# Establishment and Management of Broadleaved Coppice Plantations for energy

## SUMMARY

**This Practice Note reviews existing knowledge and gives outline guidance on site selection and preparation, plantation design, planting, weed control, crop management, pest management and yield for coppice plantations of a range of broadleaved species that may be grown alongside short rotation coppice (SRC) of willow and poplar. Growers seeking information on growing and management of SRC should refer to Forestry Commission Practice Note 7 and other sources of information such as the Biomass Energy Centre. Details of the Energy Crop Scheme are available at www.naturalengland.org.uk/ourwork/farming/funding/ecs/**

## INTRODUCTION

This guidance has been provided by the Forestry Commission for farmers and growers who are interested in growing a range of broadleaved species as energy crops managed on a 12-15 year cycle. The aim is to provide information on potential species, choice of site, choice of planting material, site preparation, planting and subsequent maintenance, and indicative yields and other aspects of the cropping cycle. It is **not** intended as a guide for the management of plantations of fast growing willows and poplars used for short rotation coppice (SRC) for which comprehensive guidance can be found in Forestry Commission Practice Guide 7 (Tubby and Armstrong, 2002) and on the website of the Biomass Energy Centre (www.biomassenergycentre.org.uk).

### Why grow energy crops?

Concern about climate change and increasing fossil fuel prices have led to a rapidly developing interest in and markets for alternative and renewable energy sources, and particularly for those that can be sourced from within the UK. As substitutes for fossil fuels, woody biomass crops have the potential to reduce the carbon dioxide emissions that contribute to climate change as outlined in the recent UK Biomass Strategy (Defra, 2007). Climate change mitigation and adaptation are key political drivers at the present time, especially since the Stern Report commissioned by the UK Government.

Energy crops can make a contribution to emission reduction, because they recycle atmospheric CO2, whilst the use of fossil fuels releases carbon into the atmosphere that would otherwise be stored. Therefore, there is a growing opportunity for a domestic industry based on energy crops through emerging markets for mitigating CO2 emissions. These markets are developing rapidly so it would be advisable to seek specialist advice about the wider implications. Potential sources of information include the Biomass Energy Centre and the National Non-Food Crops Centre (www.nnfcc.co.uk).

Energy crops grown in the sustainable way outlined by Tubby and Armstrong (2002) provide a renewable source of energy and the harvested biomass can be used as fuel in powers stations or in heating systems to supply heat and power separately or in combined systems. Woody biomass can be produced in a range of batch sizes and over differing time scales, which provides considerable flexibility to fit the production of energy crops with the demands of other farming activities. In addition, energy crops require a reduced chemical input when compared to conventional arable husbandry, and so can provide a less intensive use of agricultural land and enhance the local environment through increased biodiversity.

### Why grow broadleaved coppice instead of SRC for energy?

Before the Industrial Revolution, and the consequent use of coal, gas, oil and electricity for heating and power, wood based fuel was the main way in which our forbears heated their dwellings and cooked their food. The decline in the use of such fuels over the last two hundred years is, at least in part, a reflection of the declining forest area of the British Isles and the availability of cheap alternative fuels and timber supplied from abroad. By contrast, the use of wood for energy has been maintained in many countries of central and northern Europe where wood using industries have been a more consistent component of the rural economy. Thus, investing in broadleaved energy crops can be seen as a return to more traditional and sustainable forms of land use. General background to the management of traditional coppice woodlands can be found in Harmer and Howe (2003).

That said, the productivity of the other broadleaved species considered in this guidance will be appreciably less than can be obtained with the willow and poplar cultivars now widely used for SRC. Therefore their planting is likely to often be as part of a wider SRC scheme where these species can be used to provide habitat continuity, possibly by linking other areas of woodland to create a network in the wider landscape. They may also be used if some of the area identified for SRC has pockets of poorer soils or corners that are awkward for machine working. Lastly, some people may wish to create new areas of broadleaved coppice woodland to provide sources of wood fuel for a rural enterprise, possibly as small logs to be used in modern efficient woodburning stoves.

