Research to ascertain the environmental and economic implications of alternative and non-food crops: Impacts on the countryside

A study for the Countryside Agency

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INSTITUTE FOR SUSTAINABLE DEVELOPMENT IN BUSINESS

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Table of Contents

Executive Summary

This report investigates the economic and environmental implications of non-food crops on the quality of the English countryside with a special focus on the East Midlands region.

For many rural communities the countryside with its visual, ecological, and historical qualities is an asset that underpins such valuable economic activities as tourism, recreation and farming. Non-food crops have the potential to further enhance these economies by diversifying rural incomes, while at the same time encouraging sustainable development and conserving the character of the countryside. However, there is a concern that the unprecedented interest in non-food crops in the last three years could also *undermine* the quality of the countryside through sheer scale of plantings and/or unsustainable management practices.

This report sets up an analytical framework to determine what impact development of the non-food crops sector might have on the quality of the countryside. It considers (1) the policy- and market-based factors driving the sector's growth, (2) the present day extensity of non-food crop plantings, and (3) the intensity of the practices used to manage them.

It finds that there is extensive public support and increasing private sector interest in energy crops such as short rotation coppice (SRC) willow, oil crops such as oilseed rape, and fibrous crops such as linseed flax, especially where they are grown simultaneously for dual purposes (such as oil and fibre). Because each of these crops is planted at a different scale, managed in a different way, and used for different industrial applications, it is impossible to make blanket statements about the impacts of all non-food crops on the countryside. It can be concluded, however, that there is a strong likelihood that planted hectares of these crops will increase significantly over the next decade.

The key drivers behind increased plantings are: (1) EU and UK policy goals to increase the production of energy from renewable resources such as biomass, (2) the long term decline in food commodity prices faced by farmers, (3) regulatory and competitive pressures on industry to innovate more environmentally-friendly products, and (4) among the speciality crops, renewed interest by pharmaceutical and related companies in the capability of plants to perform functions that cannot be artificially reproduced in a laboratory.

There is reason to believe that non-food crops can indeed coexist with a high-quality countryside, since they are already growing today in tracts of various sizes throughout England. Often times non-food crops are actually conventional food crops – ancient and familiar features of the English landscape, being grown for novel non-food purposes in industry for which the plant is somehow suited. While it remains important from an aesthetic and biodiversity point of view that no single crop or group of crops dominate the landscape, the greater concern is *how* the crops are grown rather than which crops are grown.

Management practices will thus be a central question in the future expansion of the non-food crops sector, including impacts on soil, water, and biodiversity. One of this report's key recommendations is that future policy efforts to maintain and enhance countryside quality should hold non-food crops to the same high management standard as conventional food crops. One way to comprehensively assess their impacts is by developing life cycle assessments for individual crops, so that progress toward important policy goals can be balanced with acceptable environmental quality.

1. Background to the study

Crops grown for non-food uses in energy production, textiles, pharmaceuticals, health and beauty products, packaging and other industrial applications have received increasing attention in recent years. Publicly-funded economic development programmes treat these non-food applications as a potential growth industry with strong environmental benefits. Policies like the Strategy for Sustainable Farming and Food encourage farmers to diversify their operations away from increasingly unprofitable food crops, into higher value crops used often for non-food purposes. Expanded plantings of energy crops like Short rotation coppice (SRC) willow and miscanthus are also central to the Government's goal of confronting climate change through increased generation of energy by renewable means.

At the same time the private sector is also beginning to respond to incentives to increase production of crops for non-food uses primarily in the areas of energy, fibres, and oils. Companies are also investigating similar industrial applications in response to rising oils prices, environmental regulations, and the possibility that plants can be used in the manufacture of substances that are superior in performance to their synthetic counterparts. This groundswell of interest has raised concerns among groups such as the Countryside Agency that rapid growth in the sector may have adverse impacts for the countryside, which is itself a valuable economic asset.

Greater demand for non-food crops raises the question of what impact the sector's development will have on the English countryside visually, culturally, and environmentally. Rural industries like tourism depend on the high quality of the countryside, and this industry alone attracted a total spend of £14 billion in 2000 including around 80 million visits and overnight stays from domestic visitors alone. Conserving the integrity of the countryside is vital to maintaining and growing these industries as they are an indispensable source of income in many rural areas.[1] The countryside also provides critical 'public goods' such as the conservation of biodiversity and the sequestration of carbon dioxide.

Farmers may be moving land out of food production and into non-food crop production to capture market demand and favourable public supports for non-food crops. If this were the case, increased plantings could potentially have an adverse effect on the

[1] Countryside Agency (2003) "Rural economies: Stepping stones to healthier futures."

countryside by detracting from its aesthetic and environmental quality. The purpose of this report is to investigate the effect of economic development in the non-food crops sector on the quality of the English countryside.

The relationship between crops grown for non-food purposes and countryside quality is a complicated one. Economic activity has for centuries shaped the countryside, creating the hedges, ponds, woodlands, and other semi-natural features that make it as strikingly attractive as it is today. Modern economic activity, including tourism itself continues to shape the landscape as well as maintain these diverse historic features. Raising non-food crops is just as much an activity that 'produces' the countryside by conserving its agricultural character, as it is an activity that threatens to degrade it through intensive planting practices, monocultures, and genetically modified (GM) crops. The farmers who plant crops for non-food uses are at once the curators, creators, and exploiters of the rich asset that is the English countryside.

This paper proceeds through a discussion of the issue in the following way. We first clarify the position of non-food crops within the Land Based Industries in the East Midlands, underlining the recent challenges and opportunities for the sector. We then look at the various techniques, criteria, and methods that have been used to assess the quality of the landscape and the countryside in the past. Special attention is given to techniques used to study changes similar to those that economic development in the non-food crops sector might cause. A number of criteria for considering the effect of non-food crops on the landscape are identified. The next three sections on market and policy factors, planting extensity, and management intensity are the analytical heart of the report. They consider a wide body of evidence including case studies, agricultural census data, agronomic data, and policy documents, evaluating them against the pre-established criteria. Finally, we draw conclusions and make recommendations to the Countryside Agency.

2. Non-food crops in the context of the Land Based Industries

Non-food crops are a sector within the Land Based Industries (LBIs), a diverse grouping of businesses that derive their income from, for, and through the land and its direct products. The LBIs include animal care such as veterinary and equine services; non-food types of agribusiness such as urban forestry and agricultural engineering; and other services such as biodiversity research, biodiversity conservation, and sustainability certifications for timber harvesting. Aside from the type of goods and services it produces, the Land Based Industries are defined in part by the size of their firms: 94% of businesses in the sector employ fewer than five people, and 60% of businesses are sole traders, meaning the sector is comprised almost entirely of small and micro-enterprises. Because these businesses earn their incomes in ways that are based on the productivity and integrity of the land, they are directly responsible for managing more than 85% of the UK's total landmass.[2]

Case study 1: Boots Group plc, Beeston

Ed Galley works in the Department of Technology and Technology Policy at the corporate campus of Boots Group plc in Beeston. His company uses extracts from a range of speciality crops in its health and beauty products including evening primrose, lavender and tea tree oil, among others. The Boots case study demonstrates the extended supply chain through which products from these crops travel before they are used in the company's products.

Boots does not source speciality crops from farmers or other primary producers directly. It purchases highly refined, purified essences and extracts from supplier groups who mediate the relationship between growers and manufacturers. These supplier groups, or even their subcontractors, are the companies that actually source the raw material from growers. Boots' role in the supply chain is to release highly confidential briefs to trusted supplier groups that specify in detail the production standard of the specific product. Suppliers then source the raw materials globally and Boots has a contract with Kew Gardens to analyse the materials against the specifications.

Boots buys these refined products in relatively small quantities. At the maximum, certain starches and lipids are occasionally purchased in quantities of 2-3 tonnes while at the lower end for certain essences and extracts an order may be for 30 or fewer kilograms. Boots maintains a policy of 'dual sourcing' all of its plant-based inputs from at least two different regions so that if there is a disruption in the supply from one source, the production of their health and beauty products will not be affected.

Boots' suppliers are not necessarily UK based companies that purchase their raw plant material on the international market. One reason for this sourcing pattern is that companies need to work with Boots for many years to gain the company's confidence to be trusted with commercially sensitive briefs. Even if an outside supplier has a product that is clearly superior in price or quality, this sensitivity means that it will be able to serve Boots' demand only with great difficult.

This case study shows that the market forces that drive the production of speciality non-food crops are truly global, and that there are extended, sophisticated supply chains connecting growers to end users. For this reason, as well as that of confidentiality, growers would need to work with intermediary companies to find a market for their crop. However, despite the market being difficult to access, it appears to be both sizeable and responsible to market forces, which could represent an opportunity for UK growers.

[2] Lantra (2003) "Environmental and Land-based Market Assessment."

They have historically provided land management services as a by-product of other economic activities to the public free of charge, however with declining incomes in the farming sector and renewed emphasis on carbon sequestration at the national level among other issues, policies are shifting to support land management itself. Supporting these businesses is a way to increase rural incomes while also generating more desirable public benefits like high quality, aesthetically appealing landscapes and healthy ecosystems rich in biodiversity. Supporting the production of non-food crops and innovative industrial applications for them is seen by Defra, Dti, and many of the Regional Development Agencies as a way to achieve these multiple policy goals.

Non-food crops are becoming a central feature of rural economic development efforts in the Land Based Industries. They have benefited from extensive regional and national R&D funding for the last 20 years as well as public policies and programmes of various kinds. Although the industry has moved quite slowly during that time, experts believe that it has recently gained a certain momentum of its own as evidenced by unprecedented attendance levels at non-food crop application conferences, increasing involvement of the private sector (and especially members of the oleo and pharmaceutical industries), and more comprehensive and committed policies by government.[3]

3. Assessing countryside quality and countryside change

a. Various techniques have been used over time

This section looks at the different methods that have been used to understand the value of the countryside and changes that occur to it over time. It identifies the techniques that have been used to assess changes similar to those potentially posed by non-food crops. Since most of the previous techniques used to understand this new kind of change are not well suited to our purposes, we create our own framework in which to analyse data on the potential impacts of non-food crops.

The way the countryside is valued and assessed has evolved over the last 30 years in England. In the late 1970s the first assessment techniques attempted to value the countryside in strict quantitative terms by assigning it a fixed monetary value. Although a starting point, this was eventually felt to be an incomplete assessment because it did not including the more qualitative, experiential factors not well

[3] Smallwood and Tompkinson (2005) National Non-Food Crops Centre, personal communication.

represented in monetary terms. In the 1980s assessment techniques then began to become more refined by moving from total 'landscape evaluations' toward assessments that considered the value of distinctly different sections of the landscape relative to one another. More qualitative 'landscape assessments' followed on from this trend, making the important analytical difference between objective evaluations of landscape features (two rivers, one ridgeline) and subjective inventories like people's perception of 'landscape character.' Character is a term that includes the types of land use and the pressures for change to those uses. It became still more comprehensive in the mid 1990s with 'landscape character assessments' which make the further distinction between characterising the landscape through description and passing judgement on the desirability of those features.[4]

Today there is a general consensus that quantitative assessments, like revenues generated from rural tourism, need to be used along side qualitative indicators like the landscape's emotional appeal and cultural history to comprehensively understand its value. Its quality, as well as changes to that quality, are today tracked in terms of unique regional features like farm types, ecological character, visible and hidden archaeology, woodland cover, and surface geology. Today assessments also consider the historic dimension of the landscape, as well as input from members of the public who can identify landscape characteristics with subjective value and collective meaning. Features that monitor environmental integrity like biodiversity, farming and management activities, and unique ecological characteristics are also included. All of these features have been considered in the classification of the countryside into distinct 'landscape-types' or 'characterisations' like wolds, vales, fens, edges, and parklands.

Throughout this evolution of assessment techniques indicators have been developed to assess pressures similar to those potentially posed by non-food crops. The report Countryside Quality Counts (2004) identified two of these. It took the approach that seven distinct elements shape countryside character: woodland, boundaries, agriculture, settlement and development, semi-natural habitats, historic features, and river and coastal management. The elements most important to capturing the potential impacts of non-food crop plantings on the countryside are woodland and agriculture.

[4] Swanwick for the Countryside Agency (2002) "Recent practice and the evolution of Landscape Character Assessment."

Change to the woodland element is understood by the study as variations over time in the location and magnitude of woodland cover. This change is determined using data from the National Inventory of Woodlands and Trees, information from the Woodland Grant Scheme Agreement, and information on Forestry Commission Planting. Even more relevant to non-food crops is the agriculture element. Change to it is understood as variations over time in the total cultivated area, the extent of arable and set aside lands, and the main grassland types. Also considered are the spatial locations of farms, their number, and their size distribution and type. The June Agricultural Census is the main source of data to analyse change in the agriculture element of the landscape.

Economic development in the non-food crops sector, however, may potentially impact the quality of the countryside in ways that these change-indicators do not capture. There is concern for example that non-food crops will negatively affect biodiversity levels even more so than their conventional food crop counterparts. There is the possibility that non-food crops could be grown on an industrial scale that is potentially inconsistent with the regional character of the countryside. Still other concerns centre on the possibility that development of the industry might push GM non-food crops into commercial production in the UK, threatening the character of the countryside in an entirely different way. Unfortunately, techniques to assess the potential for these kinds of change from expanded plantings of non-food crops have been sparse.

b. Since there are not well-developed techniques for understanding the impacts of non-food crops, we establish a framework for analysing impact data

From the discussion thus far it has become clear that assessing impacts on the countryside is not an easy task. There are numerous ways to express 'impact' (in biodiversity, extensity, and monoculture terms), and the definition of countryside itself has been evolving for 30 years. The countryside is also incredibly diverse with its many unique landscape types, meaning the scale of impact will vary in quality and magnitude from place to place. There are dozens of crops that can be or have been grown in the UK for non-food purposes. Furthermore, non-food crop planting data are often incomplete or gathered and owned by private companies and thus commercially sensitive. Even where data are publicly available there is often no systematic indication of whether a crop like oilseed rape is being raised for food or non-food applications.

Given these complications we have developed a number of criteria to help answer the central research question, namely 'How does economic development in the non-food crops sector impact on the quality of the countryside?' The criteria form an analytical framework with which we consider various kinds of qualitative and quantitative data. The criteria are:

1) *Policy support and market demand* for non-food crops, because these drive both the extensity and intensity of plantings, and give an indication of how the sector is likely to expand in the coming years.

2) The change in the *extensity* of non-food crop plantings in hectares, because the amount of new plantings significantly impacts the visual experience of the countryside though changes to land-use.
3) The *intensity* of non-food crop production, because environmental impacts can be generally understood by considering a combination of the crop characteristics, their suitability to English growing conditions, and the inputs they require.

Within this framework we consider different kinds of data from widely varying sources to understand the issue comprehensively. These include:

- Non-food crop databases -- like the Interactive European Network for Industrial crops and their Applications (IENICA) and BioMat -- which detail the agronomic characteristics of key species. Special attention is paid to biodiversity impacts, necessary inputs, and the scale at which the crops are grown.
- Regulatory and advocacy databases -- like those of the EU Agriculture and Environment Biotechnology Commission, www.genewatch.org, and Defra -- that track trials, experiments, and commercial production of GM crops.
- Three regional case studies including a fibrous crop research laboratory, a biomass grower/processor, and a heath and beauty products manufacturer.
- Over a dozen personal communications with regional and national experts on non-food crops and related issues.
- Data from Defra's June Agricultural Census as it relates to the changing number of hectares in non-food crop production.
- Numerous government policy documents, subsidies, programmes, and support schemes that encourage economic development in the non-food crops sector.

For the purposes of this report a non-food crop is plant grown for its plant-derived materials, derivatives, and by-products for commercial non-food purposes. We have omitted from the definition those products derived from micro-organisms, the non-food applications of animal products, plants grown for ornamental purposes and forestry grown solely for timber because they were deemed to fall outside the scope of the study.[5] We do however mention those crops grown primarily for their food purposes, but a portion of whose production may be used for non-food purposes.

There are dozens of types of crops that can be grown for non-food uses in England (see the complete list in Appendix A). In order to give depth and focus to the study we have narrowed them down to the ten most important "to watch crops". These were chosen to represent each of the five general application categories – fibres, energy, oils, carbohydrates, and speciality crops – and on the grounds that they have the greatest potential for cultivation in the East Midlands. They are also the crops that have the greatest potential to change the landscape in terms of extensity and intensity, and they are the subject of the strongest policy, industry, and research interest at this time.

The crops are:

- Sugar beet
- Wheat
- Oilseed rape (OSR)
- Linseed flax
- Hemp
- Nettle
- Miscanthus (elephant grass)
- Short rotation coppice (SRC) willow
- Lavender

Throughout the report we consider influences on crops grown for non-food purposes from regional, national, and international organisations including public and private sector entities. Yet in assessing the present and likely countryside impacts we concentrate on the regional dimension.

Overall we aim to identify the general type, extent, and location of the impact of non-food crop plantings, now and in the near future. We are much less concerned with passing judgement on whether these potential changes add to or detract from the quality of the countryside. Whether or not these changes are consistent with existing character types is a question to be left to a broader group of stakeholders. It is our

[5] See non-food crops definition set out by the National Non-Food Crops Centre, www.nnfcc.co.uk/index.cfm.

hope that the Countryside Agency can integrate these findings into ongoing regional and national efforts to document broader change and pressures to countryside quality.

4. Considering the evidence: government policy and market demand

This section looks at the policy and market-based factors that encourage the production of crops for non-food uses in England and the East Midlands. Government policy support and market demand are important because they ultimately drive farmers' decisions of which non-food crops to plant and in what quantities. They suggest which crops are of greatest importance to the Government in achieving its objectives related to climate change, sustainability, and economic development, and subsequently which crops are likely to be most strongly promoted in the future. Here we consider the demand created by direct crop subsidies, strategic policy documents, research and promotion efforts, and policies like the Renewable Obligation in electricity generation. These policies, programmes, schemes, and projects are listed according to their key criteria in Appendix C, 'Regional, national, and EU policy initiatives to support crops grown for non-food uses.'

We find generally that there exists some market demand for well-established, co-productive non-food crops like oilseed rape and flax. However the demand for the crops that will affect the quality of the countryside is heavily driven by public policies and subsidies. In our assessment, government-led policies like the Renewable Obligation, direct commodity supports for certain non-food crops, and extensive R&D investments have been important drivers of the market to this stage. Public support from regional, national, and EU levels affects the market at all stages in the supply chain from the original growers to the harvesters to the processors and marketers to the end consumers.

