

# Growing Our Own Wood Fuel

## Warwickshire County Council

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## Executive Summary

### Objectives

The primary objective of this report is to identify how Warwickshire County Council (WCC) can provide and grow its own secure wood fuel supply for its current and potential future biomass boiler installations with the added possibility of fuel sales into the wider biomass end-use markets. It is expected that demand for wood fuel in the UK will exceed supply in the short to medium term and this will lead to an increase in the price of wood chip and wood pellets both fuel types expected to be used by WCC.

WCC intends to utilise its own biomass fuel supply from its current woodland estate but as this may be limited and if further biomass boilers are to be installed, WCC will need to understand the issues associated with the development and use of biomass fuel crops including appropriate land use, crop agronomy, economics and the logistics of wood fuel supply. This report aims to provide up-to-date information on all these aspects as well as determining capital and revenue budgets necessary for a range of biomass wood fuel crops, cost comparators for fossil fuels and woody biomass and the availability of grants to support the work.

### Introduction

In order to reduce carbon emissions and to increase energy security as fossil fuels become scarcer and potentially more expensive, WCC is currently building a case for a programme of investment in biomass boilers. WCC's draft Carbon Management Action Plan includes a presently unfunded proposal for the installation of 25 biomass boilers by 2015. If and when these boilers are installed it is hoped that the biomass wood fuel supply will be sourced entirely from WCC's own estate therefore, if this is to be the case WCC now needs to assess the extent of its potential involvement with the establishment, management, harvesting and delivery logistics of this fuel supply.

Warwickshire is currently one of the least wooded counties in England with woodland cover estimated at just 10% of which 4% is ancient woodland. An ongoing assessment<sup>1</sup> has been made separately of the quantities of wood fuel that could currently be harvested from WCC's own estate and this has provided a small baseline of fuel that may be harvested sustainably beyond which supply from future energy crops and/or third party suppliers may be required. Beyond this in-situ woodland, sustainable biomass wood fuel supply can be developed for the future by the establishment of short rotation forestry (SRF), short rotation energy forestry

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<sup>1</sup> **Rural Communities, Environment & Economy, 2009.** Sourcing of wood fuel from Warwickshire County Council's estate.

(SREF) and short rotation coppice (SRC). Each of these biomass fuel crops will be discussed in this report.

WCC has already identified a number of advantages in using wood fuel from its current woodland estate including fuel cost savings, improved woodland management leading in turn to increased biodiversity. Establishing biomass fuel crops will provide the following additional advantages:

- Provision of a sustainable, renewable, long-term and virtually carbon neutral secure fuel supply.
- Improved landscape and biodiversity benefits.
- Potential for the sale of fuel supply at profit.
- Potential for developing pellet production facilities for own-use and possible sale to domestic customers.

## Work summary

The work carried out includes the following:

- Provision of basic details related to the agronomy, suitability and economics of biomass fuel crops including SRF, SREF and SRC.
- A short list of potential WCC sites suitable for SRC production identified by site visits and their potential yields achievable using Defra's online "opportunities maps".
- Provision of a résumé of the relevant grants available.
- A comparison of the production costs of biomass fuel crops with "conventional" arable crops and grassland.
- An indication of when energy crops will be required to augment WCC's future biomass fuel supply.
- Development of three heat load scenarios using data on WCC's existing and potential boiler installations in conjunction with published data on fuel usage and estimates of land area requirements developed by the Biomass Energy Centre (BEC).
- Creation of an interactive spreadsheet comparing present fuels costs (p/kWh) of gas, oil, LPG and wood chip. The spreadsheet shows how the price of wood chip (at 30%, 40% and 50% moisture content) will need to change in order to achieve savings compared to the current price of mains gas at all price points between 1p and 10p per kWh.
- Different models have been provided for the implementation of fuel supply.

## Conclusions

- There is potential for woodchip from SRC and trees grown on land owned by Warwickshire County Council to provide an economically viable source of fuel to any biomass boilers deployed.
- Of the 16 WCC's tenanted smallholdings briefly visited for this project, six would be suitable for the production of SRC, with approximately 230 to 260ha in total area allowing for unplanted land for headlands, rides, protection of views, etc. Individual, detailed site assessments would be required prior to decisions being made on actual use. A further eight sites, although slightly less suitable due to the number of neighbouring properties, number of sloping fields, etc, could also be planted providing a further 320 to 350ha.
- The tenant farmers who passed comment on growing SRC for WCC did say that the price paid for the harvested crop would have to match or be more than the prices paid for their livestock or arable cropping.
- Poplar, often cited as an SRC energy crop, should only be grown as SREF due to the difficulties associated with its establishment and use as coppice.
- The most cost-effective means for WCC to grow SRC would be for specialist contractors to supply, plant and harvest the willow. Either WCC tenant farmers or local agricultural contractors could carry out the standard agricultural operations.
- If grown by WCC tenant or grown by the council itself, SRC has the potential to compete with and compliment woodfuel from forestry and arboricultural arisings and help provide a stable and sustainable fuel source for council owned boilers.

## Recommendations

- If WCC make the decision to grow SRC (or SREF) then it is strongly advised that the Establishment Grant applications are submitted as early as possible to Natural England during the year prior to planting. The application process will take at least three months and no land work should be carried out prior to grant approval. Land preparation should ideally begin in the summer/autumn of the year before planting which means applications should be submitted, at the latest, in May or June of that year. Submitting an application does not commit the applicant to growing the crop.
- Before WCC contacts their tenant farmers to discuss the option of growing SRC or that WCC wishes to use the land for SRC, WCC will need the answer to the farmer's question "What will I be paid?" either for growing and supplying the SRC or for land rental.
- WCC will need to draw up an appropriate, ideally short and straightforward, grower contract for their tenant farmers if the tenants are to grow the crop on behalf of WCC. This contract will be needed by the tenants if they are to be eligible to apply for the Establishment Grant.
- Ideally contracts will need to provide growers with an annual income, not just a payment at harvest. This will help 'sell' the concept of the crop and will help minimise cash flow problems often associated perennial crops.
- WCC should have a number of staff who understand the requirements of the Establishment Grant, how SRC fits into the landscape, crop agronomy, pests and disease, the use of contractors plus harvesting logistics and how to efficiently store the harvested material.
- Site feasibility studies should be carried out to establish site suitability, likely boiler size requirements and fuel storage arrangements at the most promising school sites should be carried out
- Care should be taken to ensure that boiler installations and fuel supply development are carried out in a coordinated way to ensure sufficient fuel of the correct quality is available as boilers come on line. SRC has a typical lead in period of four years from planting.
- Care must be taken to ensure that existing woodfuel suppliers in the region, some of whom may have received publicly funded grant support, are not disadvantaged by the council developing its own woodfuel supply chain.

## Introduction

Biomass is a form of renewable energy that has great potential to help meet current and future energy demands and, unlike most other renewable sources, it offers potential as a source of both heat and electricity, offering high conversion efficiencies. The purpose of this report is to provide information on the potential for growing specialist biomass fuel crops specifically on Warwickshire County Council's (WCC) own estate. The prospects for local biomass fuel supply along with the economic implications of new biomass crops are assessed. This report should be read in conjunction with that recently completed following the ongoing project assessing the current quantities of wood fuel that can be harvested from WCC's woodland estate<sup>1</sup>.

Energy crops, grown as fuel for the production of heat and/or power offer the opportunity for the full potential of biomass to contribute to meeting renewable energy targets. The two most common energy crops are short rotation willow coppice (SRC) and the grass Miscanthus. The development of energy crops for renewable energy production is a relatively new industry with potential for considerable expansion, offering benefits to growers, developers, consumers, local communities and the environment.

An Establishment Grant is available under the Energy Crops Scheme (ECS) through Natural England which provides 50% funding for all approved costs associated with the establishment of these crops. Grant funding is not available for ongoing crop management, harvesting, storage or delivery of the harvested material. Establishment of short rotation energy forest (SREF), harvested over a longer time scale than SRC, is also covered by this grant.

Unlike SRC which is usually harvested every three years, SREF is harvested between seven and 15 years depending on the rate of growth and the type of end product required e.g. wood chip or logs.

If energy crops are included in the general mix of agricultural crops in a well thought-out and informed way, there could be significant environmental and ecological benefits alongside the development of a fully sustainable energy resource.

## Biomass Fuel Crops

### Short rotation forest (SRF)

During the last few years there has been considerable interest in the potential for using fast growing tree species to produce large volumes of fuel on relatively short rotations of eight to 20 years. Much of this interest has come from industrial power generators keen to source very large volumes of homogeneous fuel for use in co-firing or dedicated biomass fired power stations. Proponents of SRF believe this system is more productive than SRC or Miscanthus and that the wood produced in SRF plantations is easier to handle and process than material from other perennial crops.

Species often associated with SRF include ash, sycamore, birch and alder. However, much of the current commercial interest in this approach focused on more exotic species such as *Eucalyptus nitens*, *E. gunnii*, and Southern beech *Nothofagus spp.* The performance of these species in UK conditions is not fully understood. Coppice trials using Eucalyptus species in the 1980s and 1990s showed that productivity could be high but that frost damage and damage caused by Silver Leaf disease could be severely limiting. Managing these species as single stem trees rather than as coppice could help reduce the incidence of single leaf but the impact of an unseasonal frost on young growth is a risk.

SRF is not a well defined sector at present and many of the practices involved overlap with the cultivation of SRC on one hand and conventional coppice and forestry techniques on the other. In view of Warwickshire Landscape Guidelines, developed to maintain or enhance the defining characteristics of areas within Warwickshire, planting of exotic forest species may not be appropriate at all WCC sites. There is scope within the guidelines for using native species for SRF and traditional woodland creation in some areas, in particular the guidelines characterise Dunsmore as being 'well wooded'. New plantings could help link existing woodlands and could be designed to deliver recreational and educational opportunities as well as fibre and fuel. This position will tend to move SRF more towards the conventional forestry end of the spectrum and require an acceptance of reduced yields. However, in terms of aesthetic and ecological benefit, this approach has a number of positive features. It would blend more effectively with existing forestry management practices and minimise the need for additional training and machinery to manage effectively.

The wider environmental impact of SRF with exotic species is currently unknown although this is now being investigated by a project funded by the Department of Energy and Climate Change and Forestry Commission England and managed by Forest Research.

### Establishment and management

The silviculture and management of SRF in the UK is still under development. It is often associated with the use of biodegradable or photodegradable plastic mulch that is used to

suppress weed competition and encourage rapid root development. A typical establishment regime may be:

- Autumn year 1: spray off weeds with glyphosate.
- Late autumn year 1: use a single tine deep plough to relieve soil with the distance between plough lines generally 2-2.5m.
- Spring year 2: use a tractor-towed rotovator to prepare seed bed 'strips' approximately 1.7m wide and to a depth of 20cm. This may require multiple passes.
- Spring year 2: (optional) lay degradable mulch on the prepared seed bed strips and plant seedlings through the mulch. Planting may be carried out using a machine or manually. Supply and fit vole guards (site dependant).
- Summer year 2: replace dead seedlings and control localised weed growth.
- Depending on species, planting density, growth rates and end market it may be possible to take thinnings from year 4 and again at years 6 and 8. A final harvest may take place between years 8 and 20 depending on management objectives and crop performance.
- After final harvest, depending on species and management objectives, the site could be destumped and replanted or regrowth from the cut stumps could be encouraged and the plantation managed as coppice.

## Harvesting and processing

The most effective methods for harvesting and processing SRF have not yet been identified in the UK. It is likely that specialised forestry harvested designed to take thinnings from conifer plantations could be used in SRF. Once extracted roundwood could be stacked on bearers and air dried to the target moisture content before chipping and hauling. These operations could possibly be carried out by companies operating in the woodfuel sector in the region at present. Other equipment such as feller bunchers using hydraulically powered shears to cut stems could also be used but these are rarely encountered in the UK. Whole tree harvesting with self propelled terrain chippers could be another approach but again, such harvesters are not commonly encountered at this time. It is not possible to give a firm indication of likely harvesting costs. Trials are currently evaluating small scale tractor mounted harvesting heads which could be well suited for harvesting small blocks of SRF.

## Direct seeding

An alternative approach could be to use 'direct seeding'. Instead of planting seedlings to establish new woodlands and plantations this technique relies on the sowing of tree seeds at high densities directly to the new woodland site. This technique can only be used with a limited range of species: oak, sycamore and ash being the most widely tested. Research has shown that compared to traditional forestry establishment practice, which relies on seedling transplants, this method can lead to reduced time to canopy closure and 'site capture', perhaps

taking three to five years instead of five to ten years to achieve. This means that a newly planted site may take on the appearance of woodland more quickly than traditional planting using rows of tree shelters. Ground preparation is similar to that required for arable crops and can be carried out using agricultural equipment. This has the effect of potentially reducing establishment costs compared to traditional silviculture.

On the downside directly sown tree seeds can be very susceptible to predation from mice, voles, squirrels and birds and as a result the technique is best used on open, new woodland sites rather than for restocking existing woodland areas. The technique can also be unreliable, especially on sites with heavy clay soils where seeds may be at risk of rotting or failing to germinate. As a result it is a method that should only be considered on good quality lowland site, perhaps used as improved pasture for arable crop production. Carried out in favourable conditions direct seeding can produce a rapidly established woodland environment able to produce a range of wood products including fuel from thinnings.

## Economics

The economics of establishing and harvesting SRF in Britain are largely unknown. A series of trials is currently being established in England and Scotland to help develop a better understanding of the wider environmental and economic performance of the crop. At the time of writing (April 2010) data from these trials suggests that costs for establishing SRF at a planting density of 4,500 trees per ha are approximately £2540 per hectare. A break down of these costs is shown in Table 1 together with cost for conventional woodland planting operations without and without mounding (mounding is a technique used on wetter sites to help improve drainage and reduce weed competition). Costs for ploughing and cultivation were not available for these sites but as they are standard agricultural operations the relevant costs shown in Table 2 will apply. Where necessary SRF sites were fenced against rabbits at a cost of £4/m (this compares to the figure of £4/m or against deer at £6.5/m).

**Table 1 Costs associated with establishing SRF, conventional woodland and 'directly seeded' woodland<sup>2</sup>**

<b>SRF</b>	<b>£/ha</b>
Pre-plant spraying	10
Planting by machine	490
Plant material	900
Supply and fitment of vole guards	990
Post plant spraying (manual)	150
<b>Total</b>	<b>2540</b>
Conventional woodland creation (machine planting, 2500 trees/ha, excluding fencing)	1100
Conventional woodland creation (using mounding, 2500 trees/ha, excluding fencing and maintenance)	2200
Direct seeding (including cultivation and weed control in first year, excluding fencing and maintenance)	1190

## Short rotation energy forest (SREF)

Under the current ECS a range of additional tree species became eligible for the Establishment Grant alongside willow and poplar SRC. These are:

- Poplar (*Populus nigra*)
- 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*)

<sup>2</sup> SRF data kindly supplied by Alan Harrison, Forestry Commission Scotland  
 Direct seeding information adapted from Willoughby et al (2004)

All are species native to Britain except for sweet chestnut introduced in the Roman era and sycamore 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<sup>3</sup>. Because these trees are mostly native to Britain they provide a natural habitat for many species of wildlife including some that are suffering due to the intensification of land use over the last 50 years.

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 may be suitable for more acid or alkaline soils. Because of this a number of options are available to the grower including the possibility of planting mixed species particularly where biodiversity and factors other than the volume of harvested material are important.

The productivity of these species will be appreciably less than can be obtained from the willow and poplar varieties used for SRC therefore their planting is more often part of a wider SRC scheme where these species can be used to provide habitat continuity, possibly linking 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 but, as with SRC, steep slopes should be avoided as they will hinder harvesting and extraction of the wood.

It is important to bear in mind that at the end of a 12 to 15 year cutting cycle an SREF plantation may be between 8-10m in height so it is essential to consider its impact on the landscape, not only as it is growing but when it is felled. 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.