## THE SPECIES

A number of broadleaved species are covered by this guidance, namely:

- Common or black alder (*Alnus glutinosa*)
- Silver birch (*Betula pendula*)
- Hazel (*Corylus avellana*)
- Ash (*Fraxinus excelsior*)
- Small-leaved lime (*Tilia cordata*)
- Sweet chestnut (*Castanea sativa*)
- Sycamore (*Acer pseudoplatanus*)

All are native species to Britain except for sweet chestnut which was introduced in the Roman era and sycamore which was introduced in the Middle Ages. These species provide the framework for most of the broadleaved woodlands that were the natural cover of much of lowland Britain (Rackham, 1990). Because these trees are mostly native to Britain, they provide a natural habitat for many species of wildlife including some that are suffering because of intensification of land use over the last 50 years. Some general notes on these species are given in the Appendix.

A point to note is that all the species listed above are normally grown from seed and there is a much wider genetic variation contained within the planting material than in the clonal varieties of willow and poplar which are the basis of SRC. Furthermore, at the present time, there is no genetically improved material available for any of these species so that plantings are, in some sense, recreating wild populations of trees. Also, that it is often recommended to use trees that are grown from seed obtained from sources close to the locality which should be adapted to the local climate (Herbert *et al*., 1999).

### Soil conditions

A study of the Appendix will show that most of these species will grow reasonably on a wide range of soils although very wet or very dry soils are best avoided. Soil pH should normally fall between 5 and 7.5 although some species (see Appendix) may be suitable for more acid or alkaline soils. Because of this a number of options are available to the owner which can include the possibility of planting species in mixture, particularly where biodiversity and factors other than the volume of produce are important. Before any pans are made or operations undertaken, the potential site for planting and soil pits dug at intervals to check for any changes in soil type or potential areas of compaction or poor drainage. An ultimate aim is that all soils should be well cultivated to give a rootable depth of 30 cm or more. Steep slopes will hinder harvesting and extraction of produce.

When planted as energy crops, these species will take up nitrogen and so can be used to tackle nitrate pollution in Nitrate Sensitive Areas or Nitrate Vulnerable Zones. Based on evidence from SRC crops (Tubby and Armstrong, 2002) , nitrate and pesticide levels in groundwater beneath broadleaved coppices should generally be much lower than beneath fertilised grassland or arable land due to nutrient uptake by the trees and reduced chemical inputs. They can also be planted along lower field margins and riparian zones to act as a buffer for retaining diffuse pollutants draining from adjacent agricultural land.

### Landscape

It is important to bear in mind that at the end of a 12 to 15 year cutting cycle a broadleaved energy plantation may be up 8 to 10 m in height. It is therefore important to consider the impact this will have on the landscape, not only as it is growing but when it is felled. Therefore forest design principles should be considered at the early planning stages as these may influence the size of the area to be planted, particularly in relation to adjoining areas of woodland and/or SRC. The layout must conform to the UK Forestry Standard and useful advice can be found in:
www.forestry.gov.uk/website/publications.nsf/WebPubsByISBN/0382F67DB8C1F12180256F9E00597C34

### Archaeology

The planting of broadleaved energy crops should also conform to the UK Forestry Standard where heritage features and the protection of archaeological sites are concerned. Ploughing, sub-soiling and tree root growth can damage archaeological sites and deposits. Guidance can be found in the *Forests and archaeology guidelines*

(Forestry Commission, 1995) and at www.helm.org.uk/upload/pdf/Biomass-Energy.pdf

### Biodiversity

The habitat created by broadleaved energy plantation is different to that within conventional agricultural crops. All these species support a large number of insects, most of which cause little damage to the crop, and whose presence attracts songbirds and other forms of wildlife. Shade tolerant plants may become established under the crop canopy while headlands and access rides can provide a 'woodland edge'-type habitat where flowering plants may thrive. Before applying pesticides to the crop their possible impact on this biodiversity should be carefully considered. Pesticides should not be used as a matter of course and the precautionary approach outlined in Willoughby et al. (2004a) should be followed.

## Site preparation

A high standard of site preparation is essential to obtain quick establishment, to maximise yields and to produce a uniform crop. Operations should only be carried out when the soil is dry enough to allow machinery onto the ground without compacting the site. However, the intensive complete cultivation required for establishment of SRC may not be essential when planting broadleaved energy crops. This is because the normal practice will be to plant rooted seedlings which are slightly more tolerant of weed competition than the unrooted cuttings used in SRC. The decision about the type and intensity of cultivation may depend upon the scale and objective of the planting. For instance, if undertaken as a small component of a bigger SRC scheme, then the prescriptions for SRC site preparation given in Tubby and Armstrong (2002) should be followed. However, if this is a broadleaved energy crop planting undertaken in its own right, then the guidance given by Willoughby and Moffat (1996) should be considered.