However, there is reason to believe that this has begun to change in the last one or two years with the greater involvement of commercial interests responding to high oil prices, public pressure to improve environmental performance, or advancements in the understanding of non-food crop properties. Because our main concern is the impact of non-food crops on the quality of the countryside we maintain our focus on the early stages in the supply chain where crops are likely to have the most pronounced impact.

a. Research, development, and promotion

Over the last 15 years the Government has run a number of programmes that have invested in non-food crop research, development, information dissemination, and network-building among commercial interests. These started in the late eighties when there were virtually no viable markets for non-food crops besides wood or straw residues for particle board.[6] Most of the programmes were carried out in an uncoordinated manner at research universities around the country. In 1999 the *Government-Industry Forum on Non-Food Uses of Crops* was formed to provide government and industry with strategic advice on the uses of non-food crops. A productive alliance, the Forum completed its work in September 2004 (a series of research and policy papers), and all of the Forum's activities have now been subsumed by the Government-supported *National Non-Food Crops Centre* (NNFCC) in York.

The NNFCC's objective is to be the single, independent, authoritative source of information on the use and implementation of non-food crop products and technologies in the United Kingdom. The Centre disseminates scientific and technical information to increase knowledge and understanding within and outside the sector. It also initiates and facilitates technology uptake to meet the Government's and society's wider sustainable development objectives. From the perspective of the leadership of the organisation the establishment of the centre and related developments represents something of a 'take-off' for non-food crops and their applications. Deputy CEO Maggie Smallwood commented that attendance at conferences has grown in recent years to unprecedented numbers, and that greater proportions of these attendees are coming from the private sector oleo and pharmaceutical industries especially. Interest levels were never this high or this vested through the 1990s. Partial explanations for this trend include increasingly heavy taxes on petroleum products, technological advancements in the manufacture of non-petroleum fuels, stricter environmental standards and regulations, and advancements in the field of chemistry that demonstrate the performance advantages of natural materials over synthesised ones. Funding for the NNFCC initially came from Defra (£250K/year) and the Dti (£100K/year), and is guaranteed for the next two years. However given the 10 years of Government R&D investment and the momentum non-food crops have achieved in recent years, it is likely that the Centre will continue to be funded in the future.[7]

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[6] Tompkinson (2005) National Non-Food Crops Centre, personal communication.

[7] Smallwood and Tompkinson (2005) CEO and Deputy CEO, NNFCC, personal communication.

Today a number of similar organisations also promote non-food uses of crops at the EU level, like the *Interactive European Network for Industrial Crops and their Applications* (IENICA) and the now defunct BioMat. IENICA is funded by the European Commission at a rate of about €500,000 per year, and has the broader functions of the two. It organises events and writes newsletters, helps to network commercial interests through conferences, advocates policies favourable to the non-food crops sector, as well as performs the database function of BioMat. It has been in operation since 1997 though has recently reached the end of its funding cycle and is awaiting a decision from the Commission as to whether funding will be granted for another 3 years. If funding is granted it is likely that IENICA's remit would expand to advance the non-food crops agenda not only in Europe, but in Africa and possibly other continents.[8]

By contrast, *BioMat* is more of a website than an organisation. Its primary function is to make available the results of projects supported by the Commission in the area of biological materials for non-food products. These include results from the Fifth Framework Programme, the FAIR Programme, as well as ongoing research from the Fifth and Sixth Framework Programmes. The site also contains a fully searchable database of organisations who registered their websites with BioMat. Its funding of €60,000 per year has also run out but the organisers are applying to the Commission for another cycle.

b. Policies, strategies, and indirect supports

The place of non-food crops in Defra's rural development planning was clarified recently by the release of a "*Strategy for non-food crops and uses: Creating value from renewable materials*" in November 2004. There are a number of sections of direct interest to this investigation such as the document's claim to have already undertaken actions to better understand the environmental impacts of expanded plantings of non-food and energy crops. Defra has begun to study whether there is a need for environmental impact assessments for non-food crop plantings that would consult with statutory authorities on matters relating to soil, water, and landscape impacts. Acknowledging that large volumes of non-food crops will need to be grown to meet energy-related policy goals, it has also commissioned a review of the potential impacts of energy policy on UK biodiversity, including assessments of forestry activities and energy crops. In addition to these studies Defra has also begun

[8] Melvyn Askew (2005) Head of Agriculture and Rural Strategy, Central Science Laboratory, personal communication.

implementing Cross Compliance programmes under the new Common Agricultural Policy (CAP) which are intended to deliver greater biodiversity benefits for the sector. Future actions laid out by the strategy are to:

- "Commission another study on other non-food crops to identify significant impacts of crops and their management systems on biodiversity including an assessment of the effect of increasing diversity of crop production
- Prepare best practice guidance to help farmers maximise profits from non-food crops whilst delivering biodiversity benefits
- Develop a case study on maximising crop yields (and profits) while minimising impacts by using low input systems and managing field margins and other non-productive areas sensitively to protect and enhance biodiversity
- Assess the potential to develop an accreditation scheme for non-food uses of crops to certify sustainability." [9]

The strategy also identifies five strategic outcomes that the development of the non-food crops sector can help achieve. These include (1) climate change and energy to the extent that non-food crops can substitute for fossil fuel use; (2) natural resource protection – by delivering greater biodiversity benefits than food production and substituting the use of finite resources; (3) sustainable consumption and production, since plant-derived products have the potential to improve business competitiveness; (4) sustainable rural communities through increasingly profitable income opportunities; and (5) a sustainable farming and food sector, by boosting the profitability and sustainability of the sector generally. This multi-faceted interest in the sector's advancement would seem to indicate that there is strong policy support for the strategy among a diversity of government agencies and departments.

It is also important to note that the Strategy envisions a very large-scale expansion in non-food crops and especially energy crops in the coming years. Estimates are that 1.3 million hectares in the UK or 7% of all UK agricultural lands, will need to be devoted to these crops in order to meet UK and EU policy targets for fuel and energy.

One study conducted jointly by *ADAS Consulting and the Central Science Laboratory* found that the UK's climate, soils, and growing conditions are best suited to planting oilseed rape (OSR) and wheat. OSR is grown for its oil primarily while its by-product is used for animal feed. The study found co-productive crops like these (oil and meal) to be most economical. It recommended that new policies aim at developing new

[9] Defra and Dti (2004) "A Strategy for non-food crops and uses: Creating value from renewable materials," page 21.

markets for existing crops shown to thrive in UK soil conditions, rather than planting crops that are less agronomically suited to serve existing markets. These policies should be used to bridge the gap between the crops in which the UK has a natural advantage and existing markets for non-food crops generally. One way to do this is by using crop by-products such as wheat straw as a packaging material, for example. It also found that growing energy crops is justified regardless of their marginal profitability by the UK's carbon dioxide abatement goals, meaning international market competition is irrelevant. On these grounds the report recommends they be supported regardless of their competitive position.

What the report illustrates is that it makes economic sense to grow crops that are well-suited to the local climate both because fewer inputs are required and because the UK already has an existing foundation of technical expertise and agricultural infrastructure to grow, harvest, and process these crops. Straw bailing infrastructure already exists for wheat for example, which can be converted with few modifications to harvest and transport miscanthus grown for energy generation. It also makes economic sense to explore *dual-uses of crops* that have the potential to yield multiple valuable end products. Varieties of oilseed rape grown for food uses are dual-use for example because the residues remaining after oil extraction can be used as animal feed. This is not the case however with varieties grown for oils used in non-food industrial applications since the post-processing meal is unsuitable as animal feed. Residues from hemp and flax grown for fibres for industry are similarly unsuitable. The point is that crops with dual uses are often the most profitable crops for farmers to grow, and finding uses for crop residues is an important economic dimension of the non-food crop issue.[10] In both cases, the UK's historical experience with certain crops gives it an advantage of expertise and technology in developing new applications.

Of any of the crops grown for non-food purposes in the UK, energy crops such as short rotation coppice (SRC) willow receive some of the strongest policy support. A major driver behind increased plantings of biomass energy crops have been the *Renewable Obligation policies* set out by the UK and to a lesser extent the EU. The Renewables Obligation mandates that power companies generate a portion of their electricity

[10] It also raises the distinction between 'non-food crops,' 'crops grown for non-food purposes,' and 'non-food uses of crops,' which is not purely semantic. Farmers frequently grow crops for food and non-food applications simultaneously, and for that matter sometimes plant a generic crop at the beginning of the growing season without a particular market application in mind. Favouring convenience over accuracy, we treat the terms somewhat interchangeably throughout this report.

through the use of renewable fuel sources. The policy has increased the demand for biomass crops toward the end consumer stage in the supply chain, causing production changes all the way back through to the processors, harvesters, and ultimately the growers. The knock on effects of these and related policies are today becoming visible in the East Midlands: at a recent meeting at the county offices a representative from a boiler-manufacturing company called Instatherm explained how his company was researching ways to retrofit their existing coal-fired boilers to accommodate new fuel sources like woodchips.[11]

The policy goal is to achieve 10% of all electricity consumption in the UK from renewable energy sources by 2010.[12] It is certain that a prominent source will be biomass, and highly likely that this source will be grown largely in the UK. The mandate is accompanied by other 'helping' policies (to be elaborated in the following section) which are intended to move the market toward achieving this ambitious goal. Capital grants for renewable energy generation projects have been expanded, as have R&D programmes into building the supply capacity of the energy crop industry. Electricity generation that co-fires with coal and biomass is allowable now, though the goal is to phase out coal so that by 2016 only 100% biomass-fired generation will qualify toward the Renewables Obligation. The UK now generates about 2.67% of its electricity through renewable resources, meaning the demand for electricity derived from bio-fuels could very well quadruple in the next five years. Also under consideration by the Government is a bio-*fuels* obligation which would mandate that a certain percent of the fuel consumed by automobiles and industry be bio-fuels, often derived of course from non-food crops.[13]

Regional initiatives have lent further support to energy crops, including wood chips from forestry residues and energy crops alike. The *Nottinghamshire Wood Heat Project* is a local government initiative to create market demand for wood fuels by converting existing plants from coal or other fuel sources to wood heat. About £400,000 has been spent on this initiative over two years and there is no fixed end date to the programme. Four plants have been converted during the course of the project. There also appear to be similar initiatives occurring in Leicestershire with the conversion of certain school buildings to wood heat.

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[11] Regional Bioenenergy Group convened by the Nottinghamshire County Council, January 18th, 2005.

[12] Defra and Dti (2002) "Bio-energy: A growing energy supply."

[13] REStat (Renewable energy statistics database for the United Kingdom) (2005), www.restats.org.uk.

There is also a strategy and research document titled "*Joint action plan for the development of wood-based bio-energy in the East Midlands*" developed jointly by emda and regional partners. Divided into two parts, it first appraises the viability and overall market potential for bio-energy and bio-fuels in the East Midlands, identifying opportunities and constraints to the industry's development. Second, it identifies to what extent the factors for the market's development exist in the region, including suppliers of technology, expertise, and capital. Neither are mandatory obligations though like the Renewable Obligation they are expected to further increase demand for biomass energy crops by identifying and removing barriers to the industry's development.

c. Direct supports to individual crops

The *Energy Crops Scheme* (ECS) was set up by Defra to encourage the production of non-food biomass crops like miscanthus and short rotation coppice (SRC) willow, in large part to meet the UK's renewable energy goals. The programme covers about 50% of the capital costs of establishment - £920 per hectare for miscanthus, and £1000 to £1600 per hectare for SRC willow depending on land type. It also subsidises the establishment of SRC producer groups including the purchase of harvesting machinery and other costs. The programme commenced in 2001 with a budget of £3.5 million and is planned to finish in 2006. It has subsidised hundreds of hectares of energy crops around the country on dozens of farms in accordance with certain land management and processing requirements. The scheme is compatible with a number of other support policies and programmes, to follow.

The locations of ECS plantings are shown in Appendix F, 'Growing locations map for Energy Crops Scheme.' What is notable is that the distribution of projects is highly uneven across the country and indeed roughly concentrated in four general clusters: those around Shropshire and Staffordshire, those around the East Midlands, those around Yorkshire and Humberside (a former coal mining area), and those in the Northeast. The two most likely determinants of this distribution pattern are the suitable agricultural soils in or near these areas including their existing infrastructure for agricultural production, and second a requirement in the details of the ECS that crops be planted within close proximity of the power station to which the crop will eventually be sold (see Appendix H, 'Locations of remaining coal-fired power stations in the UK' for more information). The distribution of ECS grant recipients is depicted in Appendix F, 'Growing locations map for Energy Crops Scheme.' [14]

[14] Also related to the spatial distribution of non-food crop plantings is Appendix G, 'Growing locations map for oilseed rape under contract with Green*ergy.*

The *Bio-energy capital grant scheme* was set up by Defra, Dti, and others to promote the efficient use of biomass energy, and especially energy crops, by stimulating the early deployment of heat and electricity generation projects fuelled by biomass. It does this by awarding capital grants towards the cost of equipment in working installations. The scheme is aimed at project developers and organisations that are already interested in investing in heat or electricity projects. About £66 million has been devoted to the scheme.

At the EU level, reforms to the *Common Agricultural Policy* (CAP) have also directly supported plantings of non-food crops. In 2003 support payments to farmers were decoupled from the actual production of food commodities, and today compensate farmers for maintaining and 'producing' public benefits like biodiversity protection and landscape conservation. Various premiums, payments, schemes and aid programmes for veal, hops, beef, and seed commodity production have been replaced by the Single Payment Scheme, which aims more to support the public benefits above. Two aspects of the new policy regime bear on the impact non-food crop plantings have on the quality of the countryside: Cross Compliance and the Environmental Stewardship Scheme.

The most recent rules on *cross compliance* favour certain non-food crops by exempting them from set aside management requirements. This does not mean non-food crop growers can disregard other management requirements like the mandatory buffer strip adjacent to hedgerows and sites of special scientific interest, etc. It does mean however that producers can plant non-food crops on the same land required to be left as set aside, meeting this particular management requirement and receiving crop support at the same time. Administered under the Arable Area Payments Scheme this has been eloquently named the 'Production of Non-Food Crops on Set Aside Land Scheme'.

The *Environmental Stewardship Scheme* was launched this year to provide funds to farmers and land managers to maintain landscape character, conserve soil, and tackle the decline in dispersed wildlife species. The funding for this agri-environment scheme originally came from the EU, though England with its special interest in boosting the reward to farmers for environmental conservation is matching the EU payment. This means the supports to qualifying land-based recipients are essentially doubled. England's additional contribution applies at least for the years 2005 and 2006 and possibly longer. There appears to be at least a preliminary consensus within Defra that land devoted to non-food crop production under the Energy Crops Scheme can also qualify for support under this scheme, provided it meets the management requirements of both.

Case study 2: Renewable Energy Suppliers Ltd., East Drayton

John Strawson grows SRC willow which he harvests, processes, and sells as biomass fuel to an area power station. His growing and processing operations benefit heavily from the various non-food crop policy schemes including the Energy Crops Scheme (ECS), the set aside exemptions, and indirectly the Renewable Obligation. His case illustrates how the policies in this section overlap and complement one another to stimulate production.

Mr. Strawson devotes about 200 hectares to SRC willow, all of which is grown on set aside land. In addition to the planting subsidy under the ECS of £1000 per hectare he also runs a producer group called Renewable Energy Growers, Ltd. to support his own and others' operations. After harvesting Mr. Strawson processes the crop on site, grinding it into a fine, sawdust-like consistency that can be mixed with crushed coal and burned at the nearby power station. The station buys the fuel to meet its generating requirements under the UK Renewable Obligation.

The crop has strong environmental advantages. It is harvested only once every three years and does not require tilling. Herbicides need be applied only in the first year after which fast vertical growth out-competes weeds. Once established the crop provides a rich, relatively undisturbed habitat for hare, squirrel, fox, and farmland birds.

Visually the crops are quite tall with leafy tops and stalks of approximately 3-5 centimetres in diameter. At maturity the plants, which look like thin, spindly trees, stand seven to nine meters tall. They are planted neatly in rows. On a site visit in mid spring the crop stood in stark contrast to Mr. Strawson's neighbour's fields which had been recently tilled for planting. Mr. Strawson's crop grew in intact soils, showed visible wildlife amidst the crop, and was already budding. The neighbouring fields lay upturned, prone to erosion, and with no visible wildlife.

Mr. Strawson is a business man and his operation would not be economical without the benefit of extensive support policies for energy and non-food crops. His case shows just how much public support is required to persuade a farmer to grow this particular non-food crop. While the market for energy crops may be fairly immature on its own, his responsiveness to the raft of market-moving policy incentives in a coordinated way can be a profitable venture.

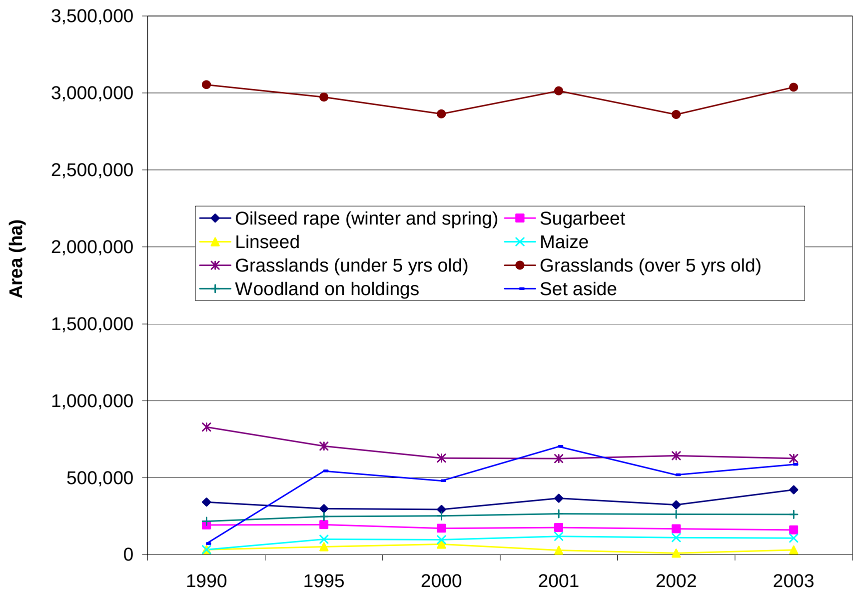
The Rural Payments Agency administers a number of *direct commodity supports* for certain crops with non-food end uses under the Integrated Administration and Control Systems and other payment areas. They appear to have been negotiated with the other EU member countries under the CAP. The supports include the Starch Refund Scheme, Fibre Processing Aid for Hemp and Flax Processors, and the Support Programme for Sugar Used in the Chemical Industry. Each gives financial support for the production, processing, or refinement of the crop as pertains to its non-food end uses.

