Land Use Consultants

Bioenergy: Environmental Impact and Best Practice

Final Report

Prepared for Wildlife and Countryside Link by Land Use Consultants

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January 2007

BIOENERGY: ENVIRONMENTAL IMPACT AND BEST PRACTICE

FINAL REPORT

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by
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14 Great George Street
Bristol BS1 15RH
Tel: 01179 291 997
Fax: 01179 291 998
luc@bristol.landuse.co.uk

CONTENTS

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EXECUTIVE SUMMARY

BACKGROUND

1. Land Use Consultants, with Kevin Lindegaard, was commissioned in August 2006 by Wildlife and Countryside Link to undertake a study looking at the potential environmental impacts of increased bioenergy production and use in the UK.

2. Faced with the problem of climate change, the UK Government has pledged to reduce national CO_2 emissions by 60% by 2050 and generate 10% of our electricity from renewables sources by 2010, increasing to 20% by 2020. Meeting these targets will require significant changes to the way our energy is used and produced. As a result, it is anticipated that the demand for bioenergy derived from a variety of sources such as wood, perennial grasses, conventional crops and waste will grow rapidly over the next decade.

3. Substantially increasing the production of bioenergy from agriculture and forest resources offers real potential to reduce greenhouse gases and meet wider environmental objectives such as the creation of new native woodland and the management of the existing woodland resource. However, it also has the risk of placing severe environmental pressures on our limited natural resources.

4. Wildlife and Countryside Link support the development of the bioenergy industry and believe that it has the potential to make a substantial contribution to the renewable energy mix and deliver wider environmental priorities. However to realise these opportunities, it must be produced sustainably – with real carbon savings, avoiding negative impacts on the natural and historic environment and wherever possible delivering positive environmental benefits. This study sought to identify the main environmental impacts of increased bioenergy production and use and the policy measures needed to minimise any negative impacts and enhance positive benefits.

STUDY APPROACH

5. To inform the preparation of this report, three main tasks were undertaken as follows:

Task 1: A review was undertaken of the current utilisation and production of energy crops in the UK and the policy drivers and technological developments that will influence future production and use.

Task 2: A desk based review of relevant literature was carried out to identify existing research on the potential positive and negative impacts of bioenergy production and existing good practice management guidance on the sustainable production and use of bioenergy crops.

Task 3: Consultations were undertaken with 30 key stakeholders in the field of bioenergy for the purpose of: discussing the potential impacts of bioenergy production and gathering opinions on what policy or practical measures are needed to ensure that bioenergy is produced sustainably.

STUDY SCOPE

6. The study considered the potential environmental impacts of bioenergy generated by:

1) **Wood based fuels,** e.g. multiannual short rotation coppice (SRC); short rotation forestry (SRF); and forest residues and low grade timber.
2) **Perennial grass crops,** e.g. multiannual miscanthus, canary reed grass and switchgrass.
3) **Conventional crops** annual crops, e.g. sugar beet, cereal crops, sorghum, oil seed rape, linseed and sunflowers.

7. The study did not cover bioenergy produced from animal waste and wood waste. It is however acknowledged that these sources have the potential to make a significant contribution towards the Government's renewable energy targets.

POLICY AND TECHNOLOGY FRAMEWORK

Current production and use

8. Energy crops currently account for a very small proportion of UK energy generation and fuel use and are less significant than other forms of bioenergy such as landfill gas and waste combustion. A high proportion of energy crops are imported such as wood used in co-firing and imported biodiesel from oilseed rape grown elsewhere in the EU or palm oil from further afield. A considerable amount of waste material is produced which currently fails to be used for energy generation. This includes forestry residues, waste wood and straw.

9. Larger areas of crops that could be used for biofuels are grown in the UK but currently nearly all of these crops are used for conventional food uses. Conversely the area of crops specifically grown as biomass (SRC and miscanthus) is small.

Current policy drivers

10. The last ten years have seen a completely new set of policies encouraging renewable energy, cascading down from international and EU commitments, that have arisen to address the imperative of climate change. Although the targets for increased utilisation of renewable energy as a whole are well established, the role that energy crops make in the mix of renewable sources remains more fluid.

11. In the UK the Renewables Obligation and, from April 2008, the Renewable Transport Fuels Obligation, are the primary policy instruments stimulating increased production and utilisation of energy crops. There is as yet no Renewable Heat Obligation and work needs to be undertaken into the feasibility of regulating such a system. Government is committed to introducing a mandatory emissions trading scheme (Energy Performance Commitment) and, although the focus of this will be as much on reducing energy use, it is likely to encourage a range of businesses and the public sector to source more of its energy from renewable sources, including bioenergy.

12. Agricultural policy now has less influence on the individual crops that farmers choose to grow, although, incentives to grow energy crops are likely to remain as part of the national Rural Development Programmes. However, set-aside, which has been a stimulant to produce oilseed rape for biofuel use, is likely to be removed as a compulsory element of agricultural policy in the next few years. This conversion of 'fallowed' set-aside which had developed biodiversity benefits to energy crops will have significant environmental impacts. There has been little policy direction at either EU or national level in relation to the environmental impacts that energy crops have.

Technological developments

13. The most carbon efficient conversion technologies are those that produce heat or CHP directly from the energy crop rather than those that produce electricity. The greatest potential green house gas savings can be gained through the gasification of biomass to produce electricity, the burning of woodchip to generate heat and the use of second generation biofuels produced from biomass.

14. The most significant developments are likely to occur in the conversion technologies available to convert crops to heat and fuel. All of these new technologies are some way from commercial exploitation but there is increasing interest from large energy companies in their development. These new and more carbon efficient technologies will result in a widening in the range of feed stocks that can be exploited, enabling multi-annual biomass crops (SRC, SRF and miscanthus) and crops such as grass and maize to become potential biofuel feedstocks.

15. In contrast, there are likely to be fewer technological developments in the production, harvesting, transport and storage of the annual biofuel crops in the UK (oilseed rape, wheat and sugar beet) since these are well established commercial crops. However, there could be greater differentiation in varieties suited for bioenergy production and increases in the carbon efficiency of production systems (i.e. fewer tractor passes and agrochemical applications).

16. In comparison to the production and processing of annual biofuel crops (such as oilseed rape and wheat), production systems for the multiannual biomass crops (willow and poplar SRC, SRF and miscanthus) are in their relative infancy. Greatest improvements are likely to be seen in the processing of the harvested biomass to create a denser and more consistent feedstock that is cheaper to transport and more suitable for use in mechanised boilers.

17. Key technological limitations are likely to remain the bulkiness of biomass crops and the high transport cost, resulting in the clustering of field production close to processing plants.

The likely impact of increased demand on crop areas

18. Projections of the area of energy crops needed to deliver short term (2010) renewable targets have been made on the basis of the current commercially available conversion technologies and feed stocks. These show that straw, waste wood and woodfuel have the greatest immediate potential to contribute to renewable heat and power but that they are constrained by the lack of infrastructure and markets (with the electricity generation co-firing market dominated by imported materials).

19. Over a longer time span (to 2020), short rotation coppice and miscanthus offer the greatest potential to increase the area of UK-sourced biomass used in heat and power generation. The quantity of straw and woodfuels from conventional forestry are likely to remain relatively static, although an increase in energy crop prices could see some diversion of material from existing markets.

20. If short rotation coppice and miscanthus are to play a significant role there will need to be a step change in the area of these crops. The production of 10 percent of current energy needs from these crops would require an 86 fold increase in their area to 1.3 million ha, which is an area slightly greater than the current area of temporary agricultural grassland (grassland in rotation with arable crops).

21. The relatively high cost of transporting biomass crops means that these crops are likely to be clustered around the energy plants. Although developments in primary processing of cropped material into denser pellets could see these transport distances lengthen, it is likely that large generating plants could see upwards of 10% of the available agricultural land area within their catchment used for energy cropping. There are thus important environmental implications for the location of these plants.

22. Projections for meeting the targets on biofuel utilisation suggest that the 5% target by 2010 is achievable from UK sources of oilseed rape and wheat grown and processed using current technologies. The NFU calculate that the additional area of biofuel crops (around 900,000 ha) could be accommodated within the land currently used for obligatory set-aside (assuming this requirement is removed during the Commission's forthcoming CAP 'health check') and the land currently used to grow wheat that is surplus to domestic demand. The contribution of recovered vegetable oils from industry and of imported biofuels is likely to reduce this demand.

THE ENVIRONMENTAL IMPACTS OF BIOENERGY

23. As part of the study, a detailed literature review was undertaken of the potential negative impacts and positive benefits of the different forms of bioenergy (i.e. SRC, SRF, forest residues and low grade-timber, perennial grasses and conventional crops). A summary of key findings is provided below.

Short rotation coppice

- ***Landscape:*** The height of mature SRC crops could obscure landscape features, e.g. stone walls, hedgerows and key views and lead to a change in landscape character. However if designed appropriately SRC could add structural diversity to existing agricultural landscapes and could provide an opportunity for the restoration and reinstatement of boundary features, e.g. hedgerows and the expansion of woodland areas.
- ***Biodiversity:*** Some existing evidence suggests that SRC could displace open farmland bird species, e.g. grey partridge, lapwing, skylark and corn bunting. If species traditionally grown in the UK and low impact management strategies are used however, SRC has the potential to increase the abundance and diversity of ground flora (including stable perennials), farmland bird species, mammals and invertebrates compared with grassland and arable crops – particularly in the early stages of crop growth. SRC could also be used to buffer woodlands and vulnerable habitats from more intensive forms of agricultural production.

- ***Water:*** SRC has high water requirements which could exacerbate water shortages particularly in areas with low rainfall. Care must therefore be taken to avoid planting SRC on, or adjacent to, sensitive wetland areas and wet meadows. SRC is however effective at absorbing available nitrogen, and it has the potential to be used to improve water quality, tackle nitrate pollution problems, buffer vulnerable habitats and treat wastewater and landfill leachate.
- ***Soil*:** Due to the need for relatively heavy harvesting machinery, SRC crops could cause soil compaction during harvesting. The root matt of SRC does however have the potential to have a stabilising impact on soils and could be used to reduce soil erosion and sedimentation problems.
- ***Archaeology***: Ploughing and sub-soiling of root growth of SRC could damage archaeological sites and deposits if sensitive sites are not avoided.

Short rotation forestry

- ***Landscape*:** Planting of species such as eucalyptus could have a significant impact on landscape character as it is non-native to the UK. The planting of SRF in sensitive open landscapes could also have a detrimental impact on landscape character. SRF could however provide a market opportunity for the creation of new native broadleaved woodlands, or the expansion of existing woodlands.
- ***Biodiversity*:** Trees with the densest canopies, e.g. eucalyptus and nothofagus could, discourage ground feeding birds. Bird species adapted to open habitats could also be threatened if significant areas of SRF are planted. SRF has the potential however to have a positive impact on biodiversity if native species are used and if it replaces arable or improved grassland. The understorey vegetation of SRF can provide suitable habitats for a number of invertebrate and mammal species and native woodlands can support a greater abundance and species richness of birds than intensively managed agricultural land.
- ***Water***: SRF and in particular non-native species tend to have high water requirements which could have a significant impact on local hydrological regimes and groundwater availability. As with SRC, SRF has lower input requirements compared with other energy crops and therefore has the potential to reduce nitrate pollution compared with arable and grassland areas.
- ***Soil*:** Tree planting could have a stabilising impact on soils due to the infrequency of soil cultivation. This could be used to reduce soil erosion and sedimentation problems.
- ***Archaeology***: The root growth of SRF could have a direct impact on the physical integrity of sites of archaeological interest comparable with other intensive landuses such as commercial forestry and intensive arable cultivation.

Forest residues and low grade timber

- ***Landscape***: The creation of new access tracks could have a negative landscape impact if inappropriately located. However, the felling and thinning of even age woods could help to diversify the age structure of woodlands and the use of forest residues could help to create a market for the restoration of historic coppiced landscapes.

- ***Biodiversity***: There is some concern that the removal of forest residues could lead to the depletion of nutrient and deprive small vertebrates, invertebrates, mammals (e.g. bats) and fungi of important habitat and food resources. Developing a market for forest residues could however provide an opportunity for the diversification of the woodland structure and the removal of non-native species from Plantations on Ancient Woodland Sites (PAWS), semi-natural and open BAP habitats. The reintroduction of coppicing and thinning could also open up dense plantations, improve development of ground flora and aid the restoration of neglected coppice woodlands which still contain species dependent on coppice cycle, e.g. butterflies.
- ***Water***: The removal of forest residues could increase the sedimentation of water courses and affect the potential to regulate water flow as deadwood captures and stores significant amounts of water, reducing run off on slopes.
- ***Soil***: The removal of forest residues has the potential to lead to an increase in the susceptibility of soils to erosion and remove nutrients. The use of heavy machinery for harvesting forest residues could lead to greater soil compaction.
- ***Archaeology***: The use of harvesting machinery and the creation of woodland tracks has the potential to impact on archaeological remains if appropriate mitigation is not put in place.

Perennial grasses

- ***Landscape***: Miscanthus and switchgrass are non-native in the UK and can grow to up to 3m in height. This could have a significant impact on landscape character if inappropriately sited. However, reed canary grass is native. If grown in its natural habitat and in a location which doesn't displace unimproved wet grassland, it could bring positive landscape benefits – particularly if replacing arable or ley pasture.
- ***Biodiversity***: Very little research has been undertaken looking at the impact of mature stands of perennial crops on biodiversity. There is concern that mature perennial grass stands could have a negative impact on open farmland species such as skylarks, meadow pipits and lapwing, and research suggests that reed canary grass does not attract the same density of species of flora and fauna as miscanthus and SRC. However studies indicate that young miscanthus stands, and to a lesser extend reed canary grass, could potentially benefit native weeds and provide foraging habitat for ground nesting bird species and for a wide range of species that exploit crops for invertebrates, seeds and cover if inputs are kept to a minimum. Recent studies also indicate that young miscanthus crops could support a more diverse and abundant array of native invertebrate species than arable fields (if the use of pesticides is avoided).
- ***Water***: There is a lack of uncertainty regarding the potential impact of growing perennial grasses on water use and water quality. However, mature stands of perennial grasses do not require the application of herbicides or fertilisers. They could therefore, improve ground water quality if planted on former arable sites. Perennial grasses also offer opportunities for improving ground water quality by planting buffer strips along watercourses and for the remediation of waste waters.

- ***Soil***: There is concern that there could be a high risk of soil erosion on susceptible soils in the establishment year and a high risk of soil compaction during harvesting as heavy machinery is required to harvest the crop during winter.
- ***Archaeology***: The use of harvesting machinery and root growth has the potential to impact on archaeological remains if appropriate mitigation is not put in place.

Conventional crops

- ***Landscape***: An increase in the demand for conventional crops for bioenergy could lead to an expansion in mono-cultures and market forces could encourage the growth of crops in marginal areas where the aim is to encourage habitat restoration and the conversion of arable land back to other semi-natural habitats.
- ***Biodiversity***: Conventional crops typically require greater inputs of fertiliser, herbicide and pesticide than other bioenergy crops. The replacement of natural regeneration set-aside with oil seed rape or cereals could have a detrimental impact on some farmland birds. Some crops, such as sugar beet, however have been found to benefit a number of farmland bird species such as stone pink-footed geese, curlew, finches, buntings, lapwing and skylark.
- ***Water***: The use of conventional crops such as cereal sand oilseed rape require significant inputs of fertiliser, pesticides and herbicides which can have a negative impact on water quality as a result of nitrate leaching.
- ***Soil***: The frequent tillage of annual crops such as sugar beet wheat or oilseed rape could lead to a greater risk of soil erosion compared with the cultivation of other energy crops.
- ***Archaeology***: Deep ploughing and root growth has the potential to impact on archaeological remains if appropriate mitigation is not put in place. Care therefore needs to be taken to site crops away from sites of archaeological or cultural heritage importance.

CONCLUSIONS AND RECOMMENDATIONS

24. The report sets out eight key conclusions and principles as follows:

Principle 1: Delivering Sustainable Bioenergy

Key Outcomes for Sustainable Bioenergy Development

Bioenergy developments *should*:

Woodlands and semi-natural habitats

- **assist in converting Plantations on Ancient Woodland Sites (PAWS) back to semi-natural woodland** through the gradual removal of conifers;
- **facilitate the restoration of certain priority non-woodland habitats** such as heathlands, moorlands and unimproved grasslands through the removal of trees as appropriate.

- **seek to reinvigorate the sensitive management of the semi-natural woodland resource,** with woodland management guided by Woodland Management Plans, that take account of potential environmental impacts including conservation of archaeology and specific species.

Bioenergy crops

- **ensure that the scale and location of planting is appropriate** both in terms of its impact on landscape character and the environment;
- **be managed in ways that have been demonstrated to benefit biodiversity** e.g. including the establishment of rides, conservation headlands and retention and creation of boundary hedgerows;
- **increase habitat and landscape diversity through the use of different varieties and age stands of crops** to avoid extensive monocultures that are both highly visible in the landscape and of lower biodiversity value;
- **use native species or species traditionally used in the UK,** to maximise the benefits for biodiversity;
- **maximise the opportunities for buffering, extending and relinking vulnerable semi-natural habitats;**
- **maximise carbon savings and benefits for biodiversity and water quality by minimising the use of fertilisers, herbicides and pesticides.** Where inputs are required, organic fertilisers should be used to reduce the carbon-footprint;
- **maximise the opportunities for community involvement and public access.**

Bioenergy developments *<u>should not:</u>*

- **be located in environmentally sensitive areas** such as wetlands, wet meadows, extensively managed semi-natural grassland or scrub and marginal habitats;
- **replace, or be maintained on, land uses that are known to support greater levels of biodiversity** (e.g. semi-natural/ priority habitat) or areas which have the potential to be **restored** to these habitats;
- be grown in locations which could:
  - adversely affect **soil structure** or increase **erosion and sedimentation;**
  - lead to a negative impact on the **carbon balance** (because of the presence of high carbon soils);
  - adversely affect the **quality or quantity of water** resources and the **biodiversity of aquatic environments;**
- involve the **use of any GM strains** to minimise the risk of contamination.