When planted as energy crops, these tree species will take up nitrogen and can therefore be used to deal with nitrate pollution in Nitrate Sensitive Areas or Nitrate Vulnerable Zones. Based on evidence from SRC crops, nitrate and pesticide levels in groundwater beneath broadleaved coppice should generally be much lower than those beneath fertilised grassland or arable due to nutrient uptake by the trees and reduced chemical inputs<sup>4</sup>. 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.

A high standard of site preparation is essential to ensure 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 SRC establishment may not be essential when planting broadleaved energy crops. This is because the normal practice is to plant rooted

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<sup>3</sup> **Rackham O, 1990.** *Trees and woodlands in the British landscape.* J M Dent and Sons Ltd, London.

<sup>4</sup> **Tubby I & Armstrong A, 2002.** Establishment and management of short rotation coppice. Forestry Commission Practice Note 7.

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. If it is undertaken as a small component of a bigger SRC scheme, then the advice given for SRC site preparation should be followed. If the SREF is being planted in its own right then the guidance given by Willoughby and Moffat<sup>5</sup> should be considered.

As with SRC, these broadleaved species are palatable to a range of mammals so rabbit fencing may be necessary. If only a small area of SREF is being established then it may be more cost effective to consider the use of individual tree shelters for protection against mammal damage.

Planting takes place either in early or late winter (between November and March) depending on site, local climate and the ability of the supplying nursery to deliver against a particular schedule. Planting of bare-rooted plants is generally done using a spade where a notch is cut into the soil, the roots of the plant inserted into the space opened up and the soil firmed round the roots with the side of the spade and consolidated with the foot. Most SREF will be established by planting but there is also the option of direct seeding as described by Willoughby et al<sup>6</sup>. This method has produced good results in experiments and in a few operational trials but there are risks associated with unfavourable germination conditions, poor quality seed and predation by mice and voles. If these risks 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.

Again, as with SRC, it is impossible to over-emphasise the importance of establishing young trees in conditions free from weed competition. However, it is not necessary to keep the site as weed free as is required for SRC establishment but the aim should be to maintain as weed free a minimum circular area of 1.2m diameter around the newly planted trees for up to three years following planting. If trees are planted in tree shelters, weed control is far simpler.

Once the newly planted trees are established it should be possible to cut them back to initiate coppice regrowth and to produce multiple stems but this should not happen until the trees are 1-2m tall and growing vigorously since earlier cutting could result in renewed weed growth. This probably will not happen for four to five years after planting depending upon species and the fertility of the site. If the SREF is being grown as part of an SRC plantation then it may be feasible to link the timing of the first cut to the first harvest of the SRC. Once the initial cut has

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<sup>5</sup> **Willoughby I & Moffat A, 1996.** Cultivation of lowland sites for new woodland establishment. Forestry Commission Research Information Note 288.

<sup>6</sup> **Willoughby I, Jinks RL, Gosling PG & Kerr, G, 2004.** Creating new broadleaved woodlands by direct seeding. Forestry Commission Practice Guide 16.

been made, further harvests can be made on a ten to 15 year cycle, again depending upon the rate of growth and the type and size of product needed eg chip or logs.

The range of estimated yields for SREF is from 1 to 60dt/ha/yr 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 here. In general terms and given current knowledge it seems reasonable to assume that SREF will produce at best half but more likely one-third to a quarter of the yields that might be expected from a SRC crop grown on the same site. The costs of establishing a new SRF plantation are likely to be similar to those associated with establishing SRC (see Table 1).

## Short rotation willow coppice (SRC)

SRC consists of densely planted, high yielding varieties of willow, harvested on a two to four year cycle, although usually harvested every three years. The Osier or basket willow, *Salix viminalis*, a shrub form native to the UK, is parental stock to many of the willow varieties planted for use as an energy crop. SRC is a woody, perennial crop, the rootstock or stools remaining in the ground after harvest with new shoots emerging the following spring. An SRC plantation should be viable for up to 30 years before re-planting becomes necessary although this will depend on the productivity of the stools and also on the wishes of the landowner.

The varieties of willow used as energy crops have been bred specifically through the UK and European plant-breeding programmes to ensure high yields, erect, straight stems for ease of harvesting plus resistance to or tolerance of rust, the main disease of willows. These varieties are protected by Plant Breeders' Rights and are only supplied via specialist nurseries. In accordance with EC Regulation No. 2100/94, no further multiplication or propagation is permitted from any Plant Breeders' Rights protected willow plants, rods or cuttings whether assigned, purchased or supplied. This regulation prohibits unlicensed willow multiplication or propagation for own and others' use as well as for sale.

Willow grows very quickly when young and has the advantage of the presence of ready-formed root primordia along the length of all stems so that cuttings, taken from the stems, root rapidly after planting. Compared with rooted transplants, cuttings are relatively cheap and easy to produce in great numbers and are the standard planting material used for SRC establishment.

As a perennial crop, SRC may be in the ground for up to 30 years therefore its impact on the local landscape, ecology, archaeology and public access must be considered alongside the operational parameters. For example, SRC can reach 7-8m in height prior to harvest so it is important to ensure that views from neighbouring properties are not blocked and also

significant views from public rights of way are not obscured. Advice is provided within the Forestry Commission's Guideline Note on SRC in the landscape<sup>7</sup>.

To be eligible for the Establishment Grant (further details in the section on SRC Economics page 27), proposed sites must be at least 3ha in size although this can be made up of smaller plots if they are in a localised area. To achieve economies of scale for all field operations but most particularly harvesting, the larger the plantation, ideally more than 5ha and of one field, the better. Larger areas of connected fields can be worked efficiently but hedges, trees, dry stone walls, etc must not be removed as a condition of the Establishment Grant. The ideal field shapes are square or rectangular minimising the need for short row lengths or requirement for changes in direction when planting and subsequently harvesting. Choosing fields that can be harvested efficiently and economically is of critical importance.

Height and weight restrictions on roads or tracks leading to an SRC plantation need to be considered for all machinery involved in planting and harvesting the crop. Also the ease of access for high-sided vehicles if the harvested material is to be loaded to lorries direct from the field.

## Climatic and geographic factors related to SRC production

### Rainfall

SRC can tolerate much wetter conditions than other crops and can also withstand intermittent flooding but not being permanently waterlogged. Drought rather than flooding is more likely to result in reduced yields but if the water table is within 1m of the soil surface and the willow is well established, drought conditions can be withstood. An average annual rainfall of less than 600mm may not provide sufficient moisture to sustain good crop growth.

The sheltered south Midlands, including Warwickshire, is a relatively dry area with annual rainfall levels around 600mm and less than 175 rainy days each year compared to around 200 for the rest of England. Rainfall tends to have an even distribution through the year with summer amounts associated with showery, convective rainfall. However, in the five years to 2008 the number of extreme rainfall events leading to flooding within Warwickshire had increased.

Where potential SRC sites are prone to annual flooding the crop will survive but consideration must be given to operational requirements, particularly the need to carry out winter harvesting.

### Temperature

As the UK native Osier or basket willow, *Salix viminalis*, is parental stock to the majority of willow varieties currently planted as SRC, it will tolerate much of the temperature range found

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<sup>7</sup> Bell S & McIntosh E, 2001. Forestry Commission Guideline Note: Short Rotation Coppice in the Landscape.

across England although the effect of altitude, rainfall and length of season will have a significant bearing on productivity. Air and soil temperatures are the most important factors influencing the onset and breaking of dormancy in plants which, in turn, largely determine the length of the growing season.

Sunlight provides radiant energy to raise the temperature and also increase the humidity of air and soil which play a major role in stimulating plant growth. Sunlight and the consequent high temperatures encourage maximum new growth, enhanced food storage in plants and firmer tissues. Under sunny conditions and with moist soil, willow SRC can grow 2-4cm per day in spring and summer.

Since the Midlands region is some distance from the sea, which has a moderating effect on temperature, the annual temperature range is more pronounced than in most parts of the UK. Sharp winter frosts are common and there are occasional very hot summer days, particularly in the south and east of the region. These temperature extremes of both winter and summer are a key characteristic of the Midlands climate. Spring tends to arrive late in the south Midlands, generally in April but average summer temperatures of 22°C do tend to be higher than those of south England. The average number of days with air frost varies from about 40 to 65 depending on altitude and aspect. Ground frost occurs on average on about 100 to 125 days per year.

### Altitude

Willow coppice has been established at a few sites between 250 and 300m above sea level (ASL). Yields have been low at these sites, 3 to 5odt/ha/yr, mainly as a consequence of thin soils but also due to late heavy frosts killing young leaves and therefore reducing the length of the growing season.

The majority of commercial coppice is grown below 200m ASL. Apart from the difficulties with poor soils, high rainfall, landscape implications, etc that are frequently associated with land above 250-300m asl, there are operational problems also. Ideally SRC should be established on land with no more than a 7% slope, certainly no greater than 15%, purely for the safety and efficiency of harvesting the crop.

Altitude within Warwickshire should not be a limiting factor for the successful establishment of SRC as there is little land over 250m ASL.

### Land and soil suitability

Land identified as most likely to produce viable SRC falls within the Agricultural Land Classification (ALC) Grade 2 and Grade 3. Grade 3 land is capable of growing a restricted range of arable and some root crops as well as producing good yields of grass. Commercial SRC has been grown predominantly on Grade 3 land with the use of Grade 2 increasing slightly as more SRC has been established over the years. Grade 1 land is not appropriate as it has maximum flexibility in terms of crop production and would be very unlikely to be made available for low

value cropping such as SRC. Grade 4 land is also usually inappropriate as it mainly falls within upland situations, has poor soil conditions due to high rainfall and poor drainage therefore generally restricting it to grass production and marginal crops with occasional forage crops. Grade 5 is classed as very poor agricultural land with the principal limitations being a combination of climate and soil wetness; it is normally limited to rough grazing.

SRC has been established on a wide variety of soil types ranging from heavy clay to sand including land reclaimed from sand and gravel workings, reclaimed colliery spoil and landfill sites. There is growing interest at Natural England in working with local government to support SRC planting on former landfill and gravel quarry sites<sup>8</sup>. As many of these sites are of variable soil quality it is worth considering the introduction of trial sites under the energy cop scheme.

Heavy clays tend to remain cold in spring and this, combined with compaction, has led to poor establishment on some clay sites. However, if the site is sub-soiled and slow establishment tolerated, clay soils can prove extremely productive. Sandy soils will benefit from quantities of material such as farmyard manure or treated sludge cake being incorporated during the land preparation stage to help bind the soils and provide organic matter. Difficulties associated with sandy/ gravelly soils are due to droughting although if the water table is within 1m of the soil surface and the SRC has been planted early enough, it will survive. Weed control, of critical importance for good SRC establishment, is difficult on organic, peaty soils. Soil pH should be in the range 5.5 to 8.

Willow will grow best where there is sufficient soil moisture within 1m of the soil surface. It can tolerate far wetter conditions than other crops and can withstand flooding but not being permanently waterlogged. If a site being considered for SRC is prone to flooding most years, the willow will survive but consideration must be given to operational requirements, particularly the need to harvest the site in winter.

## Designated areas

Applications for establishing SRC are subject to the Environmental Impact Assessment (Forestry) (England and Wales) Regulations 1999. These regulations mean that plantations over a certain threshold size must have consent from the Forestry Commission before work can proceed. The thresholds are shown in Table 2.

Above these thresholds all proposed SRC plantations will be required to have a determination i.e. a decision as to whether or not there is likely to be a significant impact on the environment and consequently a requirement for an Environmental Impact Assessment (EIA). This does not mean that all applications so determined will need a formal EIA.

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<sup>8</sup> Chris Rea, Natural England 0300 060 2045 [Christopher.rea@naturalengland.org.uk](mailto:Christopher.rea@naturalengland.org.uk) 07/5/2010 *Pers Comm*

**Table 2 Size thresholds for SRC applications related to environmental impact**

Land type	Threshold
National Nature Reserve	No threshold
Site of Special Scientific Interest	
World Heritage Site	
Scheduled Ancient Monument	
Special Areas of Conservation	
A site classified or proposed as a Special Protection Area	
National Park	2 hectares
Area of Outstanding Natural Beauty	
Other land	5 hectares

### Basic crop agronomy

The importance of efficient land preparation prior to the planting of SRC cannot be stressed too highly. As SRC is a long-term, perennial crop, ensuring ideal conditions at establishment will reap benefits at first and all subsequent harvests. Weed control is the most critical part of coppice establishment with complete eradication of all invasive perennial weeds being essential prior to planting. The crop is planted in the spring, between March and May generally at a density of 15,000 cuttings per hectare, using machines specifically designed for efficient planting. Willow rods (whole stems) of between 1.5 and 2.5m in length are manually fed into the planter's mechanism, which cuts the rods into the required length of cuttings, inserts the cuttings vertically into the soil and then firms the soil around each cutting. Five or more willow varieties are planted per site to help reduce problems with disease and pests.

Depending on ground conditions the planted material can grow rapidly in the first year, the two or three shoots growing from each cutting potentially reaching 3m in height. During the February or March after planting the stems are cutback to within 10cm of ground level to encourage the growth of multiple stems, i.e. the true coppice. Generally three years after cutback the crop is harvested between October and March, weather and ground conditions allowing. The equipment used for harvesting will depend on the requirements of the customer/end-user, i.e. the preferred method of fuel storage or the boiler fuel specification but in all cases the harvesting equipment will have been specifically developed for the purpose. Harvesting can produce chips (up to 50mm in size but usually 35mm) or billets (8-20cm in length) depending on the machinery used. The most common method of harvesting to date

has been direct chip harvesting using forage harvesters fitted with specifically designed SRC headers, which will produce chip of the required size. The stems are cut, chipped and then blown into an accompanying trailer. Depending on the quality of the crop, the harvesting rate is usually between 5 and 8 hectares per day. If a billet harvester is used the billets will need to be chipped prior to use as biomass boilers generally need the fuel in chip form. Chipping dried billets can prove difficult as the wood tends to shatter rather than chip and large amounts of dust and fine material can be produced.

The moisture content (MC) of SRC at harvest is usually within the range 45-60%. The fuel specification of many biomass boilers may require the chip to be below 30% MC although boilers able to use chip up to 50% MC are becoming more common. Burning wetter chip will lead to a reduction in boiler efficiency but having the option to use it does allow more flexibility in fuel use.

New stems will grow in the spring after harvest and, if land preparation and establishment have been carried out effectively, no herbicide application should be required after harvest or for the rest of the life of the crop.

Planting, cutback and harvesting require the use of specialist machinery but the majority of other operations involved in SRC production such as land preparation, spraying and fertilising can be completed using conventional farm machinery.

Apart from ensuring rabbits are kept out of the crop particularly through establishment i.e. the first 18 months from planting but ideally up to first harvest, there are few mammal pests that will cause significant damage. Hares and deer may enter the crop and can cause some damage (hares will easily cross rabbit fencing; deer fencing is extremely expensive and only allowed under the establishment grant in extreme situations). Leatherjackets (larvae of the crane fly or daddy long legs) will need to be controlled during land preparation if the SRC is being planted into ex-grassland. The other main invertebrate pest of SRC which may have to be controlled is the willow beetle of which there are three species. Both the adults and larvae eat willow leaves. The adults over-winter under the bark of mature trees, in fence posts, etc emerging as the temperature increases during late winter/early spring. They move into the edge of the coppice to feed prior to mating after which they move further into the crop. If the beetle population reaches critical numbers during the edge-feeding stage, then spraying with an appropriate insecticide using an orchard-sprayer or equivalent should reduce numbers enough to prevent serious damage. Overspraying an entire plantation would prove costly both financially and ecologically as the insecticides used are not specific and would destroy many beneficial insect species.

