars (Figure 14), Southern beech and willow.

On fertile sites dry weight yields from such energy crops achieve about 10 tonnes per ha per year five years after planting and may reach 11 - 15 tonnes per ha per year on a 3-4 year coppice cycle (Cannell, 1982). However, even if one million hectares of such crops were established only 3 per cent of Britain's energy needs would be met and, moreover, fertile land in the lowlands is needed to achieve the yields postulated. As well as energy from the wood it has been suggested that the foliage could be used for fodder.

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GLOSSARY

Botanical names of trees mentioned in the text by their common names

Alder	*Alnus glutinosa*	Oak	*Quercus* spp.
Ash	*Fraxinus excelsior*	Poplars	*Populus* spp.
Beech	*Fagus sylvatica*	Sweet chestnut	*Castanea sativa*
Birch	*Betula pendula, Betula pubescens*	Southern beech	*Nothofagus procera, Nothofagus obliqua*
Eucalypts	*Eucalyptus* spp.	Sycamore	*Acer pseudoplatanus*
Hazel	*Corylus avellana*	Willow	*Salix alba, Salix fragilis*
Hornbeam	*Carpinus betulus*	Monkey puzzle	*Araucaria araucana*
Lime	*Tilia cordata*	Coast redwood	*Sequoia sempervirens*

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