An overview of the subsidy rates can be found in Appendix C. These programmes have gone unmentioned by any of the experts consulted in this study, and seem to lie somewhat outside the main non-food crops discussion. They are however significant financial subsidies and almost certainly encourage increased planting of these particular crops and products.

5. Considering the evidence: Land based issues of *extensity*

To better understand the question of extensity of plantings we now look at planting data from the June Agricultural Census.[15] We consider the data from the last 15 years to see if there has been a trend in the change in number of hectares planted. There are a number of shortcomings to using this data, which will be discussed shortly, but the census categories most relevant to non-food crop production are the following: 'Crops not for stockfeeding,' which includes potatoes, rape for oilseed, sugar beet, linseed, hops and other arable crops; certain crops in the 'Stockfeeding crops' category, such as maize, that can also be used in the manufacture of ethanol alcohol and starches; and 'Other land' including woodland holdings where wood chip production from forestry residues may possibly occur, as well as set-aside lands which can be planted with certain non-food crops under new non-food crop promotion policies administered by Defra. This graph depicts trends in the extensity of planting of these crops with potential non-food end uses.

Trends in planted hectares of non-food crops for England[16]



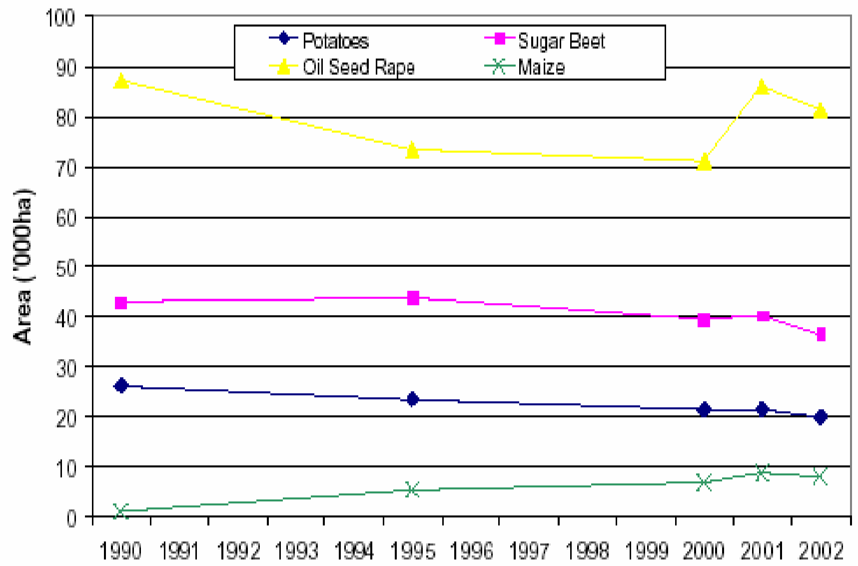
[16] Defra on-line database for the June Agricultural Census (2005): www.defra.gov.uk/esg/work_htm/publications/cs/farmstats_web/datamap_links/search_menu.asp#data.

The points of main interest are that plantings of oilseed rape have expanded by about 33% since 1990, and planted hectares of maize have increased by about 300% from 1990 levels. Sugar beet plantings have declined over the total period. Although difficult to read from the graph on account of its relative extensity, planted hectares of linseed seem to oscillate quite dramatically. Woodland holdings have been increasing gradually but steadily. A major trend is in set aside lands, which have increased dramatically from 1990 levels by over 800%, probably as a direct result of changing management requirements.

As an indicator of non-food crop plantings the set aside category is an unknown in the Census because, while some non-food crops can be grown on these lands, there is no way to know what proportion of it is actually under cultivation. What we can surmise is that the increase in set aside, under present 2005 agricultural policy conditions, represents greater *potential* for expanded planting of non-food crops. All together the various crops commonly planted for non-food applications constitute something of a non-food crops index which could be used to track plantings in future years.

We now turn to the June Census data at the regional level.

Trends in planted hectares of non-food crops for the East Midlands[17]



[17] Source: Defra's online agricultural statistics database (2005) http://statistics.defra.gov.uk/esg/reports/capmtrp/appendix2d.pdf.

Just as at the national level, there are some planting trends but nothing truly outstanding. As above, oilseed rape shows roughly the same spike in the East Midlands as in England in the last five years, suggesting that the Region has seen a recent expansion in that crop's production and/or use, though the trend over the total time scale is one of decline. Sugar beet shows a decline over the total period with that trend accelerating slightly in the last three years. Although maize production has been gently rising over the period it is unlikely to expand beyond present levels due to less favourable regional growing conditions. Excepting this last crop there actually appears to be an overall gradual *decline* in the production of crops commonly used for non-food end uses in the East Midlands. This does not mean, however, that their total end use in industry has declined.

The shortcomings of the Census data are partly a problem of the method by which they are gathered and partly a problem of accuracy. First, for a census of this scale statisticians rely on land owners to report what crops they plant and in what volumes though a standardised, country-wide mail-out survey. As with most survey methods that rely on citizen reporting, response volumes can be low. This weakens the quality of the data because more extrapolation is needed to make claims about planting patterns for the entire land area.

Second, the majority of the crops included in the data set are primarily food crops known to be grown predominately for human or animal consumption. It is impossible to tell what proportion if any of the production of a crop like oilseed rape is used for animal feed and what proportion is used for oil production (a further distinction being between oil for food and non-food purposes). These are reasons to treat the Census not as an authoritative data source but as one source among many.

Although we have not considered them here, further indicators and/or data sets of planting extensity are thought to be available from organisations like the John Innes Centre and companies such as Greenergy International Ltd., which carry out detailed research into non-food crops and their applications. This would be useful for example if the Countryside Agency wished to conduct a further, more focused investigation into strictly visual and aesthetic impacts of non-food crops on the quality of the countryside. The contact details of these organisations can be found in Appendix E, 'List of databases, research centres, and companies involved with crops for non-food uses.'

6. Considering the evidence: Land based issues of *intensity*

This section reviews the planting and management intensity associated with the 10 'to watch' crops. One of the central concerns with expanded plantings of non-food crops in the East Midlands is that they may require intensive management practices that degrade the environment. Reviewed here are issues related to management and the scale of cultivation including:

- The intensity of general management techniques, including chemical application and harvesting and rotation
- GM non-food crops
- Biodiversity
- Mass balance and Life Cycle Assessment

a. Intensity of "to watch" crops – the region and crops considered

Agricultural activity is an important sector of the East Midlands' regional economy, and has a major impact on the landscape. Eighty percent (nearly 1.3 million hectares) of the Region's land area is agricultural with many more hectares devoted to forestry. [18]

There is considerable agricultural diversity with several of the conventional food crops (such as wheat, oats, potatoes, oilseed rape and sugar beet) being grown for non-food uses, or with the *potential* for non-food uses. In addition there are several alternative crops such as lavender grown in the Region for non-food uses. For this report we have focussed our analytical efforts on 10 key crops with potential for cultivation in the East Midlands, and which are high priority in policy and commercial circles at this time. These are wheat, sugar beet, oilseed rape, linseed, flax, hemp, nettle, lavender, short rotation coppice (SRC) willow, and miscanthus. Each of these is discussed individually in some detail in Appendix B i-ix, though we highlight their key characteristics here. [19]

Each of the 10 "to watch" crops is currently growing in variously sized plantings around the Region. The East Midlands is a rich agricultural region, particularly Lincolnshire and Northamptonshire. Soils vary from the fertile silts of the fenlands in Lincolnshire, to the intensive agriculture in the Trent Valley and rises, to the conifer plantations and fertile clay soil in the north Lincolnshire clay vales, to the conifer

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[18] National Farmers Union Online (2005) www.nfu.org.uk.

[19] A main source of crop data has been the IENICA non-food crops data base, www.ienica.net/agronomyguide/ienicaagronomyguide.pdf.

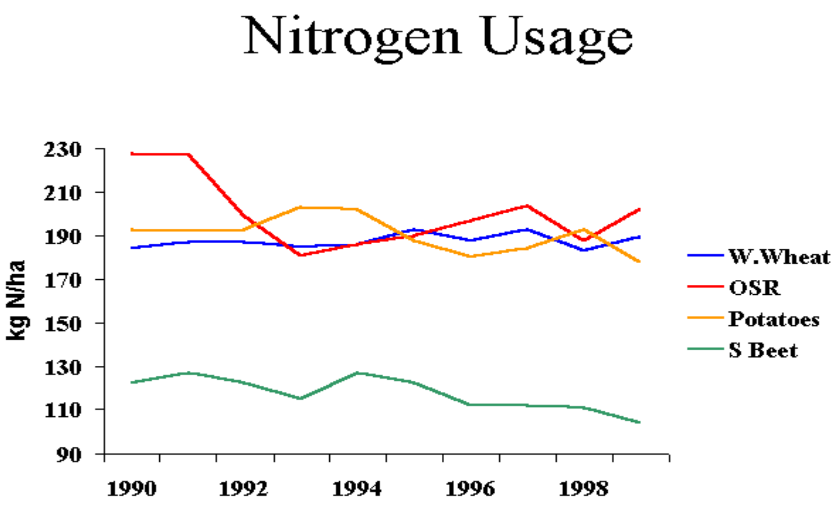
plantations in Sherwood. Each of the crops we consider is agronomically well suited to at least some of these conditions. [20]

Food crops

Wheat, sugar beet, and oilseed rape are grown over extensive areas, i.e. thousands of hectares, for both food and non-food applications. Wheat is planted over 350,000 hectares; OSR covers 100,000 hectares, while sugar beet is grown over 35,000 hectares.[21]

These would seem to have the most significant impact on the countryside of any of the crops we consider since they are managed intensively with high levels of chemical inputs, although in the case of fertilisers these may be declining. They are usually grown over large areas; cultivation is primarily for food use, but can and regularly does transfer to non-food uses. The following graph illustrates the relative use of one common input, nitrogen, among the different crops, giving an idea of their relative management intensity.

Nitrogen use in four major UK crops with non-food applications[22]



Source: The British Survey of Fertiliser Practice

[20] English Nature website (2005) www.englishnature.org.uk.

[21] Defra June Agricultural Census (2003).

[22] British Survey of Fertiliser Practice (1999).

Crops for oils and fibres

Flax and linseed are varieties of the species Linum. Flax is grown for its fibres while linseed is grown for oil, which has both industrial and food end uses. The bast fibre, the material surrounding the stem's inner core, provides the fibres which are used in the manufacture of clothing, textiles, and fibreglass-like composites. These crops can be considered visually attractive with their blue or white flowers, and they also attract insects. One of the limiting factors to their increased production is difficulty with the retting stage, namely the separation of the fibres, which is something researchers at De Montfort University are investigating (see case study 3).

Hemp is another 'dual crop' that it is grown for both oil and fibre. It has biodiversity benefits as no chemical inputs are required since its rapid growth enables it to out-compete weeds; at maturity it can stand up to four meters tall. However, cultivation is likely to be limited by the need for government-issued growing permits, although the variety grown for industrial use has only negligible levels of THC, the active ingredient of cannabis. Hemp's vast number of potential uses should override any dampening effect of the permit requirements. See the crop profile in Appendix B-iv for more information. Appendix J, 'Modern uses for hemp' further elaborates the crop's applications.

Nettle is undergoing trials for its potential use as a fibre in the manufacture of clothing, textiles, and composites. Austria and Germany have used nettle as a cotton substitute for over 50 years and so the processing technique for the fibres is well developed. Nettle requires few pesticides, but the application of fertilisers in the early growth stages helps to achieve long fibres, which may have adverse impacts on waterways by increasing nitrogen levels. See Appendix B-vi for further information.

Crops for biomass

Short rotation coppice (SRC) willow and miscanthus are grown as biomass to be used in the generation of heat and electricity. These crops are perennials, are harvested as infrequently as once every three years, require few artificial inputs for weed control and provide abundant habitat for wildlife. Visually their mature heights of 7-9 meters (for SRC) may present a significant change to the appearance of the landscape if they replace annual arable crops. See Appendices B-vii and B-viii for further information.

Speciality crops

Lavender is a low-volume, high-value crop not extensively grown in the UK, but lavender fields attract visitors. It benefits from small amounts of organic fertilisers, but requires few if any pesticides and attracts insects and birds. Lavender's most common application is in health and beauty products, but the details are usually commercially confidential.

Case Study 3: Bast Fibre Research at De Montfort University, Leicester

This case study illustrates the way fibrous crops are grown intensively to specific requirements for research into industrial applications. It asks what effect producing fibrous crops to those requirements has on the landscape.

Professor Ray Hold leads a team of researchers who are investigating industrial applications for bast fibres, the fibrous outer core of plants like flax, hemp, and nettle. The technical characteristics of these plants have commercially-promising uses in industry related to pulp and paper products, absorbents, woven and non-woven fabrics, composite board, and insulations. One particularly promising application for short bast fibres is using them in bio-composites similar, but in many ways superior to the fibreglass composites used in the manufacture of car bodies. A major research area for the laboratory is understanding ways to improve the retting process for fibrous crops. Retting is the process of separating the fibre from the wood in crops grown for fibre use. This is done either chemically or biologically by rotting the wooden part of the crop to make the fibres more accessible.

The staff agronomist on Professor Hold's team, Dr. Russell Sharp, understands the specifications industry demands of fibrous crops, as well as the crop management requirements to achieve them. When plants are grown for fibres to make linens the diameter of the stalks need to have a smaller diameter, and the fibres to be longer and a cleaner colour closer to white.

To grow flax to this specification the crop is planted at a density of around 1,500 seeds per square metre in order to partially shade the plants so they will grow long and spindly with greater length between the leaves.

There are different requirements when a fibrous crop is grown for the manufacture of composites. Colour is much less important, and profitability will depend largely on raw volume of production instead of thinness or purity. For composites however, buyers often demand that the fibres have a purer cellulose surface free of other impurities since their main concern is strong adhesions between the plastic and fibres in the composite.

Does growing to these specifications mean the landscape is impacted more intensively?

Generally fibrous crops are fairly similar to conventional agricultural crops in the intensity of their environmental impact, but it does depend on the crop. They require fewer pesticides than many food crops because they are not grown to be blemish free and do not need to meet high hygiene standards.

Since flax grows only to about 50-70 centimetres it is susceptible to competition from weeds and requires spraying with a general purpose herbicide. It also places demands on the soil that require it to be grown in a rotation system with food crops, with only one flax planting every five to six years. By contrast, nettle grows to two meters and requires slightly less pesticide application. Nettle is a perennial that grows for up to 10 years, meaning it requires such infrequent tillage that soil erosion is minimised.

Dr. Sharp believes that the prospect of wide spread planting of genetically-modified (GM) fibrous crops is very unlikely. A number of studies of potential modifications have been done, yet nothing has been released commercially. The main problem with the three crops is that the actual fibre formation is not well understood, meaning researchers would be unsure what properties of the plant to modify.

Furthermore, in his view one of the major selling points of these fibrous crops to industry is the green reputation and environmental benefits. These attributes would be fairly well undermined by GM developments. Overall, any advancement in GM technology would have to be a major break through to challenge the dominance of the main fibre in the market, cotton.

b. Genetically modified (GM) non-food crops[23]

Several non-food crops have undergone genetic modification to add or enhance desirable traits including higher yield and better quality oil, resistance to insects and tolerance of herbicides. Oilseed rape has had many GM varieties trialled, whereas other crops such as nettle has been of little interest to GM researchers so far.

The results from the Farm Scale Evaluations (FSEs) of herbicide tolerant GM crops, the biggest study of the environmental impact of GM crops conducted anywhere in the world, were published in March 2005. The three farm-scale trials of spring-sown oilseed rape, maize and beet showed that GM rape and GM beet did more harm to wildlife than their conventional counterparts, due to the herbicides used. The results of the farm-scale trial of winter-sown oilseed rape raised further doubts about whether GM crops can ever be grown in Britain without causing further damage to the nation's wildlife.

Although the research did not look directly at the demise of farmland birds over the past 50 years, ornithologists said the results suggested that growing GM oilseed rape would almost certainly exacerbate the problem. The broad spectrum herbicides used to spray GM rape killed broad-leaved wild flowers such as chickweed and fat hen which are important to the diet of songbirds. These differences were still present two years after the crop had been applied with the spectrum herbicides.

With the *de facto* moratorium on GM approvals in the EU from October 1998 until the awards made for importing two varieties of GM maize in 2004, there is little likelihood that GM non-food crops will be grown commercially in the East Midlands or in the UK in the near future. Following a recent report from the EU Agriculture and Environment Biotechnology Commission,

[23] More information on GM non-food crops can be found through the GeneWatch website:
http://www.genewatch.org.

> "Globally, the main genetically modified crops in commercial production are cotton, soybeans, maize, oilseed rape (canola), and tobacco. Wheat and rice are also close to commercial production . . . . Genetically modified animals in commercial production are sheep producing pharmaceuticals and those close to commercial production include fish. *No commercial production of GM crops is underway in the UK, and approval in the UK for the commercial production of GM fish looks unlikely for some time to come because of concerns about the possible impact on the environment, but each application would be assessed on its individual merits*" (emphasis added).[24]

If GM non-food crops were to be grown in the UK or the East Midlands, there would be issues for the Countryside Agency and others to consider. While GM in non-food crops does not raise the concern that consumption of the product will affect human health, there are many other associated concerns which may impact upon the countryside. Herbicide tolerant varieties could become like weeds if they spread to the surrounding areas, while cross-breeding could introduce GM varieties into areas where they are not desired. GM varieties could affect biodiversity, at least by introducing new species or hybrids into ecosystems, and they may enter the human food chain if visited by honey bees.

Hybrid varieties grown for high yields are often sterile, but there have been instances where GM varieties have been found in the wild, seemingly as a result of 'drift,' even on islands like the UK. The presence of GM canola plants growing in the wild was confirmed across Japan by a report from the Ministry of Agriculture, Forestry and Fisheries in June 2004.[25] Rape also readily grows wild in the UK, so it seems probable that fertile GM varieties would do so as well.

Perhaps the greater, more immediate impact of GM non-food crops on the East Midlands is the prospect of their cultivation overseas. If high value species such as those grown for pharmaceuticals, are grown in countries permitting GMOs, this would place the UK (and Europe) at a considerable disadvantage.

c. Biodiversity

Biodiversity is the diversity of flora, fauna and biota that provides important ecological services in securing crop protection and soil fertility. Biodiversity prevents soil erosion, replenishes ground water, controls flooding by enhanced infiltration and

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[24] Agriculture and Environment Biotechnology Commission (2004) "Horizon Scanning Report," www.aebc.gov.uk/aebc/reports/horizon_scanning_report.pdf.