If land preparation has been carried out efficiently i.e. weed control in particular, then there should be no further need to apply herbicides for the life of the crop although some growers do spray after harvest. Willow beetle infestations may never occur, may occur intermittently or

may appear every year (experience from established commercial plantations) so applying insecticide should not be an annual cost in most cases.

Compared to conventional arable cropping, where between 15 and 20 different pesticide sprays (i.e. herbicides, insecticides and fungicides) may be applied on an annual basis, SRC has significantly reduced pesticide requirements, most needed only during land preparation and crop establishment.

## Crop yields

As with other arable crops, yield is affected by temperature, soil type, water availability, general husbandry, pest and weed control. The last three items are directly under the control of the grower and can have a significant bearing on the yields achieved at harvest.

Both yields and payments are given on the basis of oven dry tonnes (odt). However, the wood chip is never actually taken down to being oven dry apart from samples taken at the time of delivery to end-users. A series of random chip samples are taken from each individual delivered load; each sample is weighed immediately then oven dried for a set period to remove all water content; each sample is then weighed again to provide the oven dry weight. Taking the oven dry weight from the fresh, wet weight provides an accurate assessment of the moisture content at delivery.

SRC yields are always given on the basis of oven dry tonnes per hectare per year (odt/ha/yr). This figure will then be multiplied by the number of years within the harvest cycle, normally three but it could be two years for a high-yielding crop or four years where the crop is poor to give the actual yield at harvest of oven dry tonnes per hectare (odt/ha).

Depending on ground conditions and efficiency of establishment the yields achievable from willow SRC at first harvest are expected to be in the range 7 to 9odt/ha/yr which equates to 21 to 27odt/ha for a 3-year harvest cycle (i.e. 1ha at 7odt/ha/yr x 3 year harvest cycle = 21odt/ha at harvest). As the moisture content of willow SRC at harvest is around 50% the actual fresh (or wet) tonnage will be between 42 and 54 fresh tonnes per hectare (e.g. 21odt/ha x 2 = 42 fresh tonnes/ha).

Payments are generally made on the moisture content at the time of delivery but payment rates are always quoted on the baseline odt figure e.g. one large biomass end-user currently (2009/10) pays £61/odt delivered which, when using the end user's own formula, equates to an actual payment of £43.67/tonne with the chip at 25% MC, £36.74/tonne at 35% MC or £33.28 at 40% MC. The wetter the chip the lower the payment.

Yields should increase at second and third harvests as the plants mature. Plant breeding programmes are continuing to identify further new willow varieties that should produce higher yields plus improved resistance to disease and pests.

## Storage and delivery of harvested material

Storage areas for the harvested material should ideally be on or close to the SRC plantation to minimise trailer movements. For both chip and billet storage an area of hard-standing or free-draining land will be needed and if a Dutch barn or similar is available this will help speed up the process of natural air drying by reducing the amount of rain hitting the stack. SRC chip can be stored efficiently outside if the stack is built correctly as the outer layer of chip forms a protective cap which allows rain water to run off and prevents re-wetting. As billets are larger than chips, the spaces between the billets allow more natural ventilation to occur preventing the difficulties sometimes associated with chip storage. It is important to note that the volume ratio of solid wood to wood chip is 1 to between 2.5 to 3 so calculating storage area requirements are a vital element of planning a fuel chain.

Table 3 shows the energy density of different fuels to allow calculation of the fuel storage requirement for a specific installations.

**Table 3 Energy density of fuel**

<b>Fuel</b>	<b>Energy density by mass GJ/tonne</b>	<b>Energy density by mass kWh/kg</b>	<b>Bulk density kg/m<sup>3</sup></b>	<b>Energy density by volume MJ/m<sup>3</sup></b>	<b>Energy density by volume kWh/m<sup>3</sup></b>
Wood chips (30% MC)	12.5	3.5	250	3,100	870
Log wood (stacked - air dry: 20% MC)	14.7	4.1	350-500	5,200-7,400	1,400-2,000
Wood (solid - oven dry)	19	5.3	400-600	7,600-11,400	2,100-3,200
Wood pellets	17	4.8	650	11,000	3,100
Miscanthus (bale - 25% MC)	13	3.6	140-180	1,800-2,300	500-650

Vehicle access for stacking, loading and haulage must be available at the storage area depending on what operations will need to take place. If billets need to be chipped prior to haulage from the site, access for the chipper must also be taken into account. Care must be taken when handling chip and billets that have not been stored on hard standing to prevent contamination with soil, stones, etc.

Over 25 times as much energy can be obtained from willow SRC when it is burnt compared to the energy used to produce the wood chip including all establishment and harvest operations. Generally it is uneconomic in terms of both finance and energy balance, to dry willow wood chip by any method other than natural air-drying unless waste heat is available.

Chip can be delivered in a range of vehicles from farm trailers to 100m<sup>3</sup> walking floor lorries. Access for vehicles is just as important at the delivery end as it is at the loading site; it is not unknown for biomass boilers and their associated fuel storage silos or bins to be situated in locations where vehicle access for fuel off-loading proves extremely difficult if not impossible. Haulage can often incur very high costs if the chip is being delivered some distance; ensuring the SRC plantation and the chip storage area are as close as possible to the biomass boiler will significantly reduce overall fuel costs.

Costs for transporting wood chip will obviously vary according to distance, type of vehicle used and contractor. The ideal situation is to have the crop growing within a few miles of the end-use so the chip can be delivered by farm trailer. Currently there are no maximum set distances between crop and end-user and SRC chip is being hauled long distances (250-500 mile round trips) for supply into large biomass end-users. Under the ECS Natural England will consider each Establishment Grant application on an individual basis to ensure that the end use is within a reasonable distance of the crop, including the method of transport and other carbon impacts. Haulage costs will probably be the main driver in the future location of energy crops in relation to their end-use.

Current haulage costs for the delivery of SRC chip for a 50-mile round trip with four loads delivered in one day will be £9 to £11/odt. This assumes the use of a 100m<sup>3</sup> walking floor lorry carrying on average 22 tonnes per load. The fresh weight of chip on the lorry will vary depending on the moisture content; the wetter the chip, the denser and therefore heavier the load. For long distance haulage (more than 200 miles) this cost will rise to between £25 and £40/odt. A 45m<sup>3</sup> bulk loader will hold approximately 10 tonnes of chip but due to the smaller capacity will tend to be more expensive per odt than the larger lorries.

Farm silage trailers, holding 10 tonnes of chip if they have extension sides fitted (5 tonnes without) will be the cheapest form of haulage but do need the end-use to be within a reasonably close distance e.g. less than 15 miles. Costs tend to be on a per hour basis and range from £40 to £50/hr.

## Advantages

### Agricultural diversification

- Improvement in rural economies due to the development of industries associated with SRC harvesting, transportation and local energy generation.
- Opportunities for farmers and landowners to diversify.
- A one-off Establishment Grant is available via Natural England, paid in the establishment year, dependent on the grower having a contract with or letter of intent from a biomass end-user who will use the harvested crop as fuel or he has a means of proving he will be using the fuel for his own biomass end-use.
- As SRC is a perennial crop and is generally harvested on a 3-year cycle, it has an overall low labour and machinery requirement compared to other arable crops.
- There is the potential for farmers to develop specialist contracting skills in planting, cutback and harvesting operations.
- The crop can be grown on marginal or reclaimed land although reduced yields must be expected.

### Environmental benefits

- SRC is a renewable, sustainable energy source for the generation of both heat and power.
- SRC used as fuel is carbon dioxide (CO<sub>2</sub>) neutral: the CO<sub>2</sub> released when the fuel is used is equivalent to that taken from the atmosphere by the plants as they photosynthesise during growth.
- Reduction in levels of acid rain: energy generation using fossil fuels is a major source of greenhouse gases which, apart from CO<sub>2</sub>, include nitrogen dioxide and sulphur dioxide, the latter also contributing to the problem of acid rain. Virgin wood-based fuels such as SRC have little or no sulphur content.
- Fuel can be used close to the area of its production, which reduces the need for long distance haulage therefore providing local energy production for local communities.
- Land cultivation takes place once during the life of the crop and is therefore significantly less intense than for other arable crops.
- There is a significant reduction in agrochemical use compared to conventional cropping:
- After efficient land preparation and establishment there should be no further need to apply herbicides for the life of the crop.
- Two or three pesticide applications may be needed during establishment to control leatherjackets (on ex-grassland) and possibly slugs (depending on soil type). When the crop is mature pesticide may be needed only if there is a serious willow beetle

infestation; the crop should be edge-sprayed at the onset of the infestation to reduce beetle numbers otherwise pesticides are not required.

- The humus content of the soil improves over time as does the soil fauna due to reduced machinery passes and the deciduous nature of the crop.
- SRC provides increased visual diversity in the landscape although it is important that the coppice is situated appropriately. Under the Establishment Grant the location of a proposed plantation will be checked and approved by the Forestry Commission before the grant can be agreed.
- SRC can be used for the treatment of wastewaters, for example sewage, farmyard run-off, landfill leachate, etc. in a similar way to constructed wetlands/reedbeds.
- SRC can be grown successfully on landfill sites although efficient land preparation, in particular weed and rabbit control is essential and often more difficult than on arable land due to the poor quality of the soils used in landfill restoration. Ideally soil depth above the cap should be 1-1.5m to allow root development although modern landfill caps are unlikely to be penetrated by roots<sup>9</sup>. SRC will also grow on old landfill sites where the soils are shallow but the roots may penetrate the cap which tend to be of poor quality. Yields will generally be low on landfill sites due to weed competition if control has not been effective, poor soil quality and also possible contaminated areas within the soils. The presence of roots and organic matter (whether from the addition of organic materials applied as fertiliser or just the recycling due to deciduous leaf fall) and the associated biological activity may play a significant role in the degradation or stabilisation of soil contaminants.<sup>10</sup> Other benefits of SRC on restored landfill include the overall stabilisation of the site as well as increased landscape and amenity value.
- SRC can be grown on contaminated land and will actively take up heavy metals helping to reduce the levels of contamination. The most suitable willow varieties for this are currently under research.

## Ecological benefits

- Provision of wildlife habitats and consequent improved biodiversity: SRC provides increased habitat diversity within the agricultural landscape leading to increases in the number and type of invertebrate and bird species present. Despite the fact that it is essential to eradicate weeds during the establishment of SRC, once the crop is mature the growth of a beneficial ground flora tends to increase. Ground cover encourages the presence of invertebrates which in turn leads to an increase in the number of small mammals and birds found. At least three times the number of plant-eating invertebrate

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<sup>9</sup> **Crow P & Houston PJ, 2004.** The influence of soil and coppice cycle on the rooting habit of short rotation poplar and willow coppice. *Biomass and Bioenergy* 26, 497-505.

<sup>10</sup> **Paulson M et al, 2003.** Practical use of SRC in land reclamation. *Land Contamination and Reclamation* 11 (3), 323-338.

species spend part of their life cycle in the canopy of willow SRC compared to conventionally grown barley or wheat<sup>11</sup>. High numbers of bird species are found throughout the year and also over the 3-year harvest cycle. For example, skylark, lapwing, yellow wagtail and snipe are often found in newly planted, cutback and harvested SRC. Species of high conservation value such as bullfinch, reed bunting and song thrush have been noted to regularly hold territories during the breeding season in SRC.

- Headlands and rides provide further habitats for a wide range of plants and animals, for example 14 species of butterfly have been recorded within SRC headlands and this might help to prevent the decline of many butterfly species associated with the agricultural landscape.
- Willow SRC can provide improved game conservation and the plantation can be designed to maximise this feature.
- As a robust and durable crop, it is suitable for urban fringe and similar areas where recreational facilities such as walking or bird-watching could be provided. Both the SRC plantations and the biomass end-use technology could be promoted as visitor attractions to provide educational opportunities as well as additional income. With potential for partnerships with local wildlife groups.

### Landscape benefits

- The potential to screen features with a negative landscape impact such as roads, industrial sites etc.
- SRC is less changeable than agricultural crops, but changes more rapidly than conventional forestry and provides a “halfway house” in terms of landscape impact. As an intermediate SRC provides the potential to form a visual link between open land and woodland areas.
- SRC is a highly effective windbreak, this can introduce sheltered areas for public access, picnic areas etc.
- SRC offers cover for wildlife particularly low nesting birds, this can increase the ornithological interest on site

Further information on landscape impact is available in appendix 6<sup>1213</sup>

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<sup>11</sup> **Sage R & Tucker K, 1998.** Integrated crop management of SRC plantations to maximise crop value, wildlife benefits and other added value opportunities. ETSU B/W2/00400/REP.

<sup>12</sup> **Bell S & McIntosh E, 2001.** Forestry Commission Guideline Note: Short Rotation Coppice in the Landscape.

<sup>13</sup> The ReLu project <http://www.relu-biomass.org.uk/Research.php>

## Disadvantages

- Long term contracts with end-users can tie up the land for a number of years.
- SRC, particularly willow, could be destructive to drainage systems but this must be measured over the lifetime of the crop i.e. 15 to 30 years.
- If the crop is sited badly it can block important landscape views or views from neighbouring properties.
- SRC has a high water uptake which must be considered when planting large areas within single catchments.
- Extreme care must be taken and appropriate machinery used at harvest to prevent rutting and compaction occurring.
- Storage of the harvested material in whatever form, if it is not to be used immediately, needs careful management.

## Economics

The economics of biomass production depend on the price the end user is prepared to pay for the fuel plus the cost of producing and delivering the fuel.

Table 4 provides an indication of costs for the establishment and harvesting of 1ha of willow SRC and costs per odt at two yields: 7odt/ha/yr and 9odt/ha/yr over a 10-year crop i.e. one establishment year plus three 3-year harvest cycles over nine years. The costs include the main operations involved in preparing the land, planting and cutting back the crop during the establishment year and the costs for harvesting assuming chip harvest and storage. There are no costs included for pest control if necessary during crop establishment (e.g. leatherjackets, slugs) and for ongoing annual management of the crop that may involve headland maintenance and possible willow beetle control.

The costs given are based on 2010 contract prices for the specialist operations such as cuttings supply, planting, cutback, remedial weed control, etc. Costs for standard arable operations such as ploughing, sub-soiling, etc are given for both the farmer carrying out the work himself (NB: note 2) and the work being carried out by a contractor. There will be scope for reducing costs e.g. where the land is clean and relatively weed free, where there are few or no rabbits and where land preparation has been carried out efficiently leading to no requirement for remedial weed control or, possibly, cutback. The costs for specialist operations, most particularly for harvesting, tend to be relatively high as there are few specialist machines currently in the UK and few contractors who are competent in SRC planting and harvesting techniques.