Wildlife and Countryside Link recommend that all plans, programmes and projects for bioenergy should, be consistent with, and seek to deliver the key outcomes outlined above.

Action: As a priority, the Government should ensure that any emerging national bioenergy plans and programmes such as those outlined below are consistent with the principals of sustainable bioenergy development as summarised in the key outcomes.

- **The forthcoming UK Biomass Strategy (which Defra is due to publish in 2007).**
- **The revised energy crops scheme (which will be introduced by Defra under the new Rural Development Programme in 2007).**
- **The Scottish Biomass Action Plan and Scottish Biomass Support Scheme (which is being prepared by the Scottish Executive and is due to be published in early 2007).**
- **The Renewable Energy Transport Obligation (which is due to come into effect in April 2008).**
- **The Woodfuel Strategy and Implementation Plan (which is due to be published by Defra/ Forestry Commission in 2007).**

25. Developing sustainable bioenergy production faces two significant challenges:

- to make positive use of the existing woodland resource which is currently economically dormant, thereby bringing positive benefits for landscape and biodiversity, as well as contributing to renewable energy production by utilizing an existing and currently undervalued resource;
- to assist in reversing the agricultural decline in biodiversity by accommodating the introduction of new bioenergy crops which clearly adopt environmentally sustainable farming practices. Management practices for bioenergy crops must minimise any adverse impacts on the environment whilst enhancing any positive benefits, if mistakes of the past are to be avoided.

26. Wildlife and Countryside Link recommend that the key outcomes outlined above should inform future bioenergy policy, programmes and projects. With the Government due to publish a number of a plans and programmes on bioenergy in the near future, it is essential that these documents and initiatives are based on the principles of sustainable bioenergy production and use.

Principle 2: Maximising Carbon Savings

Wildlife and Countryside Link recommend that increased Government support should be given to those technologies and forms of bioenergy that maximise green house gas savings whilst protecting and enhancing the environment.

Action: It is recommended that the DTI/Defra should provide clear guidance on the carbon savings associated with each form of bioenergy, including the various production pathways. This guidance should be used by the Government to redress the balance between heat, fuel and power in the forthcoming Biomass Strategy. If, as existing studies suggest, biomass holds greater potential for carbon savings per hectare of cultivated land and has the ability to deliver greater environmental benefits, the Government should prioritise the production of biomass over arable biofuels. Likewise the Strategy should reflect the greater carbon savings that can be offered by biomass heat.

27. Within the bioenergy sector the greatest potential green house gas savings can be gained through the use of biomass as a source of heat, the gasification of biomass to produce electricity, and the use of second generation biofuels produced from biomass. Biomass, and especially the management of the existing woodland resource, also has the potential to deliver greater benefits for the environment when compared to the growing of biofuels.

28. Against this background, it is recommended that Government support for bioenergy should be contingent on rewarding those forms of bioenergy that deliver the greatest carbon savings and the best deal for the environment. A much more informed understanding of the most sustainable forms of bioenergy is therefore needed, along with a clearer strategic support framework for their development.

Principle 3: Benchmarking and Environmental Assurance for Bioenergy

Wildlife and Countryside Link recommend that Government should work with industry to roll out assurance schemes to accredit all bioenergy feedstocks and processes to minimum standards of environmental practice. These should be based on industry quality assurance schemes where they exist, underpinned by a set of 'meta-standards' that ensure sufficient coverage across all feedstocks and all environmental domains. The energy generating sector should be required to report on the environmental and social sustainability of the renewable energy sources it uses, matching the requirement to be placed on the transport fuel sector.

Action: Work to develop sustainability standards for the biofuel supply chain (being led by the Low Carbon Vehicle Partnership) should be broadened to encompass protection of the historic environment and the visual landscape, ensuring that equivalent standards apply to feed stocks from all provenances.

In the absence of equivalent standards for biomass crops, Defra should commission work on sustainability standards for this sector, using the approach taken in the UK Woodland Assurance Scheme as the basis for this work.

OFGEM should require energy generators to report on the environmental and social sustainability of the renewable energy sources it uses to meet the Governments renewable energy targets, matching the requirement for the biofuels industry.

29. The Government is requiring the biofuels industry to report annually the environmental and social sustainability of the way it meets the 5% target for biofuels by 2010. No such requirement lies with the electricity generating sector. Reporting on sustainability on its own is not enough and assurance schemes provide a way of requiring all stages of the supply chain to meet minimum standards of acceptable practice. It will be most efficient for standards to build on existing industry supported schemes and it will be important that schemes do not require UK businesses to meet higher standards than those required for imported feed stocks. While work is ongoing to develop sustainability standards for biofuels, no such activity is taking place for biomass crops.

Principle 4: Promoting Small Scale Bioenergy Schemes

Wildlife and Countryside Link recommend that small scale local uses of bioenergy should be actively promoted as they provide greater opportunities for creating local bioenergy markets that are compatible with the protection of the local environment.

Action: It is recommended that the DTi and Defra should reaffirm their commitment to small scale projects by providing the necessary support and funding for a co-ordinated one-stop shop support and advice service for community and domestic renewables in England and Wales. This could be achieved through an expansion of the role and remit of existing programmes such as the Community Renewables Initiative.

30. There is real concern that the Department of Trade and Industry in their quest to meet the Government's renewable energy targets are prioritising funding and resources for large scale renewable energy projects to the detriment of small scale renewable programmes. Whilst grants for small scale schemes are being made available through the Local Carbon Buildings Programme, this programme does not provide advice and support for those seeking to design and install renewable schemes which is the key service provided by the Community Renewables Initiative (CRI), the Scottish Community and Householder Renewables Initiative (SCHRI) and Action Renewables. Funding has been secured for the SCHRI in Scotland and the Action Renewables Initiative in Northern Ireland, but there is no co-ordinated programme available in Wales. The CRI in England also does not cover household projects and the future of this programme is in question as no funding has been secured beyond March 2007. It is therefore recommended that Defra and the DTi should set out a clear strategy and funding stream for providing a co-ordinated support service for small scale renewable schemes in England and Wales.

Principle 5: Exploiting Environmental Synergies

Wildlife and Countryside Link recommend that the development of bioenergy should be encouraged in ways that maximise the contribution made to other environmental priorities such as the UK Biodiversity Action Plan, the Water Framework Directive, the EU's Thematic Strategy for Soil Protection and delivery of the European Landscape Convention.

Action: It is recommended that Natural England, SNH, and CCW undertake a detailed review of the potential impacts and benefits of bioenergy production for the various Habitat Action Plans (HAPs) and Species Action Plans (SAPs). This may require further primary research, particularly for those crops such as miscanthus where existing information is limited. Following this review, a guidance note should be produced summarising how any negative impacts of bioenergy energy production can be avoided and how bioenergy could contribute towards the delivery of HAP and SAP targets. This habitat and species-specific guidance should be disseminated widely and used to inform the preparation of Local Biodiversity Action Plans (LBAPs).

It is recommended that the Environment Agency and the Scottish Environmental Protection Agency should actively explore the opportunities for using bioenergy production to meet the objectives set out in the Water Framework Directive. This will include identifying scope in the forthcoming River Basin Management Plans (which are due to be prepared 2007-2009) to create zones where bioenergy can be used to reduce nitrate levels and alleviate flood risk. It is also recommended that DEFRA should review the opportunities for bioenergy to contribute towards the delivery of the EU's Thematic Strategy for Soil Protection.

Finally, it is recommended that Natural England, SNH and CCW should develop landscape guidelines on how to address the potential landscape effects of bioenergy production on different landscape types, indicating key sensitivities and landscape opportunities. Landscape sensitivity studies should inform Strategic Guidance and Opportunity Statements for Bioenergy (as recommended in Principle 5) assessing the sensitivity of different landscape typologies to different types of bioenergy production.

31. It is important that the policies put in place to deliver climate change targets, such as the promotion of bioenergy, does not reduce our ability to meet other environmental targets such as the Water Framework Directive, the UK Biodiversity Action Plan, the EU's Thematic Strategy for Soil Protection and our commitments under the European Landscape Convention. This study has found that rather than reducing the potential to meet these targets there are clear opportunities through the production of certain forms of bioenergy to positively contribute to these wider environmental priorities. As previously outlined, the development of short rotation forestry has the potential to encourage native broadleaf woodland which in turn can help deliver Habitat Action Plan (HAP) and woodland creation targets, and with careful planning can also make a positive contribution to landscape character.

32. At present however (other than a wide range of studies on the benefits of woodland management) there is little detailed research available on the means by which bioenergy can contribute towards the UK Biodiversity Action Plan targets, the conservation and enhancement of landscape character, soil protection and the Water Framework Directive. Further research is therefore required to ensure that the potential win-win opportunities for producing bioenergy whilst contributing to wider environmental objectives are realised.

Principle 6: Developing Strategic Spatial Guidance and Opportunity Statements for Bioenergy

Wildlife and Countryside Link recommend that detailed spatial guidance is prepared identifying the key constraints and opportunities for bioenergy developments at a sub-regional level.

Action: It is recommended that the DTI, DEFRA and Natural England should make funding available at a sub-regional level for strategic spatial assessments of the key constraints and opportunities for bioenergy development. This should lead to the publication of bioenergy opportunities statements which advise on the location and scale of opportunity for the establishment and management of bioenergy within a sub-region. A wide range of consultees including the Regional Government Offices, Regional Assemblies, Regional industry, government agencies and NGOs should be engaged in the studies.

The spatial assessments should consider the following key issues:

1. **The existing bioenergy resource within the area (i.e. woodland sites and their suitability for bioenergy production);**
2. **The key environmental constraints and opportunities for bioenergy crops in relation to:**
    - **landscape sensitivity -** i.e. undertake an assessment of the sensitivity of the landscape to bioenergy crops;
    - **biodiversity –** i.e. avoid environmentally sensitive areas such as designated sites and semi-natural habitats (including wetland, heathland and unimproved grassland) and identify opportunities for buffering, expanding and/or re-linking sensitive or fragmented habitats.
    - **topography –** i.e. avoid steep gradients which may prevent access for planting and harvesting machinery;
    - **geology and soils –** i.e. avoid best and most versatile land and identify opportunities for minimising soil erosion and sedimentation.
    - **water** – i.e. avoid areas which may have a negative impact on water resources and identify opportunities to improve water quality and minimise flooding.
    - **archaeology –** i.e. avoid impacts on sites or the setting of sites of archaeological or historical importance.
    - **transport network –** i.e. assess the capacity of the existing road network to accommodate increases in traffic generation.

3. **The economic and market factors influencing the supply and demand for bioenergy in the area.**
4. **The scale of opportunity for bioenergy across the area, linked to land suitability, yield potential, sustainable management of natural resources and landscape capacity.**

Once prepared, the opportunity statement and accompanying constraints and opportunities mapping (in GIS format) should be disseminated widely to the bioenergy industry, local planning authorities and statutory and non statutory consultees.

33. It is apparent that there is little strategic spatial guidance available at a national, regional or local level on what types of bioenergy crops should be grown where and the key constraints and opportunities determining their suitability. It is suggested that greater efforts should be made to encourage regional and sub-regional authorities to undertake further detailed assessments of the constraints and opportunities for bioenergy developments within their area.

Principle 7: Disseminating Good Practice

Wildlife and Countryside Link recommend that the accompanying guidance *'Delivering Sustainable Bioenergy Projects: Good Practice Guidance'* (2007) should be disseminated to all those with an active involvement in implementing and regulating bioenergy projects.

Action: It is recommended that:

- **the guidance is endorsed by the statutory consultees (such as Natural England, Forestry Commission, Scottish Natural Heritage, Countryside Council for Wales, Environment Agency, Scottish Environmental Protection Agency and the Environment and Heritage Service (Northern Ireland));**
- **the guidance is circulated to the bioenergy industry via the Renewable Energy Association and the new Biomass Energy Centre which is being set up as a source of bio-energy advice and best practice for farmers, industry and the public.**

34. Wildlife and Countryside Link support the development of the bioenergy industry but advocate that the principles of sustainable land management practice should be used to maximise greenhouse gas savings while protecting and enhancing landscape, biodiversity, water quality and soils. To assist this, Wildlife and Countryside Link have developed a good practice guidance document - *'Delivering Sustainable Bioenergy Projects: Good Practice Guidance'* (2007). To maximise the credibility and audience of this guidance it is recommended that the guidance is endorsed by the statutory consultees, and circulated via the industry trade associations and the new Biomass Energy Centre which is being set up by the Forestry Commission.

Principle 8: Research and Development

To inform the establishment of a strategic framework for the development of bioenergy and to monitor subsequent progress, Wildlife and Countryside Link recommend that further research and monitoring of the positive and negative impacts of bioenergy production and use should be undertaken as a matter of priority.

Action: It is recommended that Defra and statutory agencies such as the Forestry Commission, SNH, Natural England, SEPA, and EA should review the existing research gaps relating to bioenergy and commission further studies to ensure that the future development of the bioenergy industry is based on a thorough understanding of the key potential impacts and opportunities.

35. It is clear from the findings of the literature review and discussions with the expert consultees, that further research into the positive and negative impacts of bioenergy production and use is needed at a national level. The study has identified a number of notable information gaps including:

- **New crops:** There is limited information available on the potential environmental impacts of growing certain types of bioenergy crops in the UK such as miscanthus, reed canary grass, switchgrass, sorghum, linseed and sunflowers. For example, few studies have been undertaken in the UK looking at the potential impacts of mature stands of bioenergy crops such as miscanthus on biodiversity.

- **Management practices**: Further R&D is required on the management practices that can deliver both reductions in greenhouse gas savings and improve environmental sustainability of agricultural management.

- **Mammals:** very limited research has been undertaken looking at the impact of bioenergy crops on mammals.

- **Water requirements of energy grasses:** Few studies have been undertaken evaluating the water use of energy grasses and as such there is much greater uncertainty regarding their water consumption compared to traditional crops and SRC. This is of concern as water requirements for perennial energy grasses appear to be higher than that of traditional crops.

- **Landscape scale impacts:** No studies have been identified looking at the possible environmental impacts of bioenergy at the landscape scale. If the Government targets are to be met, very large areas of land will need to be used for growing biomass crops. This will inevitably have some effect on biodiversity at the landscape scale.

- **Regional impacts**: No comprehensive studies have been undertaken looking at the possible impacts on biodiversity of different types of bioenergy crops grown in different areas of the country, under different intensity levels and with different levels of inputs (i.e. fertilisers and pesticides).

- **Set-aside:** No detailed studies have been undertaken looking at the effects of replacing set-aside land with bioenergy crops. If large scale loss of rotational set-aside land is likely to occur then impacts on farmland biodiversity need to be predicted.

36. **Monitoring:** It is also suggested that a long term monitoring programme should be established with regular assessments reporting on the total area of land used for bioenergy; the type of land that is being replaced and indicators measuring the impacts on the environment, This will help to ensure the early identification of problems so that appropriate management and mitigation strategies can be put in place where necessary.

37. For all of the above it is clearly essential that the findings of any new research and monitoring work are quickly disseminated to the industry, growers and other relevant environmental agencies / bodies.

1. INTRODUCTION

BACKGROUND

1.1. Land Use Consultants, with Kevin Lindegaard, was commissioned in August 2006 by Wildlife and Countryside Link[1] to undertake a study looking at the potential environmental impacts of increased bioenergy production and use in the UK.

1.2. Demand for bioenergy derived from wood, perennial grasses, conventional crops and waste is expected to grow rapidly over the next decade as a result of the need to address concerns relating to climate change, rising fuel prices and security of supply. There are however fears that the expansion in the production and supply of bioenergy could have serious impacts on the environment including:

- a reduction in biodiversity as a result of the conversion of land to bioenergy crops or plantations;
- land use change with an increase in the use of unfamiliar crop species leading to a reduction in landscape quality;
- unsustainable use of water resources with an increase in water pollution and greater water scarcity;
- degradation of soil with the planting of crops or plantations in inappropriate areas; and
- loss of sites of archaeological importance.

1.3. In contrast, the expansion of the bioenergy industry also has the potential to generate significant environmental benefits such as:

- reinvigorating the sensitive management of certain habitats i.e. ancient woodland;
- facilitating the restoration of certain priority habitats i.e. Plantations on Ancient Woodland Sites (PAWS) and heathland; and
- reducing the intensity of some land uses and aiding the buffering and extension of vulnerable habitats.

1.4. This study seeks to identify the main environmental impacts of increased bioenergy production and use and the policy measures needed to ensure that any negative impacts are avoided or minimised and any positive impacts enhanced. With the support of over eight million people and responsibility for managing over 476,000 hectares of land, the members of Wildlife and Countryside Link are in a unique

[1] Wildlife and Countryside Link brings together voluntary organisations concerned with the conservation and protection of wildlife and the countryside. Their members practise and advocate environmentally sensitive land management and food production and encourage respect for and enjoyment of natural landscapes and features, the historic environment and biodiversity. This project is being steered by a sub-group of Link members on behalf of the Link membership including representatives from Butterfly Conservation, the Wildlife Trust, Campaign to Protect Rural England, the Royal Society for the Protection of Birds, the National Trust and the Woodland Trust.

position to influence the way in which the biomass and biofuels industry develops, and to ensure that production is managed in a way that delivers maximum benefits for the environment.

STUDY AIMS

1.5. As set out in the brief, the key aims of the study were:

1. To gain an informed understanding of the potential impacts of bioenergy production on the environment and the landscape.
2. To apply this knowledge to formulate policy recommendations which can be used to encourage the UK government and its associated agencies to pursue the sustainable production and use of biomass and biofuels.
3. To develop practical guidance for use by bioenergy developers and land managers on developing and implementing sustainable bioenergy projects.

1.6. This report presents the findings of the first two aims of the study. A second report provides practical guidance on managing the implementation of bioenergy projects.