### Subsoiling

Ex-arable sites may have a plough pan, or soil compaction problems, that could restrict root development. This type of problem should be picked up in the preliminary site survey discussed above. Any compaction should be relieved by subsoiling, carried out preferably in summer using a subsoiler with winged tines when the soil is dry enough to maximise shattering and minimise soil damage.

### Subsequent cultivation

If being treated as for a SRC crop, the site should be ploughed in the late autumn or early winter to 30 cm and left to over-winter in this state to allow frost to break the soil down further. A fine tilth will ease planting, to aid the development of a healthy root system and improve the effectiveness of residual herbicides. To achieve this it is recommended that a power harrow is used immediately before planting. Power harrowing is preferred to rotovating as it keeps moisture, which has accumulated over winter, in the rooting zone whereas rotovation tends to bring moisture from the main rooting zone to the surface, replacing it with dry surface soil.

If the site is being treated as for a new woodland then the guidance and flow charts provided by Willoughby and Moffat (1996) should be followed. In particular, the potential weed competition on the site should be considered and an effective regime of cultivation and weed control be developed before any operations are undertaken.

Often, leaving arable stubble in situ can help reduce weed competition following planting and ease establishment.

### Protection from mammals

All these broadleaved species are palatable to a range of mammals. Rabbits and hares, in particular, can cause serious damage for two to three years after planting while deer can cause serious damage to coppice stools. Voles can girdle young stems but are usually only a problem if the site is weedy and offers them suitable cover.

Protection against rabbits and deer can be provided by wire mesh fencing suitably dug in to deter rabbits from burrowing underneath (Trout and Pepper, 2006). This is an expensive operation and the fence will need regular inspection to maintain its integrity. Temporary, reusable fencing, made of lightweight wire or high tensile plastic shows great promise for coppice protection with potential savings compared with the cost of more traditional post and wire fences. Electric fencing can be installed but this also needs regular inspection to ensure that weeds do not short it out. It should only be considered as a temporary measure.

If only a small area of broadleaved energy plantation is being established, then it may be more cost effective to consider the use of tree shelters for protection against mammals. A wide range of shelter designs are now available on the market, but the general principles for deciding whether to use fencing or tree shelters follow guidance given by Hodge and Pepper (1998).

Mature trees of all these species can be attacked by grey squirrels and this could be a problem if trees are gown on longer rotations of 10-15 years. Damage risk will be dependent on the proximity of other woodland suitable for holding resident grey squirrel populations. Guidance on grey squirrel control can be found in Mayle et al. (2007).

# ESTABLISHMENT

## Plantation design, spacing and mixtures

Before planting, it is important to plan for future harvesting and extraction and to ensure that the layout will not compromise the efficiency of future operations.  A central access ride of 4-5 m width should be laid out through any planed area larger than one hectare and narrower racks could be located at 40-50 m intervals through the remainder of the site. The recommended planting density for establishing new broadleaved coppice woodland is at around 2500 stems $ha^{-1}$ which is equivalent to about 2 by 2 m spacing (Harmer and Howe, 2003). This is closer than the spacings currently used for establishing many broadleaved amenity plantings, but is justified by the need to obtain rapid site capture if a reasonable productivity is to be obtained from a broadleaved energy plantation. There may be benefits from using a closer spacing within the row and wider spacing between them, since this will aid machine access for weed control in the years following planting.  Thus one spacing that has been used in conventional forestry plantings for this purpose is 2.5 m between rows with trees planted at 1.5 m within the rows. At the present time, there is little evidence to suggest that there are benefits to reducing the spacing further to achieve densities higher than 2500 stems $ha^{-1}$ .

If the broadleaved planting is taking place as a component of a larger SRC scheme, then it is important to make the broadleaved planting large enough to withstand any competition and shading effects caused by the faster growing SRC crops. Although there are no experimental trials to demonstrate this type of interaction, first principles suggest that the broadleaved areas need to be a minimum of 0.25 ha to be resilient to the impact of the adjoining SRC crop and preferably appreciably larger, perhaps 1 to 2 ha in size.