**Table 4 Indication of costs for establishing and harvesting  
1 hectare of willow SRC in 2010**

Operation	Item cost	Farm er costs £/ha	Contra ct costs £/ha	Approximate costs <i>in £/odt</i> assuming 3 harvests i.e. 10 year crop at the following two yields:			
		A	B	21odt/ha		27odt/ha	
				Total yield in <i>odt/ha</i> for 3 harvests assuming no increase in yield over the life of the crop			
				63		81	
<b>Land preparation</b>				A	B	A	B
Weed control + applicationx2		44	50				
Sub-soiling		35	50				
Ploughing		45	55				
Rabbit fencing	£4.5/m	605	605				
Power harrowing		32	45				
<b>Land preparation costs</b>		<b>761</b>	<b>805</b>				
<b>Establishment</b>							
Cuttings + storage at £50/ha	15000 @ 5p	800	800				
Planting		210	210				
Rolling (ring) x 2		24	34				
Weed control + application		152	155				
Remedial weed control		70	75				
Cutback		38	38				
Weed control + application		65	68				
<b>Establishment costs</b>		<b>1359</b>	<b>1380</b>	<b>21.57</b>	<b>21.90</b>	<b>16.78</b>	<b>17.04</b>
<b>Gross costs</b>		<b>2120</b>	<b>2185</b>	<b>33.65</b>	<b>34.68</b>	<b>26.17</b>	<b>26.98</b>
<b>Establishment Grant - 50%</b>		<b>1060</b>	<b>1093</b>	<b>16.83</b>	<b>17.34</b>	<b>13.09</b>	<b>13.49</b>
<b>Net costs</b>		<b>1060</b>	<b>1093</b>	<b>16.83</b>	<b>17.34</b>	<b>13.09</b>	<b>13.49</b>

<b>Harvesting</b>							
Chip harvesting		310	310	14.76	11.48	11.48	11.48
Tractor & trailer x 2		85	100	4.05	4.76	3.15	3.70
Handling & storage				1.50	2.00	1.50	2.00
Loading lorries		20	25	0.95	1.19	0.74	0.93
<b>Harvesting costs in £/odt</b>				<b>21.26</b>	<b>19.43</b>	<b>16.87</b>	<b>18.11</b>

**No index-linking or Single Farm Payment**

***included***

- 1** Costs from Agricultural Budgeting & Costing Book Nov 2009
- 2** Costs for standard agricultural operations are given for farmers doing the work themselves (A) and contractors (B). Please note that it is difficult to provide typical farmers costs as they may use different machinery to the contractors (who will generally use high-horsepower machinery) and farmers will also have different labour and insurance costs, overheads and profit margins than a contractor.
- 3** Assumes 33% rabbit fencing
- 4** On ex-grassland sites leatherjacket control will be required during land preparation at £15/ha for the pesticide + £15/ha for 1st application; the 2nd application can be applied with the post-planting herbicides
- 5** No haulage costs included for moving planting and harvesting machinery to sites
- 6** No haulage costs included for moving chip to end-use
- 7** Willow beetles are the only pest that may need to be controlled in the mature crop. Insecticide (£90/L applied at 0.05L/ha) should be edge-sprayed using an orchard sprayer (£35/hour) or similar when the population reaches critical numbers.

## Basically:

- Land preparation costs including weed control, sub-soiling, ploughing and power harrowing will be approximately £180/ha. These costs will increase slightly if more than two applications of Roundup are required to control the weeds and pesticide is needed to control leatherjackets on ex-grassland sites. All standard agricultural costs will vary depending on whether the work is carried out by the farmer himself or a contractor.
- Rabbit fencing, required at most sites to some degree, is one of the highest costs associated with SRC establishment, the other being the cost of the willow cuttings. In
- Table 4 costs for only 33% rabbit fencing have been included in the assumption, for example, that the rabbit population is based perhaps in adjacent woodland to one side of the SRC site. Full rabbit fencing will be around £1,800/ha.
- Rolling the site after planting, post-planting and post-cutback weed control can be carried out by the farmer or an agricultural contractor and will be around 250/ha which includes the recommended herbicides.
- The specialist costs of the willow cuttings, cold storage of the cuttings, planting and cutback are set costs from specialist contractors supplying the appropriate energy crop willow varieties and using appropriate machinery. 2010 prices are £1,048/ha excluding haulage of the machinery to site and travel and subsistence for the operatives.
- If remedial weed control is needed during the establishment year the costs can be high depending on the weeds needing to be controlled and the herbicide required. Grass weeds can be controlled using standard spray equipment (around £10/ha excluding the herbicide). Broadleaved weeds require either a hooded sprayer or specific sprayer designed to keep spray drift away from the willow and this will be around £50/ha

excluding the herbicide and possible machinery haulage costs. It is much better and considerably cheaper to eradicate all weeds prior to planting.

- Harvesting costs are currently £310/ha excluding fuel for the harvester, haulage of the machinery to site and travel and subsistence for the driver. The harvesters are large machines and have to be moved by low-loader which costs between £4 and £5 per mile depending on the haulier.
- Two tractors and silage trailers with extended sides for moving the chip at harvest plus a telescopic loader for stacking the chip will cost approximately £125/ha. Three tractors and trailers will be needed if the chip storage area is more than 5 miles from the SRC site. It is important to keep the harvester working so there must always be a trailer running alongside it with one waiting to move into place as the previous trailer becomes full.

### Single payment scheme

The single payment scheme (SPS) or single farm payment was introduced in 2003 as part of the Common Agricultural Policy reform and is now the European Union's main agricultural subsidy scheme. It aims to reward farmers not just for food production, as with previous schemes, but for land management and environmental stewardship. Under the scheme farmers have greater freedom to farm to the demands of the market as subsidies are no longer linked to production whilst environmentally friendly farming practices (known as cross compliance) are better acknowledged. The SPS is run in England by the Rural Payments Agency (RPA).

In order to receive the full single farm payment a farmer must comply with a set of statutory management requirements which relate to areas of public, animal and plant health, environment and animal welfare. The farmer must also demonstrate that he is keeping his land in good agricultural and environmental condition i.e. under cross compliance. All agricultural activities are covered by cross compliance and each farmer must comply with the requirements across the whole agricultural area of his farm holding regardless of the amount of land entered into the SPS. Most of these standards are based on legal requirements and farmers should already be following them.

To be eligible for single farm payments, an applicant must:

- be a farmer as defined by the European Union
- have eligible land at his disposal on 15<sup>th</sup> May of the scheme year - this land must be eligible for SPS for the entire calendar year (eligible land is defined as any area of a farm holding taken up by arable land and permanent pasture, except for forested areas [this does not include SRC] and areas used for non-agricultural activities)
- hold payment entitlements

Farmers wishing to apply to the SPS need to complete an annual application form and would normally contact the RPA for any advice needed.

Rate values for the 2009 SPS in England were £168.49/ha.

## Short rotation poplar coppice

Poplar has only been used as an SRC crop on a small scale to date, usually planted adjacent to willow SRC to provide visual diversity. Although varieties of fast-growing poplar have been produced there are some difficulties associated with their use as SRC. Current recommended and approved poplar varieties best suited to SRC are listed by the Forestry Commission<sup>14</sup>. Poplar varieties are controlled under the Forest Reproductive Material Regulations (Statutory Instrument No. 891, 1977), which are in place to improve the quality of poplar varieties, increase production and ensure that the most suitable varieties are used. These Regulations also control the marketing of poplar varieties so that reproductive material is only available from registered sources.

Some varieties of poplar are extremely susceptible to the fungal disease rust which can lead to the death of the plants although other varieties are currently unaffected<sup>15</sup>. If poplar is to be planted care must be taken to follow all Forestry Commission guidance on the appropriate varieties to use.

Poplar grows best in deep fertile soils although it will grow in most conditions with the exception of shallow soils and those that remain waterlogged. The density of poplar planting has been lower than that for willow, being 10–12,000 cuttings per hectare. Poplar cuttings must have an apical bud within 1cm of the top of the cutting unlike willow which can produce shoots along the length of the cutting. This means that poplar cannot be planted using the commercial willow planters as the cuttings have to be manually processed to ensure the presence of the apical bud. Modified cabbage planters have to be used instead. Due to the ridged nature of poplar stems, the cuttings also tend to cause blockages in the planter mechanisms.

Planting and establishment are similar to that for willow but due to its apical dominance, poplar will not produce numerous shoots after cutback and often reverts to single stem growth. Generally a maximum of three shoots will appear from the cut stool and this is the main reason why many poplar stands are allowed to grow on as single stems and then harvested after seven years' growth.

Poplar tends to produce higher yields than willow, although this may be site specific, particularly when allowed to grow on for four years or more from cutback. As poplar produces

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<sup>14</sup> **Forestry Commission, 2005.** English Woodland Grant Scheme - Operations Note 008.

<sup>15</sup> **Forestry Commission, 2005.** Tree death in poplar plantations.

fewer, heavier stems, consideration must be made to the harvesting machinery used; it must be capable of dealing efficiently with large diameter, heavy stems.

The removal of poplar SRC at the end of its life is more problematic than willow. The rooting system of poplar produces a large main taproot that grows down into the soil rather than the horizontal rooting structure of willow SRC. Removal of the stools following final harvest and spraying off of the shoots will generally require a large excavator.

Most of the new poplar varieties have been bred for high yield but also for growing as a single stem crop. Current poplar breeding programmes continue to work towards increasing yields but also aim to produce varieties which will coppice more readily and also have a long-term resistance to rust. A number of the varieties planted in the mid-90s succumbed to rust as their resistance to the disease broke down.

## Miscanthus

There are three grasses that could be considered suitable as biomass fuel sources with the potential to produce similar yields to SRC: Miscanthus, reed canary grass and switchgrass. Currently only Miscanthus is supported under the ECS with an Establishment Grant and is in commercial production for its main market, Drax power station in South Yorkshire. The other grasses are promising and currently being researched but are further from commercial exploitation.

Miscanthus species are woody, perennial, rhizomatous grasses originating from Asia which have the potential for very high rates of growth.<sup>16 17</sup> Miscanthus, commonly called elephant grass, may be familiar as a flowering garden ornamental but it is the non-flowering forms that are of interest agriculturally.

Miscanthus is spring planted with the stems or canes produced during the summer being harvested from February to March. This growth pattern is repeated every year for the lifetime of the crop which should be at least 15 years. Miscanthus spreads naturally by means of underground storage organs (rhizomes) although their spread is slow and there is no uncontrolled invasion of hedges or neighbouring fields. The rhizomes can be split and the pieces re-planted to produce new plants. Efficient planting requires specialist machinery whilst harvest operations can be done with conventional farm machinery such as mower/conditioners and balers.

Miscanthus uses sunlight more efficiently than native plants to produce high yields. It generally grows well in the south of the UK but is less well adapted to the climate in the north. Similar to

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<sup>16</sup> Bullard M J & Nixon P M I, 1999. *Miscanthus agronomy for fuel and industrial uses*. Project report (NF0403) for MAFF.

<sup>17</sup> Bullard M J, Nixon P M I, Heath M C, 1997. Quantifying the yield of *Miscanthus x giganteus* in the UK. *Aspects of Applied Biology, Biomass and Energy Crops*, 49, 199-206.

SRC in that it is perennial and harvested in the winter but on a 1-year cycle compared to 2-4 years for SRC. The fuel has a similar calorific value per unit weight as wood and could possibly be used for the same biomass end-use or, more likely at the small-scale, in boilers specifically designed to use agricultural residues such as straw. The potential advantages compared to SRC are that the harvested fuel is relatively dry, standard agricultural equipment can be used for harvest and the yield potential is higher (10 to 15odt/ha/yr<sup>-</sup> as opposed to around 7 to 9odt/ha/yr<sup>-</sup> for SRC).

Key determinants of yield are sunshine, temperature and rainfall, the latter most critical in affecting yield capability. More experience is needed of yields under a wide range of soil conditions but current information suggests that most lowland agricultural sites in England should be suitable for Miscanthus cropping with the highest yields coming from deep, moisture retentive soils. Miscanthus has been reported growing and producing high or reasonable yields on a wide range of soils from sands to high organic matter soils but the key to high yield is moisture supply<sup>18</sup> therefore sandy or other free draining soils should ideally be avoided. Heavy clay soils should also be avoided as establishment and growth tends to be poor. As with SRC, land of Grades 2 and 3 will be the most commonly planted and if land preparation and management of the crop are carried out efficiently, yields should be in the range 10 to 15odt/ha/yr<sup>-</sup>, occasionally 20odt/ha/yr<sup>-</sup>. Grade 4 or 5 land should be avoided.

From the second year onwards the crop is harvested annually with the second year harvestable yields ranging from 4 to 10odt/ha/yr<sup>-</sup> and those in the third year 10odt/ha/yr<sup>-</sup> or more. After two to five years harvestable yields reach a plateau and stabilise. The reason for the variation in time taken to reach a plateau depends on planting density, soil type and climate. At sites where there has been a low planting density e.g. 10,000 plants/ha or where moisture supply or exposure limit yields, there may be a longer 'yield-building' phase e.g. up to five years.

The major constraint to long season growth is late frost which destroys early spring foliage and effectively reduces the duration of the growing season. An established crop (i.e. 2+ years old) can withstand such events but yield will be reduced as a consequence.

The full environmental and ecological impact of Miscanthus is not yet fully understood although there will be some gains due to the cover and perennial nature of the crop. However, two studies comparing Miscanthus with cereals indicated that Miscanthus seemed to provide a habitat that encourages a greater diversity of species than cereal crops.<sup>19 20</sup> In these studies three times as many earthworms and spiders were found in Miscanthus and it also supported a

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<sup>18</sup> **Clifton-Brown J C & Lewandowski I, 2000.** Water use efficiency and biomass partitioning in three different Miscanthus genotypes with limited and unlimited water supply. *Annals of Botany*, **86**, 191-200.

<sup>19</sup> **Christian D G, Bullard M J, Wilkins C, 1997.** The agronomy of some herbaceous crops grown for energy in Southern England. *Aspects of Applied Biology, Biomass and Energy Crops*, **49**, 41-52.

<sup>20</sup> **Jones M & Walsh M, 2001.** *Miscanthus for energy and fibre*. James and James: London, 192pp.

greater diversity of spider species. One of the studies showed that Miscanthus had five more mammal species and four more bird species than a crop of wheat. Miscanthus can also act as a nesting habitat for both ground nesting birds in the early spring (e.g. skylarks) and reed nesting birds (e.g. reed warbler) later in the summer.

### Advantages of Miscanthus

Many of the advantages associated with SRC are similar for Miscanthus such as carbon neutrality. Specific advantages are:

- Ease of storing and handling the baled crop; it will be suitable for bale feed lines in large-scale power stations and some small boilers.
- Heavier bales allow a greater amount of biomass to be transported per lorry so cutting the number of lorry journeys needed and consequently cutting emissions and improving overall energy balance.
- No significant pests or diseases yet encountered.
- Ability to blend Miscanthus bales with other baled products such as straw.
- Ease of destruction once the crop is no longer wanted; the rhizomes may be harvested and sold on to establish new plantations as there are no varieties and no Plant Breeders' Rights.

### Disadvantages of Miscanthus:

- Long term contracts with end users may tie up land for a number of years.
- Large-scale development of a monoculture may attract landscape and environmental criticism - there are no varieties available as with SRC so there is also a significant risk of an entire crop being lost if a pest or disease does pose a threat.
- Large scale storage of harvested material at risk of fire.
- Baled material may need secondary conversion by grinding or chopping for small boilers.
- High yielding Miscanthus has a high water uptake that must be considered when planting large areas within a single catchment.
- Miscanthus has a high ash content compared to wood chip and due to the high chloride and potassium content it can also cause corrosion problems within boilers.

## Grants available

The Energy Crops Scheme (ECS), under which the Establishment Grant is available for SRC and Miscanthus, is part of the Rural Development Programme for England 2007 - 2013 which is jointly funded by the UK and EU through the European Agricultural Fund for Rural Development. The ECS has been developed in partnership with the Forestry Commission, DECC and Defra with the grant managed and paid by Natural England (NE).

The approved list of SRC species eligible for the grant is willow, poplar, ash, alder, hazel, silver birch, sycamore, sweet chestnut and lime.

The ECS scheme supports the cost of establishment of Miscanthus or SRC with payment made on the basis of:

- 50% of actual costs i.e. suppliers/materials/contractors costs and/or
- 50% of on-farm costs i.e. use of own labour and machinery where applicable

Establishment costs cover operations such as land preparation, rabbit fencing, purchase of planting stock, planting, weed control and first year cutback. The caveats associated with the grant include:

- The harvested crops must be used for heat, combined heat and power (CHP) or power generation. Own use is permitted.
- At least three hectares with a minimum block size of 0.5ha must be planted. There is no upper limit on the amount of eligible land that can be entered in the scheme. Planting may be phased over three years.
- Applications are subject to an environmental appraisal including a site visit.
- Successful applicants must enter into a five year agreement with Natural England.

To be eligible, the applicant must be the lawful occupier of the land included in the application (owner or tenant) and have responsibility for farming the land. This can include local authorities. All joint occupiers of the land, e.g. a partnership, must sign and be bound by any agreement under the Scheme. The land must be registered on the Rural Land Register (RLR) as land parcel details will need to be entered on the application form.