[25] Japan for Sustainability (2005) "Spread of Genetically Modified Canola Confirmed across Japan," www.japanfs.org/en/jfs/index.html.

reduces runoff, recycles nutrients, controls microclimates, regulates the abundance of undesirable organisms, and detoxifies noxious chemicals. There are real agricultural and other costs to declines in biodiversity:

> "When . . . natural services are lost due to biological simplification, the economic and environmental costs can be quite significant . . . agroecosystems deprived of basic regulating functional components lack the capacity to sponsor their own soil fertility and pest regulation."[26]

There are concerns that non-food crops may have an adverse effect on bio-diversity. Measuring biodiversity is an inexact science; the method usually used is to count larger species such as migrating farmland birds as indicators of biodiversity further down the food chain. Biologists suggest that if the species toward the top of the food chain are healthy and abundant then the species further down are as well. [27]

Any land use, whether crops, uncultivated or forestry, has an impact on biodiversity. According to a report commissioned by the Department of Trade and Industry (Dti) on the effects of energy grass plantations on biodiversity,

> "The most widespread effects [of changes in agricultural practices] on both the arable flora and fauna, are mainly due to pesticides. Most winter cereals receive about seven different types of pesticide each year, i.e. two to three herbicides, three fungicides and an insecticide . . . . fertilisers account for about 50% of the total energy used in farming." [28]

Replacing a food crop with a non-food crop such as SRC willow may support a different set of wildlife. It requires a life cycle assessment combined with a biodiversity assessment to tease out which is a net beneficiary to biodiversity, and to particular species. An extensively planted crop that is managed in an intensive way will be problematic, but most crops are grown in rotation to conserve natural soil fertility. Consequently, mono-planting year on year is unlikely.

Land management controls already exist to protect and strengthen biodiversity in the UK. Some of the potential negative impacts of converting from food to non-food crops will be minimised by these requirements. It is already required that Environmental Impact Assessments be made where:

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[26] Altieri, M.A. (1999) "The ecological role of biodiversity in agro-ecosystems" in *Agriculture, Ecosystems and Environment* 74 (199), page 19-31.

[27] Ian Butterfield and Ian Paterson (2005) English Nature, personal communication.

[28] Soil Association response to Defra consultation on Strategy on Non-Food Crops and Uses (August 2004).

- Crop production qualifies for Single Payment under CAP (cross-compliance rules must be applied)

- Trees are planted over a significant area

- A crop is planted on previously uncultivated land (where this would have significant environmental effects)

- Grants for energy crops cultivation are given under the Energy Crops Scheme

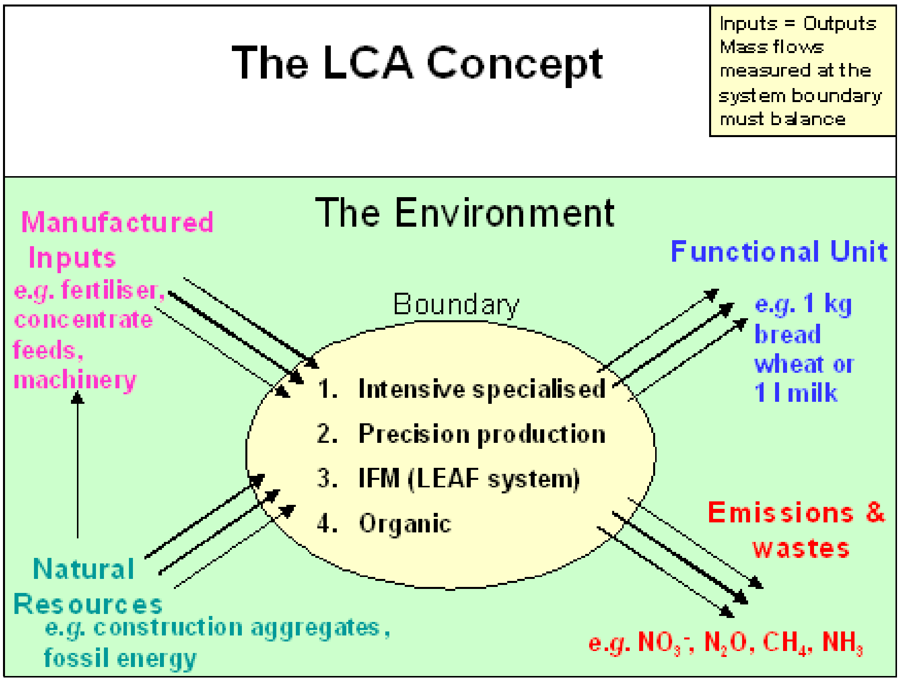
d. Mass balance and Life Cycle Assessment

Measuring the impact of non-food crops could be analysed and hence initially quantified through Life Cycle Assessment (LCA). LCA is in effect a combination of *mass balance* and *energy balance.* LCAs are being developed by the Silsoe Research Institute at Cranfield University, supported by Defra (see below).

Mass balance is used to measure and quantify the flow of material over a period of time to maximise resource efficiency. The underlying principle is that within an enclosed system the total mass is constant; it may be moved or transformed to different states, but it is not created or destroyed. So within a closed system the mass of inputs and the change in mass outputs should balance. This is not just of theoretical interest since it has significant practical advantages for resource productivity. Improved rates of recovery, recycling and re-use means that materials stay in the economy for longer and the environment benefits. Also the flow of resources to disposal and the associated environmental impacts will be reduced.[29]

The Silsoe Research Institute's (SRI) work on LCA, is an example of how the technique could be used in the Land Based Industries. Within an agricultural context the diagram below illustrates what inputs and outputs are considered.

[29] Linstead, C. & Ekins, P. (2001) Mass Balance, UK Royal Society for Nature Conservation.



Using this model of analysis the SRI is examining the environmental burdens and resource use involved in producing a range of agricultural and horticultural crops. The exercise has resulted in LCAs for:

- Bread wheat
- Potatoes
- Oil seed
- Tomatoes
- Eggs
- Pig meat
- Poultry meat
- Beef
- Sheep meat
- Milk

The data for each production system will be a table of values which can be modified and data quality and sources should be recorded to ensure the reliability of comparisons. The Institute has established that:

> "The production systems will encompass the range of typical methods and intensities, e.g. organic, conventional, extensive, LEAF, precision and integrated. The actual choice of production systems will be specific to each commodity."[30]

LCA and bio-diversity analysis could be used to develop a modified ecological footprint. This would involve examining the specific inputs, outputs, and impacts on biodiversity for individual crops to develop a foot print for each. In this way individual crops could be assessed for their impacts and compared to one another. This initiative would also need to consider issues of extensity of plantings, as well as intensity, though the visual impact of crops would likely be excluded since this assessment is subjective.

[30] Silsoe Research Institute Mathematics Research Group (2005) *Life Cycle Analysis Concept*, www.sri.bbsrc.ac.uk/science/bmag/lca.htm.

For biomass crops, the energy used to grow the product would be offset by the energy produced when it is burned, but the waste emitted to the atmosphere (either in combustion or transportation) would need to be included. Oil crops such as OSR are either grown for food-quality oil, or for non-food oil for fuel or lubricants. While the processing wastes from the food crop can be used as animal feed, the waste from non-food rape cannot. The question arises, how is the waste disposed of and what are the economic and environmental costs? These questions have not been included in the Silsoe Research Institute's LCA work.

The conversion rate for oil crops to bio-fuels is known, although the energy needed to convert them varies according to each crop. The biodiversity impact of management should also be known for individual crops in a way that can be used to compare impacts across crops. This assessment should consider autumn planting as opposed to spring planting; insecticide, pesticide and fertiliser use; sowing and harvesting methods; crop rotation; water inputs and run offs. Perhaps this assessment could be the Environmental Impact Assessment being developed by Defra.

A modified ecological footprint would focus on the benefits of certain crops and varieties and would help to identify where improvements in crop management and planting decisions can be made or need to be made. It is one way to ensure that new problems are not created at the same time solutions are sought to CO_2 emissions and other environmental problems. The Silsoe Research Institute has laid the foundations for this important kind of analysis.

e. Conclusions on the intensity of non-food crop management

The intensity of non-food crop management is very context-dependent, i.e. the ability of the crop to crowd out weeds, the effect of insect deprivation, climactic and soil conditions, and the intensity of the crop. A highly intensively managed crop with low extensity may have a low impact.

Changing weather conditions are impacting on weed and insect control; milder, wetter winters are advantageous to both. Consequently it seems unlikely that management of non-food crops will be very different from food crops, but each crop and variety will need to be considered individually. Species, varieties and end use will effectively dictate the intensity of their management.

7. Conclusions and recommendations

This investigation established a framework of three main criteria for assessing the impact on the countryside of crops used for non-food purposes, namely (1) the various policies and market forces driving their production, (2) the extensity at which they are planted, and (3) the intensity with which they are grown and managed. Within the framework this report has considered a wide range of data sources from policy documents to case studies to expert interviews. Based on our analysis of this data we have reached a number of conclusions about the likely impact of non-food crops on the quality of the English countryside.

Expanded production of crops for non-food uses is not mutually exclusive with a high quality countryside. Hundreds of thousands of hectares of crops with dual food- and non-food end uses are being grown in the UK today, which supports the possibility that they can continue to co-exist with a countryside of high visual, environmental, and historical quality. The beauty of the countryside can continue to underpin critical rural industries like tourism without necessarily being compromised by economic development in this industry.

The East Midlands will not 'explode in yellow' from oilseed rape or other non-food crops anytime soon, as one industry expert stated it. The sector has been supported by a constant flow of R&D monies and public sector support programmes for more than twenty years, and only recently have we started to see interest from the private sector. Farmers will not grow a crop, much less an unconventional non-food crop without some guarantee that there will be a market. These private individual decisions combined with agronomic requirements such as the need for rotation, form the market mechanism that ensures that certain commodities are not overproduced (for further determinants see Appendix I, 'Key factors affecting the decision to plant non-food crops').

It is impossible to generalise about the countryside impacts of non-food crops because of the vast number and variety that can be grown in English soils (see Appendix A). Some such as lavender are grown in small quantities because they are high value for low volume. Others like oilseed rape can be planted uninterruptedly across hundreds of hectares of the landscape. Still other crops such as wheat cause virtually no visual impact since the material and crop residues are, since field burning was banned, increasingly utilised for industrial use and animal bedding. Even within each specific crop there are characteristics with conflicting merits and detriments for the countryside. It is not uncommon that a crop supports high levels of biodiversity, but due to economies of scale is frequently planted in multiple hundred hectare tracts.

Efforts to improve the overall sustainability of farming in the UK should not be separated between food and non-food crops. In many cases crops used for non-food purposes are actually old products of the agricultural landscape being used to new ends, giving a new face to an age-old industry. As with conventional food crops, what a farmer chooses to grow is within reason less important than how he chooses to grow it. Inputs, rotation, tilling, and other management factors have a strong effect on environmental quality. Crops used for non-food purposes are still subject to almost all of the same land-management decisions as conventional food crops. The management principles that make conventional food crops sustainable are largely those that will make non-food crops sustainable.

Data on plantings and industry developments is widely scattered making it difficult to track changes, especially to the extensity of plantings (though this is changing with the establishment of the NNFCC and other various data bases). A lot of information on specific applications is proprietary, and the nature of some research and development in the pharmaceutical and fibre industries is highly commercially sensitive. We recommend that the Countryside Agency devise a systematic way to track changes in the sector, perhaps using the method set out in this investigation as a starting point.

Provisions should be made in future countryside quality assessments for the potential presence of GM crops. In future assessments of countryside quality scheduled to be performed every 5 years, we suggest that a GM crops category, whether for food or non-food uses, be introduced under the list 'Extent or stock of new elements.' Should a GM crop pass through the extensive regulatory processes and scientific trials, survive EU approval, and gain the support of the UK public, it would certainly be a new feature to the landscape and should be considered as such. To a lesser extent we also recommend including in future Countryside Character assessments a more sophisticated assessment of change to agricultural and woodland land uses with specific attention to non-food crops.

Consider devising a system of landscape-proofing economic development policies. The concept of 'rural proofing' economic development policies means they are equally sensitive to the needs, circumstances, and aspirations of rural communities as they are to those of urban ones. But such policies, even after they have been rural proofed, can fail to consider the tangible effects of growth and development on the countryside. We would suggest that the Countryside Agency consider developing a comparable ‘landscape-proofing’ system for economic development policies to ensure they duly recognise and do not undermine the countryside’s quality.

Such a system would scrutinise the kinds of development that have intensive impacts on the aesthetic and environmental qualities of the landscape like industrial scale agriculture. It should remain open to the possibility that appropriately managed non-food crops could actually be an enhancement to the countryside by protecting biodiversity, drawing tourists interested in these new agricultural features of the landscape, and conserving the agricultural character of the countryside. They could also play a key role in the establishment of rural hubs and information centres. This is not to say that a consciousness of the countryside does not exist in economic development planning, but that it may need to be made a more explicit and systematic feature in policy deliberation. Drawing these ideas together under an umbrella term like landscape-proofing may be a start in this direction.

Consider how to develop a life cycle assessment or a modified ecological foot print for non food crops. The Silsoe Research Institute’s research on life cycle assessment could be developed to include biodiversity leading to a modified form of an ecological foot print for each non-food crop. This would allow a more balanced comparison among individual crops according to their various advantages and disadvantages. There would need to be widespread consultation on the elements of biodiversity to be included in an analysis, as well as those relating to its measurement and reporting. LCA could become a useful tool in assessing agricultural impact, one that would complement the biodiversity and other features of Defra’s own Environmental Impact Assessment.

It is important to remember that human activity has been shaping the landscape for millennia. The aim of a modified ecological foot print is not to end this process, but to try to ensure that we consider the impact of change, in addition to becoming resource efficient and minimising the negative aspects of land management.

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Appendix A: List of crops with non-food applications suitable to grow in England

"To watch" crops determined as most likely to impact on the countryside
Sugar beet Wheat Oil seed rape (OSR) Linseed flax Hemp Nettles Miscanthus Short rotation coppice (SRC) willow Lavender

Crops suitable to grow in England		
Daffodils	Juniper berry	
Barley	Lavender	Spearmint
Bearberry	Lesquerella	Sugarbeet
Birch	Linseed	Sunflower
Bitter vetch	Limnanthes	Thyme
Bluebell	Lunaria	Valerian
Bog bean	Lupins	Vernonia
Bog myrtle	Madder	Weld
Borage	Maize	Wheat
Calendula	Marjoram	Woad
Camelina	Meadowfoam	Woodchips (residue)
Caraway	Meadowsweet	Yarrow
Cornmint	Miscanthus	Yellow iris
Cotton	Mustard	Yew
Chamomile	Naked oats	
Chicory	Nepeta	
Coriander	Parseley seed	
Crambe	Oats	
Cuphea	Oil poppy	
Dimorphotheca	Oil pumpkin	
Echium	Oilseed rape	
Euphorbia	Peas	
Evening primrose	Peppermint	
Eyebright	Potatoes	
Fibre sorghum	Plantain	
Flax	Pyrethrum	
Geranium	Rose	
Heather	Rowan	
Hemp	Sage and Clary sage	
Hops	Seabuckthorn	
Hypericum	Short rotation coppice (SRC) willow	
Jasmine	Soybean	

Appendix B: Profiles of "to watch" crops

Crops chosen by type:

Food crops with alternative uses:

i. Sugar beet
ii. Wheat
iii. Oil seed rape (OSR)

Fibre crops:

iv. Flax (and linseed for oil)
v. Hemp
vi. Nettles

Biomass:

vii. Miscanthus
viii. Short rotation coppice (SRC) willow

Essential oil:

ix. Lavender

Criteria considered

- Uses
- Growing conditions – soil, moisture, temperature, rotations
- Management – rotations, scale, fertiliser, pesticides, harvesting
- GM (Genetic Modification)
- Current cultivation – what is grown in the East Midlands
- Biodiversity
- Visual impact and implications for air, water and soil

i. Sugar Beet *(Beta vulgaris)*

Summary
Sugar beet is widely grown in the region, but due to changes in global sugar production, plantings are declining, but alternative uses could halt this decline. Its principal non-food use is for bio ethanol – more can be produced from sugar beet per hectare than wheat, and it also has a more favourable environmental impact. But the technology for conversion to bio ethanol is more complex for sugar beet than wheat, which may have an impact on expanded production. The crop has significant environmental impacts in terms of soil erosion through harvesting, demands it places on the soil, fairly intensive management requirements, and frequent pesticide applications. It may have biodiversity benefits as it is spring sown.

Uses
There are many sugar beet cultivars and almost all are capable of giving root yield of about 40 tonnes per hectare at 15.5 to 18% sugar content, yielding 6 to 7 tonnes of sugar per hectare.

100 kilograms of fresh sugar beet can yield:
- 12 – 15 kilograms of sucrose
- 3.5 kilograms of molasses
- 4.5 kilograms of dried pulp
- Varying amounts of filter cake

The annual world production of sucrose is produced mainly for food use and is also used for animal feed. The principal non-food use of sugar beet is bio ethanol production. Other uses include:

- Filter cake, as an agricultural soil fertilizer
- Molasses are combined with beet pulp to be used as feedstock in the chemical and pharmaceutical industries for fermented products such as citric acid and its esters
- Sugar molasses is of limited value for large-scale ethanol fermentation

Potential uses[1]

Mode of processing	*Examples*	*General Fields of Use*
Chemical, thermal modifications, hydrogenation	Surfactants; phosphoric acid esters; ethers; building blocks for synthesis.	Material economics: starting materials and intermediates for food, feed, pharmacy, solvents, biodegradable plastics and surfactants.
Biotransformation	Organic acids: citric, lactic, acetic. Amino acids: lysine, glutamic. Solvents: acetone, butanol. Biopolymers: PHB, PLA, single cell proteins.	Material economics: starting materials and intermediates for food, feed, pharmacy, solvents, biodegradable plastics and surfactants
Fermentation	Ethanol and other alcohols.	Energy and material economics: fuel alcohol, solvents, synthesis.

Growing conditions

- Temperature - not resistant to hard frost, roots lifted in autumn. Seed production and sugar production need to take place in different locations because frost resistance is poor, but plants need a cold shock to flower and produce seed.

- Soil - Requires a deep, well-drained, stone-free soil that is not acidic.

- Timescales - Sowing date is quite crucial, early sowing gives better sugar yields due to increased water availability earlier in the season, but sowing too early leads to a high population of bolters.