Depending upon the objectives of the broadleaved planting, there may be some desire to grow a number of species in mixture. If the aim is to create a traditional broadleaved coppice, then advice on types of mixture can be found in Rodwell and Patterson (1994) and in Harmer and Howe (2003). However, if the focus is on growing broadleaved species for energy, then it is best to concentrate on one or at most two species for ease of management and planting pattern. The main reason for planting a mixture may be if there is evidence of some lack in soil fertility in which case alder can be planted in a 25:75 or 50:50 mixture with the other main species. The pattern of mixture can be in rows or in alternate pairs or triplets within a row, the latter being preferable if the site is visible in the landscape.

## Plant material; supply and handling

The best place to obtain plants of the chosen species is from a nursery specialising in the production of forest plants. There are a number of these sited in most parts of the country and names can be obtained from your local Forestry Commission office or from one of the two relevant trade associations, the Horticultural Trades Association (www.the-hta.org.uk) or the Confederation of Forest Industries (www.confor.org.uk). Nurseries produce their catalogues of available planting stock during August and are generally ready to supply plants from late October/November until the following spring. It is important to place an order in the autumn if you wish to secure supplies of your preferred material even if you are not going to be planting for several months.

The usual time to plant broadleaved seedlings is between mid-November and mid-March, once the trees have set a resting bud for the winter. There are differences of opinion as to whether to plant in early or late winter, and much will depend on the local site and microclimate. Thus in an area prone to dry springs, it is often better to plant before Christmas, whereas in another location prone to frozen ground in January, it is better to wait until late February or March.

There are two main types of planting stock available in Britain, namely bare-root plants and containerised seedlings. The former are raised for two to three years in open beds before being lifted, the soil removed (hence 'bare-rooted') and dispatched to the planting site. The latter are similar to the type of horticultural plants purchased in garden centres, but are grown in smaller containers usually 100 -200 cc in capacity and are generally produced on a 12-18 month cycle. The fact that the latter are grown in a peat or bark based substrate means that they are delivered to the site with the roots contained in a 'plug' of the planting medium which can offer some protection against root damage, often the most serious cause of planting failure. Most forest nurseries specialise in one of these two methods of production; prices for containerised plants tend be about 10 per cent higher than those for bare root plants.

Nursery catalogues will class plants in size bands based on height, with 20-40 cm, 40-60 cm, 60-90 cm, and 90-120 cm being common categories. Bare-root stock categories often have supplementary comments based on their growing regime, thus a 1+1 plant will be two years old having spent one year as a seedling and one year in the transplant lines. Further details should be found in the catalogues, which also often list the seed sources from which the plants have been grown. If this information is not shown on the catalogue, then the nursery should be asked to confirm this before the plants are ordered.

The older and larger plants tend to cost more, but for most planting schemes the best option will be purchase plants that are between 20 and 60 cm tall, since these should have a good shoot:root balance which is often the critical factor for ensuring good survival and rapid growth after planting. The roots are the key to establishment since the first thing a newly planted young tree has to do is to take up water from the soil to supply physiological processes in the shoots and for this to occur new roots have to develop and make contact with the soil. Therefore, it follows that careful handling and storage of plants between nursery and planting site is very important and every care has to be taken that the roots do not get damaged and/or dry out in transit. When the plants are delivered from the nursery, they should be checked carefully for any sign of damage such as broken shoots or roots, poor quality root systems, and evidence of pests. Any concerns should be notified immediately to the nursery. If plants are delivered at a time when the ground conditions are unsuitable for planting (e.g. ground frozen), then the plants should be stored carefully away from direct sunlight and heat. Possible options can include a trench dug in a sheltered spot into which the trees are placed and the trench backfilled with moist soil or peat. Alternatively the plants can be stored in sealed coextruded polythene bags provided these are kept in the shade. For further details of factors that can affect plant supply and establishment success see Morgan (1999).

## Planting

As discussed above, planting may take place either in early or late winter depending upon site, local climate, and the ability of the supplying nursery to deliver against a particular schedule. Planting of bare-rooted plants is invariably undertaken using a spade whereby a ‘L’ or ‘H’ shaped notch is cut into the soil with the blade of the spade, the roots of the plants inserted into the space opened up and the soil firmed round the roots with the side of the spade and consolidated with the foot. The depth of planting should be such that the soil just covers the mark of the root collar that was visible from the nursery cultivation. Shallow planting runs the risk of exposing roots to drying out and over deep planting can bury the growing shoots. Containerised plants can be planted in a similar way or some people prefer the use of a specialist tube originally designed in Scandinavia with foot operated ‘jaws’ that first open and then close a planting slot after a plant has been ‘dropped’ down the tube into the slot.