Providing the appropriate conditions are fulfilled, the applicant may be able to combine the ECS with other grant schemes e.g. Entry Level Stewardship (ELS) although this will not apply where payment would be received twice for the same activity or if the objectives of the schemes conflict.

ELS requires a basic level of environmental management covering all farming types and including operations such as hedgerow management, stone wall maintenance, low input grassland, buffer strips, maintenance of traditional farm buildings and arable options. A farmer

receives a payment for all the land entered into ELS with the standard payment rate currently £30/ha. Provided the farmer meets a points target and agrees to carry out simple but effective environmental land management, he will be accepted into ELS. Five-year agreements are available, with monthly start dates and automatic payments every six months.

Higher Level Stewardship (HLS) aims to deliver significant environmental benefits in high priority situations and areas. It involves more complex environmental management, so a farmer will get advice and support from NE advisers. HLS is usually combined with ELS but it is discretionary and NE is looking for agreements that are likely to achieve maximum environmental benefit and represent good value for money. HLS agreements are for ten years with payments again sent out every six months.

Land in the ECS can count towards the area used to calculate the ELS points target and associated payment but a farmer must not locate any ELS options on land planted under the ECS.

Where ECS planting is on a part-field basis, ELS options may be located within the land parcel provided there is no overlap of ELS options with ECS payable areas on the ground - i.e. grant-funding cannot be claimed from two schemes (e.g. ELS and ECS) on the same piece of land.

Boundaries surrounding ECS parcels may be entered into ELS boundary management options.

HLS options must not be located within land parcels covered by planting under an ECS agreement. However, boundaries surrounding ECS parcels may be entered into HLS boundary management options.

In July 2009, Defra approved the Campaign for the Farmed Environment (CFE)<sup>21</sup> as the preferred approach to retain and exceed the environmental and ecological benefits that used to be provided by set-aside. The NFU, CLA, RSPB, the Environment Agency and a wide range of other key agriculture and related industry organisations developed the CFE. It allows farmers to continue to produce more but have less impact on the environment. There are a range of measures available within the CFE which makes taking part as flexible as possible achieved through a combination of voluntary management measures which have been developed for the CFE alongside key ELS options.

Taking part in the CFE is voluntary with the aims of helping to protect the countryside, its wildlife, soils and water quality and have the majority of farmers taking part so that the threat of future regulation will not be necessary. A farmer chooses some key in-field options when renewing or entering ELS agreements for the first time, reviews any existing voluntary management and adopts at least one of the CFE voluntary measures while also retaining existing uncropped land.

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<sup>21</sup> Campaign for the Farmed Environment (this booklet has been sent out to around 40,000 farmers with more than 10ha of arable land) <http://www.cfeonline.org.uk/>

Voluntary measure C15: Enhanced management of SRC (willow or polar only) aims to encourage farmers to consider SRC as an environmentally beneficial crop and therefore to increase SRC hectareage across England. It should be noted, however, that the NFU, following comments from the NFU Energy Crops Forum, is asking for some of the requirements under C15 to be modified as the industry considers them to be impractical.

Establishment Grant applications take at least three months to go through the system and if there are any queries over the land e.g. related to archaeology, wayleaves, etc it will take considerably longer. There is no set application window but NE are unable to guarantee that applications received after 30th September will be approved in time for the following spring planting season so applicants are strongly advised to apply well in advance to ensure time for thorough land preparation which will improve yields and allow time to order planting material. No land work should be carried out prior to grant approval as NE could refuse to pay towards the work done.

The Forestry Commission (FC) administers the public registers for new planting of SRC and as part of the application process will decide whether an Environmental Impact Assessment (EIA) is required (see) and whether the plantation will have a significant impact on the local environment. This will include possible effects on neighbouring properties, the historic environment, biodiversity, landscape, recreation and flood plain. The FC will discuss the planting design during a site visit and agree the proportion and location of open ground. After consultation, the FC will make a recommendation to approve or reject the application to NE.

The major part of the grant is paid after planting. Grant for second year activity such as cutback and weed control will be paid for in that year.

There is no specific grant for SRF. Some species associated with SRF are supported under the ECS where they may be established and managed as coppice. Currently Eucalyptus is not eligible for support from the ECS or the Woodland Grant Scheme.

SRF plantations will be subject to the normal controls on tree felling that are administered by the FC. Reverting land back from SRF to its former use will be subject to Environmental Impact Assessment regulations.

## Biomass Fuel crops in the landscape

### Hydrology

Any significant change of land use will tend to have an impact on hydrology. Planting woodland on sites may have an effect on both the water table and the amount of run off in a catchment. Generally, soils are drier under woodland than under grass, in part this is because trees intercept rain before it reaches the ground, conifer species are especially good at intercepting rain and although broadleaved species also intercept rain their impact on soil water is small. If woodland or energy crops are established on land that has previously been drained and

managed as farmland then it is likely that there will be little additional impact on site hydrology. The effect of energy crops and woodland planting on flood plains can have positive impacts such as slowing flow rates of floodwaters with the consequence of reducing peak flow pressures on flood defences downstream and allowing more water to drain through the soil rather than simply running off. Further information on trees and hydrology and on the effect of planting on floodplains is available<sup>22</sup>

## Landscape and Habitat

Concerns over effects to the landscape of planting for biomass do exist. These usually centre around the visual impact of widespread planting of unusual crops such as *miscanthus*. The introduction of native broadleaved species as either forestry, or dedicated energy crops should pose little or no threat on the scales proposed particularly in view of the small, fragmented nature of the landscape areas in Warwickshire<sup>23</sup>. It should be pointed out that in terms of habitat and landscape impact, energy crops usually have a significantly lower visual impact on a site than agricultural crops such as rape or maize, and will frequently have a greater habitat benefit than arable crops or improved grazing land.

It should be noted that site constraints exist for energy crops and forestry that may not exist for agricultural crops. Due to the long rotation lengths and more permanent character of these crops, restrictions in planting apply when working next to residential properties and along rights of way. It is common to incorporate buffers of open ground of 10m from these features to prevent significant impact on residents and this will be a requirement of any application to the energy crops scheme. Wide buffers along rights of way may provide walkers with better sight lines than if narrow buffers are used, this could help walkers feel secure when using paths. There are no specific restrictions on woodland or energy crop planting on greenbelt land<sup>24</sup> and furthermore this can provide environmental benefits by reducing the distance biomass travels before it is used in urban areas.

It is worth noting that woodland and energy crop planting is a sensitive subject near airports. Bird strike is a significant hazard for low flying aircraft and when planning any planting around airports which may increase habitat for bird populations it is strongly recommended that airport authorities be consulted at an early stage.

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<sup>22</sup> **Nisbet T.R and Thomas H.** (2006) *The role of woodland in flood control: a landscape perspective* Forest Research

<sup>23</sup> **Lucas O.**, *The Design of Forest Landscapes* 1991 OUP

<sup>24</sup> **Planning Policy Statement 22** (2004) ODPM

## Warwickshire county council sites

### Using a yield model to estimate potential SRC yields at sites owned by WCC

A yield model was used to generate yield estimates for SRC grown on sites owned by WCC. This model which describes the relationship between soil and weather conditions and coppice yield was developed in the late 1990s using data collected from willow and poplar SRC trials established across England, Wales, Scotland and Northern Ireland. A similar model was used to produce the SRC 'opportunity maps' available on the Defra website (correct at 26th April 2010). These models use annual rain fall, seasonal rain fall (March – October), growing degree days, frost days, soil pH and soil texture (sand, clay or loam) to generate yield estimates.

The model was run using the following assumptions:

- Each site has a loam soil
- Soil pH is 6
- A planting density of 13,333 cuttings per ha is used
- A mix of the willow varieties Tora (*Salix viminalis* x *S. schwerinnii*), Bjorn (*S. viminalis* x *S. schwerinnii*), Stott 10 (*S. burjatica* x *S. viminalis*), Jorunn (*S. viminalis* x *S. viminalis*) and Jorr (*S. viminalis* x *S. viminalis*) was planted at each site. These varieties have either been planted commercially or are similar genetically to those planted commercially.

Results from each model run suggest that all sites are able to produce SRC yields in the region of 8 – 12odt/ha/yr during the first two 3-year rotations. This equates to the 'suitable' classification rating used in the Defra opportunity maps. The exception to this was site 12 where the model suggested that slightly higher yields may be possible.

Although they provide a useful yardstick able to help with the site evaluation process and highlight potentially low yielding areas, estimates from yield models should not be taken as fact as significant variations in yield may be observed at the same site from year to year depending on annual temperature and rainfall patterns. The model was developed using varieties that have since been superseded; newer varieties may respond differently to site conditions compared to those trialled in the mid 1990s.

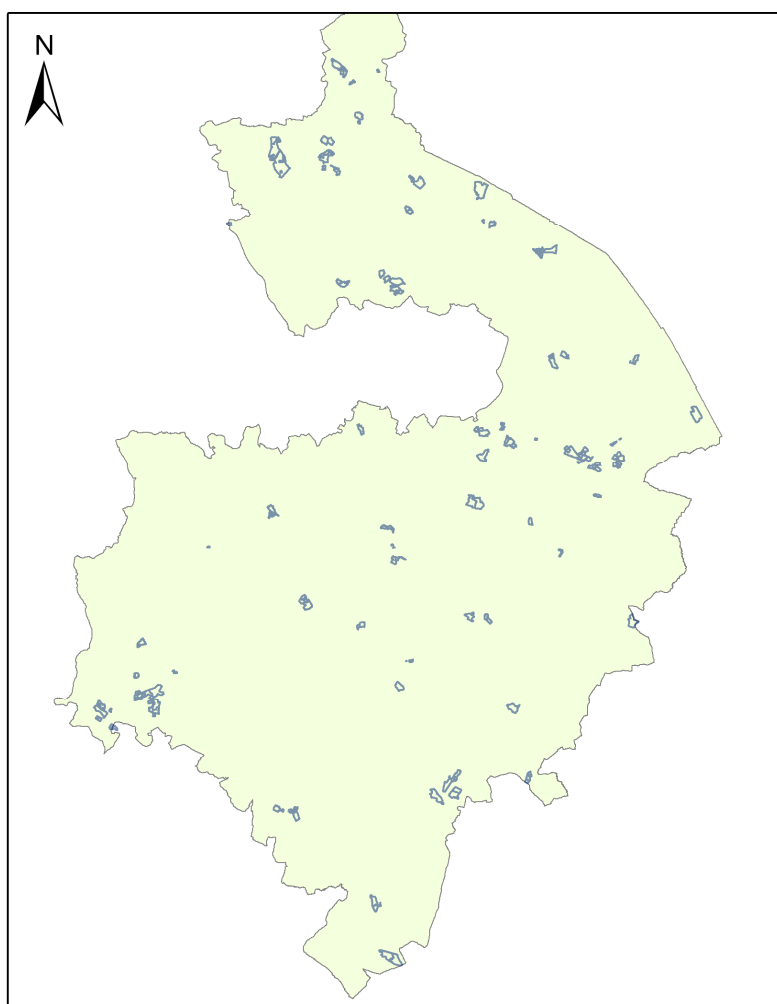
## GIS methodology

### Rationale



WCC provided an extended data set of site boundaries, site type and tenant details. This data was aggregated into geographical clusters to assess their suitability for energy crop production. This aggregation was carried out to for a number of reasons:

- To reduce the sample size to a manageable level. The original smallholdings dataset contained 279 features, (many of which were small sections of larger holdings.)
- There were also a large proportion of clustered features with intersecting boundaries. These clusters and holdings were close enough together allow some or all of each site to be planted while still benefiting from economies of scale and efficient use of machinery and transportation.
- Smaller and highly fragmented holdings present a number of difficulties when planning and developing biomass supply chains and these were effectively excluded from the sample by the aggregation process.
- Variation between closely clustered sites in terms of yield modelling and site suitability was felt to be low and reducing the sample size allowed for a more detailed assessment of promising sites rather than a low level of assessment of a wider sample (which often would show little variation over the cluster.)

**Map 1 initial data**



**Legend**

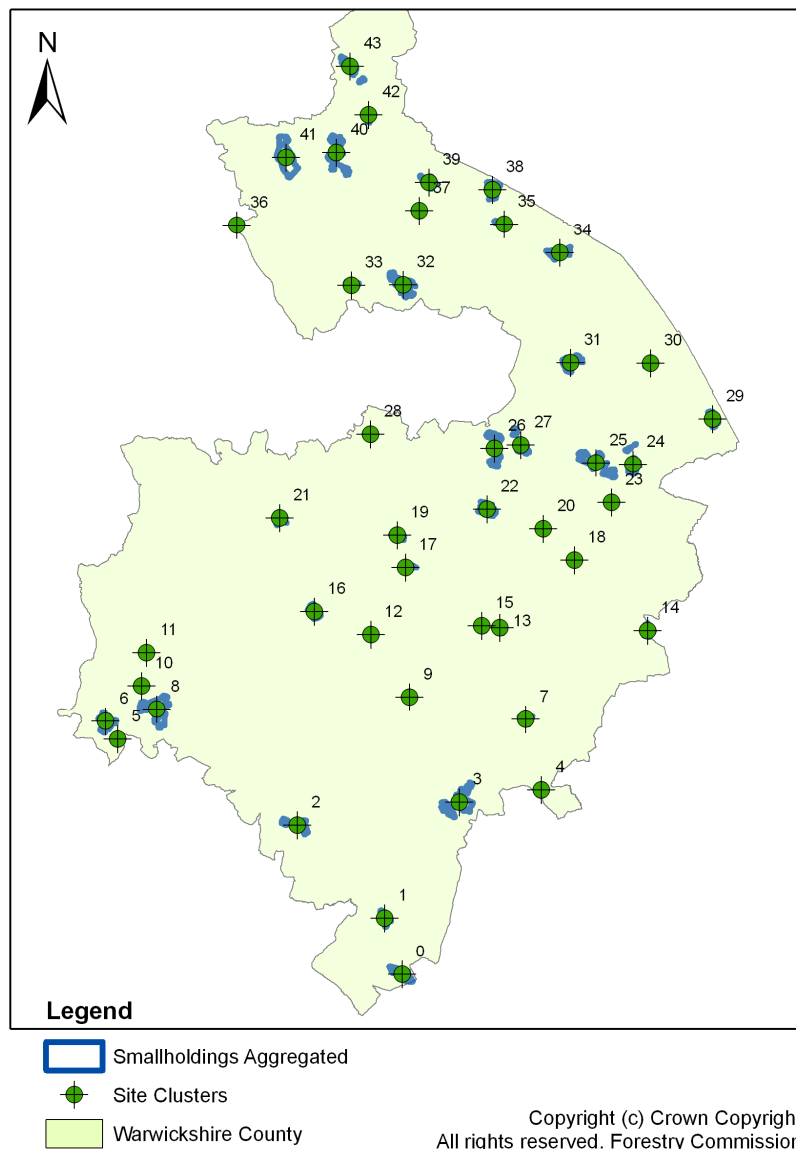
-  Smallholdings
-  Warwickshire County

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Aggregation took an initial data set (Map 1) and converted it into a map of site clusters (Map 2). This was then analysed against a number of site factors to provide a list of sites with significant potential. This short list was then used to decide which sites should be visited sites were then visited

A full, detailed GIS methodology is available in Appendix 1

**Map 2 Aggregated Site Data**



Sites were categorised and graded as:

- A. No obvious constraints to planting at this stage. (22 sites)  
This category contained mainly arable sites with no obvious constraints or minimal issues (ROW etc.). All the sites in the shortlist were of this type
- B. Some constraints or additional work required to make the site suitable for planting. (12 sites)  
This category included sites next to significant residential areas, sites with medium slopes, or with obvious constraints removing part of the site from use, such as a fragmented tenancy or areas of archaeological interest.
- C. Site clearly not viable for energy crop production. (10 sites)  
This category included sites with steep slopes, particularly small sites (<5ha) former quarries and other well established land uses such as country parks or wetlands.