STUDY APPROACH

1.7. To inform the preparation of this report, three main tasks were undertaken as follows:

Task 1: Review of policy, supply and demand and technical developments

1.8. A review was undertaken of the current utilisation and production of energy crops in the UK and the policy drivers and technological developments that will influence future production and use. An assessment of the implications of policy and technology drivers in terms of the area and type of energy crops required was also carried out.

Task 2: Literature review

1.9. A desk based review of relevant literature was undertaken. The purpose of the literature review was to:

- review existing research on the potential positive and negative impacts of bioenergy production;
- identify any uncertainty or gaps in knowledge; and
- draw out existing good practice management guidelines and measures for the sustainable production and use of bioenergy crops.

Task 3: Consultation with key stakeholders

1.10. 30 key experts in the field of bioenergy were interviewed including representatives from:

a) *Key Government departments/ agencies* - e.g. Defra, Environment Agency, Forestry Commission, Scottish Natural Heritage, Natural England and Countryside Council for Wales.

b) *Non Government organisations* from the Wildlife and Countryside Link Partnership - e.g. RSPB, Wildlife Trusts, Woodland Trust and CPRE.

c) *Bioenergy industry* - e.g. bioenergy developers such as econergy.

d) *Representative groups of land managers* – e.g. National Farmers' Union and the Country Land and Business Association.

1.11. The purpose of the consultations was to:

- identify any policy, fiscal or technological developments which will influence the future development of bioenergy;
- discuss the potential positive and negative impacts of bioenergy production on biodiversity, soil, water and landscape etc; and
- gather opinions on what policy or practical measures are required to minimise or enhance the projected negative and positive impacts of bioenergy production and use.

DEFINING BIOENERGY

1.12. For the purpose of this study, the following definitions have been used:

Bioenergy: is the inclusive term for all forms of biomass and biofuels.

Biomass: refers to the biodegradable fraction of products, waste and residues from agriculture, forestry and related industries (e.g. miscanthus, straw, timber, chicken litter and other waste material), used as a source of renewable heat or electricity.

Energy crops: is the collective name for crops produced specifically for their fuel value. This includes short rotation coppice (SRC), miscanthus, straw, wheat, potatoes, sugar beet and biogenous fuels (biodiesel from oil seeds such as oilseed rape, methanol from cereals).

Biofuels: are renewable transport fuels and include:

- ***Bioethanol***: the ethanol produced from biomass and/or the biodegradable fraction of waste.
- ***Biodiesel***: a methyl-ether produced from vegetable or animal oil, of diesel quality.
- ***Biogas***: gas produced by the anaerobic decomposition of organic matter.

1.13. Bioenergy (in the form of biomass or biofuels) can be generated from four principle sources:

1) ***Wood based fuels,*** e.g. multiannual short rotation coppice, short rotation forestry, forest residues, and low grade timber.

2) ***Perennial grass crops,*** e.g. multiannual miscanthus, canary reed grass and switchgrass.

3) ***Conventional crops,*** e.g. annual crops - sugar beet, cereal crops, sorghum, oil seed rape, linseed and sunflowers.

4) ***Waste,*** e.g. cow and pig slurry, poultry litter and wood waste.

SCOPE OF STUDY

1.14. This study considers the potential environmental impacts of bioenergy generated by wood based fuels, perennial crops and conventional crops. It does not cover bioenergy produced from animal waste and wood waste. It is however acknowledged that these sources have the potential to make a significant contribution towards the Government's renewable energy targets.

1.15. The study also focuses on the environmental impacts of an increase in bioenergy production and use within the UK. There are however widespread concerns about the increased demand for biomass and biofuel feedstocks exacerbating the unsustainable agricultural expansion abroad, particularly in tropical countries where it could have significant impact on global biodiversity. Whilst this is a key concern to Wildlife and Countryside Link and one that needs to be addressed by Government, it falls beyond the scope of this study.

REPORT STRUCTURE

1.16. The remainder of this report is structured as follows:

Chapter 2: sets out the findings of the review of policy, supply and demand and technical developments.

Chapter 3: outlines the findings of the literature review.

Chapter 4: summarises the findings of the consultations with key experts in the field of bioenergy.

Chapter 5: sets out the conclusions of the study and key recommendations seeking to promote the sustainable production and use of bioenergy.

2. POLICY AND TECHNOLOGY FRAMEWORK

INTRODUCTION

2.1. This Chapter summarises the current utilisation and production of energy crops in the UK and reviews the policy drivers and technological developments that will influence future production and use. The Chapter considers the relative carbon efficiency of different feedstocks and concludes by examining how the area and type of energy crops are likely to be influenced by these policy and technology drivers.

EXISTING BIOENERGY PRODUCTION AND USE

2.2. There are significant differences between the amount of energy crops in production and their utilisation in the UK. This is because some of the available production is being used for other purposes (for instance straw used for animal bedding, forest residues which are unused and biomass stocks used for propagation of planting material) and some utilisation is met from imported material (for instance wood co-fired with fossil fuels and biodiesel used in transport fuels). This section first examines the available data on utilisation and then the information on production.

Utilisation of energy crops

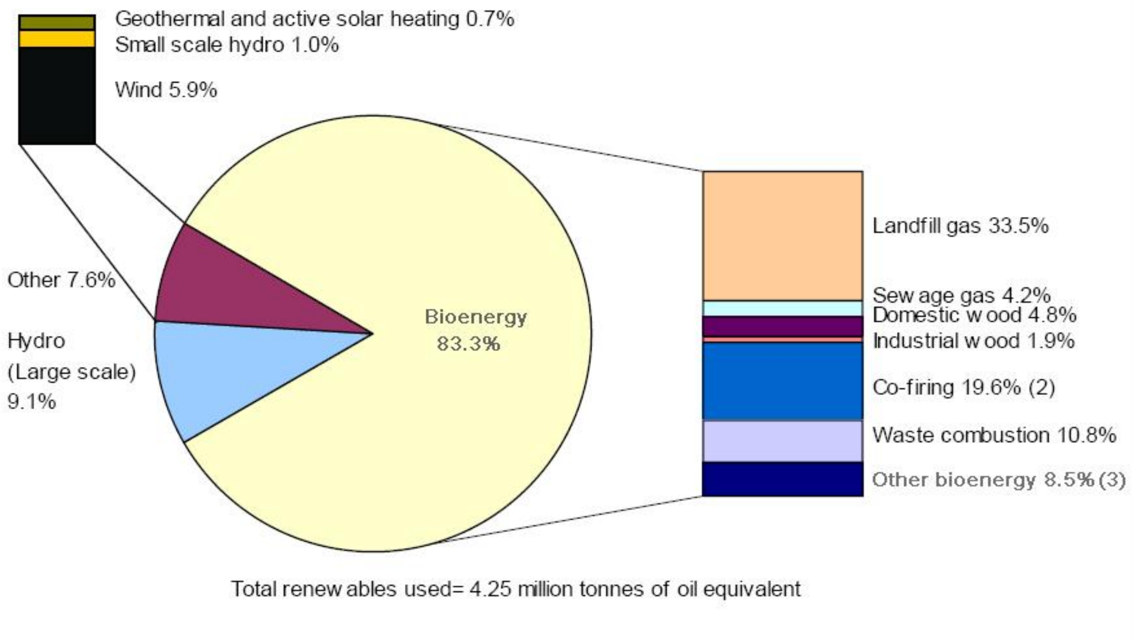
2.3. ***Overall:*** Energy crops may be used for heat and electricity production and in transport fuels. It is difficult to find reliable data which clearly identifies current uses and the data that is available uses a variety of units which make comparisons difficult. The DTI's Renewable Energy STATisticS (RESTATS) database[2] collects annual information on the utilisation of renewable energy. This shows that the renewables sector as a whole accounted for 4.25 million tonnes of oil equivalent (Mtoe) in 2005, equivalent to 1.7% of total UK energy supply. Energy crops are not separately identified but are included within the categories 'domestic wood', 'industrial wood' 'poultry litter, meat and bone, biomass, straw, farm waste and short rotation coppice (SRC)' (shown in Figure 2.1 as 'other biofuels') and 'co-firing'. The combined utilisation of these categories was roughly equivalent to 1.5 Mtoe or 0.6% of UK energy utilisation. However, these categories include sources other than energy crops such as the use of waste wood (such as pallets) in co-firing and of animal manures in anaerobic digestion.

2.4. ***Heat from biomass:*** The domestic wood category covers use of wood in open fires and stoves and the estimate is based on total UK use of 550,000 to 588,000 oven dried tonnes (ODT) per year. Industrial wood includes the use of sawmill waste, usually to heat the buildings where the waste is created but in the next few years will include purpose built Combined Heat and Power (CHP) electricity generating plants which generate heat as a recovered by-product[3].

[2] This database is maintained for the DTI by Future Energy Solutions.
[3] An example of such a development is the Port Talbot Bioenergy Plant, a 13.7 MW electric scheme involving untreated wood and due to be commissioned in 2008.

2.5. ***Electricity from biomass***: In 2005, 4.2% or 16,919 GWh of the electricity generated in the United Kingdom was generated from renewable sources, most of it from hydroelectric and wind source[4]. A study by Future Energy Solutions in 2005[5] estimated that the burning of biomass, excluding energy from waste, accounts for about 1.5% of electricity generation and about 1% of heat. The Biomass Task Force, quoting the Office for Gas and Electricity Markets' (OFGEM) second annual report on the Renewables Obligation shows that there were 11 accredited biomass electricity generating stations in England in 2003/04 and two in Scotland, with a total installed generating capacity of 158MW. There were 27 accredited generating stations co-firing biomass in England and one in Scotland, with a total installed generating capacity of 516MW. DUKES 2006 estimates that total electricity generation from biomass co-fired with fossil fuels in 2005 amounted to 2,533 GWh. However, the Task Force noted that a significant proportion of material used in co-firing is imported. A small amount of cereal straw (about 200,000 t/annum) is burned to generate electricity at a plant in Ely, Cambridgeshire.

Figure 2.1. Renewable energy utilisation, 2005



(1) Excludes all passive use of solar energy and all non-biodegradable wastes
(2) Biomass co-fired with fossil fuels in power stations
(3) 'Other bioenergy' includes farm waste, poultry litter, meat and bone and short rotation coppice

Source: DTI Digest of UK Energy Statistics, 2005. Chapter 7.

4 DUKES, 2006

5 FES, 2005. *Renewable Heat and Heat from Combined Heat and Power Plants – Study and Analysis*, Future Energy Solutions, August 2005

2.6. ***Biofuels:*** The Department for Transport estimates that in 2005 biofuels contributed 0.24% of total UK road fuel sales. This was equivalent to annual use of 33 million litres of biodiesel and 85 million litres of bioethanol (all of the latter from imports)[6]. This is much less than some other EU countries (in 2003 France and Germany produced a combined biofuel output of more than one million tonnes[7]).

2.7. The Department for Transport report states that the UK has the capacity to produce over 350 million litres of biodiesel per annum (or 1.5% of total diesel sales in 2005) and the EFRA Committee report states that 114 million litres of biodiesel should be on line by the end of 2006 (with plants at Motherwell, Teeside and Immingham). However, it should be noted that the large majority of this is likely to be derived from imported oils (such as palm oil) and from recycled vegetable oil. Plants to supply over 450 million litres of bioethanol are either under construction or in the planning process in the UK (including at Henstridge in Dorset and Immingham), equivalent to 1.75% of total petrol sales in 2005 (DfT, 2006). Finally, British Sugar and Associated British Foods are working with BP and DuPont to construct a plant at Wissington in Suffolk to produce biobutanol from sugar beet.

Production of energy crops

2.8. ***Biomass production:*** The Biomass Task Force quoted data collected by D Turley at the Central Science Laboratory on the biomass resource and its potential for energy generation (heat and electricity). The information for energy crops is shown in **Table 2.1.**

Table 2.1: Existing annual biomass resource and energy potential, UK

Biomass source	Available tonnage (dry tonnes)	Energy contained in biomass (Tj)
Forestry waste and arboricultural arisings	1,460,000	21,900-25,988
Waste wood (industrial)	3,000,000	35,700
Energy crops (SRC, SRF & miscanthus)	250,000-366,750	3,940-6,671
Cereal straw	3,000,000	40,500-49,500

Source: Biomass Task Force. See below for further explanation of sources of data.

2.9. It should be emphasised that these figures relate to the potential resource, not the amounts actually being utilised. The figure quoted for **forestry waste and arboricultural arisings** comes from a DTI study[8] and applies to GB not UK. It makes assumptions about the harvestable material other than commercial timber crops available over the next 15 years and does not include wood gained from habitat restoration (such as where heathland is restored from forestry).

2.10. The DTI study estimated the potential woodfuel resource based on industry (Forestry Commission and private sector) responses to questionnaires (**Table 2.2**). The large majority (80%) is accounted for by forest residues (from operations and

[6] DfT, (2006), *Promotion and Use of Biofuels in the UK.* Report for the European Commission by the Department for Transport, June 2006.
[7] Quoted in EFRA, (2006).
[8] DTI, (2003), *Wood fuel resource in Britain*. Report by Forestry Contracting Association with the Forestry Commission, Edinburgh.

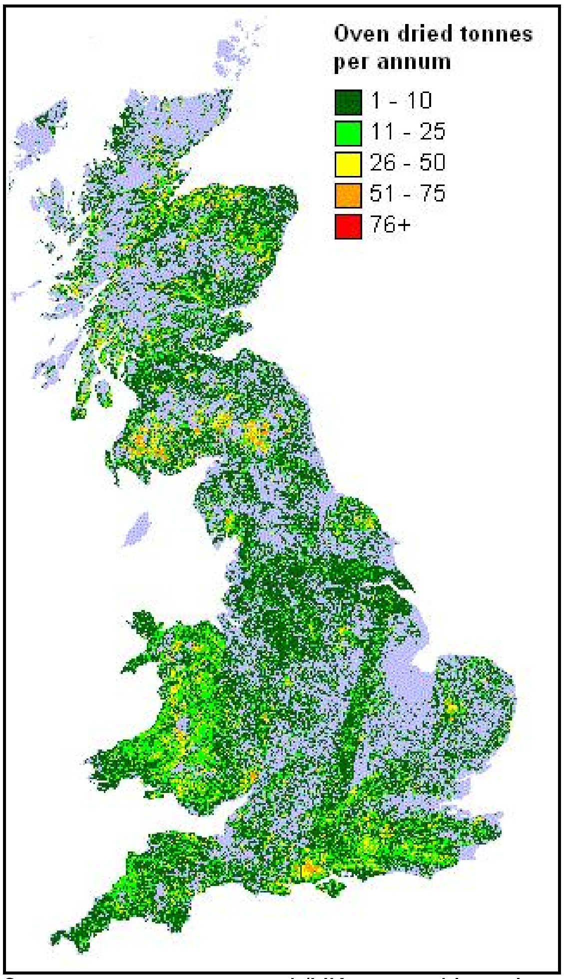
from standing timber which may be of too poor a quality for traditional timber markets (the column marked 'Forest and woodland'). The location of this resource is shown in **Figure 2.2**. 11% of the resource comes from sawmill products, the large majority of which already have markets. 9% comes from material obtained from tree work surgery, the clearance of utility lines, and track and roadside maintenance ('arboricultural arisings), most of which is currently sent to municipal composting schemes or landfill. The resource available from Short Rotation Coppice is very small in comparison (0.2% of the ODT resource).

Table 2.2: Existing woodfuel resource in GB, oven dried tonnes (ODT) equivalent

Country	Forest and woodland	Arboricultural arisings	Short rotation coppice	Primary processing co-products
England	2,394,147	616,060	15,899	289,580
Scotland	2,942,513	34,717	572	403,538
Wales	971,689	19,706	218	165,783
GB total	6,308,349	670,483	16,689	858,901

Source: DTI, (2003), *Wood fuel resource in Britain*. Report by Forestry Contracting Association with the Forestry Commission, Edinburgh.

Figure 2.2. Resource map of forestry residues for GB



Source: www.restats.org.uk/UK_renewable_policy

2.11. Overall, the DTI report estimates that, on an annually harvested basis, 1.26 million tonnes of woodfuel (ODT) is currently surplus after existing markets have been met. The majority of this comes from **branches** (410 ODT per year or 32% of the total) and **stemwood** (381 ODT or 30%) harvested from forestry operations and from arboricultural arisings (341 ODT or 27%).

2.12. The figure for **waste wood** in the Biomass Task Force report (**Table 2.1**) was provided to the Task Force by the Waste and Resources Action Programme (WRAP). Of the 5-7 million tonnes (Mt) of wood waste produced annually, only 1.4 Mt were recovered in 2004 with the majority of this being recycled. WRAP anticipate that if half of the available resource was recycled in future, the remaining 3 Mt or so could be available for energy markets.

2.13. The Biomass Task Force base the figure for **energy crops** (250,000 to 366,750 tonnes) on the forecasted area of SRC and miscanthus in 2010 of 25,000 ha, two thirds of which is expected to be SRC and one third miscanthus. It assumes average yields of 10-15 oven dried tonnes (ODT) per ha per year of SRC and 18 ODT/ha/yr of miscanthus.

2.14. Figures for **cereal straw** reported by the Biomass Task Force are based on total UK production of 9-10 Mt per year of which it is estimated that up to 3 Mt could be available, mostly in the Eastern counties of England.

2.15. ***Biofuel production:*** Data on the production of biofuels (biodiesel from oil seed rape, bioethanol from wheat and biobutanol from sugar beat) is available from a variety of sources. In 2005, the total area of cereals grown in the UK was 2.9 million ha (million ha), of which wheat accounted for 1.9 million ha. There were 519,000 ha of oilseed rape and 148,000 ha of sugar beet.[9] Only very small proportions of this have been used for biofuel production to-date.