- Moisture – can withstand much drier conditions than other crops such as potatoes or vegetables.

Management

Rotation

Sugar beet is a biennial crop. Rotations both using sugar beet and from sugar beet are important. As a break crop in an arable rotation dominated by winter wheat and barley, sugar beet is also important in integrated weed and pest management of arable crops generally. Beet cyst eelworm (*Heterodera schactii*) can be damaging and is only satisfactorily controlled by adequate rotation.[1]

Fertiliser

Sugar beet now has the lowest nitrogen usage of any major arable crop in the UK - averaging 105 kilograms per hectare compared to approximately 190 kilograms per hectare for wheat, oilseed rape and potatoes (see graph in main report section 6a).[1]

Pesticides

Sprayed on average 6.5 times a year.[2] Seedling stage is a poor competitor with weeds and can be fatally damaged by millipedes, symphalids, spring tails and pigmy-mangel beetle.

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[1] The British Survey of Fertiliser Practice (1999) Edinburgh University data library, www.datalib.ed.ac.uk/EUDL/surveys/fertiliser.

[2] British Agrochemicals Association (1994) www.cropprotection.org.uk.

Harvesting

A high standard of management of land is needed to provide a well-structured soil, free from compaction. Soil erosion through mechanical removal during harvest has been a serious problem, up to 350,000 tonnes per year, but there has been success in addressing it:[3]

- Dirt tares have reduced by more than half between 1987 and 2001 due to farm practices to minimise soil erosion.
- The UK now has the lowest dirt tare, and the highest delivery standards, in the EU.
- All soil recovered is now used in productive applications, and half of it is returned to agricultural land to replenish stocks and provide textural benefit.

GM

Up to 90 GM beet trials have been carried out in the UK each year[4], for three years and completed in 2003[5]

> "Test 2: Sugar beet, October 2003. The GM crop was found to be potentially more harmful to its environment than crops that were unmodified. Bees and butterflies were recorded more frequently around conventional crops, due to greater numbers of weeds. Verdict: GM fails."

Seed numbers were reduced by up to 80%, removing an important food source from farmland birds.[6]

Current cultivation

There is a trend of declining production in the UK, which is mirrored in the East Midlands. Around 35,000 hectares were grown in the Region in 2003.[7]

Biodiversity

Benefits

Since it is a spring crop wildlife benefits through minimised disruption to nesting species. Sugar beet provides the second largest area of spring sown crop in the UK, after spring barley, and 60% of it is grown on land that is ploughed in early spring. This combination of circumstances helps to support bird populations. In the winter a variety of habitats are created on winter stubbles, and beet fields provide an important source of over-wintering food. In spring time the crop provides nesting sites for species such as skylarks and stone curlews.

Important for weed and pest management in arable crops when used as a break crop - because its host pests and diseases are different from those of combinable crops, its cultivation reduces disease and pest levels in the rotation, and therefore contributes to lower pesticide applications. It also contributes to agricultural

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[3] Defra (2002) "Surgar Beet and the Environment in the UK," www.defra.gov.uk/corporate/consult/eisugar/report.pdf.

[4] British Sugar (2002) "The environmental impact of growing sugar beet," a submission to DEFRA, www.britishsugar.co.uk/bsweb/bsgroup/defra_impact.htm.

[6] RSPB (2003) Wales briefing report, www.rspb.org.uk.

[7] Defra (2003) Online database of June Agricultural Census data, www.defra.gov.uk/esg/work_htm/publications/cs/farmstats_web/default.htm.

sustainability by preventing monoculture and ensuring that rotational benefits are achieved. Sugar beet also reduces inorganic fertiliser requirements for subsequent cereal crops. Plant residues from the crop, e.g. leaves and root fragments, break down slowly releasing nutrients to the soil over a long period of time.[5]

Negative impacts
Sprayed often due to pests, reducing associated wildlife.

Visual impact and implications for air, water and soil
Sugar beet may not be considered visually attractive compared to other non-food crops. However, its cultivation for non-food use may replace rather than extend current plantings.

Bio ethanol produced from sugar beet shows environmental advantages in criteria such as emissions and water pollution compared to bio ethanol from wheat and potatoes and bio fuels from oilseed rape.[8]

[8] Reinhardt (2003) "Biofuels versus fossil fuels: life cycle approaches," Heidleberg Institute for Energy and Environmental Research www.european-climate-forum.net.

ii. Wheat *(Triticum aestivum)*

Summary
Wheat is by far the most important crop in the region in terms of area grown, with over three times more land under wheat than any other crop. Hence the skills and infrastructure to support cultivation for non-food uses are already well-established. Principle non-food uses are to create bioethanol, as a starch and for wheat germ oil. Wheat is grown with intensive chemical application at a monoculture scale, so it may bring the fewest biodiversity benefits of any crop considered in this report.

Uses
Wheat germ oil, wheat gluten, wheat starch and ethanol. Wheat straw also has application as a source of fibre.

- For bioethanol, wheat and sugar beet are the most likely crops for production. Wheat produces more bioethanol per tonne of crop than sugar beet, but total bioethanol yield is greater from sugar beet due to higher yields in tonne per hectare.

- Due to its high level of linoleic acid (C18:2) wheat germ oil is used for dietary purposes and in cosmetic preparations.

- Wheat is the only UK starch crop. The UK has no quota for potato cultivation as a starch crop.[9]

[9] IENICA (2004) “Report from the State of the United Kingdom – update report.”

Applications of starch and its derivatives

	Textile	Adhesives	Paper	Building industries	Surfactant	Polymers	Pharmaceutical industries	Cosmetics	Bio-industries
Native starches	*	*	*	*		*	*		*
Etherified starches	*	*	*	*				*	
Thinned starches	*		*	*					
Oxidised starches	*	*	*	*			*		*
Dextrins	*	*	*	*			*		*
Maltodextrins	*				*		*		
Glucoses				*			*		*
Dextrose	*			*	*		*		*
Maltitiol							*	*	
Sorbitol					*	*	*	*	*
Mannitol							*		
Cyclodextrins	*						*	*	*

Source: Jacques Michaud, Cerestar, Belgium, IENICA database)

Growing conditions

Well suited to East Midlands (and UK) growing conditions, hence the large areas planted.

Management

Wheat is an intensively managed crop with high levels of chemical application.

Scale

Grown over large areas, i.e. as a monoculture.

Fertiliser

Nitrogen use on winter wheat was 185 kg/ha in 1999. Milling wheats receive about 20kg/ha more nitrogen than non-milling crops, so non-food applications may receive slightly less.[10]

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[10] The British Survey of Fertiliser Practice (1999) Edinburgh University data library, www.datalib.ed.ac.uk/EUDL/surveys/fertiliser.

Pesticides

"By tonnage of pesticides the highest loads are to potatoes, wheat, winter barley, oilseed rape and sugar beet. Of the 10 most extensively used substances six are fungicides, two herbicides, one a growth regulator and one an insecticide."[11] Cereal crops on average receive around seven chemical applications a year.

GM

Wheat pollen is even more pervasive than that of OSR. So the threats of cross-breeding and contamination of non-GM crops by GM wheat varieties would be even greater than have already been seen for OSR.

The world's first genetically modified wheat, Roundup Ready developed by Monsanto, was not marketed from in May 2004 because of consumer resistance.

Current cultivation

Over 350,000 hectares were grown in the East Midlands in 2003, making it the most important crop in the region by area grown (the next largest being OSR at 100,000 hectares). Approximately 4% of the wheat grown in the UK is grown for starch production.

Biodiversity

Monoculture cultivation and high chemical application limit the benefits for biodiversity, with wheat possibly the least biodiversity-friendly crop considered in this report.

Visual impact and implications for air, water and soil

Much wheat is already grown in the region so increased area or growth for alternative uses would not represent a significant change.

For environmental impact ranking in ethanol production, including emissions and resource demand, wheat ranked second after sugar beet, above OSR and potatoes.[12]

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[11] Defra (2002) "The Government's strategic review of diffuse water pollution from agriculture in England."

[12] Reinhardt (2003) "Biofuels versus fossil fuels: life cycle approaches," Heidelberg Institute for Energy and Environmental Research, www.european-climate forum.net.

iii. Oilseed Rape (OSR) (*Brassica napus* and *B.rapa*) (Canola in North America)

Summary
Oilseed rape (OSR) is now the third most important crop in the UK after barley and wheat with nearly 500,000 ha under cultivation. Globally, it is ranked as the third most important oilseed crop after soybean and palm.[13] Bio fuels are the principal non-food use and their growth is set to continue as the Government's Renewable Energy Targets are a driving force. A £10 million bio diesel plant with a capacity of 100,000t per annum is being developed by Gree*nergy* in partnership with Tesco plc, at Immingham in Lincolnshire. This investment may help to secure establishment of crops for bio diesel in the region with the first bio diesel is expected to be produced from the plant in 2006.

Uses
The IENICA database gives a detailed review of uses of oilseed rape. It is principally grown for its oil – its seeds contain around 40% oil.

> "OSR oils have good environmental characteristics. They are inherently biodegradable, of low eco-toxicity and toxicity towards humans, derived from renewable resources, and have no net carbon dioxide contribution to the atmosphere. Their cost falls in the range between mineral and synthetic oils."[3]

The two primary varieties of oilseed rape both have non-food uses. The variety refers to whether erucic acid content is high or low. This compound is hard for animals and humans to digest.

- *00 Double low* is low in erucic acid e.g. less than 1%. It is also low in levels of glucosinolates (a sulphur compound which makes the meal by-product indigestible for animals). This is the main variety grown in the UK as it has both food and non-food uses. Farmers can grow it and decide the end use depending on markets at the time of harvesting.[14] 3.5 million hectares of 00 were grown in the EU in 1999.

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[13] ACTIN newsletter (1999) IENICA database, no. 12, June 1999.

[14] Robin Twizell (2005) OSR Grower, personal communication

- *High erucic acid rape (HEAR) varieties* are grown specifically for their erucic acid content - typically 50-60% of oil. 34,000 hectares grown in EU in 1998, i.e. 0.1% of the area planted with 00 OSR. In 2003 20,000 ha were grown in the UK. This represented a quarter of all oilseed rape grown on set aside land, but only 4% of the total area of OSR grown in the UK in 2003 (500,000 ha). It seems to be grown to a much greater extent in other EU countries such as France and Germany.

Oil from 00 rape can be used to make bio diesel (as well as for food uses). Two thousand ha of oilseed rape were grown for bio diesel in the UK in 2003.[15]

> "…the principle end-use of HEAR oil is… to produce erucamide which is used as a slip additive in polythene and polypropylene, to reduce surface friction and prevent adhesion between film surfaces. HEAR oil is also used in printing inks, lubricants and has a range of other applications."[3]

Markets for Rapeseed Oils:

Lubricants
Surface coatings
Polymers
Medicinal

Markets for Rapeseed Meal (which is high in protein):

Bio plastics
Adhesives
Cosmetics
Encapsulation agents
Lawn care products
Combustion material

Markets for Rapeseed Straw:

Fuel
Bedding material.

Growing conditions

Oilseed rape is well adapted to East Midlands soils and climate, hence the large areas grown.

Management

Rotation

The winter-sown variety is much higher yielding than spring-sown (about 50% greater) and is much more widely planted. Rape is the predominant break crop in cereal production in the UK. In this role it has replaced linseed due to its advantages of being higher-yielding, planted and harvested earlier (spreading the workload for farmers) and due to receiving a higher price (relative to linseed) as a result of Agenda 2000.[16]

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[15] IENICA (2004) "Report from the State of the United Kingdom – update report."

[16] Agenda 2000 meant that rapeseed and linseed would receive the same Area Aid Payment and cereals. Realignment began in 2000 with equalisation of prices in 2002. As linseed had received a higher area payment than OSR it became less profitable to produce, hence the switch to OSR.

Scale
Usually grown over large areas as a monoculture. It can be cross-pollinated with other wild *Brassicae,* pollination methods include wind and insects as well as self-pollination. Cross-pollination affects the glucosinolate content of the resulting seed. If cross-pollination is to be avoided physical barriers (distance or high-growing species or trees) would need to be in place.

Fertiliser
Nitrogen hungry. Applications averaged 197 kg/ha in 1999, higher than any other crop.[17]

Pesticides
High chemical inputs needed, for example 5 times per crop, costing £135 - £150 per tonne. Subject to fungal disease and aphid-transmitted viruses.

GM
Varieties
Oilseed rape is at the forefront of genetic engineering technology and several varietal types have successfully completed trial and are awaiting approval from the EU for commercial release. The developments are of two major types:

1. Enhanced or altered quality/yield characteristics.
2. Tolerance to pest, disease or herbicide tolerance.

The first varieties likely to be commercially available in the EU are the glufosinate ammonium herbicide tolerant oilseed rapes. Other genetically modified rapes are glyphosphate tolerant oilseed rape and varieties with modified fatty acid content, in particular high lauric acid rapeseed. The introduction of these varietal types will require careful planning and is at present the subject of much debate.[3] Details of many varieties, their applications and progress through the approval process are given in a report by the Agriculture and Environment Biotechnology Commission.[18]

GM trials in the UK
Large-scale farm trials of GM oilseed rape, both spring and winter varieties, have been undertaken in the UK. In both cases the varieties failed due to their adverse impacts on biodiversity. The latest trial was completed in March 2005 and involved 65 sites across the UK. Details are given in Appendix __.

Risks
The presence of imported genetically modified (GM) oilseed rape plants growing in the wild has been confirmed across Japan. The Ministry of Agriculture, Forestry and Fisheries first reported on June 29, 2004 that it had confirmed the presence of imported canola varieties growing in the vicinity of Kashima Port in Ibaraki Prefecture, on the basis of a survey conducted from fiscal 2002 through fiscal 2003.[19]

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[17] The British Survey of Fertiliser Practice (1999) Edinburgh University data library, www.datalib.ed.ac.uk/EUDL/surveys/fertiliser.

[18] Agriculture and Environment Biotechnology Commission (2002) Horizon Scanning Report, www.aebc.gov.uk/aebc/reports/horizon_scanning_report.pdf.

[19] Japan for Sustainability (2005) "Spread of Genetically Modified Canola Confirmed across Japan," December 25, 2004, www.japanfs.org.

Current cultivation
100,000 ha of OSR were grown in the region in 2003, making it the second most important crop by area planted after wheat.[20] Many farms are growing for non-food use, Appendices F and G give some details and maps on production for Green*ergy* Ltd, a company purchasing and promoting the use of OSR to make bio diesel, as well as for Defra's Energy Crops Scheme. They place particular emphasis on the green credentials of the seed they source, and require a carbon certification for crops grown and have created voluntary biodiversity measures for growers.[2]

Biodiversity
Benefits
"There is ecological evidence to suggest that oilseed rape (OSR) is a relatively beneficial crop for biodiversity, in comparison to other autumn-sown arable crops. Up to a point, an increase in the area of OSR grown for bio diesel production could have a beneficial, or at least neutral, impact on biodiversity, if it replaced winter wheat or other winter crops. Spring-sown OSR would be vastly preferable to autumn-sown rape, since it allows stubbles from the previous crop to remain in the field over winter."[21]

Negative impacts
The high agricultural chemical inputs needed can lead to reduced biodiversity, through minimisation of weeds and insects.

If winter OSR were to predominantly replace spring crops such as peas or barley, or naturally-regenerated set-aside, the overall impact on biodiversity would probably be negative. Winter OSR is worse for wildlife than spring-sown since harvesting occurs in April or May during nesting season. The National Non-Food Crops Centre (NNFCC) is launching a project to investigate the management impacts of oilseed rape and wheat grown for starch.

Visual impact and implications for air, water and soil
The large fields of yellow flowers are striking. But the countryside is not going to turn yellow overnight - requirements for rotations and a guaranteed market will moderate any rapid expansions.

OSR is a nitrogen-hungry crop and could result in increased fertiliser applications if it replaced land uses with low nutrient requirements. This could have negative impacts on water quality.[9]

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[20] Defra (2003) Online database of June Agricultural Census data, www.defra.gov.uk/esg/work_htm/publications/cs/farmstats_web/default.htm.

[21] English Nature (2003) Memo submitted to House of Commons Select Committee on Environment, Food and Rural Affairs.

iv. Linseed and flax (*Linum usitatissimum)*

Summary

Linseed flax is widely grown in the UK and around the world, primarily for its oils, though also for animal feed, fibre, and straw. It has somewhat specific growing, management, and harvesting requirements which makes it a crop whose environmental impact on the landscape is moderately environmentally intensive. With its diversity of well-established uses it is often grown on an industrial scale. Its use in non-food crop applications is fairly advanced, and the plant has been genetically modified in North America to serve these industrial markets.

Uses

Linseed is predominantly grown for industrial use in the manufacture of oils, paints, varnishes and linoleum. For information on 'Linola' types suitable for culinary use see edible linseed (SOLIN).

There is also a market for linseed meal as animal feed, and specifically as poultry feed because it increases levels of omega 3 fatty acid in eggs. Whole seed is used in the baking and confectionery industries where its health benefits are recognised. Linseed straw also has applications in biomass energy burners.

When grown for its fibrous stems the plant is called flax. Flax fibre is hollow, able to absorb up to 12% of its own weight in water. It also dries quickly, does not perspire and is anti-static by nature making it equal to man-made synthetic fibres such as fibreglass. The fibres are twice as strong as those of cotton and five times as strong as wool. Its strength increases by 20% when wet. Long fibres are used for weaving, spinning into yarn and geo-textiles; shorter fibres are used for packaging and plastic alternatives.

Growing conditions

- Soils of a fine tilth are needed for best emergence, light to medium soils needed. Does not grow well on poorly drained or sandy soils, or heavy clays.

- Temperatures - slow to establish in cold weather, susceptible to severe frost, but well suited to a cool climate

- Moisture - at harvesting needs to be thoroughly desiccated, otherwise wrapping occurs around the combine. Suited to humid climate, irrigation may be needed when drier.

- Rotations – cannot be planted directly after oilseed rape. Shared diseases with OSR, peas and beans mean a four year break from such crops may be required to control the diseases. Has been grown as a break crop throughout Europe.

Management

Sowing preferences

Early sown gives better yield, oil content and straw quality. Linseed, like rape, is sensitive to seed bed conditions, and best emergence comes from a fine tilth. The crop can be very slow to establish in cold weather. Winter varieties of linseed have now been developed and perform well providing the crop is well established prior to onset of winter. Weed control in the young crop is essential. A planting density of 400-500 plants/m^2 is preferable for linseed to facilitate competitive advantage over weeds. Flax needs higher planting density near 2000 plants/m^2 to minimise basal branching and hence improve future quality.[1]

Fertiliser

Nitrogen fertilisers are helpful at levels of about 50-100kg/ha depending on previous land use; more is needed if following stubble, none is needed if following fallow. Too much nitrogen leads to increased danger of lodging and too much fibre, so flax is frequently given no nitrogen at all.