Sites categorised as grade A were put forward to WCC as potential sites to conduct visits subject to approval from site managers, tenants etc (Table 5)

**Table 5 Sites categorised as Grade A for SRC planting using GIS data and Defra Opportunities Maps**

Site No	Site area ha	Tenants	Grid ref	Rating	Comments/ constraints	Defra Ops map classification
3	164.5	R Leach C Price K Welsby	SP 343 454	A	No obvious constraints. Several PROWs <sup>25</sup> across the sites. Land is flat except where it shelves on the east.	Suitable
40	121.7	P R White, K L Simmons	SP 247 967	A	A number of PROWs on site. No other obvious constraints.	Suitable
32	115.4	P Dyson P S Richardson	SP 299 863	A	Site bisected by M6, though the tenancy is split with different tenants on the north and south of the motorway. There are a number of PROWs across the site including the Coventry Way plus 2.5 ha of WCC woodland. Planting on this site could provide useful screening of the motorway. No other obvious constraints.	Suitable
38	94.1	I R Showell	SP 370 938	A	Single PROW on site, possible drains / watercourse. Site relatively near to Weddington and St Nicholas Park so public consultation recommended. No other obvious constraints.	Suitable
22	92	E Wells R Wright	SP 365 685	A	Site is crossed by a number of PROWs, otherwise no obvious constraints. Site is Adjacent to River Leam to the east - SRC may provide habitat benefits.	Suitable
29	62.6	I Birden	SP 543 757	A	No obvious constraints, site could mask nearby radio masts.	Suitable
2	58.9	R S Betteridge, F H Everett	SP 216 436	A	No obvious constraints, several rights of way cross the sites, land is flat.	Suitable
31	55.1	P J Orfeur	SP 431 801	A	Site is crossed by the Coventry Way, no other obvious constraints	Suitable
14	45.4	A H Russell	SP 492 590	A	No obvious constraints	Suitable
1	42.4	N Everett (bulk of the area) P Hitchman 2 small blocks	SP 285 363	A	Land is flat with no obvious constraints.	Suitable

<sup>25</sup> PROW - public rights of way

21	33	R Wallbank	SP 202 679	A	Site is bisected by M40 and rail line otherwise no obvious constraints. SRC planting may be beneficial as a sound barrier.	Suitable
42	28.9	PR White	SP 272 997	A	The site is bisected by the A5. No other obvious constraints. Planting may provide a screening effect from the main road.	Suitable
4	26.3	R Leach	SP 408 468	A	Land is hilly and adjacent to recently felled woodland. No further obvious constraints.	Suitable
15	24.7	JH Wright	SP 361 594	A	Two PROWs near Harbury village. No other obvious constraints	Suitable
17	24.6	G F Moreton, E J Rigby + small WCC areas	SP 301 640	A	Site adjacent to A452 and is adjacent to industrial and trading areas. No obvious constraints. May be close to potential end users.	Suitable
37	20.3	J Brindley	SP 312 922	A	Site is crossed by Centenary Way and relatively near to Galley Common so public consultation recommended. No other obvious constraints	Suitable
13	20.2	J A Boon Harbury Parish Council	SP 376 592	A	Site is adjacent to Bishops Bowl Lakes and may offer some habitat improvement relative to open grazing / arable. Site is reasonably flat and has a single PROW but is adjacent to the Centenary Way so some public consultation on the impact of SRC may be necessary.	Suitable
28	19.6	A Palmer	SP 273 745	A	Houses back onto the site so consideration would have to be given to the impact on the views from these properties. No other obvious constraints	Suitable
12	18.8	P Upstone & unlisted	SP 274 587	A	Site is bisected by a watercourse and adjacent to the A429. Site is flat and has a single PROW.	Very suitable
30	17.9	S R Dew D Whates	SP 495 801	A	Slope may be an issue. Site is adjacent to M6, planting may have a useful masking effect.	Suitable
5	15.0	M H S Jelfs	SP 074 504	A	Site is bisected by A46 and watercourse. No further obvious constraints	Suitable
20	12.2	D H Banks- Price WCC	SP 410 670	A	No obvious constraints	Suitable

## Site visits

Nine of the top ten sites given in Table 3 were visited to carry out a basic assessment as to land suitability for growing SRC. Site 38 at Weddington was withdrawn from the list as WCC have provided a large expenditure on the farm to convert it to an intensive dairy unit so using any of the land for SRC production is no longer economically feasible.

Table 6 gives basic comments on the suitability of the land at the 16 farms making up the nine sites. The vast majority of the fields were down to grassland for sheep or cattle grazing; a number had been down to maize in 2009 whilst a few were in arable production. The main constraints to SRC production were slopes and the presence of neighbouring properties where their views would be compromised. Other obvious features which would not prevent SRC production but would increase the unplanted areas within fields were the presence of power lines, public rights of way (PROWs), ponds and lagoons. Most of the fields were of a good size and generally surrounded by hedgerows which could not be removed so would potentially need 3m unplanted rides alongside them to allow for maintenance (depending on the direction of planting within the fields - 8m headlands are needed at the end of rows for vehicle turning). Access to some fields may need to be widened if SRC is to be grown due to the angle of turn into the fields. SRC harvesters are 4m wide and up to 9.5m long so turning into the fields from access tracks must be considered at establishment - not at harvesting.

# Site assessments

**Table 6 Farm visits to nine of the most suitable tenanted Grade A sites for SRC**

Site No	Site area ha	Grid ref	Date of visit	Tenants	Comments
3	164.5	SP 343 454	7.4.10	Mr C Price, Herberts Farm, Middle Tysoe	Land flat with slight slopes in westerly fields but deep ridge & furrow in others; most of good size. Down to grassland for sheep grazing. PROWs & power lines cross a number of the fields. Access track for WWTW crosses the centre of three fields. No neighbouring properties adjacent to the majority of the fields. Access track good but some field gates may need widening due to angle of turn.
				Mr K Welsby, Hopkins Farm, Lower Tysoe	Only the westerly fields are level enough for SRC, those to the east are too steep. All down to grassland with deep ridge & furrow in some fields. PROWs & streams cross a number of fields.
				Mr R Leach, land at Lower Tysoe	All fields of good size and flat although slight ridge & furrow in some. Soils clay/loam in places. Most fields in grassland although at least one in arable production. Few neighbouring properties apart from those across the road from the most southerly field at Lower Tysoe. PROWs cross a number of the fields but no power lines. Mr Leach apparently has his main farm away from Lower Tysoe.
40	121.7	SP 247 967	23.03.10 8.4.10	K L Simmons, Poplars Farm, Wood End	Initially refused access to the land. Most fields flat or gently sloping & of good size. The land is at a highpoint so has extensive long distance views particularly to the west. The soils are mixed with clay & black land in localised pockets; some areas stand wet. Some fields have been drained 3 times but still hold water as land sits over ex-mine workings which leads to the wet conditions and continued slow subsidence - difficult to drain as some land is now below the level of the local ditch. A spring in the fields to the west of the farm runs continually; the drain in these fields put in only 30cm below ground surface. Only 4ha of the site has never been ploughed in the last 50 years. There are neighbouring properties to the NW boundaries of the land which may have significant long distance views. Localised rabbit populations. PROWs cross a number of the fields; no powerlines. Gates generally 12' wide; one 15' wide.
				P R White, (Swan Farm - away from Hurley)	Good, large fields but with steep slopes. Significant views across Birmingham. PROWs cross a number of the fields.
32	115.4	SP 299 863	23.03.10	P S Richardson, Corley Hall Farm, Corley	Fields behind the farm buildings (western fields) sloping but not too steep. Mr Richardson had been told by previous tenant not to plough the field immediately to the back of the farm due to the shallow soils sitting on bedrock. This field slopes but not significantly; HT power lines cross it and one mature tree within it on old field boundary line. Also adjacent to mature, mixed woodland which suggests SRC could grow but soil depth would need to be checked. Other fields had been ploughed at times but virtually all now down to grassland for dairy herd. Field size relatively small but fences could be removed in places if necessary to enlarge them. Two fields across the road from the farm are flat; one down to grassland

					contains large, fenced pond whilst the other down to maize. No real problems with blocking views from neighbouring properties. Access good. Two silage clamps at the farm currently used to store food for livestock; cement base and walls so could be used to store wood chip.
				8.4.10	P Dyson, Radbrook Farm, Corley Most of the land flat but two small fields adjacent to the motorway sloping (one, with Nissan hut within it, also has a gypsy family currently in residence). Most of the fields of good size. Soils mixed; mid-range with some clay leading to wet & dry areas. Down to either grassland for dairy herd or maize. No problems with neighbouring properties. High population of rabbits had built up but Myxomatosis reduced the numbers in 2009. PROWs, power lines & ponds in most fields. Plenty of hard standing currently used for feed & silage; Dutch barns.
22	92	SP 365 685		7.4.10	E Wells, Bridge Farm, Hunningham Land very gently sloping or flat with good size fields. Primarily down to grassland with one field in cultivation. Neighbouring properties to the north of the site (on Alderman Way) with potential long views. PROWs cross some fields; lone trees within fields in places. No powerlines. R Wright, Bridge Barn Farm, Hunningham Fields flat although with remnants of ridge & furrow in places; most of good size. One field ploughed with powerline crossing it, the remaining fields grassland for sheep grazing. PROWs cross some of the fields although mainly along field edges. Fields adjacent to Hunningham Bridge overlooked by public house on the opposite side of the road.
29	62.6	SP 543 757		8.4.10	I Birden, Dunsmore Home Farm, Clifton upon Dunsmore Fields all of good size and flat apart from the smaller fields immediately to the south of the farm buildings. Soils mainly clay with loam in the northern fields. All down to grassland (sheep grazing) and maize. One neighbouring property & a nursing home adjacent to the farm overlook the fields but are at such a height that SRC will not detract from the significant long distance view. Both rabbits & hares present. No PROWs or powerlines. Access good to land although tight bend on track immediately before farm entrance but there has apparently already been some discussion regarding widening the track at this point. Barns & hard standing available for chip storage. Miscanthus currently being grown by neighbouring farmer in two adjacent fields.
2	58.9	SP 216 436		7.4.10	F H Everett, Wharf Farm, Ilmington Land mainly flat with any slopes not steep; some ridge & furrow present which could prove to be difficult. Soils heavy clay. All fields now down to arable apart from one for horse grazing as the original dairy operations have been moved to Camperdown Farm, Cherington. The triangular field to the north of the track into the farm is "a pain" due to its small size, <1ha & that it lies wet. No neighbouring properties although the southerly fields do have significant long distance views from the road. High

						<p>rabbit population. Although there are no PROWs marked on the map there are apparently some crossing the land. Powerlines cross the north easterly field. Access is good. The slurry lagoon to the south of the farm is no longer used but surrounded by planted willow and not available for agriculture.</p>
					R S Betteridge, Mabels Farm, Ilmington	<p>Most of the fields to the east of Ilmington (adjacent to those of Wharf Farm) are flat &amp; of good size although the field immediately to the east of Ilmington (recently ploughed grassland) is both overlooked by neighbouring properties and also has a powerline crossing the centre of the field. The fields to the west of Ilmington are quite steep &amp; down to grassland.</p>
31	55.1	SP 431 801	23.03.10		P J Orfeur, Brierley's Farm, Brinklow	<p>Land flat with fields of good size. Soils mixed, generally satisfactory but most fields tend to stand wet - one field has recently been underdrained to prevent flooding. Down to grassland for sheep grazing plus some arable. One field "cold" due to the amount of manure added over the years so does not grow crops well but should be suitable for SRC. Neighbouring properties overlook the southern fields from opposite roadside and behind hedge. PROWs &amp; powerlines cross some fields. Access good. Hardstanding &amp; barns at farm. Mrs Orfeur would only consider SRC if the payments were in line with current crop prices.</p>
14	45.4	SP 492 590	7.4.10		A H Russell, North Fields Farm, Priors Marston	<p>All of the fields are flat apart from the most northerly field which slopes downhill to the north, away from the farm. Fields of a good size &amp; surrounded by well-managed hedges. Soils mainly heavy clay; 90% of land down to grassland although no livestock currently on the farm. No neighbouring properties. Few localised rabbits but a number of hares present. One PROW marked; no power lines. Machinery access good. Hard-standing area near farmhouse with many apparently unused barns also potentially available.</p>
1	42.4	SP 285 363	7.4.10		Nigel Everett, Camperdown Farm, Cherington	<p>Slopes "very gentle" according to Nigel Everett but too steep in places for SRC. Soils a mix of heavy clay in places with sand in others. Large dairy herd so all land to pasture apart from a 1.5ha field (east of Little Orchard Farm). No significant problems due to overlooking properties but SRC would block views from the farm. High population of rabbits. PROWs present across some of the fields. Slurry lagoon in field to the north of the farm. Access to all fields is good. A number of barns &amp; areas of hardstanding suitable for chip storage. Fields opposite the farm and adjacent to Little Orchard Farm are the most suitable for SRC. "If SRC is to be grown then it has to be economically viable and provide similar or better returns compared to dairying."</p>
					P Hitchman	<p>One field only with poor access - a car is passable but not machinery. It is a relatively flat field with slight ridge and furrow evident. The field has been used for sheep grazing but will now be used for a herd of alpacas.</p>

Table 7 shows the 16 farms in a hierarchy of suitability for SRC with number 1, site 14, North Fields Farm at Priors Marston potentially being the most ideal. The first six farms within the list are the most suitable farms for SRC, the following eight being less so. Total site or farm hectareage is given plus a very rough estimate of the hectareage that may be available for SRC production having taken into account slopes or neighbouring properties. This does not, however, take into account land areas that must be left unplanted for vehicle turning headlands, rides, PROWs, power lines and land around trees, ponds or any archaeological features if present.

**Table 7 Hierarchy of most suitable tenanted sites for SRC production**

<b>SRC hierarchy</b>	<b>Site Nº</b>	<b>Total site area ha</b>	<b>Potential SRC area ha</b>	<b>Tenants</b>	<b>Comments</b>
<b>1</b>	14	45.4	45.4	A H Russell, North Fields Farm, Priors Marston	Land away from overlooking properties; currently not used for livestock or crops; fields flat; hard standing & barns available for storage. Potentially an ideal site.
<b>2</b>	3	61.7	46.9	R Leach, land at Lower Tysoe	Land flat; few neighbouring properties; fields apparently situated away from the main farm. A good potential site.
<b>3</b>	29	62.6	59.0	I Birden, Dunsmore Home Farm, Clifton upon Dunsmore	Most fields flat; may need to take into consideration views from neighbouring properties; storage area available in barns. A good potential site.
<b>4</b>	2	28.0	28.0	F H Everett, Wharf Farm, Ilmington	Land flat; few neighbouring properties; some ridge & furrow to be considered; hard standing & barns for storage.
<b>5</b>	22	92.0	81.7	E Wells, Bridge Farm, Hunningham	Land mainly flat; fields of good size; some neighbouring properties overlooking part of site.
<b>6</b>				R Wright, Bridge Barn Farm, Hunningham	Good sized, flat fields; only one neighbouring property.
<b>Total ha:</b>	<b>289.6</b>	<b>261.0</b>			
<b>7</b>	3	51.5	51.5	C Price, Herberts Farm, Middle Tysoe	If land at Lower Tysoe (2) planted with SRC, fields here

					could be used if required.
<b>8</b>	3	51.4	36.6	K Welsby, Hopkins Farm, Lower Tysoe	If land around Lower Tysoe is planted with SRC & more is required, the flatter westerly fields here could be used dependent on ridge & furrow.
<b>9</b>	31	55.1	53.7	P J Orfeur, Brierley's Farm, Brinklow	
<b>10</b>	32	115.4	111.1	P Dyson, Radbrook Farm, Corley	Considered as one block of land.
<b>11</b>	32			P S Richardson, Corley Hall Farm, Corley	
<b>12</b>	2	28.1	24.6	R S Betteridge, Mabels Farm, Ilmington	If required, some fields here could be brought into SRC production in addition to any planted at Wharf Farm (4).
<b>13</b>	40	42.4	36.4	K L Simmons, Poplars Farm, Wood End	
<b>14</b>	1	42.4	40.0	Nigel Everett, Camperdown Farm, Cherington	
<b>Total ha:</b>	<b>386.3</b>	<b>353.9</b>			
<b>15</b>	3			P R White, (Swan Farm - away from Hurley)	Most not suitable.
<b>16</b>	1			P Hitchman, Cherington	Not suitable.