2.16. A study for Defra by the Central Science Laboratory[10] stated that over 23,000 ha of oilseed rape was grown on UK farms for biodiesel in 2001. It is likely that all of this was grown on set-aside land and that virtually none of this would have been processed for biodiesel but would instead have been swapped on an equivalence trade basis with oilseed rape grown in Germany which was processed in that country (the UK oilseed would have been crushed for conventional food markets). The report states that "*until recently UK biodiesel production was limited to 200 tonnes"*.

2.17. It is understood that to date there has been no commercial production of bioethanol from UK grown crops. However, significant quantities of volatiles are fermented from wheat for the brewing industry. A new farmer-controlled business, Green Spirit Fuels, has started to build a plant at Henstridge on the Dorset /Wiltshire border that will be the first to produce bioethanol from wheat in the UK. When commissioned in 2008 it will use 350,000 tonnes of wheat to produce around 105,000 tonnes of bioethanol[11].

[9] Defra, (2005), Agriculture in the UK, 2005.
[10] Turley DB, Boatman NG, Ceddia G, Barker D, Watola G, (2003), *Liquid biofuels – prospects and potential impacts on UK agriculture, the farmed environment, landscape and rural economy.* Central Science Laboratory, York
[11] NFU press release 27 June 2006. www.nfuonline.com/x8483.xml

Conclusions on current production and use

- Accurate data is difficult to source and is often difficult to compare because of the range of different units used.
- It is clear that energy crops currently account for a very small proportion of UK energy generation and fuel use and are less significant than other forms of bioenergy such as landfill gas and waste combustion. A high proportion of energy crops are imported such as wood used in co-firing and imported biodiesel from oilseed rape grown elsewhere in the EU or palm oil from further afield.
- Within the UK a considerable amount of waste material is produced which currently fails to be used for energy generation. This includes forestry residues, waste wood and straw.
- Larger areas of crops that could be used for biofuels are grown in the UK but currently nearly all of these crops are used for conventional food uses. Conversely, the area of crops specifically grown as biomass (SRC and miscanthus) are small.

POLICY DRIVERS

2.18. This section reviews public policy priorities and assesses how this is likely to influence future production and use of energy crops. In recent years, the threat of climate change and the need for sustainable development have been core drivers of public policy at an EU and national level. The renewable energy sector, and within that, bioenergy, are seen as vital components of the policy response to these overall drivers. Support for bioenergy comes from other policy domains as well, including geopolitical energy policy (reducing reliance on energy imports from potentially unstable regions of the world) and, under certain circumstances, biodiversity (ensuring sustainable futures for managed woodland habitats).

EU policy

2.19. Policy towards renewables is increasingly being lead at an international and EU level. In June 2006, the European Council adopted a new Sustainable Development Strategy which built on the previous Gothenburg strategy of 2001. The renewed strategy sets overall objectives, targets and concrete actions for seven key priority challenges for the coming period until 2010. The first of these priorities is titled "Climate change and clean energy" and restates existing targets for producing 12% of energy and 21% of electricity from renewable sources by 2010 (from the Renewables Directive 2001/77), 5.75% of transport fuels to come from biofuels by 2010 (the Renewables Directive 2003/30) and reducing energy consumption by 9% by 2017 (the Energy Efficiency Directive 2003/739).

2.20. Prior to this, and in preparation for the UN's Kyoto Convention, The European Commission's White Paper 'Energy for the Future: Renewable Sources of Energy' (1997) identified bioenergy as one of the most promising areas for growth in renewable energy, particularly combined heat and power (CHP), and indicated that biomass would be a main contributor and could triple its energy provision (from a 3% baseline in 1997). The EU Biomass Action Plan (2005) sets out measures to promote biomass in heating, electricity and transport. The Action Plan anticipates a doubling in the use of biomass from 4% to 8% of overall energy needs by 2010, with particular potential for increasing its generation of heat.

2.21. The EU Emissions Trading Scheme came into operation in January 2005, with the first National Allocation Plans covering the period 2005 – 2007. This allocates carbon dioxide emission allowances to installations which are subject to the trading scheme, allocated by sector and by installation within the sector. The energy sector is covered by this Scheme and power stations therefore have emissions targets to achieve. CHP is a key element in the UK National Allocation Plan for the energy supply sector.

2.22. The EU Biofuels Directive was agreed by the European Council and Parliament in May 2003. The Directive seeks to reduce life-cycle emissions of carbon dioxide from transport across Europe, and to reduce the EU's future reliance on external petrochemical energy sources. It requires Member States to set indicative targets for biofuels sales for 2005 and 2010, and to introduce a specific labelling requirement at sales points for biofuel blends in excess of 5%. Member States must take account of specific 'reference values' when setting their national indicative targets. These are effectively a target, although not mandatory, and are 2% (of energy content) of all petrol and diesel used for transport purposes by the end of 2005; and 5.75% by the end of 2010. Translating these reference values into equivalent values on the basis of sales by volume will therefore depend, among other things, on the anticipated split between biodiesel and bioethanol sales (since the energy content of each is different). Member States have until July 2007 to set their 2010 targets.

2.23. The EU Biomass Action Plan (December 2005) and Biofuels Strategy (February 2006) set out the European Commission's actions to stimulate increased production, processing and consumption of biomass and biofuels by businesses and national governments and for supporting new technological innovation through research.

National policy

2.24. Defra has recently described its mission as enabling a move towards 'one planning living'[12] and climate change is described as being the most dangerous threat to human life. Action to address climate change is a key driver of Government policy and is evident in a wide range of policy documents and strategies.

2.25. National policy towards the renewables sector is set out in the DTI's Energy White Paper 'Our Energy Future – Creating a Low Carbon Economy' (2003) with the need to cut carbon emissions being one of four goals of the energy policy. The policy confirms the national commitment to achieving 10% of electricity from renewable sources by 2010 (from the EU Renewables Directive) and suggests that specific measures will be needed to stimulate growth in renewable energy to achieve economies of scale and so reduce its costs. Support for bioenergy is pledged through a three year Bioenergy Capital Grant Scheme and an Energy Crops Scheme (part of the national Rural Development Programmes) to help farmers and foresters establish energy crops.

2.26. Prior to 2006, the definition of energy from renewable sources in the UK included energy from waste. However, the UK has now adopted the international definition of renewables, which excludes non-biodegradable wastes.

2.27. The main policy instrument for encouraging utilisation of renewable energy is the Renewables Obligation. This requires licensed electricity suppliers to source an annually increasing percentage of the electricity they supply from renewable energy sources, with targets of 10.4% by 2011 and 15.4% by 2015 and a strong aspiration to reach 20% by 2020 (the latter confirmed in October 2006). The system operates through the issue of Renewable Obligation Certificates (ROCs) to suppliers of renewable energy by OFGEM. These certificates may be traded separately from the electricity to which they relate to give individual suppliers more flexibility as to how they meet the demands of the Obligation.

2.28. Amendments to the Renewables Obligation Order in 2004 set out some specific requirements for co-fired power stations using biomass, namely that after 2009 they will only be eligible for ROCs if 25% or more of energy content from biomass is derived from energy crops, rising to 75% by 2011. This gives a considerable impetus to electricity generators to source energy crops. After 2016 co-firing power stations

[12] Open letter from Secretary of State for the Environment, David Milliband, to the Prime Minister, July 2006. www.defra.gov.uk/corporate/ministers/pdf/milibandtopm-letter060711.pdf

will be excluded from receiving ROCs (with an impetus to move entirely across to firing from renewable sources).

2.29. The Government is currently consulting on further changes to the Renewables Order. The most significant proposal is that obligations should be 'banded' enabling Government to encourage certain renewables technologies at the expense of others. The consultation paper suggests that this could be done by altering the relative value of ROCs (with certain renewables technologies receiving more than 1 ROC per MWh of power and others receiving less than 1 ROC per MWh). If this proposal is adopted, Government will use this 'multiple ROC' system to encourage emerging technologies such as biomass and offshore wind while tailoring support to cheaper technologies like landfill gas and co-firing. The consultation closes in January 2007 and if the principal of banding by 'multiple ROCs' is agreed a further consultation will follow on its implementation.

2.30. In November 2005, the Government announced the creation of a Renewable Transport Fuel Obligation (RTFO), to come into effect in April 2008. The RTFO sets a target for 5% by volume of all road fuels to come from biofuels by 2010. This is somewhat less than the indicative target set by the EU Biofuels Directive of 5.75% by energy content. Fuel suppliers are required to meet this target themselves or buy certificates to make up any shortfall. The level of the obligation starts at 2.5% in 2008-09, rising to 3.75% in 2009–10 and then 5% in 2010–11. The 5% target should result in an annual reduction of carbon emissions of over 1 million tonnes (MtC), equivalent to taking one million cars off the road. The Government has signalled its intention of increasing the target after 2010, subject to the European Commission changing EU fuel quality standards. To put the target in perspective, the UK is currently sourcing around 0.24% of its total fuel supply from biofuels, with almost all of this coming from recovered waste food oil and imported oils.

2.31. Government has acknowledged that the benefits of different biofuel feedstocks, in terms of their carbon efficiency and other environmental impacts, is variable. Particular concerns have been expressed about certain overseas feedstocks imported to the UK such as palm oil. As a result, Government has required fuel suppliers to report on the carbon and wider social and environmental impact of their biofuel supply chains each year. In addition, in 2005 the Government commissioned a study through the Government and industry-sponsored Low Carbon Vehicle Partnership (LowCVP) to establish the feasibility of developing Carbon and Sustainability Assurance schemes for renewable road fuels. Work continues through the LowCVP to develop a methodology for calculating the carbon intensity of biofuels and a set of environmental standards for biofuels.

2.32. Prior to the introduction of ROCs and the RTFO, the main policy instruments encouraging utilisation of energy crops were the Non Fossil Fuel Obligation (NFFO) Orders for England and Wales and for Northern Ireland (NI-NFFO) and Scottish Renewable Obligation (SRO) Orders. These sought to assist the renewables industry by allowing premium prices to be paid for electricity for a fixed period. **Table 2.3** shows the status of projects licensed under the NFFO Orders to the end of 2005. Biomass plants accounted for 12% of the capacity of all commissioned projects and 7% of contracted projects.

Table 2.3: NFFO Orders: status summary as at 31 December 2005

Technology	Contracted projects		Commissioned projects	
	No.	Capacity (MW DNC)	No.	Capacity (MW DNC)
Biomass	32	256.0	10	138.9
Hydro (small-scale)	146	95.4	61	44.2
Landfill gas	329	699.7	217	472.2
Municipal and industrial waste	90	1,398.2	37	264.0
Sewage gas	31	33.9	21	22.6
Wave	3	2.0	1	0.2
Wind	302	1,153.7	101	258.5
Total	933	3,638.9	448	1,200.6

Source: *www.restats.org.uk/renewables_obligations.html*, quoting information from NFPA, Scottish Executive, Northern Ireland Electricity. Includes projects contracted under NFFO 1 and 2.

2.33. Although of less direct relevance to bioenergy production, it is worth noting that the UK Emissions Trading Scheme (ETS) was introduced in April 2002, predating the EU ETS. The scheme, which is voluntary and has involved 33 participants, ends in 2006, with final reconciliation taking place in March 2007. Since the introduction of the Renewables Obligation, reduced emissions arising from energy generated from renewable sources that is meeting the Renewables Obligation cannot be traded under the scheme.

2.34. The Government has committed to replacing the ETS with an Energy Performance Commitment (EPC). This will be mandatory on large non-energy intensive business and public sector organisations and will only cover CO2 (the ETS covers six greenhouses gases). Defra commissioned consultants to recommend detailed options for the operation of the EPC[13] and these are currently under consideration by Government.

2.35. One further and important national document is the report of the Biomass Task Force. This was established in 2004 to assist Government and the biomass industry in optimising the contribution of biomass energy to renewable energy targets and sustainable farming, forestry and rural objectives. The Task Force concluded that the potential supply of biomass is large and that demand should lead supply. Nevertheless it recognised that there is still a need to kick start the development of supply chains whilst markets are developing. It specifically noted a need to support development of supply chains for energy crops in England. The Task Force was unable to consider the feasibility of a 'Renewable Heat Obligation' as a stimulus to wood and biomass heat which several reports, including the EFRA Committee's have since called for.

2.36. The Government responded to the Task Force's recommendations in April 2006. It renewed its commitment to heat from biomass with a new round of the Bio-energy Capital Grants Scheme dedicated to biomass heat/CHP projects in 2006 and the launch of a new five-year capital grant scheme for biomass heat and biomass CHP projects. In relation to electricity generation from biomass, the Government has agreed to review the bureaucratic hurdles to greater use of co-firing. Government

[13] NERA and Enviros, (2006), *Energy Efficiency and Trading Part II: Options for the Implementation of a New Mandatory UK Emissions Trading Scheme*. Report to Defra, 28 April 2006.

Departments, particularly Defra and the Department for Education & Skills will map the potential for procuring more of its energy from renewable sources (with Defra undertaking a feasibility assessment of converting its estate to biomass heating).

2.37. The Government, through DTI and Defra have made available a variety of capital grants programmes and other financial incentives to stimulate the production and use of bioenergy. The DTI's Low Carbon Buildings Programme provides grants for microgeneration technologies to householders, schools, community organisations, the public sector and businesses. The programme started in April 2006, replacing the DTI's Clear Skies and Solar PV programmes and runs for three years. Grants are available for the purchase and installation of automated-feed wood pellet stoves and wood-fuelled boiler systems, provided minimum standards of energy efficiency have already been installed. Defra's Bio-energy Infrastructure Scheme operated in 2005 and opens again in March 2007. It assists farmers, foresters and businesses to develop the supply chain for energy crops and woodfuel. The Enhanced Capital Allowance Scheme provides tax incentives to companies investing in renewable energy technologies including woodfuel and biomass boilers. It is managed by the Carbon Trust on behalf of Defra and HM Revenue and Customs. Support for the production of biomass crops are described below.

Agricultural policy

2.38. There are two elements of the Common Agricultural Policy, as it operates in the UK, that are relevant to the development of energy crops.

2.39. ***Commodity support and set-aside***: Firstly, the main subsidy regime ('Pillar I'), which since January 2005 has been simplified to the Single Payment Scheme (SPS), requires farmers to set-aside an obligatory area of land. Under certain circumstances, farmers may use this set-aside land to grow crops that are not part of the supported regime (such as cereals, oilseeds and protein crops for human or animal consumption). Farmers have been growing 'industrial' oilseed rape on set-aside land for over ten years and much of this is ear-marked for biodiesel production. However, as noted in paragraph 2.14, the lack of biodiesel processing capacity in the UK, means that it is actually crops grown in countries such as Germany that are processed for bio-diesel, with this obligation being swapped on an equivalence basis for the crops grown on set-aside in the UK.

2.40. The continued existence of set-aside as a measure to control the supply of supported crops is something of an anomaly after the 2005 reforms which 'decoupled' the Single Payment Scheme from production of particular commodities. Set-aside was retained by the Commission because, with other forms of market support still in place such as intervention price support and export subsidies, there was a risk that EU arable farmers would continue to produce a surplus of crops that would infringe trade agreements with other countries such as the US. However, the further dismantling of these forms of market support between 2005 and 2007 means that by 2008 there is likely to be little if any justification for maintaining set-aside. EC Agricultural Commissioner, Mariann Fischer Boel, recently confirmed her desire to see compulsory set-aside removed as part of the European Commission's CAP 'Health Check' that will take place in 2007.

2.41. The future requirement for, and use of, set-aside is a significant one for environmental bodies in the UK. Set-aside that is left fallow and allowed to regenerate naturally has produced significant benefits to biodiversity as a source of cover, seeds and insects, especially during the winter and early spring. Such set-aside can be particularly valuable when used as a buffer between intensive agricultural activity and sensitive habitats and it can provide effective protection to buried archaeological features. Its benefits to the visual landscape are more questionable.

2.42. As noted above, the 'decoupling' of agricultural support from production subsidies and controls and the incentives for growing energy crops on land that is surplus to other forms of agriculture is likely to mean that there will be less set-aside land in the UK. The retention of land that is now set-aside and has developed high environmental value, or the future use of 'fallowed' land for environmental purposes, are likely to require specific measures under Pillar II of the CAP. Current signals from the European Commission are that such measures will not be available under the main Pillar I regime.

6.21 There is an additional payment that was introduced at the same time as the SPS to support the growing of energy crops. This is the Energy Crops Aid Payment (ECAP) which provides an annual payment of £45 per hectare for energy crops that are grown on land claiming the SPS, but not land that is being used to fulfil the set-aside obligation. All crops grown for energy use (i.e. for heat/power/transport/fuel) are eligible for the ECAP, except sugar beet. Where multi-annual energy crops (such as SRC) are grown on non-set-aside land, the ECAP must be claimed in order for the land to claim the SPS. The ECAP is not the same as the Energy Crops Scheme which is described below.

2.43. ***Pillar II:*** The second element of the CAP that is relevant to energy crops are the Rural Development Programmes ('Pillar II'). Separate programmes operate in each of the UK territories. They set out a range of measures, combining EU and national agricultural policy, of which two are particularly relevant. Under the EC regulation heading of 'investments in agricultural holdings' an Energy Crop Scheme was established in England providing grant aid for the establishment of miscanthus. The forestry measure mirrored this with the introduction of an Energy Crop Scheme providing grant aid for short rotation coppice (willow and poplar). These schemes have closed to new applications and will be replaced in the next Rural Development Programmes (2007-2013).

2.44. The Welsh Assembly Government chose not to offer an equivalent scheme, instead seeking to expand demand for energy crops and funding crop trials (through the Willows for Wales project). In Scotland, grants for establishing SRC are included in the Scottish Forestry Grants Scheme (at a lower rate than in England) and there is no establishment grant for miscanthus. In Northern Ireland, the Forestry Service operates a Challenge Fund for Short Rotation Coppice Energy Crops which promotes the planting of willow SRC.

Conclusions on current policy drivers

- The last ten years have seen a completely new set of policies encouraging renewable energy, cascading down from international and EU commitments, that have arisen to address the imperative of climate change. Support for the renewables sector, and for bioenergy within this, is becoming a core element in overall strategic approaches for sustainable development.