Pesticides

Herbicides are used for weed control on the young crop, partly due to it being a non-competitive species. Increased densities when grown for flax may reduce need for herbicides against weeds but increase pests and disease vulnerability, hence a requirement for greater pesticide application. The flea beetle can cause considerable damage requiring insecticide applications.

Harvesting

Harvesting can be a major problem with linseed, particularly if the crop is late, incompletely desiccated or lodged[22]. Lodging can be serious in linseed but crops often recover if lodging occurs early in the season. Late lodging severely impedes harvest, with very little bulk in the crop to support itself and allow room for the combine knife to get underneath. Crops must be very well desiccated at harvest to avoid wrapping in the combine, and great care must be taken to ensure thorough penetration of the desiccant into the crop.

The development of stripper heads has been particularly helpful for the linseed crop, as bolls tend to ripen well before the stems are ready for the combine knife. They allow the successful harvesting of later maturing varieties and of more northerly crops than might otherwise be possible, so long as the crops are standing reasonably well.

Flax crops intended for best quality fibre are pulled when the lower leaves have fallen; the pulled flax is then retted (this is a controlled rotting process), and

[22] Lodge refers to crops which have been hit by heavy rain and/or wind and are no longer standing upright.

scutched to separate the loosened fibres from the bulk of the stem tissue. Yields of fibre are normally in excess of 1 tonne per hectare.

Linseed is harvested when the capsules are ripe: often combining is facilitated by preceding chemical desiccation of the stems, seed yields of 2 t/ha or more often being obtained.

GM

Genetic modification of flax or hemp to alter the characteristics of the pectin layer, facilitate fibre extraction and improvement of fibre quality via modification of cell wall structure are particular targets of research. Identifying relevant genes is one subject of an EU research project on hemp the HARMONICA project .

The only field trial to have actually taken place (IN THE UK?) with GM fibre crops other than cotton is for herbicide tolerant flax in Canada.[23]

Linseed flax is being genetically modified in North America which suggests the profitability of such activities. The following article excerpt, dated almost a decade ago, was taken from a trade publication:

> "'Genetically altered flax receives regulatory approval' --
> A linseed flax variety, CDC Triffid, has been genetically engineered by a team of researchers at the University of Saskatchewan's Crop Development Centre to grow in contaminated and normal soils, and has received regulatory clearance in Canada. The new variety was engineered with a gene from thale cress which provides immunity to contaminated soil caused by a common class of herbicides used by cereal farmers. Because the herbicides do not degrade well, the farmer has a problem deciding what to do with the land in the years following cereal crops. The new flax, an industrial product that will be used to make paints and varnishes, could be grown on these soils."[24]

Current cultivation

Two thousand hectares of flax was grown in the UK in 2003, and 31,000 hectares of linseed. Around 4,700 hectares of linseed was grown in the East Midlands in the same year.[25] [26] Flax and linseed plantings have declined significantly since 1999 due to the implications of Agenda 2000[27] which has made linseed less profitable than oilseed rape as a break crop in cereal production.

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[23] GeneWatch UK (2004) "Non-Food GM Crops: New Dawn or False Hope? Part 2: Grasses, Flowers, Trees, Fibre Crops and Industrial Uses," a GeneWatch UK Report by Sue Mayer.

[24] Western Producer (1996) "Genetically Altered Flax Approved for Use in Paints and Varnishes," June 27, 1996.

[25] Defra (2003) Online database of June Agricultural Census data, www.defra.gov.uk/esg/work_htm/publications/cs/farmstats_web/default.htm.

[26] IENICA (2004) "Report from the State of the United Kingdom – update report."

[27] Agenda 2000 meant that rapeseed and linseed would receive the same Area Aid Payment and cereals. Realignment began in 2000 with equalisation of prices in 2002. As linseed had received a higher area payment than OSR it became less profitable to produce, hence the switch to OSR.

Biodiversity
Linseed flax is known to provide seeds for seed-eating birds like Linnet, a UK priority species; greenfinches and goldfinches also feed on the crop. These biodiversity benefits are somewhat offset however by the applications of herbicides for weed control and pesticides to reduce the threat of the flea beetle.

Visual impact and implications for air, water and soil
The flowering period may last for some weeks though individual flowers are short-lived. Linseed flowers are commonly bright blue, but may be pale blue or white, while most flax cultivars bear white flowers. Flowering is usually considered attractive.

Pesticide use is greater than for some other crops considered here, and using a desiccant is another chemical application, adding to the resource use and emissions associated with this crop.

v. Hemp (*Cannabis sativa*)

Summary
Hemp is one of the highest yielding and least intensive crops to cultivate. It has a huge variety of non-food uses, for which non-narcotic varieties are used. It appears to be well-suited to East Midlands growing conditions, but the greatest barrier to expanded plantings is likely to be the need for licensing and policing.

Uses
Fibre from hemp is suitable for paper-making, cigarette papers, printing and could complement/replace wood pulp. It is less subject to yellowing in paper-making than wood pulp. In the past it has been used in production of clothes and ropes too. Some high quality hemp clothes are being developed, but are currently using Chinese-grown hemp fibres. It is reported to be the longest and strongest of the natural fibres. The seed contains 30-35% oil, rich in C18:2 and C18:3, which has a number of industrial and food applications. Appendix J shows the wide range of potential uses.

Growing conditions
Soil – requires a well drained but water retentive soil to optimise yields. Well-suited to lighter, sandier soils, as found in parts of the East Midlands including Nottinghamshire.

Management
Rotations
Annual, planted end of April/early May, harvested early August. Research in Holland suggests that fungal diseases and pests can be reduced in traditional crops if grown in rotation with hemp. It is highly self-compatible so that there is no need for crop rotation – it can be grown in the same location for several years. It is also effective as an isolation crop, preventing outcrossing of other crops because of its tall, fast growing stature.

Fertiliser
Initial fertiliser recommendations are 80-160kg/ha nitrogen, 800-120kg/ha phosphate and 160-200kg/ha of potash, no further applications will be required. Cost estimate is £80/ha for fertiliser. Seeds cost £150/ha (IENICA 2002).

Pesticides
Fibres can be cultivated without use of insecticides (unlike flax). No herbicide is required as the plant smothers out any infestations. Field choice, pre-seeding tillage, shallow seeding, and packing after seeding all help to ensure that the hemp stand will emerge quickly and uniformly to gain advantage over the weeds.

Harvesting
Costs are estimated as cutting £70/ha, baling £80/ha and haulage £50/ha.[28] Retting time is generally 2 to 6 weeks from cutting depending on weather conditions, then the fibres are baled.

Public perception
Costs and risks increase due to the misperception that the crop is the high THC variety. A licence from the Home Office is required to grow hemp (£87/grower for 2001). Hemp crops can be the target of vandalism so another crop is usually grown around the field edge to hide the crop.

GM
Not currently applicable.

Current cultivation
An area is due to be planted in Nottinghamshire in 2005. It has already been grown in other locations in the region.

Biodiversity
The lack of chemical applications required for hemp encourages biodiversity. It is biodiversity-friendly in terms of species numbers.[29] "Hemp plantations especially increase the numbers of birds... Scientific studies have shown that birds with a staple diet of hemp seeds can live up to 20% longer, be much healthier, have more lustrous feathers and produce more off-spring."[30]

Visual impact and implications for air, water and soil
Hemp can grow up to 4m tall. It may be grown in the same location for several years so may be more of a permanent feature of the landscape than other crops.

[28] IENICA database (2005).

[29] Mountford and Small (1999), "A comparison of the biodiversity friendliness of crops with special reference to hemp (Cannabis sativa L.)," Published online at http://mojo.calyx.net/~olsen/HEMP/IHA/jiha6206.html.

[30] UK Cannabis Internet Activists (2005) www.ukcia.org/industrial/hemp/biodiversity.html.

vi. Nettle *(Utrica dioica)*

Summary

Nettle cultivation for fibre and other uses has been used in Germany and Austria for decades, but is still in the research and development stage in the UK. Research is underway at De Montfort University. Cultivation on a commercial scale is unlikely until such projects have been completed. As a fibre it could bring "green" benefits as an alternative to cotton.

Uses

Uses are similar to flax and hemp, with potential applications including textiles, paper, culinary, medicinal and biomass uses.[1]

In trials, yields of dry stems have ranged from 3-4 t/ha on poorer soils to up to 10t/ha on better plots.

Growing conditions

Soil – rich, disturbed soil.

Management

Rotations

A perennial, can grow for up to 10 years, with yield increasing with time.

Fertiliser

Thrives on over-fertilised soils. The crop will require a high level of nitrogenous fertiliser application to achieve high yields. Up to 300kg/ha of nitrogen may be required for highest yields.[1]

Pesticides

Certain varieties, particularly the taller ones, are thought to be largely resistant to weeds and pests, thus lowering the use of chemicals during the growth period.[31] It is a very competitive species so weed control is not needed where

[31] IENICA database (2005) www.ienica.net.

crop establishes well. Pesticides may be needed on poorer soils where nettles do not establish as well, to avoid contamination.

Harvesting
Harvest is currently more difficult for nettle plants than for hemp. Crops have to be harvested manually.

GM
Green credentials are the selling point of alternative crops. Nettles compare favourably with cotton in this respect, since there is much development of GM in cotton. For nettles, there is insufficient knowledge of fibre formation, so it would be hard to know what to modify.

Current cultivation
Only around 2 hectares are currently planted in East Midlands, as part of the STING research project.[32] Project may extend if successful. Grown more extensively in other European countries e.g. Germany, Austria, Switzerland and Italy.

Biodiversity
Nettles are currently the only host to 28 insect species and an important host to a further 18 species.[1] Disruption to associated flora and fauna is minimised through the lack of ploughing (since it is a perennial) and through the need for manual harvesting.

Visual impact and implications for air, water and soil
Reaches up to 2m in height, and may be in same location for up to 10 years.

[32] STING research project - Sustainable Technology in Nettle Growing – is a 3.5 year study sponsored by Defra into whether nettles can be grown as a commercial crop. Five to ten hectares are intended to be planted as an experimental plot.

vii. Miscanthus *(M. sinensis, M. sacchariflorus)*

Summary

Miscanthus has the potential for considerably expanded planting in the region, with incentives through renewable energy targets and the associated Energy Crops Scheme. Currently it is only grown in one or two locations. It is a perennial with some varieties tolerating water logging, requires less chemical inputs and intensive management than many other crops. It has several biodiversity benefits. Its height of 3-4m could represent a considerable contrast to previous crops at planting locations.

Uses

- Uses include as a fuel to be burnt, and for its fibres in paper, insulation board and possibly concrete.

- 1 kg of crop dry matter = c. 0.4 kg of oil in energy content, when burnt as a fuel.

- The power output of 1t of dry mass of Miscanthus when burnt is approximately 1.67 MWh.

- Fibre yield: 6 t/ha

Growing conditions

- Soil - light soils only yield well if rainfall is adequate, and on heavy soils there may be compaction and harvesting problems. Deep soils tend to produce higher yields.

- Moisture – some varieties can tolerate water logging. Although *M. sinensis* is reputed to be susceptible to water-logging in its establishment year, there are some observations that *M. sacchariflorus* usually occupies wet areas and yields more dry matter in wet plots than in dry plots, and prefers heavy soils or the waterside.

Management

Rotations

Miscanthus does not typically reach its peak yield until the third or fourth season. Hence subsequent yields should be much higher. It is anticipated a stand of Miscanthus would remain viable for 15 years.

Fertiliser
As a C4 crop N-use efficiency is higher in Miscanthus than in C3 crops, so little if any nitrogen needs to be applied, and for other fertilisers applications are not likely to exceed 75 kg/ha P and 100 kg/ha K.[33]

Pesticides
Weeds can check growth in the first two years of growth, various herbicides have been used to address this. Herbicides need only be applied once a year for the establishment years.[34] A large number of pests and diseases attack the crop although no any one major pest or disease causing serious loss is apparent.[1] It can therefore be grown without insecticides or fungicides.

Harvesting
Harvested once a year, between October and the spring. Best biofuel quality attained from spring-harvested crop.

GM
Not currently applicable.

Current cultivation
One site of 35 hectares in Northamptonshire through Defra's Energy Crops Scheme. Previously Nottinghamshire and Rutland. There was a trial near Mansfield, Nottinghamshire for around seven years, limits to success there were attributed to sandy soil conditions rather than unfavourable climate in the region.[35] In England, there is considerable planting in Cambridgeshire and Staffordshire.

Biodiversity
There are several biodiversity benefits gained from Miscanthus cultivation, and few recorded drawbacks. As a perennial requiring single planting rather than being cultivation every year it provides nesting for ground birds and winter foraging for birds, mammals and invertebrates.[2] Also March as harvesting time may be beneficial for wildlife.

It is associated with rich weed vegetation, eg 48-68% weed coverage in fields. Compared to reed canary grass it has supported substantially more skylarks, meadow pipits and lapwings, and more ground beetles, butterflies and invertebrates.[2] Few invertebrates are supported by the crop, but many by the associated weeds.[2]

Visual impact and implications for air, water and soil
They are similar in appearance to some strains of bamboo, a grass growing to 3-4m in height.

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[33] IENICA crops database (2005) www.ienica.net.

[34] The Effects of Energy Grass Plantations on Biodiversity, Cardiff, 2004

[35] Peter Nixon (2005) Miscanthus specialist with the Bio-Renewables Group, ADAS Arthur Rickwood, personal communication.

viii. Short rotation coppice (SRC) willow (*Salix)*

Summary

The drive for increased energy production from renewable sources, mediated by schemes such as the Energy Crops Scheme, has led to expansion of areas under SRC Willow in the East Midlands. It is likely to remain and probably increase in significance in the coming years. Willow is one of the fastest growing temperate tree crops with the capacity to put on 10 metric tons of dry weight per year when grown as short rotation coppice. It represents a significant visual and hydrological change to the landscape if replacing set aside crops or fallow land, but this is not necessarily a negative impact and there are biodiversity benefits from its cultivation.

Uses

The wood is coppiced and then chipped or made into fine sawdust for use as a bio fuel, as an additive to coal dust in power stations with it becoming an alternative in the medium term.

Growing conditions

Soil – Very wet or very dry soils are not suitable. If prone to soil moisture deficit or water-logging it may not be suitable due to erosion and compaction during coppicing.

Management

Rotation

Harvested every three years, in situ for around 10 years. Little maintenance required once established.

Fertiliser

Low input. Fertiliser application is only needed during the first one to two years.[1]

Pesticides

Currently limited chemical application is required: "During preparation and the first year after planting, good weed control is advocated to aid establishment. Herbicide use is generally less important after this time."[36]

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[36] UK Government Forest Research (2005) www.forestry.gov.uk.

However, pests have proved a greater problem than anticipated and high inputs of agrochemicals may be necessary.[37] Aphids are becoming a more significant pest as cultivation extends from a traditional cottage industry to commercial cultivation for biomass production. The giant willow aphid in particular is difficult to control. Colonies can cover most of the stem surface of 1-3 year old trees, it is frost hardy and ladybirds have limited effect on it as predators, perhaps due to concentration of chemicals from the willow in the aphid's body. Yield could be cut by up to 50% depending on pest numbers.[38] This could affect viability as a crop or at least requirements for pesticide application in years to come.

Harvesting
"The use of heavy machinery on wet or saturated soil can potentially result in severe wheel rutting, compaction, yield loss, and soil damage which could restrict future field operations. The most likely reason for low yields, associated with compaction, is an inability of the crop to meet the evaporative demand of the atmosphere because of restricted rooting and unfavourable soil physical conditions. This problem is likely to be particularly acute in Eastern England where soil water deficits can be large and winter water logging severe."

GM
Not currently applicable.

Current growing

- 200 hectares near Retford, Nottinghamshire.
- In total, four locations in Nottinghamshire, three in Lincolnshire and one in Derbyshire through Defra's Energy Crops Scheme.

Biodiversity
Benefits

- SRC willow encourages high biodiversity, for example when mixed with an area of intensively managed grassland, improving habitat and food supply for wildlife.

- Both abundance and diversity of small mammals, such as wood mice, seem to be greater in weedy SRC plots (than non-weedy plots).

- If "planted on farmland [it] may provide new areas of suitable breeding habitat for some woodland, scrub and ruderal vegetation bird species, possibly resulting in local population increases." Many songbird species are attracted to SRC. Some migrant warbler species that are becoming less common elsewhere are often seen in stands of SRC willow.

- As native trees, willows attract and support a wide range of woodland and other birds and as such contribute significantly to nature conservation and local biodiversity. The feeding foundations for this support are the 450 invertebrate species, including many insects that are associated with willows. The traditional cottage industry use of willow means few insects have assumed pest status.

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[37] Ernest Cook Trust UK (1994) "Crops for Industry and Energy." www.nf-2000.org/secure/Other/F465.htm.

[38] Simon Leather (2004) MSc Course Director, Biological Sciences Department, Imperial College at Silwood Park, Ascot, Berkshire. Posted on the Global Association of Online Foresters website: www.foresters.org.

- Shade tolerant plants may become established under the dense crop canopy. Headlands and access rides can provide a 'woodland edge'-type habitat where flowering plants may thrive.[39]

Negative impacts

"The impacts on water tables are likely to be significant, and this could have impacts on biodiversity, especially if plantations are sited close to wetland habitats." In some cases though this may be an advantage, enabling cultivation in flood-prone areas and perhaps even mitigating against flood risks.[40]

Ground flora is often sparse (where herbicides are used regularly). Where extensive weed populations do occur they are generally dominated by a few species of low conservation value, for example common nettle and rosebay willowherb.[6]

Willow may attract woodland birds, but restrict other species by replacing other habitats. Species characteristic of open farmland habitats, such as lapwing, skylark, and corn bunting, are unlikely to use SRC crops as a breeding habitat.

Visual impact and implications for air, water and soil

SRC can be a considerable change from set aside. Trees can grow to 6-9m high. Establishment in the same location for 10-20 years means the trees are likely to remain for a longer period in the same location than other crops. If greenhouse benefits are to be realised, SRC is most likely to be grown near power stations. The degree of benefit from being a renewable energy source is greatly dependent upon distance from the power station, to minimise emissions through transport.