When assessing potential sites for the production of SRC the following features need to be taken into account:

- Slope - ideally not more than 7%; definitely not more than 15%.
- Size and shape of fields - there is no set minimum size but available row lengths should be considered plus economies of scale particularly with regard to harvesting.
- Soil type.
- How the SRC will fit aesthetically into the surrounding landscape.
- Views from neighbouring properties and PROWs.
- Access - not just access into fields but also bridge heights, widths and weight restrictions leading to the site.
- Amount of unplanted area - vehicle turning headlands are required plus rides if hedges have to be maintained, PROWs are present or natural breaks have to be placed across the rows if the fields are more than 400m in length. Features such as powerlines,

wayleaves, ponds, trees, archaeology, etc will all have to have unplanted areas around them.

- Availability of suitable storage area for the harvested SRC as close as possible to the plantation to minimise haulage and the need for multiple tractors and trailers at harvest.

## Site Assessment for Forestry and SRF development

There are a number of options for planting and management trees for biomass which do not fall clearly into either agricultural or forestry categories. A number of site visits were conducted at sites deemed to be marginal for SRC but which offered some potential for less conventional silvicultural systems. These sites were situated across the whole county and had a range of existing land use types.

Several of the sites were assessed during the desk exercises associated with the SRC site selection work, but existing site constraints lead to them being dropped from the SRC field survey.

The areas considered for SRF were:

- Shipston School (3.2ha)
- Cherry Orchard Landfill site (4.7ha)
- Polesworth School (6.7ha)
- Stockton Landfill Site (7.1ha)
- Pineham Farm (10.0ha)
- Coney Grey Farm (11.4ha)
- Hell Hole Landfill Site (27.5ha)

There are a number of variations possible for planting on these sites. The energy crops scheme (ECS) provides grant funding for biomass planting of a number of native broadleaves species, to be managed as coppice. This money is available for establishment providing that the biomass produced has an established buyer, which could also be a WCC installation. An important decision at this stage is how any planting should be funded, as all of these grant schemes

**Map 3 SRF Sites**



**Legend**  
 SRF Inspection Area

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have their own specific requirements and funding rates.

Results of the field visits are summarised in Table 8. All of the sites offer some potential although each site has its own challenges. The largest site, Hell Hole Landfill, has problems with trespass which could lead to new plantings being damaged. However, as this area is already being used by the public there may be some potential in developing the site as a community forest which could provide facilities for dog walkers, horse riders, ramblers and possible play areas or education facilities. There are woodland areas on either side of the site, any planting on site would have the effect of joining these habitats. There is a large amount of guidance available on establishing woodland on brownfield sites and landfill. This should be studied before embarking on any planting schemes.

**Table 8 SRF site visits**

Site	Area (ha)	Site Condition	Constraints / Other Notes	Possible Planting / management	Opportunities
Shipston School	3.2	The site is rented out for grazing at present, bringing in a small amount of income (~£300/yr). However the site is reverting to Hawthorn / bramble scrub and will need some management to retain grazing value.	Power lines cross the site and there is a drainage ditch which limits access for machinery. The site is likely to require fencing against damage from rabbits on new planting.	Either conventional mixed broadleaf (BL) coppice or fast growing BL species (eg Birch or Poplar) managed on 10-15yr rotation	The site presents a good opportunity to provide a resource for adjacent school either through woodfuel, or as an educational resource. The open area that would be required under the power lines could allow planting while retaining an open area for educational facilities. It may be worth considering whether funding could be made available from educational sources to provide an educational resource (eg an outdoor classroom) on site.
Cherry Orchard Landfill site	4.7	The site has 10-15% existing amenity planting. The site has a number of slopes which could affect machinery access. There are no obvious problems with soil or contaminants on site.	There are a number of paths crossing the site which is surrounded by housing. The site has formerly been used for landfill. Any planting on the site should take this into account. The site is adjacent to a public waste	Mixed BL planting to expand existing woodland area, while retaining glades and public footpaths. Particular attention should be given to rooting depth and species type <sup>26</sup> to prevent root penetration of the clay cap on	The site presents a good opportunity to develop a local community woodland. Trees could be harvested and then dried in the adjacent waste recycling facility. This facility also has a shop which could stock logs from the woodland for sale as local fuel.

<sup>26</sup> **Crow, P. 2005**. The Influence of Soils and Species on Tree Root Depth. *Forest Research Information Note*. [http://www.forestry.gov.uk/pdf/fcin078.pdf/\\$file/fcin078.pdf](http://www.forestry.gov.uk/pdf/fcin078.pdf/$file/fcin078.pdf)

			recycling centre. There is some evidence of rabbits on site and any planting should take this into account.	the landfill material.	
Polesworth School	6.7	The site is composed of a 4.5ha field used by the school for sports and area of 2.2ha which appears to be used for grazing. The sites appear to be fertile, but there appears to have been significant landscaping work carried out the school field – this may imply poor soil quality and/or depth.	The school is concerned about public access to the site, and would be unlikely to welcome development of community woodland.  While the site appears to be well drained and fertile, it is unclear if sufficient rooting depth would be available for tree crops on site.	SRC would be possible on the larger of the 2 areas, but the smaller area has fairly tight constraints in terms of access. Alterations would need to be made to boundaries on the site to allow access. Woodland with a longer rotation length may be preferable to local interests to maintain the screen from the motorway, this may favour a longer rotation crop managed for larger diameter material.	The site lies between an area of housing and the villages of Polesworth and Dordon and the M42. Any planting on the site could provide valuable sound and visual screening from the motorway. The proximity of housing and playing fields indicate that there may be interest locally in community woodland – though this would have to be reconciled with the local school's concerns regarding access.
Stockton Landfill Site	7.1	Around half of the site is currently used for grazing and the remainder is rough scrub land.  Within the scrub area, there is a large amount of natural regeneration of native broadleaves (Hawthorn and Ash)	The site has formerly been used for landfill. Any planting on the site should take this into account. Particular attention should be given to rooting depth and species type to prevent root penetration of the clay cap on the landfill material.  It is understood that there are	Either conventional mixed broadleaf (BL) coppice or fast growing BL species (eg Birch or Poplar) managed on 10-15yr rotation	The site is currently unproductive and of very limited economic value. Biomass planting could be a beneficial use of the site to provide a useful source of income.  No obvious further non timber benefits on the site.

		There is evidence of a large rabbit population on site, and the soil quality appears to be relatively poor.	ecological interests on site and these should be taken into account when management decisions are made. Ploughing with agricultural equipment is likely to be problematic due to the amount of large stony material. There is existing woodland bordering the site and there are unlikely to be any other significant problems.		
Pineham Farm	10.0	The site is composed of 4 fields of improved grazing land	There are no obvious constraints to planting this site	The site would be appropriate for a wide range of different planting schemes including SRC	No obvious further non timber benefits on the site.
Coney Grey Farm	11.4	The site is composed of 2 fields restored from sand extraction works. The soil is poorly restored with standing water and bare earth on areas of the site. The farm has an extended area of hard standing and barns. There is a block of ≈1.7ha of poplar woodland on the west of the farm which is due to be harvested relatively soon.	The site is likely to need further investment in soil amelioration. While planting could be conducted with a fair expectation of tree growth, it is unlikely however to give a high yield. Planting on site may be opposed by Coventry airport as providing habitat for birds in flight paths.	Pioneer species such as birch may give an adequate crop. Other species would probably need some form of soil improvement before planting.	The site is next to a number of industrial units and Coventry Airport. There is potential to use the site for fuel storage and processing for delivery to the Coventry area.

Hell Hole Landfill Site	27.5	<p>The site has soils of variable quality and a number of areas of contamination where material is showing through the cap, or leachate is leaking into the soil. The cap is of variable depth as the site has been in use for a long period of time. There is a variable thickness of topsoil on site with little further information available.</p> <p>The site includes <math>\approx</math> 6ha of existing woodland</p>	<p>The site is being trespassed on frequently by members of the public for various activities including equestrian, shooting and off road biking. There appear to be active deer, badger, and rabbit populations on site. Further survey work is likely to be needed to establish the topsoil depth and any contamination issues.</p>	<p>There is potential for widespread planting on the site to reduce the risk of topsoil erosion and join woodland habitat both from the North East and the West. Expansion of the existing woodland would increase the biomass resource on site and could improve site conditions for other species.</p> <p>Particular attention should be given to rooting depth and species type to prevent root penetration of the clay cap on the landfill material.</p>	<p>There is a significant challenge in managing public access on the site though this could lead to opportunities for further site development at a later date.</p> <p>The site is currently unproductive and of very limited ecological value, planting woodland would provide a useful income from the site which could be used to provide further site amelioration.</p>
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Pictures and maps of the sites are available attached to this document in appendix 4

## Project implementation and delivery options

### Volumes of fuel required

Using a dataset showing current gas and oil use at a number of schools across Warwickshire (data supplied by WCC) estimates of the tonnes of wood chip required to displace currently used fossil fuels were made. Fuel requirement estimates were made assuming two different types of boiler operation. Under the first scenario it was assumed that biomass boilers would produce 60% of the total heat requirement of each school. The second scenario assumed that the entire heat load of each school would be provided by biomass. These fuel requirement estimates were then converted to estimates of the area of SRC required to produce the fuel. These estimates were made using the following assumptions:

Calorific value of SRC wood chip (at 50% MC)	2300kWh per tonne
Calorific value of SRC wood chip (at 40% MC)	2896 kWh per tonne
Calorific value of SRC wood chip (at 30% MC)	3491 kWh per tonne
Moisture content of SRC at harvest	50%
Yield of SRC	8 odt per ha per year
Post harvest losses through storage and haulage	5%
Efficiency of current fossil fuel boiler systems	90%
Efficiency of biomass boiler systems	85%

The Excel spreadsheet used to make these estimates has been provided to WCC as a separate output under this contract. All of the assumptions listed above can be adjusted in the spreadsheet to create fuel use and land area requirements according to how the council wishes to develop its bioenergy policy and implementation plan.

Table 9 shows the results of this exercise. If all 32 schools assessed were to be equipped with biomass boilers able to burn wood chip at 40% MC and biomass provided 60% of the total heat demand then approximately 562ha of SRC would be required to provide sufficient fuel (assuming a yield of 8odt/ha/yr is achieved). A more likely scenario could be that biomass boilers are installed as current fossil fuel boilers reach the end of their life span or as schools are refurbished. A programme of this kind applied to perhaps ten schools across the county would require in the region of 150 – 250ha of SRC to provide sufficient fuel. The exact area will vary depending on the heat demand of the individual schools involved. Table 7 shows that there is the potential to meet this demand easily from existing WCC land holdings provided tenant farmers could be persuaded to grow the crop or land was taken back 'in hand' by the council. The six most promising sites alone could potentially provide around 260ha of SRC.

It is suggested that when developing a biomass implementation plan, care should be taken when specifying fuel requirements of the boiler fleet. Although systems able to cope with very wet (50% MC) wood chip should be able to burn fresh SRC chip and wood chip produced from tree surgery, fuel handling equipment able to deal such wet, 'sticky' fuel may add considerable expense to an installation. However, it may not always be possible to dry SRC chip or chip from tree surgery operations to 30% MC which is often specified by end users and generally requires more modest fuel handling equipment. A compromise would be to install boilers able to use wood chip at 40% MC as it should be possible to dry SRC and tree surgery chip to this level by natural air drying and the fuel should be easier to handle than chip at 50% MC. Boilers and fuel feed systems able to deal with potentially irregularly sized wood chip may also be required if SRC and tree surgery material is used. Care should also be taken to ensure that boilers are correctly sized for their application (oversize boilers are inefficient and add more expense to an installation) and matched to an adequately sized fuel. More detailed advice should be sought from boiler installers at the time.

**Table 9 Actual fossil fuel (winter 2008/09) and estimated biomass fuel use and associated land area requirements for 32 schools in Warwickshire**

Name/address	Fuel Consumpti on (Gas, kWh)	Fuel Consumpti on (Oil, kWh)	Proportion of gas heat displaced by biomass	Proportion of oil heat displaced by biomass	kWh of heat to be supplied by biomass	Assumed efficiency of fossil fuel system (%)	Assumed efficiency of biomass system (%)	Biomass fuel requirement (tonnes of wood at 40% MC)	Assumed yield of SRC (odt/ha/y)	Yield through storage, transport and handling (%)	Total area of SRC required to supply sufficient 40% MC chip (ha)	Annual harvest to supply sufficient 40% MC chip
STUDLEY/High School, Humanities & Music College, Crooks Lane	316,192	292,431	60%	60%	365,174	90%	85%	132	8	5%	10	3.3
WARWICK/Myton School A Specialist Science College & Training School	1,604,867	0	60%	0%	962,920	90%	85%	349	8	5%	26	8.7
KENILWORTH/School and Sports College (Foundation), Castle Hall (Sixth	475,034	0	60%	0%	285,020	90%	85%	103	8	5%	8	2.6
STRATFORD-UPON-AVON/Stratford Grammar School for Girls A Specialist, C	455,122	0	60%	0%	273,073	90%	85%	99	8	5%	7	2.5
LEAMINGTON SPA/North Learnington Community School & Arts College, Upper	234,030	0	60%	0%	140,418	90%	85%	51	8	5%	4	1.3
HENLEY-IN-ARDEEN/River House School, Stratford Road	207,971	0	60%	0%	124,783	90%	85%	45	8	5%	3	1.1
SHIPSTON-ON-STOUR/Shipston High School, a Specialist Technology Col,	800,676	0	60%	0%	480,406	90%	85%	174	8	5%	13	4.4
DORDON/Polesworth International Language College, Dordon Road	1,677,564	0	60%	0%	1,006,538	90%	85%	364	8	5%	27	9.1
RUGBY/Bilton School A Maths & Computing College, Lawford Lane	1,559,290	0	60%	0%	935,574	90%	85%	339	8	5%	25	8.5
BEDWORTH/Nicholas Chamberlaine Technology College, Bulkington Road	4,268,559	0	60%	0%	2,561,135	90%	85%	927	8	5%	70	23.2
HENLEY-IN-ARDEEN/High School, Stratford Road	1,004,014	0	60%	0%	602,408	90%	85%	218	8	5%	16	5.5
RUGBY/Lawrence Sheriff School, Clifton Road	1,076,667	0	60%	0%	646,000	90%	85%	234	8	5%	18	5.9
RUGBY/Harris School, Harris Drive, Overslade Lane	1,202,376	0	60%	0%	721,426	90%	85%	261	8	5%	20	6.5
HARTSHILL/School (Foundation), Church Road	1,182,349	0	60%	0%	709,409	90%	85%	257	8	5%	19	6.4
STRATFORD-UPON-AVON/King Edward VI School, Church Street	1,152,923	0	60%	0%	691,754	90%	85%	250	8	5%	19	6.3
NUNEATON/Manor Park Community School & Specialist Arts, College	920,346	0	60%	0%	552,208	90%	85%	200	8	5%	15	5.0
LEAMINGTON SPA/Campion School, Sydenham Drive	1,471,212	0	60%	0%	882,727	90%	85%	320	8	5%	24	8.0
COLESHILL/The Coleshill School - a Maths & Computing College, Coventry	1,447,912	0	60%	0%	868,747	90%	85%	315	8	5%	24	7.9
RUGBY/Ashlawn School, Ashlawn Road	1,904,606	0	60%	0%	1,142,764	90%	85%	414	8	5%	31	10.4
NUNEATON/St Thomas More Catholic School & Technology, College	770,632	0	60%	0%	462,379	90%	85%	167	8	5%	13	4.2