## Replacing failures

However good the plant quality, site preparation, the planting and post planting care, it is likely that a number of trees will fail during the first growing season. In August following planting, the site should be carefully walked and note taken of the number of trees that have died. If the number is close to or exceeds 10 per cent, then replacement s should be ordered for replanting (aka 'beating-up') the following spring. If a mix of species was planted and one has shown particularly poor survival, then it may be better to avoid that particular species and replace it by another that has proved more successful. Further beating-up can take place in the second spring after planting, but it is generally not worth replacing failures after that year because the older trees will be well established and will out compete any new plants.

### Seeding

Although this guidance assumes that most broadleaved energy crops will be established by planting, the reader should be aware of the option of creating a coppice plantation through direct seeding. The methods that can be used are described by Willoughby et al. (2004b) and have been shown to give good results in experiments and in a few operational trials. There are risks associated with unfavourable germination conditions, poor quality seed, and predation by mice and voles, but provided these can be minimised the result can be the more rapid creation of a natural, mixed plantation of a range of species, obtained at a somewhat lower cost and with lower inputs of herbicides. However, the pattern of seedling distribution can be variable and possibly less amenable to systematic management for wood fuel, especially in the period leading up to the first coppice cut.

## PROTECTION

### Weed control

It is impossible to overemphasise the importance of establishing young trees in conditions free from weed competition. This is particularly important in the south and east of the country where weeds will compete for moisture during the summer months and thus limit the resources available to newly planted trees. It is not necessary to maintain the site as weed free as is required for SRC (Tubby and Armstrong, 2002) but the aim should be to maintain as, a minimum, a 1.2 m diameter circular area rounded the newly planted trees weed free for up to 3 years following planting. With new planting, particularly if mechanised spraying is contemplated, it will often be more practical to maintain a 1.2m wide weed free band along the line of the planted trees.

The untreated area between the weeded spots or bands can rapidly be invaded with noxious weeds such as ragwort and thistle, which can be costly to manage. To minimise future problems, the areas between the rows should be sown with a low productivity dwarf rye grass sward before planting. Often it is most practical to sow the entire site with a grass sward before planting, then spray out planting lines with a broad spectrum product in the spring. An alternative, if the soil does not require cultivation to relieve compaction, is to leave arable stubble undisturbed – see Willoughby and Moffat (1996) for detailed guidance on the different options available. If the broadleaved coppice is to be managed on a high input regime to maximise productivity (as for SRC), then the best policy is to aim to keep 100% of the site weed free until canopy closure.

Non chemical methods of weed control should be the preferred option, if practical. Willoughby et al (2004a) give details of the possible alternatives, but the use of sheet mulch materials is likely to be the most cost effective option.

Currently, on anything other than a small scale, the use of herbicides is likely to be by far the cheapest method of weed control. The choice of suitable products for maintaining the weed free areas will depend on the range of weed species anticipated and reference to Forestry Commission Field Book 14, *Herbicides for farm woodlands and short rotation coppice* (Willoughby and Clay, 1996) is recommended. A greater range of products is available for SRC than for conventional forestry.

Weed control can be divided into three phases: before cultivation, shortly after planting and after cut back or harvesting. All perennial weeds should be sprayed with a broad spectrum contact herbicide such as glyphosate before any cultivation takes place. If a grass sward is established, planting lines should be sprayed out with a broad spectrum herbicide in the autumn before planting. Once the crop has been planted, a sheet mulch should be applied, which should last for up to 3 years by which time trees will usually be well established. Alternatively, if plant protection products are used are used, residual soil acting herbicides should be applied to control germinating weeds. Given good post-planting weed control, crops should remain clear for most of the growing season, but on the most fertile sites further targeted applications of broad spectrum products may be necessary to control emerging weeds. If trees are planted in tree shelters, weed control is far simpler. Competing vegetation can be controlled through repeated applications of broad spectrum products such as glyphosate, with little risk of damage to trees. Bear in mind however that on the most fertile sites, without the use of residual herbicides, broad spectrum products may need to be applied on several occasions throughout the growing season. Willoughby and Clay (1996) list products that are safe to use around trees for use on a given weed population but herbicide availability has altered with new legislation and it is important to check the current arrangements covering the use of particular products. Once the trees have reached 75-100 cm in height, their growth and developing canopy should shade out most weed competition. Weeding after harvesting is unlikely to be major problem unless the coppice regrowth is poor.