"In the case of the EU Water Framework Directive (WFD), well-managed bio fuel and other non-food crops could help regulate water flows to mitigate the risk of floods and drought, especially woody crops that are harvested on long rotations. Therefore, depending on the way they are planted and managed, bio fuels and non-food crops could help both to mitigate climate change and to adapt to its effects. These aspects should be captured in any cost benefit analysis associated with options for the production and use of bio fuels."[41]

Wood chips show ecological advantages over perennial grasses and wheat when used as a solid bio fuel. [42]

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[40] and [41] SNH letter to Bio fuels Consultation, July 2004.

[42] Reinhardt (2003) "Biofuels versus fossil fuels: life cycle approaches," Heidleberg Institute for Energy and Environmental Research, www.european-climate-forum.net.

ix. Lavender (*Lavandula officianalis, L. latifolia* (spike), *L. x intermedia* (lavandin))


Summary
Lavender is an example of a speciality crop, grown for its essential oils. Only a small area is grown in the region, but it brings biodiversity benefits and can attract tourists to the countryside. Associated tourism with such crops would bring a much greater impact on the countryside than the management techniques required.

Uses

- Main applications of lavender oil are for perfumes, after-shaves and fragrances for cosmetics and toiletries.
- Lavandin oil is more likely to be used where lower cost 'rougher' fragrances are required, for example in soaps, detergents and household products, also used as a flavouring agent in food and drinks.
- Spike lavender oil can be used in the production of fine varnishes and lavenders.

The yield of oil varies considerably from season to season, as the age of the bushes and weather affect both the quality and quantity of the oil produced. Approximately 50 kg of fresh flowers with 15 cm stalks will yield about 30g of oil. One hectare of lavender in its prime could yield in a favourable year 35 - 45 kg oil, but an average of 11 kg would be a reliable estimate.[43]

Growing conditions
Can be grown on poor soils.

Management
Rotation
In commercial practice, bushes are seldom retained after the fifth year, and to maintain a supply, some planting must be done each year.

Scale
As a low volume, high value crop it is usually grown over a small area in the UK.

[43] IENICA database (2005) www.ienica.net.

Fertiliser
Most plants enjoy a little manure, and it will certainly help to establish healthy plants quickly. High potassium feed promotes flowering, but too rich a soil may result in limp, over-leafed plants.[44]

Pesticides
Few if any applications needed.

GM
Not currently applicable.

Current growing
Trent Valley Lavender at Gunthorpe, Nottinghamshire has operated since 2000. Three acres (around 1.2 ha are planted). It is only open on special days but attracts a maximum of 5,000 visitors a year.[45]

Biodiversity
Excellent for encouraging wildlife by attracting bees, butterflies and other flying insects. The insects attract foraging swallows and house martins whilst gold finches will feed on the dry seed heads and use it as nesting material.

Visual impact and implications for air, water and soil
Small areas of purple fields.

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[44] Norfolk Lavender website (2005) English lavender farm, www.norfolk-lavender.co.uk.

[45] Bill Warrior (2005) Trent Valley Lavender, personal communication.

Appendix C: Regional, national, and EU policy initiatives to support crops grown for non-food uses

Note: These initiatives were selected from the larger number related to non-food crops on the grounds that they 1) pertain to England specifically, 2) support the crops identified by this report for more in-depth treatment, and 3) support production at the early planting stages of the supply chain since this is where impact on the landscape is likely to be the greatest.

Governmental scale of initiative	Policy, programme or project	Project type	Objective or description	Approximate budgets or yearly expenditures	Programme duration
EU and EU / ENGLAND					
EU	Interactive European Network for Industrial Crops and their Applications (IENICA)	Research and promotion	Establishes crops, products, and contact databases; assesses markets, opportunities, and constraints; promotes technology transfer through conferences, newsletters, and discussion.	500,000 Euros per year operating budget.	Has been running since 1997; funding ended 2004. EC now considering application for new funding cycle.

EU	Biological Materials for Non-Food Products (BioMat)	Research and promotion	Displays results of EC projects in the area of biological materials for non-food products. Includes newletter, databases, catalogue of projects, and information dissemination activities.	210,000 Euros over 43 months, or 60,000 Euros per year.	Project began in 2001 and is now completed. Applying for more funding from EC but website intact.
EU - Common Agricultural Policy	The Entry Level Pilot Scheme	Land management subsidy	Encourages simple environmental management on UK farms - compatible with ECS. Presently being run as a pilot programme with the intent of a full scale launch in 2005.	£30 per hectare.	Commenced with recent CAP reforms.
	Fibre Processing Aid for flax and hemp processors	Commodity support	Direct supports for fibres produced from flax and hemp straw. UK subsidy cannot exceed 12,100 tonnes of short flax and hemp fibre, and 50 tonnes of long flax fibre.	Short flax hemp fibre receives 90 Euro/tonne, long flax fibre receives 160 Euro/tonne.	At present, indefinitely.

	The Starch Refund Scheme	Commodity support	Encourages the use of EC Community-produced starch which might otherwise be replaced by cheaper starch imports. Payable to users of starch manufactured from maize, wheat, potatoes, rice that is used to make eligible products usually for industrial, chemical, and pharmaceutical sectors.	Varies.	At present, indefinitely.
	Support Programme for Sugar Used in the Chemical Industry	Commodity support	Encourages use of sugar rather than artificial sweetener in manufacturing processes. Payments are on basic and intermediate products including white and raw sugar, isoglucose, sucrose syrups, and other sugar forms.	Refund rate 100kg: for white sugar is 6.45 euros, raw sugar it is .0645 euros multiplied by a floating rate.	At present, indefinitely.
EU / England	Production of Non-Food Crops on Set Aside Land Scheme		Permits growers to designate hectares of land for growing certain crops. Crops harvested must be used in the manufacture, within the Community, of products not primarily intended for human or animal consumption (known as industrial crops). The grower continues to receive set-aside compensation provided scheme conditions are met.	Dual compensation under Energy Crops Scheme and setaside schemes.	At present, indefinitely.

ENGLAND					
England	"A strategy for non-food crops and uses: Creating value from renewable materials"	Research and promotion + Strategy document	An over-arching strategy to develop a competitive agri-industry sector. Envisions that non-food crop plantings will expand to 1.3M hectares in the UK or 7% of UK agricultural lands to meet EU targets for fuel and energy. Key 'strands' include consumer awareness, promotion in industry, technology development, and 'blue sky thinking.'	£2M per annum through 2003-2004; programme funding recently increased to £3.3M.	Unspecified, though strategy suggests a long term approach (10+ years).
England	National Non-Food Crops Centre (NNFCC)	Research and Promotion	Maintains research databases, provides a forum for discussion, advises funding bodies, and disseminates information.	Jointly funded by Defra (£250,000 per year) and the Dti (£100,000 per year).	Funding secured at least to 2007.
England - Rural Development Programme	ERDP in general	Capital grants	Provides assistance for projects that develop sustainable, diversified and enterprising rural economies and communities. Primary aim is to help farmers adapt to changing markets and develop new business opportunities.	£150M	2001-2006

	Energy Crops Scheme (ECS)	Capital grants	Goal to supply large and small power generation with a CO2 neutral feedstock. Also subsidizes start-up producer groups. Started in 2002, expires in 2006. Defra aims to support 16,700 hectares of SRC and 5K of miscanthus by 2006/7.	£3.5M total allocation. Subsidizes establishment of miscanthus and SRC willow at rate of £920 per hectare and £1600 per hectare - or about 50% of total cost.	2001-2006
	Countryside Stewardship Scheme	Land management and preservation support	To encourage farmers and land managers to sustain the beauty and diversity of the countryside. Not incompatible with Energy Crops Scheme.	Unspecified.	2001-2006
	Environmental Stewardship Scheme	Land management and preservation support	Provides funds to farmers and land managers to maintain landscape character, conserve soil, and tackle the decline in dispersed wildlife species.	Unspecified, though subsidy rates are £30 - £60 per hectare or higher, depending on the management standard.	Unspecified.

	Woodlands Grants Scheme	Capital grants	Gives incentives to landowners and leaseholders to increase wood production, including SRC willow.	£29M total allocation (some overlap with ECS), subsidies at rate of £400 per hectare.	2001-2006
	Rural Enterprise Scheme	Capital grants	Encourages farmers to diversify their farm businesses to improve their economic viability. Main categories of diversification are non conventional agricultural crops (for pharmaceuticals) and novel crops to serve new niches (fibre).	£150 total allocation (EU and England).	2001-2006
England	Bio-energy capital grant scheme	Capital grants	Promotes the use of biomass for energy, and in particular energy crops by awarding capital grants towards the cost of equipment in working installations.	£66M total allocation (primarily from Dti, and National Lottery's Transforming Communities Programme).	Expires 2010.
England (and EU)	Renewable Obligation(s) / Non Fossil Fuel Obligation	Production mandate + capital grants	Mandates that 10% of electricity produced in Britain be produced renewably by 2010. Spurred in part by EU Renewables Directive encouraging countries to produce 12% of energy renewably by 2010.	None, though various support scemes (many included herein) to facilitate transition.	Indefinitely - emissions reductions goals set to 2020 and beyond.

England	ADAS and Central Science Laboratory study	Reseach and promotion	Examined which crops are best suited to the UK's growing conditions, as one indication of which crops should be supported through policy.	Unspecified.	Completed late 1990s.
REGIONAL - EAST MIDLANDS					
Regional	Rockingham Forest Trust - Energy from the Forest	Research and promotion + capital grants	Seeking to create local branding of fuel wood, fuel chips, and firewood by offering training courses, market assessments, etc.	£85,000 per year.	2003-2006
Regional	Nottinghamshire Wood Heat Project	Capital grants	Creating market demand for woodfuels. Four plants have been converted so far to run on wood heat.	£400,000 spent so far over two years, no definitive budget.	Indefinitely.

Regional	Joint action plan for the development of wood-based bioenergy in the East Midlands	Strategy document	Two phases: (1) Appraises the viability and overall market potential for bioenergy and biofuels in the East Midlands, identifying opportunities and contraints to the industry's development (2) Identifies suppliers of techonology, expertise and capital 'ingredients' for development.	Unspecified.	Completed in 2003-2004.

Regional	Destination 2010: regional economic development strategy for the east midlands	Strategy document + Capital grants	Various sections pertain to the promotion of non-food crops including 'environment and development' and 'rural development'. Goals include recruiting inward investment in the non-food crops supply chain infrastructure, diversifying agricultural production, and building the environmental economy.	No specific allocation - applicants with strong projects bid into a large general emda pot.	Strategy runs until 2010.

Appendix D: List of personal communications

- Melvyn Askew, Head of Agriculture and Rural Strategy, Central Science Laboratory
- Ian Butterfield, Deputy Team Manager and Group Head, English Nature
- Donna Clarke, Business Development Manager, Greenergy International Ltd.
- Sarah Hugo, Central Science Laboratory
- Ian Law, Technology Translator, National Non-Food Crops Centre
- Peter Nixon, Environmental Consultant, Bio-Renewables Group ADAS Arthur Rickwood
- Linn Oxborrow, Textiles Industry Expert, Nottingham Trent University
- Ian Patterson, Regional Policy Officer, English Nature
- Russell Sharp, Staff Agronomist, Textile Engineering and Materials Research Group (TEAM), De Montfort University
- Maggie Smallwood, Deputy CEO, National Non-Food Crops Centre
- John Stawson, Managing Director of Renewable Energy Suppliers, Ltd.
- Jeremy Tompkinson, CEO, National Non-Food Crops Centre
- Robin Twizell, Oilseed Rape Grower, Renewable Energy From Agriculture (REFA)
- Jack Ward, Regional Director, National Farmers' Union

Appendix E: List of databases, research centres, and companies involved with crops for non-food uses

1. DATABASES

Agriculture and Environment Biotechnology Commission
http://www.aebc.gov.uk
Set up in June 2000 to provide the UK Government and Devolved Administrations with independent, strategic advice on developments in biotechnology and their implications for agriculture and the environment. It takes ethical and social issues into account, as well as science. Works alongside the Human Genetics Commission (HGC) and the Food Standards Agency (FSA).

Biological Materials for Non-Food Products
http://www.biomat.net
Website displays results from EC-supported investigations into biological materials for NFCs, including final results from the Fifth Framework Programme, FAIR Programme, as well as ongoing research from the Fifth and Sixth Framework Programmes. Also contains a website database of BioMat registrants.

Database of UK public research on Non-food uses of crops
http://aims.defra.gov.uk
Established as a focal point for information on the UK funding bodies and R&D relevant to NFCs, this website contains a list of UK funding bodies and their activities, as well as a searchable database with the relevant R&D projects. Data base includes project profiles with abstracts, objectives, funding details, and other standardized information.

Genewatch UK
http://www.genewatch.org
Not-for-profit group that monitors developments in genetic technologies from public interest, environmental protection and animal welfare perspective. GeneWatch believes people should have a voice in whether or how these technologies are used and campaigns for safeguards for people, animals and the environment. They work on all aspects of genetic technologies - from GM crops and foods to genetic testing of humans.

IENICA: Interactive European Network for Industrial Crops and their Applications
http://www.ienica.net
The authoritative website on non-food crop R&D in Europe. Website contains extensive country reports on NFC industrial activities in Europe, a plants database, policy updates, events, newsletter, commercial, and enquiries sections.

Joint Nature Conservation Committee (JNCC)
http://www.jncc.gov.uk
Forum through which conservation groups (Countryside Council for Wales, English Nature, Scottish Natural Heritage) deliver their statutory responsibilities for Great Britain. One of these responsibilities is enriching biological diversity. Website contains important reports and links to biodiversity monitoring, indicators, and action plans in the UK.

National Non-Food Crops Centre
http://www.nnfcc.co.uk
The new informational centre for NFCs in the UK, subsuming activities from previous NFC initiatives including the Government-Industry Forum on Non-Food Uses of Crops, ACTIN (Alternative Crops Technical Interaction Network), and contributions from the land-based industries consultancy ADAS.

UK Biodiversity Action Plan (BAP) website
http://www.ukbap.org.uk
The UK BAP is the UK Government's response to the Convention on Biological Diversity signed in 1992. The plan describes the UK's biological resources and details a plan for their protection. The BAP website provides access to the species, habitat and local action plans; a database of biodiversity reports; factors affecting the decline of species and habitats; as well as other updates to policies and programmes protecting biodiversity.

2. RESEARCH ACTIVITIES (listed on NNFCC website)

a. Universities and colleges

Bolton Institute of Higher Education Deane Road BOLTON BL3 5AB Tel: 01204 528851	University of Durham Old Shire Hall DURHAM DH1 3HP Tel: 0191 374 2000
University of Bristol Senate House Tyndall Avenue BRISTOL BS8 1TH Tel: 0117 928 9000	University of Exeter Northcote House The Queen's Drive EXETER EX4 4QJ Tel: 01392 661 000
Brunel University UXBRIDGE Middlesex UB8 3PH Tel: 01895 274000	University of Huddersfield Queensgate HUDDERSFIELD HD1 3DH Tel: 01484 422 288
University of Cambridge The Old Schools CAMBRIDGE CB2 1TN Tel: 01223 337733	Imperial College of Science, Technology and Medicine South Kensington LONDON SW7 2AZ Tel: 020 7589 5111
Cranfield University Cranfield Campus CRANFIELD Bedfordshire MK43 0AL Tel: 01234 750111	John Innes Centre Norwich Research Park Colney Norwich NR4 7UH Tel: 01603 450 000
De Montfort University TEAM – Dr. Ray Hold LEICESTER Research includes: short fibre flax and STING (nettles) Contacts: Professor Ray Harwood Tel: 0116 255 1551	University of Leicester University Road LEICESTER LE1 7RH Tel: 0116 252 2522

x

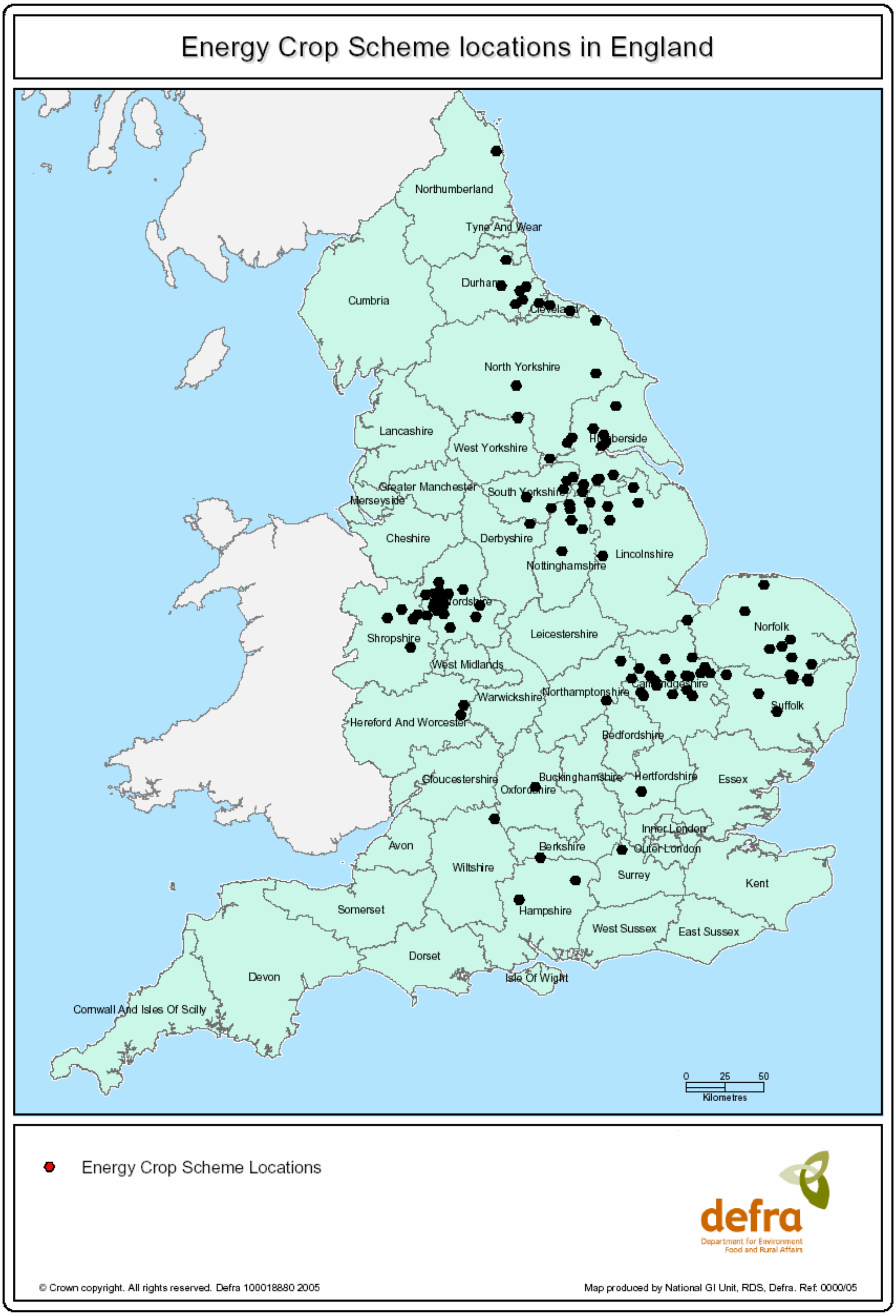
Liverpool John Moores University Rodney House 70 Mount Pleasant LIVERPOOL L3 5UX Tel: 0151 231 2121	University of Sheffield Western Bank SHEFFIELD S10 2TN Tel: 0114 222 2000
Loughborough University LOUGHBOROUGH Leicestershire LE11 3TU Tel 01509 263 171 Research includes: Plant processing technologies (1997-2001	University of Surrey Stag Hill GUILDFORD Surrey GU2 5XH Tel: 01483 300800
University of Manchester (now combined with UMIST) Oxford Road MANCHESTER M13 9PL Tel: 0161 275 2000	University College London Gower Street LONDON WC1E 6BT Tel: 020 7679 2000
Middlesex University Trent Park Bramley Road LONDON N14 4XS Tel: 020 8411 5000	University of Warwick COVENTRY CV4 7AL Tel: 01203 523 523
University of Nottingham University Park NOTTINGHAM NG7 2RD Tel: 0115 951 5151 Research includes: starch to create film, phyto-remediation with willow, OSR seed quality	Wye College, University of London Wye ASHFORD Kent TN25 5AH Tel: 01223 381 2401
University of Oxford University Offices Wellington Square OXFORD OX1 2JD Tel: 01865 270 000	University of York Heslington YORK YO10 5DD Tel: 01904 430 000
University of Reading Whiteknights PO Box 217 READING Berkshire RG6 6AH Tel: 01189 875 123	