Name/address	Fuel Consumpti on (Gas, kWh)	Fuel Consumpti on (Oil, kWh)	Proportion of gas heat displaced by biomass	Proportion of oil heat displaced by biomass	kWh of heat to be supplied by biomass	Assumed efficiency of fossil fuel system (%)	Assumed efficiency of biomass system (%)	Biomass fuel requirement of wood at 40% MC)	Assumed yield of SRC (odt/ha/y r	Yield loss through storage, transport and handling (%)	Total area of SRC required to supply sufficient 40% MC chip (ha)	Annual harvest to area supply sufficient 40% MC chip
NUNEATON/Higham Lane School A Business & Enterprise College, Shanklin	1,391,953	0	60%	0%	835,172	90%	85%	302	8	5%	23	7.6
NUNEATON/Alderman Smith School, Radnor Drive	1,359,091	0	60%	0%	815,455	90%	85%	295	8	5%	22	7.4
RUGBY/High School (Foundation), Longrood Road	682,604	0	60%	0%	409,562	90%	85%	148	8	5%	11	3.7
NUNEATON/Etone Technology Language Vocational College, Leicester Road	1,287,764	0	60%	0%	772,658	90%	85%	280	8	5%	21	7.0
WARWICK/Aylesford School. A Specialist Language & Music Co, Shelley Av	1,333,752	0	60%	0%	800,251	90%	85%	290	8	5%	22	7.3
WARWICK/Round Oak School & Support Service, Brittain Lane	386,680	0	60%	0%	232,008	90%	85%	84	8	5%	6	2.1
ALCESTER/St Benedict's Catholic High School, A Maths & Computing Coll	414,836	0	60%	0%	248,902	90%	85%	90	8	5%	7	2.3
SOUTHAM/College, Welsh Road West	1,072,725	0	60%	0%	643,635	90%	85%	233	8	5%	18	5.8
LEAMINGTON SPA/Trinity Catholic School, A Specialist Arts and, Technol	1,008,464	0	60%	0%	605,078	90%	85%	219	8	5%	16	5.5
NUNEATON/George Eliot Community School, a Business & Enterprise Colle	698,889	0	60%	0%	419,333	90%	85%	152	8	5%	11	3.8
ALCESTER/High School Technology College, Gerard Road	646,689	0	60%	0%	388,013	90%	85%	140	8	5%	11	3.5
<b>Total fuel requirement (tonnes)</b>								<b>7453</b>			<b>561</b>	<b>186.8</b>
<b>Total areas (ha):</b>												

## Fuel costs: fossil fuels vs. biomass

There is significant variation in the price of biomass fuel around the country as factors such as local demand, local availability, competition between suppliers, delivery distances and load size can all influence cost. Similarly, the fossil fuel market has been volatile over the last three years which makes price comparisons between biomass, gas and oil difficult and also go rapidly out-of-date. An 'average' price for a tonne of wood chip at 30% MC from forestry operations is around £80 delivered although prices in the range of £50 to £90 may be encountered. At £80 the price per kWh is 2.3p which compares well with oil (around 4.4p per kWh at the time of writing) and gas (around 4.1p per kWh at the time of writing).

Wood chip from SRC is generally sold to large power generators rather than the heat market. The power generation market is a high volume, low value market which pays around £20 to £40 per tonne of 40% MC chip depending on haulage arrangements. At these prices it is difficult to recruit new SRC growers as margins are very tight compared to other land uses. However, if the same material can be sold to the heat market then higher prices may be achieved. For example, a price of £57 per tonne delivered for 40% MC chips from SRC gives the end user a competitive fuel cost (1.97p per kWh) and should also provide a financial incentive for the grower. After the cost of production, harvest and haulage and assuming a yield of 8odt/ha/yr and land rent of £85 per ha (data supplied by WCC) it is estimated that the annualised return on 1ha of SRC is around £285 per ha (not including any single farm payment entitlement).

The relationship between fuel price, crop yield, production, harvest and haulage cost and land rent is complex. The Renewable Heat Incentive will also influence these relationships and could effect what an end user may be prepared to pay for fuel. This incentive, payable to the boiler owner, is due to take effect from April 2011. Government held a consultation exercise on the incentive (which applies to other renewable heat technologies such as solar and heat pumps as well as biomass) during 2010 and suggested the incentive could be set at 6.5p per kWh for boiler in the range of 46 – 500kW and 2.5p per kWh for larger systems. These values may change following the consultation exercise. To allow WCC to explore the relationship between capital cost, fuel cost and RHI a simple spreadsheet model has been produced and is delivered as a separate output. As delivered the model contains gross assumptions about the capital cost of boiler installations and likely boiler sizes – more accurate estimates of these variables fall beyond the scope of this project but should be made before business decisions are made.

Using data presented in table 7, making crude assumptions about capital costs and likely boiler size (and hence RHI payment) payback periods were in the region of 8 – 15<sup>27</sup> years for boilers up to 500kW, at current fossil fuel prices and using SRC either grown on contract and bought in at £57 per tonne at 40% MC or 'home grown' by WCC and bought at a price of £50 per tonne at 40% MC. Larger schools such as Bedworth may need boilers above 500kWh to supply

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<sup>27</sup> Compared to an approximate boiler lifespan of 20 years

sufficient heat. This reduces the level of RHI payment on a kWh basis and increases the length of payback. However, significant savings can still be realised if payback periods are extended. Using data from WCC and assuming the price of gas remains at 4.1p per kWh for the next 10 years the gas bill for Bedworth over the next decade could be in the order of £1.9million. Using a biomass boiler to produce 60% of the heat demand could save in the region of £900,000 during this period although the total system payback period is likely to be extended over several decades. Using biomass to supply 65% of the heat could deliver a further £100,000 saving. It should be stressed that these estimates, and the models that generated them, are crude and should not be relied on alone to develop business decisions, however, results from the models suggest significant savings if schools used biomass to provide their base load heat demands. Also, the RHI payments may change from those suggested in the consultation document and that payment will be made according to a heat meter or 'deeming' process which calculates likely heat loads of specific buildings to prevent boilers being run unnecessarily to generate income.

## Costs of land use change

In parallel to the investigation into the relationship between fuel cost, RHI, capital and payback time a model was developed to examine how market price, production, haulage and harvest cost, yield and land rental could affect income to the SRC grower. This is developed as a separate output. This work suggests that the annualised margin per ha after production, haulage and harvest and land rental (data supplied by WCC, £185 per ha per year) costs have been accounted for (with support from the energy crops scheme but excluding SFP) is around £285 assuming a yield of 8 odt/ha/yr. This increases to £449 if yield is increased to 10odt/ha/yr and falls to £223 if only 7odt/ha/yr is achieved. This change of land use would be no of cost to WCC as tenants would still be paying land rental.

The possibility of WCC taking land back 'in hand' to grow SRC was also investigated. Under this scenario the annualised margin would increase to £373 per ha, even if SRC was then being sold to the end user (schools) at £50 per tonne delivered (at 40% MC) instead of £57 as assumed in the 'SRC contract grown by tenant' scenario. This compares very favourable to the current income per ha generated by renting land to tenants (£185 per ha on average, Carolyn Cox *pers comm.*). This suggests that it may be beneficial for WCC to carefully consider taking land back in hand if it is going to deploy biomass boilers on its estate. This approach could also give some level of energy security.

There is little information on the effect SRC has on the sale value of land. Anecdotal evidence suggests that local circumstance will dictate where SRC is seen as a negative or positive SRC could be considered a benefit if a firm market for the crop exists nearby and the crop is well managed. On the other hand a poorly managed crop with no market may not be an attractive proposition and land values would fall. However, it has been reported that small blocks of SRC have changed hands at higher than expected values where the coppice can be used as a game cover.

It is likely that if SRC has been removed from a site (after 20 – 30 years) and arable or grazing land restored then drainage will need replacement or repair. WCC land agents suggest that this will cost in the region of £1.80 - £3.00 a meter for laying plastic pipe and around £60.00 – 75.00 per hectare for mole draining (Carolyn Cox *pers comm.*)

## Contract, staffing and processing options

### SRC

To date, contracts between SRC growers and biomass end-users have generally been for ten years' duration (one year's establishment plus three 3-year harvest cycles), occasionally with a break-point at five years to allow the grower to end the contract should he wish to. This equates to the five year duration of the ECS Establishment Grant: if the crop is removed before it has been in the ground for five years after planting then the grant plus interest would have to be repaid to Natural England. All contract prices have been paid on an oven dry tonne basis, with RPI linking generally on an annual basis from the date of contract signing although one end-user did use RPI linking from the date of first harvest. Some contracts will be paid ex-farm (the end-user covers haulage costs) whilst others will be a delivered price (the grower covers haulage costs). Currently there is little difference between the overall prices paid for SRC wood chip by the large biomass end-users.

Grower contracts with specific end-users dictate that all of the SRC produced from the contracted set hectareage will be supplied to the end-user. Supplier contracts with end-users are far more flexible *for the grower* as he will supply harvested SRC to the end-user as and when he is able or wishes to do so. Contracts that stipulate supply of a set or minimum tonnage of wood chip with financial penalties in place if the grower does not achieve the tonnage are not recommended. Too many factors could cause the grower to be unable to achieve a set tonnage and it is unlikely that a farmer would sign up to this form of agreement.

If farmers are to grow SRC on behalf of WCC they will need proof in the form of a contract (or at least a letter of intent stating that WCC will take the harvested crop) from WCC in order for them to be eligible to apply for the Establishment Grant. When farmers are looking into growing SRC one of their first questions will be the guaranteed price they will be paid for the wood chip. Contracts will be of secondary importance but the simpler and shorter they are the easier it will be for farmers to accept them.

There are currently two experienced companies in England who carry out SRC planting and harvesting and also supply the appropriate willow varieties. They have their own specialist planting and harvesting machinery for the work whilst one further company is equipped to carry out willow harvesting. The two companies have 12 and seven years' experience of planting and harvesting commercial SRC. It is important to ensure that the correct machinery is used to plant and particularly to harvest the crop.

The current price to buy a Swedish 4-row SRC willow planter is approximately £50,000. There are no effective British-made alternatives although a planter is in use consisting of four Swedish planter units built into a British manufactured frame. New direct-chip harvesters will be approximately £250,000-£280,000 which includes the forage harvester and specialist SRC header. Forage harvesters can be bought second hand which will reduce the cost considerably although the header has to be specially made and would be between £90,000 and £100,000 (including fitting).

The most cost-effective means for WCC to establish and harvest SRC would be for specialist contractors to supply, plant and harvest the willow. Planting is carried out once whilst harvesting would occur on an annual basis when the coppices mature but as both operations are limited to specific times of the year this means that if expensive machinery was bought by WCC it would be standing idle for the rest of the year. Experienced operatives would also be needed again for only a few months per year - a three man team for planting plus a driver for the harvester. Unless WCC is considering contracting out SRC planting and harvesting services across the UK, investing in specialist machinery is not likely to be economically beneficial. Standard agricultural operations (subsoiling, ploughing, spraying, etc) could be carried out by WCC tenants assuming they have appropriate machinery (livestock or dairy farmers may not) or local agricultural contractors could be used.

It would be beneficial for WCC to have a number of people on its staff who understand the requirements of the Establishment Grant, how the crop fits into the landscape, SRC crop agronomy, pests and diseases, the use of contractors plus harvesting logistics and how to efficiently store the harvested material. This would allow them to choose effective contractors, oversee crop establishment, management and harvesting and organise the fuel supply logistics.

### Tree stations

During discussions with Warwickshire County Council it became clear that woodchips from tree surgery and woodland management operations could also produce fuel that could be used in biomass boilers. It may be possible to aggregate roundwood and woodchip from multiple sources such as SRC, street trees, park land trees and woodland management operations at one site where the material could be dried and processed to provide a homogenous fuel to boilers operating on the council buildings estate. This approach may help reduce the quantity of green waste and wood going to landfill (something Defra are currently working towards) and may help ensure adequate supplies of fuel are available. Keeping the number of different fuel types required by biomass boilers owned by the council to a minimum would also help achieve this. This type of system has been developed at other sites in England, perhaps the best known is the Croydon Tree Station set up by Bioregional in 2001. Bioregional have also developed a Tree Station in Nottingham capable of dealing with 19,000 tonnes of wood a year. During site visits it was noted that Cherry Hill, Coney Hill and Hell Hole landfill sites offered some potential as sites where the storage and processing of timber could take place. Ideally a tree station

would be positioned close to a large town to maximise yield from street trees and park trees, and close to a main road so that fuel could be delivered to sites around the county.

## Conclusions

- There is potential for woodchip from SRC and trees grown on land owned by Warwickshire County Council to provide an economically viable source of fuel to any biomass boilers deployed.
- Of the 16 WCC's tenanted smallholdings briefly visited for this project, six would be suitable for the production of SRC, with approximately 230 to 260ha in total area allowing for unplanted land for headlands, rides, protection of views, etc. Individual, detailed site assessments would be required prior to decisions being made on actual use. A further eight sites, although slightly less suitable due to the number of neighbouring properties, number of sloping fields, etc, could also be planted providing a further 320 to 350ha.
- The tenant farmers who passed comment on growing SRC for WCC did say that the price paid for the harvested crop would have to match or be more than the prices paid for their livestock or arable cropping.
- Poplar, often cited as an SRC energy crop, should only be grown as SREF due to the difficulties associated with its establishment and use as coppice.
- The most cost-effective means for WCC to grow SRC would be for specialist contractors to supply, plant and harvest the willow. Either WCC tenant farmers or local agricultural contractors could carry out the standard agricultural operations.
- If grown by WCC tenant or grown by the council itself, SRC has the potential to compete with and compliment woodfuel from forestry and arboricultural arisings and help provide a stable and sustainable fuel source for council owned boilers.

## Recommendations

- If WCC make the decision to grow SRC (or SREF) then it is strongly advised that the Establishment Grant applications are submitted as early as possible to Natural England during the year prior to planting. The application process will take at least three months and no land work should be carried out prior to grant approval. Land preparation should ideally begin in the summer/autumn of the year before planting which means applications should be submitted, at the latest, in May or June of that year. Submitting an application does not commit the applicant to growing the crop.
- Before WCC contacts their tenant farmers to discuss the option of growing SRC or that WCC wishes to use the land for SRC, WCC will need the answer to the farmer's question "What will I be paid?" either for growing and supplying the SRC or for land rental.
- WCC will need to draw up an appropriate, ideally short and straightforward, grower contract for their tenant farmers if the tenants are to grow the crop on behalf of WCC. This contract will be needed by the tenants if they are to be eligible to apply for the Establishment Grant.
- Ideally contracts will need to provide growers with an annual income, not just a payment at harvest. This will help 'sell' the concept of the crop and will help minimise cash flow problems often associated perennial crops.
- WCC should have a number of staff who understand the requirements of the Establishment Grant, how SRC fits into the landscape, crop agronomy, pests and disease, the use of contractors plus harvesting logistics and how to efficiently store the harvested material.
- Site feasibility studies should be carried out to establish site suitability, likely boiler size requirements and fuel storage arrangements at the most promising school sites should be carried out
- Care should be taken to ensure that boiler installations and fuel supply development are carried out in a coordinated way to ensure sufficient fuel of the correct quality is available as boilers come on line. SRC has a typical lead in period of four years from planting.
- Care must be taken to ensure that existing woodfuel suppliers in the region, some of whom may have received publicly funded grant support, are not disadvantaged by the council developing its own woodfuel supply chain.

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Publications marked with § are included as electronic copies with the project report.

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