## Pests and diseases

The broadleaved species being considered in this guide can be attacked by a range of insect pests and fungal pathogens, but in general and provided the chosen species are suited to the site, the effect of such attacks should not be such as to imperil the survival of the coppice plantation. This is a major difference from SRC crops where the clonal basis of the varieties being grown can make the crops more vulnerable to pathogens (Tubby and Armstrong, 2002). A number of publications describing pests and diseases of broadleaved trees are downloadable from the Forestry Commission website (www.forestry.gov.uk) and Forest Research provide 'Tree Doctor' (www.forestry.gov.uk/fr/INFD-5V7HC), an interactive PC based program to help growers identify common pests and diseases of trees.

# SUBSEQUENT MANAGEMENT

## Cut back

Once the newly planted trees are established, it should be possible to cut them back to initiate coppice regrowth and to produce multiple stems. This should not happen until the planted trees are 1-2 m tall and growing vigorously since earlier cutting could result in renewed weed growth. This probably will not happen for 4-5 years after planting depending upon species and the fertility of the site. If the broadleaved coppice is being grown as part of a SRC enterprise, then it may make sense to link the timing of the first cut to the harvesting cycle of the SRC crops. Cutting back should take place in the winter and the cut should have a sloping face to encourage the shedding of water and, if possible, be south facing to encourage drying (Harmer and Howe, 2003). Hand tools were traditionally used to make this cut, but trials have shown no difference between such tools and chain saws in terms of the quality of the coppice regrowth: it is the cleanness of the cut which seems to be the critical factor.

## Cutting cycle

Once the initial cut has been made, further cuts can be made on a 10-15 year cycle, again depending upon the rate of growth and the type and size of products that are sought. A longer cycle will be appropriate where it is hoped to produce fire logs for own use or for sale, while a shorter cycle may be better if a wood chip product is envisaged. The coppice is always harvested after leaf-fall and before bud burst.

## Fertiliser requirements

The production of inorganic fertilisers relies heavily on the use of fossil fuels. When these products are used on broadleaved coppice plantations the carbon and energy budgets of the crop are altered. Each application of inorganic fertiliser in effect increases both the amount of energy consumed by the trees system and the amount of $CO_2$ and other pollutants emitted. Furthermore, the application of inorganic fertiliser is an additional cost for the grower to bear. Given the comparatively slow growth rates of these crops compared to SRC, it is very unlikely that use of fertilisers will result in sufficient increase in yield to offset the energy used and costs incurred. If nutrient deficiencies are thought to be a potential problem, then the most effective option will be to mix a percentage of one or more alder species into the planting to improve the overall nutrient status of the site – see the section on ‘plantation design, spacing and mixtures’ above. As the trees are harvested after leaf fall, nutrients contained in the foliage are recycled back into the soil. Only nutrients in the harvested stems are removed from the site. Leaf litter turn over and atmospheric nitrogen inputs will compensate for a large amount of the nutrients removed and the relatively slow growth rates mean that issues of nutrient depletion in SRC discussed by Tubby and Armstrong (2002) are very unlikely to occur.

An alternative to inorganic fertiliser in SRC crops is the use of sewage sludge or livestock slurry. There is no reported experience of applying such materials to slow growing broadleaved coppices other than on brownfield sites with soils being restored after mineral extraction or similar practices. If such materials have been used successfully on adjoining SRC crops, then there may be a case for cautious trials on broadleaved coppices, but the growth response is unlikely to be dramatic.

## YIELDS

Appendix 1 lists the outline yields that may be expected from the broadleaved species that have been considered in this note. The range of estimated yields is from 1 to 6 odt $ha^{-1}$ $yr^{-1}$ ,although these figures are derived from a very limited database and often from old trials in broadleaved woodlands that were not fully stocked or intensively managed. They are also based on somewhat longer coppice rotations than are considered in this guide. In general terms, and given current knowledge, it seems reasonable to assume that the broadleaved species considered here will produce at best half and, more likely, one-third to a quarter of the yields that might be expected from a SRC crop of poplar or willow grown on the same site.