- Although the targets for increased utilisation of renewable energy as a whole are well established, the role that energy crops make in the mix of renewable sources remains more fluid.

- In the UK the Renewables Obligation and, from April 2008, the Renewable Transport Fuels Obligation, are the primary policy instruments stimulating increased production and utilisation of energy crops. There is as yet no Renewable Heat Obligation and work needs to be undertaken into the feasibility of regulating such a system.

- Government is committed to introducing a mandatory emissions trading scheme (Energy Performance Commitment) and, although the focus of this will be as much on reducing energy use, it is likely to encourage a range of businesses and the public sector to source more of its energy from renewable sources, including bioenergy.

- Agricultural policy now has less influence on the individual crops that farmers choose to grow, although incentives to grow energy crops are likely to remain as part of the national Rural Development Programmes. However, set-aside, which has been a stimulant to produce oilseed rape for biofuel use, is likely to be removed as a compulsory element of agricultural policy in the next few years. This conversion of 'fallowed' set-aside which had developed biodiversity benefits to energy crops will have significant environmental impacts.

TECHNOLOGICAL DEVELOPMENTS AND LIMITATIONS

2.45. If the anticipated increase in use of energy crops is to be realised, the technological limitations that are currently holding back the sector will need to be addressed. This section reviews the key limitations and the likely developments that may arise in the medium to long term. It does so by examining the different stages in the supply chain. A detailed examination of the environmental impacts of production of different energy crops is reserved for Chapter 3.

Increased utilisation arising from new forms of processing

2.46. Although final processing of crops into energy or fuel is at the end of the supply chain, it is helpful to consider this stage first because it obviously has a huge influence on demand for the crops.

2.47. It is often emphasised that bioenergy crop conversion technologies (the means of turning the harvested crop into the final energy required) are in their infancy compared to conventional energy supply chains such as those for petrochemical fuels and electricity generated from coal, gas or nuclear sources. Significant advances in bioenergy conversion technologies are expected in the medium to long term that will make the sector more carbon efficient and more economically competitive with non-renewable sources and will also change demand for the different energy crops.

a) Advances in heat and electricity generation

2.48. Current energy generation from biomass sources involves aerobic combustion (i.e. burning in air), with electricity usually created from a steam-driven turbine. Although this is entirely compatible with existing electricity generation (allowing co-firing for non-renewable feed stocks), it is relatively inefficient (where electricity alone is utilised, conversion rates of around 25-30% are typical for biomass, increasing to 75-85% where heat is also utilised in CHP plants). There are two main alternatives to aerobic combustion.

2.49. ***Gasification*** involves combusting material in a specially controlled flow of air or sometimes steam and is more efficient than simply burning in air. The technology is relatively well advanced and municipal waste authorities have shown interest in gasification as a means of reducing waste and creating heat and power. Bristol City Council is one of the first to have commissioned a plant that will take 30,000 tonnes of waste a year and generate 1.8 MW of heat and power. The ARBRE project in North Yorkshire involved the gasification of SRC material. However, it is significant that none of the recent energy crop processing plants such as those at Lockerbie in Dumfriesshire and the Wilton 10 site on Teeside have chosen to use gasification as their energy conversion technology.

2.50. ***Pyrolysis*** involves heating the fuel without air or steam to decompose it and drive off volatile combustible gases. Pyrolysis leaves a carbon-rich char which may then be burned or gasified. It is capable of dealing with very heterogeneous fuel sources which makes it particularly attractive to biomass crops where the chemical constituency is often variable. The technology is less well advanced compared to gasification and the capital cost of plants is significantly higher than conventional burning or gasification. Nevertheless, one of the recent projects (Charlton Energy at Frome in Somerset) is using this technology.

b) Advances in biofuel processing

2.51. Bioethanol and biodiesel are currently referred to as 'first generation' biofuels since they are created by conventional 'tried and tested' fermentation technologies. Although many in the biofuel industry are at pains to point out that there is considerable scope for improving the efficiency of these first generation fuels, there are limits to the extent that bioethanol and biodiesel can be combined with petrochemical fuels and used in current distribution changes and engines. There is widespread agreement that, in the long term, a series of 'second generation' technologies may offer major benefits, both by offering greater carbon savings and by being more compatible with petrochemicals.

2.52. ***Biobutanol*** represents a mid way point between current biofuels and true second generation fuels. A similar fermentation process which can use the same feed stocks (such as wheat or sugar beet) is used to create a slightly different organic compound (biutanol) which has a higher energy content and can be blended with conventional fuels at higher rates. BP and Dupont are taking a lead in its development and are behind the plant at British Sugar's site at Wissington in Suffolk that will generate biobutanol from sugar beet.

2.53. ***Anaerobic digestion*** involves biological activity from bacteria to break down organic compounds. The carbon balance achieved is generally much higher than for bioethanol and biodiesel because all of the crop can be used. Methane is the main utilisable product under current techniques and, being a gas, is a versatile fuel. However, methane is also a highly damaging greenhouse gas and it is essential that losses of the gas to the atmosphere are minimised.

2.54. The technique is most suitable for wet materials and there has been much interest in anaerobic digestion of wet waste, including farm livestock (cow and pig) slurries. The Renewable Energy Association website identifies ten anaerobic digestion plants in the UK including Organic Power at Horsington in Somerset, which is promoting its own patented system that can make use of energy crops. Other EU countries, particularly Germany, are considerably further advanced than the UK.

2.55. ***Ligno-cellulosic ethanol*** is produced when woody material, including straw, is subject to an enzyme process that has been developed by Iogen, a Canadian company. Shell is currently working with Iogen to bring the technique to commercial production. The advantage is that it allows a wider range of feed stocks to be used to create bioethanol, particularly those that are more carbon efficient than annual crops such as oilseed rape and wheat.

2.56. ***The Fischer-Tropsch process*** involves using a catalyst to synthesise complex hydrocarbons from more basic organic chemicals including plant material. It has been used commercially for several decades in South Africa to convert coal to liquid transport fuels. Choren Industries in Germany, supported by Shell, is developing a means of gasifying woody biomass using this process.

2.57. All of these advanced techniques offer the potential to increase the efficiency of energy conversion and the potential for energy crops to contribute to renewables targets. In terms of demand for different feedstocks, anaerobic digestion is significant since it can use 'wetter' feed stocks such as grass and maize that are not currently considered as viable biomass crops. The second generation biofuel techniques are important since they would enable a move away from annual crops such as oilseed rape and wheat in favour of more carbon-efficient multiannual crops such as SRC, SRF and miscanthus. However, it seems that large scale commercial adoption of these techniques is some way off – perhaps five to 20 years (with gasification and anaerobic digestion being closest to the market).

2.58. The remainder of this section reviews potential developments in the supply chain of existing feed stocks. Most attention is given to the 'novel' crops such as SRC and miscanthus since technological innovation is likely to be less significant in established crops such as commercial forestry and conventional arable crops.

Selection and propagation of planting stocks

2.59. Plant breeding has great potential to enhance the efficiency of energy crops. The greatest potential in the UK comes from breeding varieties of so called 'C4' species[14] that are suitable to our climate. Miscanthus is a C4 species, as are maize and sorghum, all of which are thought to have additional potential in the UK. Several of the global plant breeding companies have programmes in the early stages of development to breed varieties of C4 species that are more suitable to temperate climates. This includes research at the Institute of Grassland and Environmental Research (IGER) at Aberystwyth.

2.60. The last 30 years have seen breeding programmes for willow and poplar varieties that have high annual growth rates for biomass production (particularly in Sweden and at the Long Ashton Research Station near Bristol). However the high yields demonstrated in controlled field trials (which are generally on small plots of intensively managed high quality arable land) have often failed to be achieved on commercial plantations (which, for economic reasons, have tended to be on more agriculturally marginal land).

2.61. There is potential for further improvements in varieties, particularly in terms of quantifying more accurately the growth potential on different grades of land and the pest and disease resistance of different varieties. Latest varieties should produce yields of 10 to 12 oven dry tonnes per hectare per year at the first harvest with a 20 to 30% increase for the second harvest, where they are grown on good quality land.

2.62. Work is also taking place at Southampton University to select poplar varieties with better coppicing attributes that would make this species more suitable for short rotation biomass production.

2.63. The National Institute of Agricultural Botany (NIAB) has expressed an interest in testing willow and poplar varieties to produce a 'recommended list' of varieties with different agronomic characteristics in the same way that it does for arable crops.

[14] C4 species, which are common in the tropics, use a different bio-chemical pathway during photosynthesis which gives a higher density of carbon than the more temperate C3 species.

However, the relatively long lead time needed for this work (at least three years) makes this problematic since they would require material for their trials almost before the varieties have been selected. Any 'recommended list' system would thus require a level of co-operation from plant breeders that might be difficult to achieve in this highly competitive commercial environment.

2.64. In comparison, there is probably less scope to increase yields of the first generation biofuels (oilseed rape and maize), which have been a mainstay of conventional arable cropping in large parts of the temperate world for many years. Nevertheless, there may be opportunities for breeding new varieties that maximise starch production (for bioethanol production) or particular oils (for biodiesel). For example over the last decade, varieties of oilseed rape have been bred with high levels of erucic acid which is more suitable for industrial uses (as a hydraulic oil) than in earlier varieties grown for food oils.

2.65. The environmental risks of introducing new varieties and species should not be underplayed. As well as the impact on populations of pests and diseases and on wider biodiversity, there could be significant impacts on countryside landscapes from the introduction of unfamiliar crops.

2.66. In terms of SRC crops it is worth noting that many of the high yielding varieties of willows that have been bred are multi-species hybrids which consequently have low fertility rates. Others varieties are derived from Russian and Siberian species which flower in January and February, much earlier than most native willows, reducing the likelihood of cross-fertilisation.

2.67. Genetic modification (GM) of energy crops is almost certainly being pursued outside the EU, most probably for crops grown in more tropical climates. In the short term there is a moratorium preventing the commercial production of GM crops in the EU and there would appear to be no field trials taking place of GM varieties intended specifically for energy crops. Nevertheless, pressure to improve the contribution of bioenergy crops to renewable energy production is likely to increase. Public concern about GM might be expected to be less for energy crops than for crops that enter the food chain. Notwithstanding the comments above, the risk of the transfer of novel genes from GM crops to wild plants ('cross-contamination') is much higher for varieties with closely related native and naturalised species (such as oilseed rape, willow and poplar) than for those that do not (such as maize). Wildlife and Countryside Link opposes the commercial approval of any GMOs until regulations can be improved, and until GMOs can be shown, through rigorous scientific testing on a case-by-case basis, not to have any wider environmental, animal welfare or wildlife impacts[15].

Field establishment and production

2.68. While the annual biofuels crops are all grown from seed, where techniques are well developed, there is scope for improving the systems for establishing multiannual biomass crops.

[15] Wildlife and Countryside Link Position Statement on Genetically Modified Organisms, (June 2006).

2.69. Miscanthus is currently propagated from rhizomes which are lifted and split from the parent crop and planted using a cabbage planter. Although this is a reliable vegetative technique (the offspring are all identical to the parent material), it is expensive. Miscanthus tends to be an 'out breeding' species (meaning that seed is usually genetically very different) but work is taking place at the Institute of Grassland and Environmental Research (IGER) at Aberystwyth to see if 'in breeding' seed can be developed with more genetic homogeneity (similar to cereals). If this is successful it should reduce the cost of establishment, although it would lengthen the breeding process (potentially to 15 years compared to the 10 years for vegetative breeding).

2.70. Willow and poplar for SRC has conventionally been established from relatively long 'whip' cuttings taken from parent stools. Although mechanical step planters have been developed (in four or six rows), the process is relatively slow and expensive. Growers organisations have shown interest in establishing crops by planting or ploughing in 'billets' (shorter sections of stem around 20cm long). This would reduce the cost of planting and mean that growers could create their own propagating material more easily (some growers harvest their crop in billets) – something that is opposed by the breeders and producers of planting material.

2.71. The field production of biofuels (oilseed rape, wheat and sugar beet) is currently no different from that of conventional crops grown for human consumption or animal feeds. This leads to relatively poor carbon ratios compared to the multiannual biomass crops, although, as noted above, carbon ratios are much higher if second generation conversion technologies, such as anaerobic digestion, are used. There is interest in reducing the number of tractor passes and applications of pesticides and fertilisers to improve the carbon ratio. The same considerations are being addressed (and have been addressed for some time) with the conventional crops.

2.72. The field production of willow, poplar and miscanthus requires relatively little intervention between successful establishment of the crop (usually involving one or two herbicide sprays and then a single cut-back to stimulate multi-stem coppice growth) and harvest. Research has been conducted by some growers' organisations into the agronomic benefits of pesticide applications (particularly against willow beetles) but this is not usually economically efficient and reduces the crops carbon efficiency. Best practice dictates that five diverse varieties of willow or poplar should be grown together, reducing the risk of a pest or disease epidemic in the crop.

2.73. In contrast, miscanthus currently has no significant pests or diseases that are endemic in the UK, but the single species that is currently grown increases the risk of a catastrophic breakdown in resistance in the future.

2.74. Best practice guidance[16] in the design of SRC plantations follows that for forestry, encouraging the creation of blocks which fit into the wider landscape, reducing the visual impact of large clear fells and make use of open rides for biodiversity. This guidance has a minimal impact on productivity and is widely accepted by the industry.

[16] Forestry Commission, (2002), *Establishment and management of short rotation coppice.* Defra, (2004), *Growing Short Rotation Coppice – Best Practice Guidelines for applicants to Defra's Energy Crops Scheme*.

Harvesting

2.75. As with propagation and establishment, the harvesting of oilseed rape, wheat and sugar beet grown for biofuels is no different from conventional crops and it seems unlikely that there will be significant advances.

2.76. There are at least two different means of harvesting SRC. In Sweden most growers use a modified forage harvester (a large horizontally mounted rotary blade used to cut grass silage) which produces a relatively small wood chip. Renewable Energy Growers in the UK have developed a modified sugar cane harvester which gathers the coppice row into a reciprocating blade (similar to a combine harvester) and then cuts the stems into 'billets' about 20cm in length. In both cases the cut material is placed or 'blown' into a tractor pulled trailer travelling beside the harvester. Harvesting takes place every three years.

2.77. There are advantages to the second 'billet' harvester in terms of the quality of the cut material (see below) but the machine is significantly heavier than 'chip' harvester. Since SRC is currently harvested in the winter period (after leaf fall and before leaf burst), this can present problems of soil damage, particularly on the headland around the field where there is less of a root mat (the dense root mat created by willow in particular can support machinery that would otherwise sink into the soil). The development of more light weight harvesting machinery would not only reduce the risk of soil damage but would enable SRC cropping on heavier and wetter soils that are agriculturally marginal for other crops and are currently likely to be permanent grassland.

2.78. Miscanthus is harvested in winter after the leaves have senesced. This is done annually using a forage harvester, with the cut material baled using conventional 'big bale' straw balers.

2.79. As noted above, SRC and miscanthus (and forest residues) are currently harvested during the winter (December to March) which is a time which suits most arable farmers, there being few other activities taking place, but produces a higher risk of soil damage and reduces the availability of expensive harvesting machinery, compared to year round harvesting. Research at Long Ashton Research Station found that there was no long term reduction in the vigour of SRC coppice stools from summer harvesting. However this creates a problem of leaf inclusion in the harvested SRC material and is likely to harm nesting birds and other breeding wildlife. Miscanthus would not be suitable for summer harvesting because of the much higher moisture levels of the cut material. As a result there is currently no interest in summer harvesting – although this could return.

Transport

2.80. Compared to the biofuels (particularly wheat and oilseed rape) SRC, SRF, forest residues, miscanthus and straw are relatively bulky, low density, materials to transport and, in the case of SRC and forest residues, when first harvested they have a high moisture content (around 50%). Transport costs relative to energy content are therefore relatively high. As a result, Government guidance is that the maximum distance from field to processing plant should be 25 miles for large installations and 10 miles for small plants.

2.81. The Royal Commission for Environmental Pollution's report on biomass[17] calculated the relative costs of transporting biomass crops by different means (comparing road, rail and ship) and showed that miscanthus was the cheapest on a weight basis, followed by chipped SRC and forest residue, followed by straw. To overcome this cost limitation, there has been interest from both the SRC and miscanthus sectors in creating a denser form of material on or close to the farm where it is grown. This is covered further below.

First processing and storage

2.82. As noted above, SRC, SRF and forest residues have a high moisture content when harvested (around 50%), making them expensive to transport and more inefficient to burn. In Sweden, SRC, SRF and forest residues are often burned wet in medium sized community heating schemes close to where they have been grown shortly after harvesting. As a result Swedish boilers have been designed with a 'moving grate' process where the cut material is gradually dried out using residual heat from the burning process as it moves toward the boiler. In the UK, co-firing with fossil fuels and the new generation of more efficient boilers require a dryer, denser and more consistent feed stock. As a result, SRC, SRF and forest residues tend to be left to dry in large heaps or rows close to where they have been grown until they have a moisture content of less than 35%. (Although quantities of biomass are often referred to in 'oven dried tonnes' or ODT for comparison, oven drying does not take place). Material cut into small chips tends to degrade during this process, particularly through fungal growth, whereas material cut into billets dries more evenly and is less susceptible to mould. As noted above, the preference for billeted material being shown by some growers currently requires heavier harvesting equipment, with the disadvantages this confers. This issue does not occur with miscanthus since it has a much lower moisture content (between 15-20%) when harvested and can be baled straight away.

2.83. There is interest in the further processing of biomass to increase its density, reduce water content and create a more consistent material more suited for mechanical handling in boilers. Most imported SRC and forest residues come in the form of pellets with a moisture content of less than 15%. Several businesses operating in the UK are developing their own processes such as John Strawson (creating 'Koolfuel' from billets, consisting of different grades of wood granules), Biojoule (creating a pellet from chipped material) and BICAL (creating pelleted miscanthus). Although this extra processing adds cost and reduces carbon efficiency at this stage in the supply chain, this can be offset by the improved conversion efficiency to heat and energy and lower transport costs. Quoted prices for pelleted SRC are around £150 per tonne when delivered in small quantities to small-scale heat plants but the cost of larger volumes for co-firing are likely to be much less (perhaps £70). This compares to £45 per tonne for basic dried chips or billets (not including transport).