b. Other groups involved with non-food crops

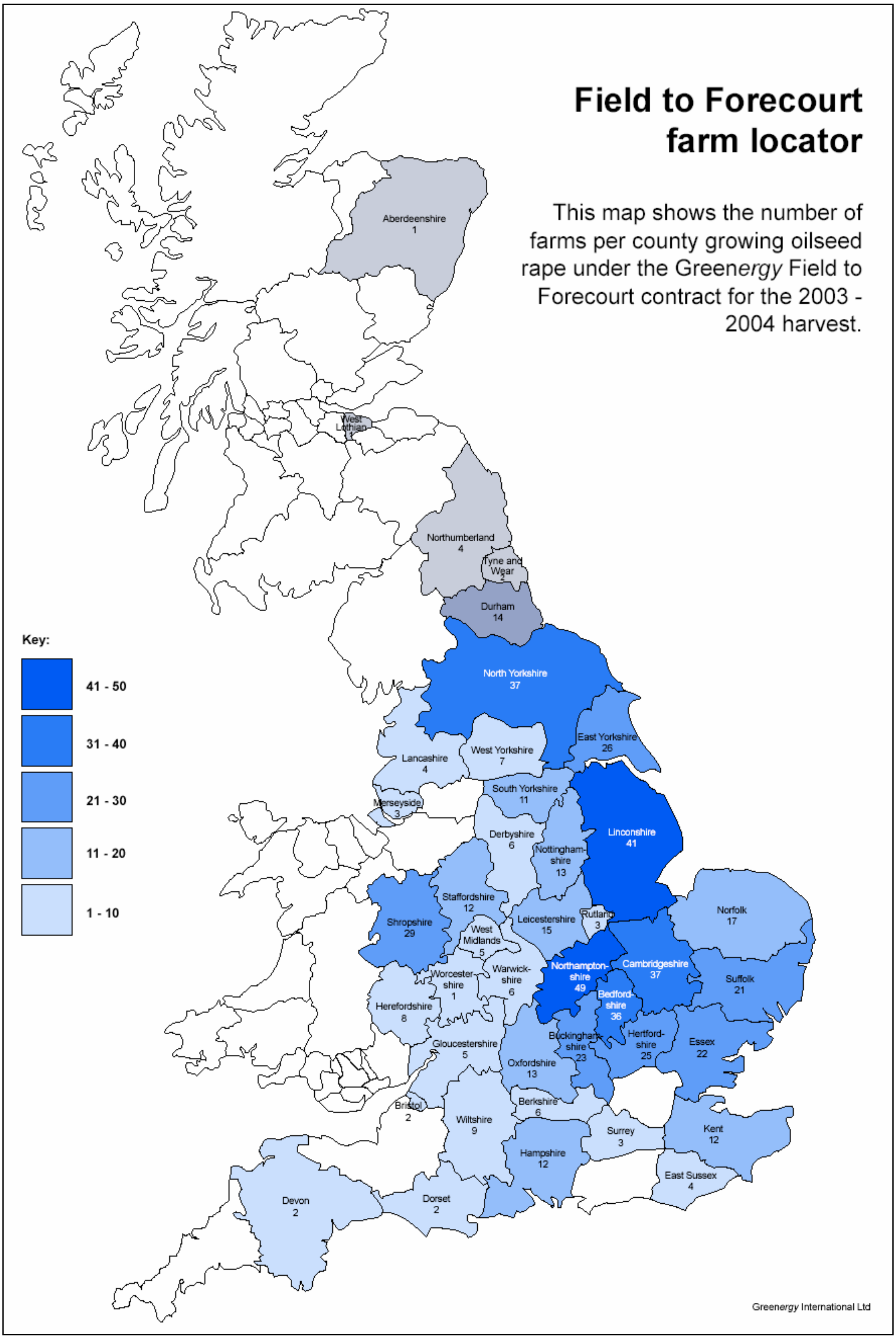
ADAS ADAS Headquarters Oxford Spires Business Park Kidlington OXFORD OX5 1NZ Tel: 01865 842 742	Dalgety Arable (Contact: Julie Goult) Cheveley House Fordham Road NEWMARKET Suffolk CB8 7AH Tel: 01638 569 430 Contact: Julie Goult
Agros Associates Croc Na Boull Muir of Ord ROSS-SHIRE Scotland IV6 7TW Tel: 01463 870 996	DuPont (UK) Ltd (Contact: Martin Livermore) Block B The Mill Site 40 Station Road CAMBRIDGE CB1 2UJ Tel: 01223 464 500
Bio-Renewables Group ADAS Arthur Rickwood Mepal Ely CAMBRIDGESHIRE CB6 2BA Tel: 01354 692531 enquiries@bio-renewables.co.uk Specialities: Miscanthus and SRC	Henry Doubleday Research Association Ryton Organic Gardens COVENTRY Warwickshire CV8 3LG Tel: 02476 303 517
The BioComposites Centre, University of Wales, Bangor, Gwynedd, LL57 2UW UK. Telephone: +44 (0)1248 370588 Fax: +44 (0) 1248 370594 E-mail: biocomposites@bangor.ac.uk http://www.bc.bangor.ac.uk/index.htm	Home-Grown Cereals Authority 223 Pentonville Road LONDON N1 9NG Tel: (0171) 520 3920 (central office) Contact: Frank Oldfield ICI Technology Room D331
British Sugar plc PO Box 26 Oundle Road PETERBOROUGH PE2 9QU Tel: 01733 422 532 Contact: Peter Williams	John K King and Sons Coggeshall COLCHESTER Essex CO6 1TH Tel: 01376 561 543
Cargill plc Camp Road Swinderby LINCOLN LN6 9TN Tel: 01522 556 100 Contact: Trevor Robinson	National Farmers' Union 164 Shaftesbury Avenue LONDON WC2H 8HL Tel: 020 7331 7200 Contact: Rachel Wright

Natural Fibres Organistion Church Court Clewers Hill WALTHAM CHASE Hants SO32 2LN Tel: 01489 891 233	Springdale Crop Synergies Ltd, Springdale Farm, Rudston, Driffield, EAST YORKSHIRE YO25 4DJ http://www.springdale-group.com Tel 01262 421 100
Pira International Randalls Road LEATHERHEAD Surrey KT22 7RU Tel: 01372 280 2000 Contact: Mike Hancock	Sustainable Industries Ltd. Broadcasting House Rouge Bouillon ST HELIER Jersey JE2 3ZA Tel: 01534 618 123 Contact: Paul McClory
Policy Studies Institute 100 Park Village East LONDON NW1 3SR Tel: 020 468 0468 Contact: Malcom Eames	The Textile Consultancy Ltd. Anvil House 70 High Street ABERDOUR Fife KY23 0SW Tel: 01383 860 870
SCOPA 6 Catherine Street LONDON WC2B 5JJ Tel: 020 7836 2460	Wilton Centre PO Box 90 MIDDLESBOROUGH Cleveland TS90 8JE Tel: 01642 436 598 Contact: Dr Sue Topham
Semundo 49 Great North Road Great Abington CAMBRIDGE CB1 6AS Tel: 01223 890 777	Zeneca Plant Science Fernhurst HASELMERE Surrey GU27 3JE Tel: 01428 655 418 Contact: Dr Mike Bayliss

Appendix F: Growing locations for Energy Crops Scheme



Appendix G: Growing locations map for oilseed rape under contract with Green*ergy*



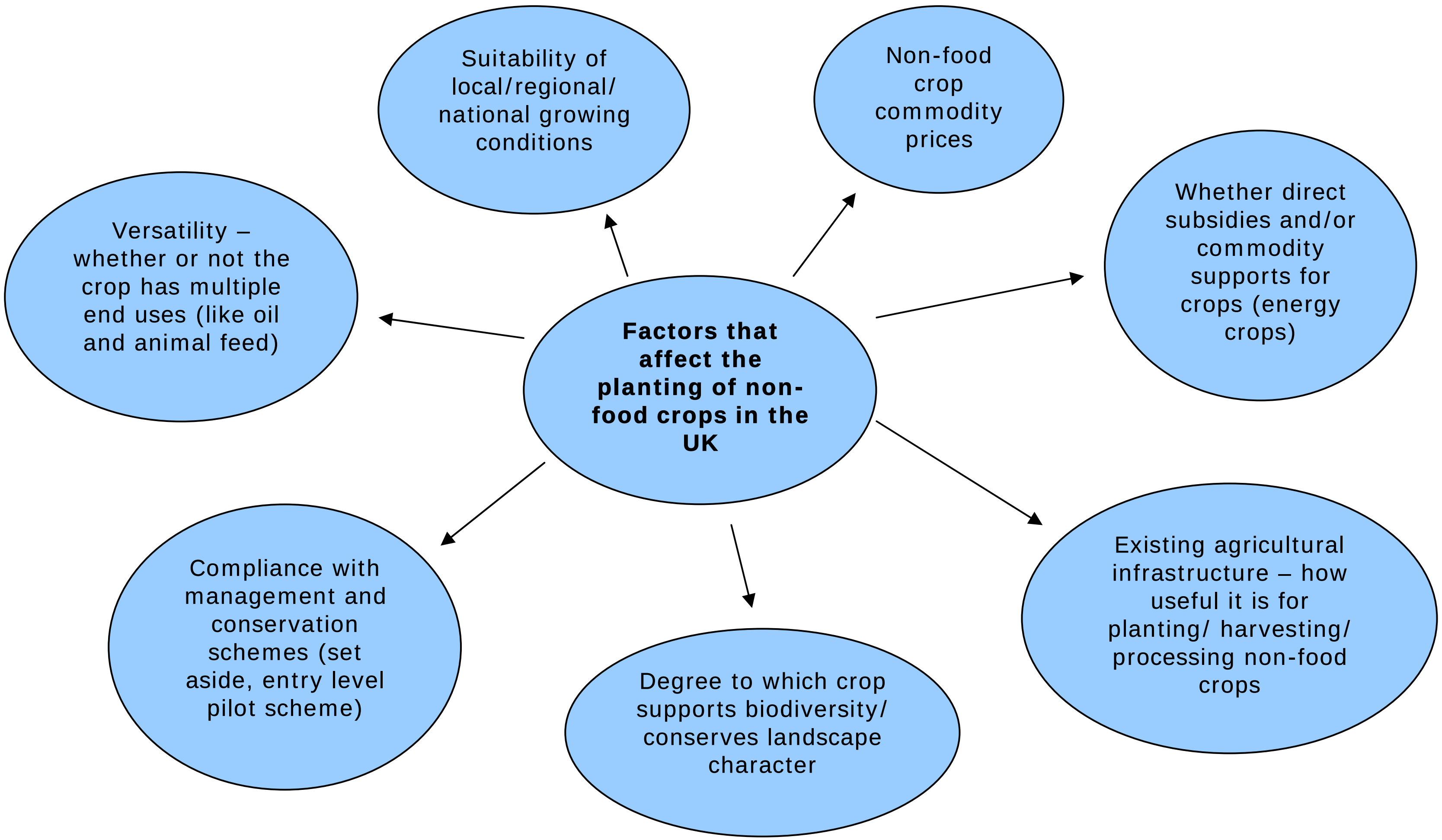
Appendix H: Locations of existing coal-fired power stations in the UK

Station	Location	Grouping according to ECS clusters*	Owning company
Cockenzie	East Lothian	-	Scottish Power
Ferrybridge	West Yorkshire	YH	AEP
Longannet	Clackmannanshire	-	Scottish Power
Fiddler's Ferry	Cheshire	SS	AEP
Kilroot	Northern Ireland	-	AES
Ironbridge	Shropshire	SS	Powergen
West Burton	Nottinghamshire	EM	London Energy
Tilbury	Essex	-	Innogy
Didcot A	Oxfordshire	-	Innogy
Kingsnorth	Kent	-	Powergen
Eggborough	North Humberside	YH	British Energy
Rugeley B	Staffordshire	SS	International Power
Cottam	Nottingham	EM	London Energy
Ratcliffe	Nottingham	EM	Powergen
Aberthaw	South Glamorgan	-	Innogy
Drax	North Yorkshire	YH	AES

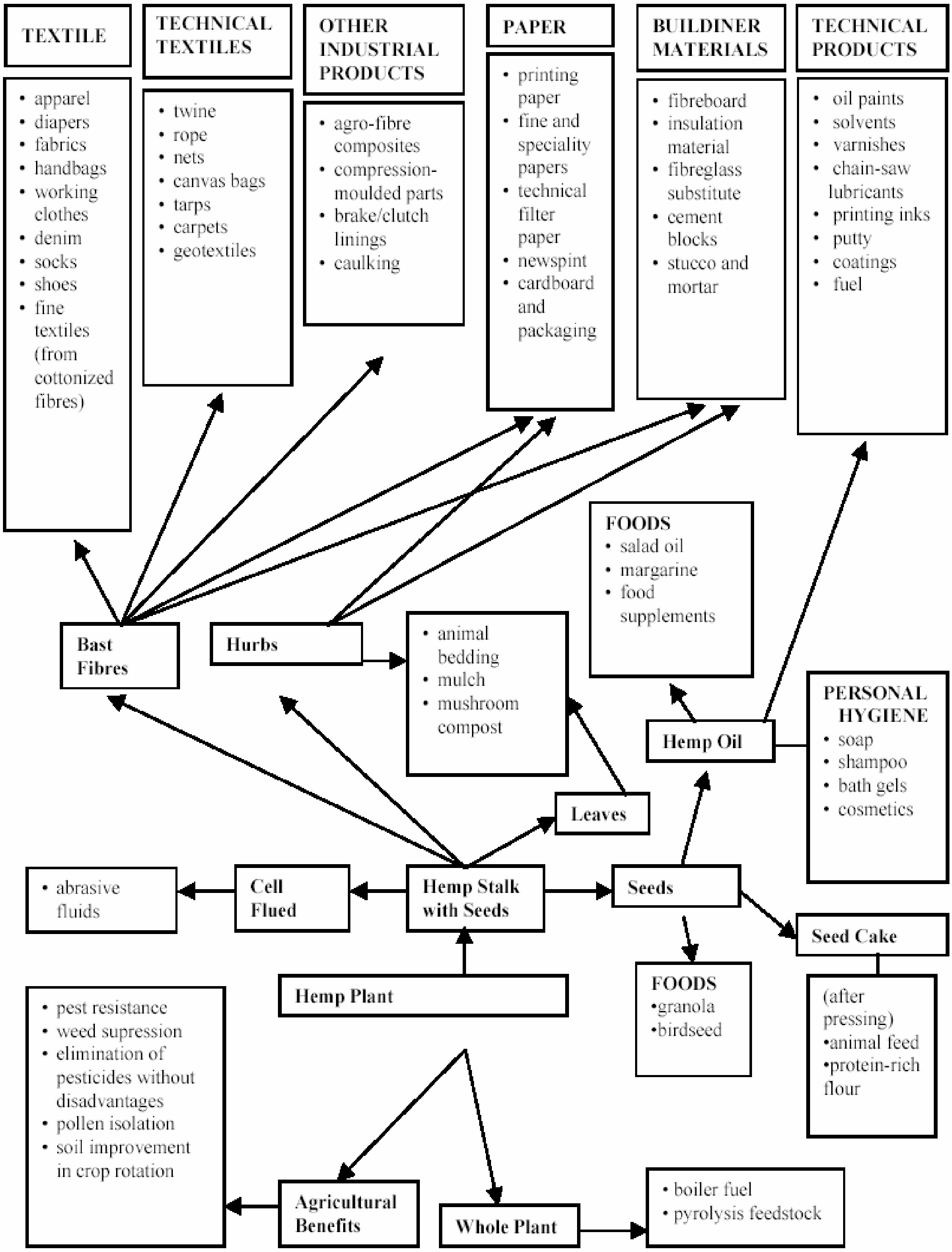
*The clustering pattern formed by the distribution of energy crop plantings under the Energy Crops Scheme can be partially explained by the presence of nearby power stations, since the ECS requires that crops be grown near the point of use. These stations nearby a cluster have been designated accordingly: Shropshire-Staffordshire (SS), East Midlands (EM), and Yorkshire and Humberside (YH). None of these stations are near the fourth cluster located in the Northeast.

Source: Friends of the Earth Scotland (2005) www.foe-scotland.org.uk.

Appendix I: Key factors affecting the decision to plant non-food crops



Appendix J: Modern uses for hemp



Source: Interactive European Network for Industrial Crops and their Applications (IENICA) www.ienica.net/crops/hemp.pdf.