## USEFUL ADDRESSES

Short rotation coppice plantations may be eligible for grant aid under the Energy Crops Scheme (ECS). Full details and application forms are available on the Natural England Website:
www.naturalengland.org.uk/ourwork/farming/funding/ecs/
Or by post, phone or fax from:
Natural England, Yorks and Humber,
Units 2 and 3, Northallerton Business Park, Standard Way,
Northallerton, North Yorkshire, DL6 2XQ.
Tel: 01609 767400. Fax: 1609 767451

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Appendix 1 – Outline information on the broadleaved species that might be grown as energy crops along with SRC. See footnotes for further detail.

| **Notes on a range of broadleaved species that might be grown as energy crops** | | | |
|---|---|---|---|
| **Species** | **Characteristics** | **Soil preference** | **Estimated yields ($ODT\ ha^{-1}\ yr^{-1}$)** |
| Common alder | Found widely on stream sides and on poorly drained areas. A tree that can grow up to 30 m tall but coppices well and grows rapidly when it is young. Can fix nitrogen through association with the micro-organism *Frankia* which forms nodules on the root systems. This means that the species is often used on degraded or impoverished soils to improve fertility. | Tolerant of wide range of soils, preferably moist ones with a pH of more than 6. It should not be used on acid peats or badly aerated soils.<br>If this species (also other alders – see footnote 3) is being planted to improve soil fertility, then planting stock should be carefully inspected to ensure that the roots show good nodule development. | 3-5 |
| Silver birch | A rapidly growing pioneer species which can grow into a tree 25 m or more tall. It is a less reliable coppicing species than most of the others listed in this table. If it is grown for coppice, it is important that the stools are cut close to the ground. Coppice stools tend to be relatively short-lived. | Well suited to more acid soils that are often dry and sandy. On wetter soils, the closely related downy birch (*Betula pubescens*) may be more suitable, but this tends to be slower growing than silver birch. | 2-4 |
| Hazel | Normally found as a shrub species in the understorey of native broadleaved woodland. | A wide range of fertile soils, but best where there is some moisture e.g. clay-loams. Not as | 1-2 |

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| | Coppices reliably and stools can survive for several centuries. Tends to produce a number of small diameter stems which may not be easy to harvest. | productive on acid and dry soils. | |
| Ash | A fast growing tree which can exceed 35 m in height. Coppices well and the stools are often long lived. The whitewood produced is a favoured firewood, in part because of the relatively low levels of moisture in fresh felled wood. | A species that is site demanding, growing best on moist deep fertile loams, and some lime in the soils. Does not grow well on drier soils. | 3-6 |
| Small-leaved lime | A tree that can grow to over 25 m tall. Coppices well and the stool can persist for many years. It was never a favoured coppice species, in part because of the poor quality of the firewood. | Suited to most fertile soils from sandy loams through to clay loams, but is not suited to very moist or shallow, dry soils. | 2-4 |
| Sweet chestnut | A tree that grows to 30 or more metres tall. An excellent coppicing species which is found particularly in south-eastern Britain. Smaller sizes of timber can also be used to make cleft chestnut paling. | Prefers deep acid sandy loams with good drainage, and is not suited to poorly drained or calcareous soils. | 3-6 |
| Sycamore | A tall tree reaching over 35 m tall on suitable sites. Coppices well but stools are often quite short lived. Should not | Suited to a wide range of fertile and deep soils, but growth is poorer on acid or poorly drained soils. Tolerates exposure | 3-6 |

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| | be planted close to native broadleaved woodland of high conservation value in case the regeneration colonises the understorey. Often damaged by grey squirrels. | better than any of the other species on this list. | |

## FOOTNOTES.

1. This guidance is a distillation of more detailed information that can be found in a number of texts. For more specific guidance consult, amongst others, Harmer and Howe (2003), Savill (1991), Rodwell and Patterson (1994) and the interactive information available provided through the Ecological Site Classification Decision Support Systems (www.forestry.gov.uk/fr/infd-5v8jdg) – see also Pyatt et al. (2001).
2. The estimates of yields are based on experience gained from discussions with practitioners and other reports in the literature, but readers should be aware that there is a lack of comprehensive experimental trials with growing these species on coppice regimes and so these estimates should be treated with caution.
3. If the soil is impoverished, and the use of alder species is desirable to improve growth, then there are three other non-native alder species which could be considered, namely grey alder (*Alnus incana*), Italian alder (*Alnus cordata*) and red alder (*Alnus rubra*), all of which have been widely used on reclamation schemes. These have similar or slightly greater productivity than common alder. Grey alder and Italian alder are better suited to drier soils and Italian alder will also tolerate calcareous soils: red alder performs best on alluvial or moist clay-loams.