[17] RCEP, (2004).

Crop removal

2.84. Although SRC and miscanthus are both thought to have a viable life of at least 20 years, there inevitably comes a time when the grower wants to remove the crop, perhaps to replant elsewhere on the farm with new varieties. Miscanthus is relatively easy to remove, being killed with a herbicide in the early autumn. The standing crop is then harvested as normal and the rhizomes are broken up mechanically and ploughed in before the field is cropped again the following year. Some regrowth in subsequent crops must be expected but this is not insurmountable, particularly where the field is put down to grass.

2.85. Removing willow SRC is somewhat more complicated and usually involves taking the field out of cropping for a whole year. Once the final harvest has been taken, the stools are sprayed with a herbicide. Two further sprays may be needed to kill the plant. The root mat is then shredded mechanically and left to rot down before being ploughed in.

2.86. Removing poplar SRC is usually more problematic. Poplar develops a strong tap root and usually a large dense stem at ground level. It is usually necessary to mechanically dig up the root balls or, for very large stools, to mechanically grind them out. This involves the loss of at least one cropping year and can be expensive both in time and money and in carbon (tractor diesel).

2.87. SRF is regarded as a more long term crop and landowners usually make a commitment to retain the land as forestry for several decades. The issues of returning the land to agricultural uses, as and when they occur, are similar to those of SRC.

Conclusions on technological developments

- The most significant developments are likely to occur in the conversion technologies available to convert crops to heat and fuel. All of these new technologies are some way from commercial exploitation but there is increasing interest from large energy companies in their development.

- The new conversion technologies are likely to result in a widening in the range of feed stocks that can be exploited. This is particularly the case for biofuels where the generation of Ligno-cellulosic ethanol and the Fischer-Tropsch process could see the multi-annual biomass crops (SRC, SRF and miscanthus) becoming a potential feed stock. Similarly, anaerobic digestion could see crops such as grass and maize, combined with suitable waste streams, becoming a major source of methane. These crops are more carbon efficient than the annual crops currently used.

- In general there are likely to be relatively few technological developments in the production, harvesting, transport and storage of the annual biofuel crops in the UK (oilseed rape, wheat and sugar beet) since these are well established commercial crops. However, there could be greater differentiation in varieties suited for bioenergy production and increases in the carbon efficiency of production systems (i.e. fewer tractor passes and agrochemical applications).

- In comparison, production systems for the multiannual biomass crops (willow and poplar SRC, SRF and miscanthus) are in their relative infancy. Greatest improvements are likely to be seen in the processing of the harvested biomass to create a denser and more consistent feedstock that is cheaper to transport and more suitable for use in mechanised boilers. Techniques for harvesting the crop are also likely to improve, with the potential for machines that are lighter and less likely to damage soils (potentially enabling cropping on heavier and wetter soils and making harvesting less weather dependent).

- Nevertheless, key technological limitations are likely to remain the bulkiness of biomass crops and the high transport cost, resulting in the clustering of field production close to processing plants. The greater cost and time taken to remove poplar SRC at the end of the production period, compared to willow and miscanthus, is likely to continue to make this crop less attractive to growers.

CARBON SAVINGS

2.88. This section summarises the potential carbon savings that the main forms of bioenergy can deliver. As outlined in the House of Commons EFRA Committee Report (2006), quantifying the carbon saving potential of any source of bioenergy is a complex process as the end result is influenced by a range of factors which are in themselves difficult to evaluate. Carbon savings are affected by agricultural practice, production, processing methods and transportation of the feedstock. A study undertaken by Sheffield Hallam University and the Low Carbon Vehicle Partnership (2003) shows that the greatest potential green house gas savings can be gained through the gasification of biomass to produce electricity and the burning of woodchip to generate heat.

Table 2.4: Potential Green House Gas Savings from a Range of Bioenergy Technologies compared with Conventional Fossil Fuel Equivalents

Electricity Generation	% saving in GHG versus fossil fuel reference
Grid Electricity	
Electricity from miscanthus	84%
Electricity from SRC woodchip	84%
Electricity from forest residue	86%
Electricity from straw	59%
Gasification of forest residue wood chips	95%
Gasification of SRC woodchips	95%
Small Scale Heating	
Oil fired heating boiler	-
Combustion of woodchip	93%

Data source: Defra from: *Carbon and energy balances for a range of biofuels options*, Sheffield Hallam University (2003); and *WTW evaluation for production of ethanol from wheat*, Low Carbon Vehicle Partnership, (2004), Contained within House of Commons EFRA Committee (2006) *Climate Change: the role of bioenergy*.

2.89. A summary of the potential greenhouse house savings from different biofuels are summarised in **Table 2.4.** It is important to note that there is considerable variation in the potential carbon savings from biofuels identified in different studies**,** owing to the use of different methodologies and assumptions. This table compares woodfuel used in electricity only situations and wood chip in heating situations against coal and gas. Carbon savings are inevitably greater for heating and CHP. **Table 2.5** summarises the findings of two of the most recent studies.

Table 2.5: Potential Green House Gas Savings from Biofuels compared with their Fossil Fuel Equivalents

Transport Fuels	% saving in GHG versus fossil fuel reference	
	Source: Sheffield Hallam Univ. (2003) & Low CVP (2004)	Source: E4tech (May 2006)
Diesel (ultra low sulphur)		
Biodiesel (from oil seed rape)	53%	38 -57%
Biodiesel from recycled vegetable oil	85%	-
Second generation diesel	-	94%
Petrol (ultra low sulphur)		
Ethanol from wheat grains	49-67%	7-77%
Ethanol from sugar beet	54%	32-64%
Ethanol from sugar cane	-	88%
Ethanol from wheat straw	85%	
Ligno-cellulosic ethanol	-	73-94%

2.90. As can be seen from **Table 2.4,** the carbon savings that can be achieved from second generation biofuels produced from biomass are substantial with estimated GHG savings of up to 94%. This assessment is supported by the Society of Motor manufacturers and Traders who have stated that in addition to the greater potential carbon savings offered by second generation biofuels; they have the advantage of generating significantly higher yields per hectare of land as the whole crop can be used. As noted in the EFRA (2006) report, according to Volkswagen, the estimated yield per hectare from second generation feedstock is at least three times greater than that of rapeseed biomass.

2.91. A study by the automotive and oil industry in Europe, supported by the European Commission[18], has assessed the GHG emissions of a wide range of automotive fuels and powertrains, using whole life-cycle analysis. The fuels examined included compressed natural gas, biogas, bio-ethanol and biodiesel, and hydrogen from a variety of sources, compared to conventional petrol and diesel. The study found that the GHG savings of biofuels such as ethanol and biodiesel using current production and conversion technologies are critically dependent on the precise processes used (such as the inclusion of CHP) and the fate of by-products. The GHG balance is particularly uncertain because of nitrous oxide emissions from agriculture. Looking to the future, the development of novel processes for converting the cellulose of woody biomass (such as from SRC, SRF or forest arisings) or straw into ethanol and

[18] EUCAR *et al,* (2006), *Well-to-wheels analysis of future automotive fuels and powertrains in the European context.* European Union Council for Automotive Research (EUCAR), CONCAWE (The oil companies' European association for environment, health and safety in refining and distribution) and the Joint Research Centre of the EU Commission. Version 2b, May 2006. http://ies.jrc.ec.europa.eu/WTW.

diesel offer the opportunity for more significant GHG savings, but are still likely to rely on high energy use. Highest greenhouse gas savings arise from compressed natural gas derived from liquid livestock manures due to the reduction in methane emissions to the atmosphere. Appendix I of the report contains detailed data tables comparing the whole life-cycle GHG savings (measured as grams of CO_2 equivalent per km) for different fuels using a wide range of different variables (such as different conversion technologies and types of vehicle engine). This makes it difficult to summarise quantitative data in a simple table.

Conclusions on carbon savings

- The most carbon efficient conversion technologies are those that produce heat or CHP directly from the energy crop rather than those that produce electricity.
- The wide range of variables involved in whole life-cycle analysis of different sources of bioenergy makes it difficult to make like-for-like comparisons of overall carbon savings.
- However, it would appear that the greatest potential green house gas savings can be gained through the production of biogas from wet livestock manures, the gasification of biomass to produce electricity, the burning of woodchip to generate heat and the use of second generation biofuels produced from biomass.

FUTURE DEMAND – PREDICTIONS FOR CROP AREAS

2.92. Public policy has set clear challenges for increased utilisation of renewables for energy generation and in transport fuels. Technological developments, particularly in new conversion technologies, will present new opportunities and a variety of different projections have been made for the role of energy crops in the renewables mix. However, these projections need to be tempered with an understanding of the current capacity of the industry and the realistic rate of expansion under the existing economic climate.

2.93. As already reviewed earlier in this Chapter, overall targets have been set for the utilisation of renewable energy for both electricity generation and road transport but the proportion of these targets attributable to energy crops has not been set. Instead, Government is looking for markets to determine the role of different technologies and feedstocks.

2.94. The Royal Commission on Environmental Pollution has put forward some of the most challenging targets. Their 22nd report (*Energy – The Changing Climate*) proposed two targets for energy production from biomass by 2050 of 3 GW and 16 GW.

2.95. A paper by English Nature, reviewing demand for energy crops across the UK as a whole[19] projected that an area of 1.5 million hectares of crops could be expected by 2010. This paper suggested that the area could be split between oilseed rape (47%), SRC willow and miscanthus (30%) and wheat and sugar beet (23%) but it takes no account of the woodfuel resource. These calculations appear to be based on an

[19] English Nature, (2003), *English Nature Discussion Paper on Biofuels*. Paper by Anna Hope and Brian Johnson. June 2003.

estimate of what is practically feasible rather than what is needed to reach particular targets.

2.96. While the suggested targets for oilseed rape, wheat and sugar beat could be met by diverting conventional crops to energy use, the target for SRC willow and miscanthus is much more challenging, not to say unrealistic. On the basis that there is 15,000 ha of these crops in current production and a further 10,000 ha is under establishment or planning, (based on the figure of 25,000 included in the Biomass Task Force report) the target of 450,000 hectares of SRC and miscanthus by 2010 would appear to be unachievable. Consideration of what is practically possible under current economic conditions is covered below.

Heat and power from biomass

2.97. Most recent studies have based projections of the quantity of energy crops on the Government's target of 10% of electricity generation to come from renewables sources by 2010. This is equivalent to 3 GW of electricity, of which 1 GW is expected to come from biomass.

2.98. The DTI study on the **woodfuel** resource[20], estimated that there is an operationally available resource of 3.1 million oven dried tonnes (ODT) a year, of which 1.26 million ODT currently has no market, most of which is derived from forest residues (paragraph 2.11). Assuming a calorific value of 20 GJ per tonne, this available resource is sufficient to generate around 0.2 GW (at a conversion efficiency of 25%) or 5.3 terrawatthours (Twh) of heat (at 85% conversion efficiency). This is equivalent to 20% of the 1 GW target for 2010, although there is currently insufficient infrastructure for this resource to reach generating plants by 2010.

2.99. The DTI study made predictions for the future availability of woodfuels from traditional forestry and found little increase over the period to 2021. This is perhaps surprising but the report emphasises that the finding has been carefully checked. It states that the stability of supply is due to the predicted size distribution of the timber produced over this period, with most of the increased production coming from larger diameter material which will be harvested for existing timber markets. The report notes that the restoration (i.e. bringing into active management) of ancient woodland sites and planting of short rotation forestry (SRF) are likely to increase but calculates that these will not make a significant difference to overall woodfuel availability by 2021.

2.100. It is likely that recent developments, including the increased rate of removal of plantation forestry from ancient woodland sites, will increase the feedstock of woodfuels above those estimated by the DTI study. It is likely that the new Woodfuel Strategy for England, being prepared by the Forestry Commission during 2007, will forecast greater energy generation potential from woodfuel.

2.101. The potential quantities of **straw and waste wood** that could be available for heat and power are significant **(Table 2.1)**. Both have a calorific value similar to woodfuel and, assuming a conversion efficiency to electricity of 25%, the 6 million tonnes estimated by the Biomass Task Force could produce nearly one GW of

[20] DTI, (2003), *Woodfuel resource in Great Britain*. Report by Forestry Contracting Association with the Forestry Commission, Edinburgh.

electricity. However, like the woodfuel resource, there is currently no infrastructure established to collect it. The quantity of the resource is also likely to be relatively stable in the short to medium term, with any increase in straw dependent on diversion from existing markets for livestock bedding.

2.102. This study is not aware of any targets for the contribution that the energy crops **SRC and miscanthus** could make to the 1 GW electricity generation target by 2010. Assuming an annual yield of 10 oven dried tonnes per ha, generating the entire 1 GW would require an area of around 1.2 million ha (based on the same conversion factors used in the RCEP report, but with an energy conversion factor of 25%). Given the current area of around 15,000 ha, this would require an eighty-fold increase in the current areas of SRC and miscanthus which is clearly impractical over such a short time scale.

2.103. A more realistic target for the area of SRC and miscanthus by 2010 might be 40,000 hectares although this would still require the establishment of an additional 25,000 hectares in the next three years, which is challenging given the current lack of a planting grant. Planting on this scale would require 30 planting machines plus teams and 25 harvesters plus teams, compared to the ten or so of each operating in the UK at the present[21]. An area of 40,000 ha would contribute only 3% of the 1 GW target.

2.104. In reaching overall targets for biomass inclusion in renewable energy generation, particularly in co-firing, account needs to be taken of imported feed stocks such as palm oil expeller and olive oil residues. A recent study on the use of biomass in co-firing[22] calculated that imported palm and olive wastes account for 52% by weight of biomass currently used in co-firing and that other non-crop feed stocks (such as tallow) account for a further 11%. This leaves just over a third derived from energy crops, a significant proportion of which comes from waste wood. It would appear that a high proportion of the energy crop feed stock is imported from Scandinavia. SRC is estimated by the study to be contributing only 0.3% of the biomass used in co-firing and miscanthus only 0.04%. This again demonstrates the low base of domestic energy crop production in relation to the challenging targets that have been set for its use.

2.105. Based on these estimates of the available and potentially achievable resource, it is clear that UK sources of biomass, particularly from straw, waste wood and woodfuel have the potential to meet the 1 GW electricity generating target (3.3% of total generation) for 2010, but that it is unlikely that this will be reached while there is no infrastructure in place to transport the resource to electricity generating plants and while the majority of material currently used in co-firing is imported.

2.106. Although there are no Government targets for heat generation from renewable sources, a report by Future Energy Solutions for the DTI suggested that the renewable proportion of total heat generation could increase to 1.8% by 2010 and to 5.7% by 2020. The Biomass Task Force was more ambitious, arguing that it should be possible to increase the renewables share of the heat market to 3% by 2010 and 7% by 2015 provided that the measures it suggests are adopted.

[21] Estimates by Kevin Lindgaard.
[22] DTI, (2006), *Evaluating the Sustainability of Co-firing in the UK*. Report by by Themba Technology Ltd and The Edinburgh Centre for Carbon Management, September 2006.

2.107. The contribution from energy crops (SRC, SRF and miscanthus) in the period to 2010 is likely to remain very small. However, the rate of growth over a longer term could be very significant, if public policy directs it. Over a period of 20 or 30 years, it becomes realistic to consider a much more significant contribution from these crops.

2.108. In the remainder of this section, it is assumed that the resource available from straw, waste wood and woodfuel, remains static and that all of the increase is met from increased production of biomass crops, of which SRC and miscanthus are likely to be the most significant. This assumption of a static supply of straw, waste wood and woodfuel relies on the current price differentials between existing markets and the biomass market being maintained. It should be noted that a rise in the price of biomass material could see an increased proportion of these materials diverted to energy generation, although the rate of increase is contained by the total available resource. For instance, the DTI woodfuel report (DTI, 2003) places the total woodfuel resource at 3.1 million tonnes ODT, of which 1.26 million tonnes is currently surplus to demand (paragraph 2.95).

2.109. The Royal Commission's more recent report on Biomass[23] calculated that around 440,000 ha of biomass crops are required to generate 1 GW of energy (both heat and power). This assumes an average annual yield of 10 ODT per ha at a calorific value of 10 GJ per tonne and a conversion efficiency of 75% (which is only likely to be achieved in CHP plants). Based on these figures, achieving the Royal Commission's targets for the year 2050 of 3 GW (paragraph 2.91) would require some 1.3 million ha of biomass crops and achieving the higher 16 GW target would require 7 million ha of biomass crops. These would require an increase in the current area of SRC and miscanthus of 85 times and 466 times, respectively, over this 44 year period.

2.110. To put these areas in perspective, the total area of cultivated land (arable and horticultural crops, set-aside and bare fallow) in the UK in 2005 amounted to 5.1 million ha and the area of temporary grassland added a further 1.2 million ha[24]. Woodland and forestry occupied a further 2.7 million ha (GB)[25] (**Table 2.6**).

2.111. It is clear that if the RCEP projection is to be met without significant reductions in the current area of cultivated land used for food production, land that is currently permanent pasture (5.7 million ha) and possibly also rough grazing (4.4 million ha with sole rights and 1.2 million ha with common grazing rights) would need to be cultivated, with major environmental consequences. Based on the total UK agricultural area in 2005 of 18 million ha, the RCEP projections are equivalent to 13% of this total agricultural area. As noted above, these calculations take no account of the contribution of biomass sources from current uses of this land (such as straw or grass and maize which could be used in anaerobic digestion) or from existing forestry.

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[23] Royal Commission on Environmental Pollution, (2004), *Biomass as a renewable energy source*. www.rcep.org.uk

[24] Defra, (2005), *Agriculture in the UK 2005*.

[25] Forestry Commission, (2003), *National Inventory of Woodland and Trees, Great Britain.*

Table 2.6: Current crop and woodland areas

Crop	Area (thousand ha)	Proportion of total agricultural area
Wheat	1,868	10%
Oilseed rape	519	3%
Sugar beet	148	1%
Other arable and horticultural crops	1,908	10%
Bare fallow	140	1%
Set-aside	559	3%
Temporary grassland	1,193	6%
Permanent grassland	5,711	31%
Rough grazing (sole rights and common)	5,590	30%
Total agricultural area (incl farm woodland)	18,509	100%
Forest type	**Area (thousand ha)**	**Proportion of total woodland area**
Conifer	1,306	49%
Broadleaved	854	32%
Mixed	211	8%
Coppiced and coppice with standards	24	1%
Open space, windblow and felled	270	10%

Sources: Crop areas from Defra, 2005. *Agriculture in the UK 2005*. Woodland areas from Forestry Commission, 2003. *National Inventory of Woodland and Trees, GB.*

2.112. The Royal Commission report makes some interesting estimates of the proportion of land cover around different sizes of processing plants that would need to be converted to biomass production, based on the maximum transport distance of 25km around each plant[26]. **Table 2.7**, which is taken from the Royal Commission report, shows how small (1 MW) CHP plants with a fuel conversion efficiency of 75% require about 400 ha of biomass feed stock which amounts to a land take density of 0.2% in the 25km area around the plant (rising to 0.6% if a maximum distance of 15km is used). For larger plants with a 42 MW output, the feed stock density rises to 8.7% in a 25km radius around the plant, rising to a 22% density where a maximum distance of 15km is used. It should be noted that these figures for feedstock density are based on the total land area, not the area of land available for agricultural production. It should also be noted that plants with a lower conversion efficiency (such as the 32% often quoted for electricity-only steam-cycle biomass plants) would require a significantly higher feed stock density.

[26] The RCEP report erroneously states that the figures are based on a 50km radius whereas the calculations in Table 4.5 in the report, reproduced here, use a distance of 25km.

Table 2.7: Relationship between plant size and efficiency and feed stock density

Type	Energy output (MW)	Conversion efficiency	Fuel input (MW)	Wood (odt/yr)	Land use (ha)	Feed stock density
Small heat-only	1	75%	1.3	4,056	406	0.2%
Small gasification/ Pyrolysis	1	75%	1.3	4,056	406	0.2%
Large gasification/ Pyrolysis	39	80%	49	158,167	15,817	8.1%
Large steam-cycle CHP	42	80%	53	170,333	17,033	8.7%

Source: Royal Commission for Environmental Pollution, 2004

Biofuels

Where biofuels are concerned, the NFU made some estimates in August 2006 to show that the UK could supply the 5% target for transport fuels by 2010 under the RTFO[27]. **Table 2.8**, which uses the figures presented in the NFU paper, projects that the target for petrol can be met from 375,000 ha of wheat and that for diesel can be met from 840,000 ha of oilseed rape. It is understood that these projections are considered broadly realistic by Defra.

Table 2.8: Illustration of land involved in supplying RTFO for 2010

Fuel	Estimated 2010 demand (million tonnes)	5% by volume (Billion litres)	Feedstock required (million tonnes)	Land Involved (yield)
Petrol	19	1.2 Bl bioethanol	3 Mt wheat	375,000 ha (8t/ha)
Diesel	22.5	1.35 Bl biodiesel	2.7 Mt OSR	840,000 ha (3.2t/ha)

Source: NFU, 2006. www.nfuonline.com/x9763.xml

2.113. The NFU acknowledges that the combined areas of wheat and oilseed rape needed to meet these targets account for approximately 20% of the UK's arable land (including temporary grassland) or 24% of annual cropped and fallow land. The area of wheat required is 20% of the UK's current wheat area and the area of oilseed rape is 162% (or over one and a half times) the current oilseed rape area.

2.114. However the NFU points out that not all of the area of crops grown for biofuels would be additional to the areas currently grown for conventional (food and animal feed) uses. Both crops produce utilisable by-products which would replace some of these conventional crops. Wheat grown for bioethanol yields around a third of the crop as distillers grains, a high quality animal feed, and oilseed rape grown for biodiesel yields around half of the crop as rape meal, a high protein animal feed.

2.115. Taking account of these by-products, the NFU suggests that the additional area of arable land needed to achieve the 5% RTFO target from domestic production would

[27] NFU, (2006), UK biofuels - land required to meet RTFO 2010. August 2006. www.nfuonline.com/x9763.xml

effectively be 900,000 ha. This is 18% of the area of annually cropped and fallow land (including set-aside) or 5% of the total agricultural area.

2.116. The NFU points out that there is currently 559,000 ha of land in the set-aside scheme which is currently mandatory on farmers claiming the Single Payment Scheme. However, this requirement is likely to be removed in the next few years and this area will therefore become available for cropping. Secondly, the NFU calculate that around 375,000 ha are currently used to grow the UKs exportable wheat surplus, which can also be considered to be strategically available for biofuel production. This suggests that the additional 900,000 ha of biofuel crops could be accommodated within these areas currently used for set-aside and the production of exportable wheat.

2.117. The NFU also highlight that these figures assume that all of the 5% RTFO target is met from domestic production of biofuel crops and takes no account of the existing production of biodiesel from waste cooking oil and tallow (such as the 50 million litres already produced at a plant in Motherwell) or of increased imports of oil palm, olive waste and sugar cane which are likely to be highly price sensitive. The NFU also suggests that efficiency gains can be expected in the conversion of wheat and oilseed rape to their respective biofuels which will further reduce the area of crop needed.

2.118. It is interesting that the NFU's calculations take no account of biofuel production from sugar beet, despite the fact that currently achievable conversion rates for this crop are higher than for wheat or oilseed rape. However, during consultation, the NFU stated that the financial investment needed in processing plants which may be used for only a few months every year (sugar beet must be processed soon after harvest), as well as high transport costs, tend to erode the benefit of a higher conversion efficiency.

Factors influencing distribution of crops

2.119. English Nature's paper acknowledged that the location of new areas of energy crops would be influenced by a range of factors:

- **The available area of land of different agricultural quality**. Generally it is assumed that energy crops are most likely to be grown on land in grades 3 and 4 (land in grades 1 and 2 are more likely to grow more profitable horticultural and other food crops).
- **The relative profitability of conventional crops grown for human consumption**. For the biofuel crops (wheat, oilseed rape and sugar beet) farmers will be able to assess this relative profitability on an annual basis, whereas for the multi-annual biomass crops, a longer commitment and decision making process is required. This relative profitability is likely to be strongly influenced by:
    - **Public subsidy, taxation and regulation** (as referred to earlier in this Chapter).
    - **The availability and cost-effectiveness of alternative sources of biomass or biofuels,** such as imported feed stocks, forestry residues and waste vegetable oil.

- **Land use planning controls.** Requirements such as the Environmental Impact Assessment (EIA) Regulations and formal land designations such as Sites of Special Scientific Interest, National Parks and Areas of Outstanding Natural Beauty will ensure that land of high environmental quality is not available for conversion to energy crops. As they currently operate, the EIA Regulations would limit the extent to which permanent pasture could be cultivated. SSSI's currently occupy 2.4 million ha of the UK, which is around 10% of total land area. Relatively little of this area is currently under arable cultivation or temporary grassland, although a significant proportion is broadleaved woodland which produces woodfuel.
- **The location of processing plants.** The relatively high cost of transporting energy crops means that the crops must be grown close to the processing plant. As noted earlier, a distance of 25 miles is generally regarded as the maximum appropriate distance. This results in a clustering of production around plants. The location of plants will be partly dependent on the suitability of land for crop production and partly on planning control decisions.
- **Technological development** in production, transport and processing. This has already been covered earlier in the Chapter.

Conclusions on the likely impact of increased demand on crop areas

- Projections of the area of energy crops needed to deliver short term (2010) renewable targets have been made on the basis of the current commercially available conversion technologies and feed stocks. These show that straw, waste wood and woodfuel have the greatest immediate potential to contribute to renewable heat and power but that they are constrained by the lack of infrastructure and markets (with the electricity generation co-firing market dominated by imported materials).
- Over a longer time span (to 2020), short rotation coppice and miscanthus offer the greatest potential to increase the area of UK-sourced biomass used in heat and power generation. The quantity of straw and woodfuels from conventional forestry are likely to remain relatively static, although an increase in energy crop prices could see some diversion of material from existing markets.
- However if short rotation coppice and miscanthus are to play a significant role there will need to be a step change in the area of these crops. The production of 10% of current energy needs from these crops would require an 86 fold increase in their area to 1.3 million ha, which is an area slightly greater than the current area of temporary agricultural grassland (grassland in rotation with arable crops).
- The relatively high cost of transporting biomass crops means that these crops are likely to be clustered around the energy plants. Although developments in primary processing of cropped material into denser pellets could see these transport distance lengthen, it is likely that large generating plants could see upwards of 10% of the available agricultural land area within their catchments used for energy cropping. There are thus important environmental implications for the location of these plants.

- Projections for meeting the targets on biofuel utilisation suggest that the 5% target by 2010 is achievable from UK sources of oilseed rape and wheat grown and processed using current technologies. The NFU calculate that the additional area of biofuel crops (around 900,000 ha) could be accommodated within the land currently used for obligatory set-aside (assuming this requirement is removed during the Commission's forthcoming CAP 'health check') and the land currently used to grow wheat that is surplus to domestic demand. The contribution of recovered vegetable oils from industry and of imported biofuels is likely to reduce this demand.

- In the medium to long term, the development of new conversion technologies will favour the more carbon-efficient multi-annual crops (woodfuels, SRC and miscanthus) and reduce the demand for oilseed rape and wheat as biofuels.

3. THE ENVIRONMENTAL IMPACTS OF BIOENERGY

INTRODUCTION

3.1. This chapter provides a review of literature relating to the environmental impacts of bioenergy. As outlined in **Chapter 1**, the purpose of the literature review was three-fold:

- to review existing evidence on the potential positive and negative impacts of new and existing forms of bioenergy production (i.e. on landscape, biodiversity, water, soil and archaeology);
- to identify any uncertainty or gaps in knowledge; and
- to draw out existing good practice guidelines and measures for the sustainable production and use of new and existing bioenergy crops.

3.2. Literature was gathered from a wide range of sources including scientific papers, published research, books and guidance documents. An initial list of relevant literature was compiled by the research team. This was supplemented by:

- internet searches of academic studies and known research programmes;
- search of academic journals and bibliographic databases; and
- discussions with key experts to identify any relevant research that they had either commissioned, or were aware of.

3.3. The literature sources are predominantly drawn from the UK although, where appropriate, publications from Europe or further afield have been used. Full references are provided in **Appendix 1.**

DEFINING BIOENERGY

3.4. As outlined in **Chapter 1**, bioenergy (in the form of biomass or biofuels) can be generated from four principle sources:

1) **Wood based fuels,** e.g. multiannual short rotation coppice and short rotation forest residues.

2) **Perennial grass crops,** e.g. multiannual miscanthus, canary reed grass and switchgrass.

3) **Conventional crops** annual crops, e.g. sugar beet, cereal crops, sorghum, oil seed rape, linseed and sunflowers.

4) **Waste**, e.g. cow and pig slurry, poultry litter and wood waste (not considered further through this study).

3.5. Wood based fuels and perennial grass crops are primarily used to generate heat and electricity, although as outlined in **Chapter 2**, the development of second generation technologies means that in the future they are likely to be used to generate biofuels. Conventional crops are primarily used to generate biofuels for transportation and animal and wood waste is used to generate either heat and electricity or transport fuels.

3.6. The following section provides a literature review of potential environmental impacts of wood based fuels, perennial grass crops and conventional crops. For each resource the review is structured as follows:

- an overview is given of the key characteristics of the resource;
- a summary of the key environmental impacts is provided broken down under the headings of landscape, biodiversity, water, soil and archaeology; and
- a table is presented outlining the key management measures (identified from the literature review) required to minimise and/or enhance any predicted impacts. **Please note that these are not the management recommendations of Wildlife and Countryside Link.** The management recommendations of Wildlife and Countryside Link are set out in the accompanying document – *Delivering Sustainable Bioenergy Projects: Good Practice Guidance* (2007).

WOOD-BASED FUELS

SHORT ROTATION COPPICE

Overview

Short Rotation Coppice
Short rotation coppice is a method of farming certain kinds of trees to produce high yields within a short time period. The two main types of coppiced tree are willow and poplar. The crop is usually established during the Spring (March – June) by planting around 15,000 cuttings per hectare. After one year these are cut back close to the ground (i.e. coppiced) which causes multiple shoots to form. The crop is then allowed to grow for 2-4 years, after which time the fuel is harvested by cutting the stems close to the soil level. The cut stems again form multiple shoots that grow on for a further cycle to become the next harvest. This cycle of harvest and re-growth can be repeated many times, up to an expected lifespan of 15-25 years (corresponding to around 6 harvests). The shoots are usually harvested during the winter as chips, short billets or as whole stems, 25-50mm diameter and 3-4 metres long (ODPM, 2004). They are used to produce electricity and/or heat, or can be converted to biofuels using second generation technology. 
Willow (*Salix Spp.*) is the main crop used as short rotation coppice. It is relatively cheap and easy to establish. It is among the fastest growing woody species in northern Europe and can generate significant quantities of biomass in a short period. The crops have a very high energy balance, as the energy obtained can be up to 20 times as much as the energy used to grow the crop (Scottish Agricultural College, 2006). The willow species most used in SRC varieties is the osier *Salix viminalis*. This is not truly native in the UK but is naturalised having probably been brought in by the Romans. Most SRC varieties involve crosses between this species and other close relatives such as *Salix schwerinii* and *Salix burjatica* (= *Salix dasyclados*). Other common crosses include goat willow *Salix caprea* which is truly native.
Poplar (*Populus Spp.)* can also be used for short rotation coppice but it is not commonly planted and when it is, is mainly planted adjacent to willow plantations to create visual diversity. In contrast to willow, poplar is costly to establish and generally cannot be planted on contaminated land and has high water demands. In terms of varieties, *Populus deltoides* was planted extensively up to about 1998 but has since been plagued by a disease known as rust. Improved resistant varieties have been created from crosses involving *Populus nigra* and *deltoides* and pure *S. trichocarpa.*
Both willow and poplar require deep moisture retentive soils. Willow can withstand periods of water-logging and is better suited to wetter soils (often areas currently dominated by grassland farming systems) (Gove, 2006). Yields from SRC at the first harvest are in the range of 7-12 tonnes dry weight/ha/yr (Defra, 2002).

Environmental Impacts of SRC

Landscape

3.7. The character and appearance of SRC and hence its impact on the landscape changes as it grows, develops and is harvested. SRC crops can grow very rapidly from 20cm up to 6m in a four year period. In the early stages of growth, SRC is similar in appearance to agricultural crops, both in terms of height and colour, and particularly because it tends to be planted in rows. As the crop reaches around 2m in height, it typically assumes some of the characteristics of a forestry plantation, i.e. the crop has a discernable structure with stems and foliage appearing as distinct and separate elements. Once fully established, as a result of its height, the crops can merge into existing higher level vegetation, for example tree lines and copses (ETSU, 2000). After approximately 2-4 years the SRC is harvested and the cycle begins again.

3.8. The landscape implications of these changes depend upon the character and quality of the recipient landscape, the extent of physical change involved (including the scale and form of the planting and crop management e.g. rotational or clear felling), and the ability of the landscape to accommodate change. It is suggested that in some areas, SRC could hide landscape features '*under a cloak of vegetation*' (Sadler, 1993). For example, in historic landscapes such as open grazed landscapes with stone wall patterns, the height of SRC could obscure historic features and key views (CCW, 2006, Turley *et al*, 2003). Scale is also an important consideration, as whilst the planting of one field might not lead to a significant impact, the change of a whole landscape could lead to a significant reduction in landscape variety (ETSU, 2000). Some commentators however argue that SRC has the potential to add structural diversity to existing agricultural landscapes (Graham, Liu and English, 1995; McDonald *et al*, undated). Regimentation is another key concern, as the planting of SRC in rows and in regimented square blocks can create unnatural landscapes (Sadler, 1993).

3.9. In general terms landscapes with high levels of tree and woodland cover and arable or mixed farming are considered to be most appropriate for SRC (Forestry Commission, 2002). It is also important to note that cropping requires the use of heavy machinery which excludes the use of steep or boggy ground – lowland areas as opposed to upland areas are therefore more likely to be suitable.

Biodiversity

Habitats

3.10. The habitats created by an SRC plantation tend to be very different to those found within traditional agricultural crops. SRC typically supports 'woodland edge' type habitats with flowering plants along the headlands and access rides and more shade tolerant plants under the dense crop canopy (Forestry Commission, 2002).

3.11. Studies assessing the species communities supported by SRC show conflicting results. Britt *et al* (2002) found that ground flora is often sparse due to the need for regular herbicide use – particularly in the establishment phase. They found that where extensive weed populations do occur they are generally dominated by a few species of low conservation value, e.g. common nettle and rosebay willow herb. In contrast, studies by Sage *et al* (1994), Slater (CCW, 2006) and the DTI (2006) found that a wide range of plant species is present in SRC crops. Recent surveys of commercial SRC plantations indicate that there is a higher diversity of plants in both the crop and headlands of SRC plantations compared with conventional crops (Cunningham *et al*, 2004) and grasslands (DTI, 2006).

3.12. The variation in the diversity of ground flora within SRC is dependent on a number of factors such as management, geographic area, proximity to other habitats, historical land use and the age of the SRC stand (CCW, 2006; Gove, 2006; Forestry Commission, 2003a, Sage, 1998). For example, plant communities vary according to whether the previous land use was arable or grassland - plantations on former arable land tend to retain ground flora communities of arable crops rather than those of established woodland (Gove, 2006). In older SRC stands, field surveys found that more stable and diverse plant communities tend to develop with fewer annuals and invasive perennials and more slower growing perennials (Sage, 1995; DTI, 2006). It is suggested that further research is needed to determine the best management strategies within commercial SRC to encourage more stable perennials rather than invasive weeds (DTI, 2006). It is also suggested that most of the information available on flora and fauna associated with SRC in the UK relates to pre-commercial plantations, which may differ considerably from future commercial scale crops (Anderson *et al*. 2004).

3.13. There is also no specific information distinguishing between the environmental impacts of different varieties of willow and poplar, although, it is an established ecological principle that native species support greater benefits for biodiversity than non-native species. In the future, willow varieties are likely to include slightly more diverse germplasm from Asia and North America as these varieties have lower levels of disease and pests. The use of strains not traditionally used in the UK however is a key concern as they are likely to be of lower value for biodiversity and could hybridise with native willow species with implications for species genetics (CCW, 2006).

Birds

3.14. Evidence from early non-commercial willow and poplar SRC plantings in the UK indicate that SRC can provide shelter for a number of farmland species, as well as species not normally found in intensively managed arable crops, i.e. woodland species (Göransson, 1990; Kavanagh, 1990; Sage *et al*, 1994). Willow SRC often contains high densities of birds and a high proportion of migrant species in summer, while poplar often contains the same resident species as willow but fewer migrants – leading to lower overall densities (Sage and Robertson, 1996). Increased structural complexity in both willow and poplar was also found to increase the number of passerine species and individuals. Overall the studies suggest that fields of SRC containing open farmland, scrub and woodland bird species have the potential to deliver positive nature conservation gains with higher bird densities than intensive arable or improved grassland (Sage *et al*, 2006; Reddersen and Petersen 2004; Christian *et al*, 1998).

3.15. Within commercial SRC crops, evidence from a recent study undertaken by the Game Conservancy Trust (Sage, Cunningham and Boatman, 2006) indicates that commercially planted SRC has a higher diversity and density of birds in both spring and winter compared with improved grassland and arable crops. The bird communities can however be very different with warblers (in particular willow warblers), tits, finches, thrushes, robins, wrens and dunnock being especially abundant in SRC, particularly in the first year of growth. As the SRC crops mature, it has been observed that the interior of large plots tend to contain fewer breeding birds than the edge zones. The abundance of birds is believed to be linked to the length of the coppice stem, planting density and increased weediness (Sage and Robertson, 1996). For example, migrant species tend to prefer structurally dense willow stands with weeds, whereas warbler species are more common in young willow coppice and tits in older coppice (Sage *et al*, 2006).

3.16. In terms of species of conservation concern, SRC can substantially benefit reed bunting and song thrush – both of which are red-listed and have biodiversity action plans. Sage *et al* (2006) also suggest that many other species that are amber listed or contribute to the Farmland Bird Index or the Woodland Bird Index could also benefit from the planting of SRC. In addition, SRC can provide a valuable winter habitat and refuge for game birds and the headlands, being uncropped herbage, provide permanent ground nesting cover and food for partridge and pheasant (McDonald, undated). Other red-listed species characteristic of farmland e.g. spotted flycatcher, house sparrow and tree sparrow have only been recorded in low frequency in SRC plots during the breeding season (Anderson *et al*, 2004). It is also acknowledged that SRC is not a good replacement for scrub or woodland habitats as SRC does not include the same abundance of species as these habitat types (Sage *et al*, 2006). SRC may however have a beneficial role to play in acting as 'woodland edge' habitat and in buffering semi-natural habitats from more intensive land use.

3.17. Vegetation structure and crop husbandry can make SRC unsuitable for a range of species characteristic of open field landscapes, many of which are in serious decline, particularly open farmland birds. It has been suggested that open farmland bird species such as grey partridge, skylarks, lapwing and corn bunting may be displaced by SRC plantations as the vegetation height and density becomes too great (Anderson *et al*, 2004, Gove, 2006; CCW, 2006). These species do however use cut SRC and as such, could use SRC crops as a breeding habitat following crop establishment and after each winter cut (Anderson *et al*, 2004; CCW, 2006; Sage, 2006). Recently cut SRC has also been shown to be better for some open field species such as skylarks and lapwings than arable fields (Cunningham *et al*. 2004). It is also suggested that those species which are most at risk of being displaced tend to be localised in distribution and therefore with careful management, can be avoided (Sage *et al*, 2006). Avoiding the establishment of SRC on areas which are known to be used by open field species should therefore be a key siting consideration.

3.18. Danfors *et al* (1998) states that the suitability of SRC crops in the post – establishment or post-harvest years may be severely comprised by nest destruction from frequent mechanical weed control. Studies on willow SRC planted in Sweden have also found that whilst mature crops provide suitable habitat for species preferring bushy nesting habitats (e.g. marsh warbler and garden warbler) they are avoided by bird species of open habitats (Göransson 1990). The literature is therefore not conclusive on whether replacing arable land with SRC is likely to have a significant impact on open farmland birds and several commentators suggest that further research is required.

Invertebrates

3.19. SRC can support a high diversity of invertebrates compared with conventional crops (Turley *et al*, 2002). Sage and Tucker (1997) found over 50 invertebrate species or groups in SRC. Willow, in particular, can support more insect species than most other trees (Kennedy and Southwood, 1984, Sage and Tucker, 1997). However, studies on SRC have shown that this diversity is only partly reflected in pre-commercial crops. Commercial SRC crops have however shown a high abundance of earthworms and butterflies. Sage *et al* (2006) found that butterflies were more abundant than in the grassland and arable controls but tended to be restricted to the SRC headlands.

3.20. The level of species abundance is dependant though on the level of weed and pest control. It has been found that sites with a high density of ground cover can support higher populations of herbivorous invertebrates than those that have weed and pest control (Britt *et al*, 2002). Low impact management strategies are therefore essential to maximise invertebrate diversity.

Mammals

3.21. There is little information available on the potential impact of SRC on mammal species but it is thought that SRC plantations will benefit most species of mammal due to the provision of additional cover, although it may be less suitable for open field species – such as brown hare.

Water

3.22. The potential impact of SRC on the water environment is a complex issue and is dependent on a number of factors including the current type of land cover, the specific type of crop, the amount of water available and the hydraulic properties of the soil. Existing research in the UK suggests that water use is generally likely to be higher for mature SRC compared with grassland, arable land or woodland (with the exception of coniferous woodland) (Hall, 2003a & b; McDonald *et al*, undated; DTI, 2004; CCW, 2006). Annual transpiration from poplar and willow plantations with three-year old shoots is around 500mm a year, compared with 375mm a year for broadleaf forests (Hall, 2003b). The reasons for this high water use are:

1. The transfer of water vapour through the stomatal pores of SRC species is more rapid than for many other species.

2. To sustain rapid growth, SRC plants develop: (i) extensive, and in suitable soils, deep, root systems, that make available large water reserves that can be used during dry periods, that are unavailable to shallower rooted crops; (ii) a large leaf area to maximise the capture of sunlight for photosynthesis.

3. Interception losses from SRC plants are large as a result of its large leaf area (Hall, 2003b).

3.23. The water requirements in the first year of growth are likely to be lower than the existing ground cover if it is grass, arable or woodland. In contrast, in the later stages of the cropping cycle, water use of SRC is likely to be greater. In the case of poplar SRC, water use has been found to be particularly high as the stomata have little response to high atmospheric evaporative demand (DTI, 2004). As a result of the high water requirements, sites for SRC must be carefully selected and it is suggested that large-scale plantations of SRC could pose problems in eastern England where the precipitation levels are comparatively low (Hall, 2003b). Care must also be taken to avoid planting SRC on, or adjacent to, sensitive wetland areas and wet meadows.

3.24. Little research has been undertaken looking at the potential impacts of SRC on soil hydrology. A study undertaken for MAFF (2001) suggests that in soils with high water availability, the high water requirements of SRC can lead to reductions in water percolation below the root zone. This in turn can lead to a slowing of ground water recharge (McDonald, undated). Again, the significance of this impact is likely to be greatest in drier areas such as the East of England and less significant in Wales, the West of England and Scotland where rainfall levels are consistently higher (Scottish Executive, 2006).

3.25. In some locations, the slowing of ground water recharge can have a positive benefit as SRC can increase the infiltration capacity of the soil, thereby improving the soil's ability to absorb rainwater and reduce flood risk. At present however there appears to be little data available on the infiltration rates and flood storage capacity of SRC. A preliminary study examining the impact of tree shelter belts on soil infiltration rates in the Pontbren catchment in Wales found that infiltration rates in areas planted with new trees were 90% higher than grassland areas (Carroll *et al*, 2003).

3.26. As SRC management practices generally require less soil disturbance and lower inputs of fertilisers and pesticides than intensive arable or grassland management (particularly once the crop has been established), SRC can have a beneficial impact on water quality (CCW, 2006). After the establishment year, the use of herbicides for SRC is also likely to be minimal and is unlikely to be detectable in most surface and groundwater sources (Hall, 2003b). SRC is also effective at absorbing available nitrogen so leaching rates to nearby water courses can be much lower than from arable crops or fertilised grassland (Tubby *et al*, 2002; Britt and Garstang, 2002). The application of sewage sludge can however give measurable increases in nitrate leaching but the effect from single applications appears to be short lived and is less than from land under intensive agriculture (Hall 2003b).

3.27. As a result of SRC's ability to absorb nitrogen, it can be used as a 'buffer' crop which can be planted between high input agricultural crops and water courses to reduce diffuse pollution. It can also be used to tackle nitrate pollution in Nitrate Sensitive Areas or Nitrate Vulnerable Zones[28]. In Sweden, due to its high nitrate uptake and high capacity to absorb heavy metals and other soil contaminants, SRC has an established role in the treatment of waste water and landfill leachate (Aronsson *et al*, 2000, and 2001). A recent study by the Rural Economy and Land Use Programme

[28] The EC Nitrates Directive led to the designation of Nitrate Vulnerable Zones (NVZs) in catchments used for public water supplies. The NZV regulations demand that N fertilizers are not applied in excess of crop requirements.

(2006) concludes that SRC does have a clear role to play in helping to meet the requirements of the Water Framework Directive, particularly as the impacts on water quality are likely to be beneficial.

Soil

3.28. SRC can be grown successfully on a wide range of soil types but very wet or very dry soils are deemed to be less appropriate. The major risk of soil compaction is at harvesting when heavy harvesting and transporting machinery must operate on the land during winter. Soils that remain waterlogged for much of the year e.g. floodlands, boggy areas or sensitive wetlands will therefore not be suitable.

3.29. There is a high risk of erosion on susceptible soils in the first year as cuttings are planted in widely spaced rows and crop establishment is slow. Once established, the erosion risk is considered to be low as the ground is colonised by various flora (Turley *et al*, 2003).

Archaeology

3.30. No known research has been undertaken looking at the potential impacts of SRC on features of archaeological interest. The ploughing, sub-soiling and root growth of SRC can damage archaeological sites and deposits, although this is also true of agricultural cultivation. It is therefore important when identifying potential locations for SRC plantations that careful consideration is given to the potential for both direct and indirect impacts (i.e. on the setting) of features of archaeological importance. Hall (2003b) suggests that SRC should not be planted closer than 50m to archaeological remains due to hydrological considerations. However the requirement for heavy machinery to be able to turn and approach a plantation may require a larger buffer distance.

Management measures

3.31. There are three main existing publications which contain good practice guidance on the establishment and management of SRC. These are:

- Defra, (2004), *Best Practice Guidelines for Applicants to Defra's Energy Crops Scheme.*
- British Biogen, (1996), *Short Rotation Coppice for Energy Production.*
- Forest Commission, (2002), *Establishment and Management of Short Rotation Coppice.*

3.32. **Table 3.1** provides a summary of the key management recommendations outlined in the literature in relation to SRC. **These recommendations are not the recommendations of the Wildlife and Countryside Link but provide a summary of the main management measures outlined in the literature**.

Table 3.1: Summary of Management Recommendations for SRC as Identified from the Literature Review

SRC Management Recommendations
Landscape
• **Landscape character assessment**: a landscape character assessment should be undertaken prior to the planting of any new crops to understand the potential impacts on the landscape. • **Designated landscapes**: special consideration should be given to the impact of SRC plantations within designated landscapes. • **Views**: care should be taken to avoid obscuring locally important views. • **Scale:** the proposed SRC plantation should be in scale with the landscape and follow the landform. The establishment of monocultures should be avoided. • **Diversity**: landscape heterogeneity should be encouraged with the establishment of patchworks of different crops at different growth stages (although this would not suit landscapes valued for their simplicity, such as the open sweeps of rolling chalk downland). • **Rides and headlands**: to increase landscape diversity, rides and headlands should be established as well as other areas of extensively managed land. • **Edges**: the edges of the SRC plantation should be made to look as natural as possible, graded and varied in scale with the landscape. • **Standards:** planting of any new crops should conform to UK Forestry Standard – including Landscape Design Guidance. • **Adjacent habitats**: where appropriate, efforts should be made to ensure that the visual impact is minimised by planting SRC close to woodland. More detailed information on design considerations within different types of landscape is contained in the *Forestry Commission Guideline Note 2: Short Rotation Coppice in the Landscape* (Bell and McIntosh, 2001).
Biodiversity
• **Ecological value**: the intrinsic ecological value of the site should be considered before planting SRC. Growers should consider planting SRC is areas that are of low conservation value. • **Uncropped headlands and rides**: should be incorporated into the design of new plantations – as the edge habitats have been shown to support a higher density of wildlife than the interior of plots. The establishment of headlands also protects hedgerows from over-shading. • **Adjacent habitats**: the type and proximity of adjacent habitats should be taken into consideration. SRC can help to extend, buffer and link existing habitats. • **Hedgerows and emergent trees**: where possible, hedgerows and emergent trees should be incorporated into the design of SRC plantations as they can provide shelter for the crop whilst providing valuable habitat for bats, songbirds, game, wildflowers and insects. • **Mature trees:** a certain area (e.g. 15%) should be left with minimum intervention to allow the trees to mature to old age to enhance the biodiversity value for certain species (e.g. bats). • **Diversity**: wildlife diversity should be encouraged by mixing varieties and age-classes in SRC plantations – this also has benefits for controlling pest and diseases damage and maximising yields.

SRC Management Recommendations
• **Ground flora**: the establishment of ground flora should be encouraged as this increases the presence of invertebrates and birds and mammals and is valuable for pest management. The encouragement of slow growing perennials is recommended as they have lower nutrient and water requirements and reduce invasion by larger weeds, thereby reducing the need for herbicide applications. • **Scale**: the division of plantations into smaller blocks should be encouraged as they are likely to support greater wildlife diversity and abundance, however a balance needs to be struck between the issue of water use, as larger blocks of SRC use less water due to decreased evaporation from crop edges. • **Timing**: summer harvesting should be avoided where possible, as it can be detrimental for breeding birds. • **Inputs**: fertiliser, insecticides and herbicides inputs should be kept to a minimum to reduce impacts on biodiversity.
Water
• **Location**: in low rainfall areas, detailed consideration should be given to water conservation issues prior to planting. SRC crops should not be located adjacent to sensitive wetland habitats. • **Scale**: larger blocks of SRC plantation use less water then smaller blocks as there is less evaporation from the crop edges. However a balance needs to be struck between the issue of water loss and the benefits for wildlife. • **Bore holes**: important bore hole locations should be avoided if there is concern about water availability. However, if the crop can be used to reduce pollutants entering the bore hole the crop may be an advantage. • **Age**: water use by SRC is related to the age of the crop. Cutting in rotation should help to ensure that any impacts on recharge and runoff are evenly spread. • **Nutrient management**: the application of fertilisers should be avoided.
Soil
• **Soil type**: the planting of SRC on certain soil types should be avoided as the crop needs to be harvested in winter and machinery may damage wet soil. Floodlands, boggy areas or sensitive wetland areas will not be appropriate.
Archaeology
• **Identified sites**: prior to the establishment of a SRC plantation, the relevant register of sites of archaeological interest should be reviewed. Consultation with the county archaeologist and or local planning authority should also be undertaken. • **Standards**: the establishment of SRC should conform to the UK Forestry Standard regarding heritage features and the protection of archaeological sites. • **Siting**: SRC should not be located on sites of archaeological importance including areas with potential for waterlogged deposits. Care should also be taken to ensure that crop growth does not affect the setting of any sensitive sites.

SHORT ROTATION FORESTRY

Overview

Short Rotation Forestry

Short-rotation forestry is the practice of cultivating fast-growing trees that reach their economically optimum size between eight and 20 years old. Conventional forestry rotations in Britain vary between 40 and 150 years, depending on species. When felled, SRF trees are replaced by new planting or, more usually, allowed to regenerate from the stumps as coppice.

Short rotation forestry is distinct from SRC as different species are used. The underlying principle is to grow a plantation of trees at such spacing that the site is quickly utilised and then fell it when the trees reach a size that is easily harvested and handled. The size depends on the technology but is usually between 10 and 20cm diameter at breast height (1.3m) c.8-20 years old, depending on species. It is possible to use a range of species for SRF including native and established species such as alder, ash, birch, poplar, sycamore, and non-native species such as eucalyptus and southern beech (nothofagus).

Environmental impacts of SRF

3.33. There is very little recent experience of SRF in the UK and none on an extensive scale. The principles of woodland creation are however well established and a wealth of literature has been published on this which is directly applicable to SRF.

Landscape

3.34. The use of short rotation forestry is not a new phenomenon; it is a very old system of woodland management which dates back to at least the mid-15th century. As with SRC, the landscape implications of growing SRF today depend upon the quality and character of the existing landscape, the type and scale of change involved and the ability of the landscape to accommodate change. Research undertaken by Dingwall as part of a recent study looking at the potential environmental impacts of SRF (LTS research, 2006) suggests that native and or naturalised species such as ash, alder and birch are more likely to be acceptable in Britain with sycamore and poplar less so. Of the exotic species it is considered that nothofagus species are more acceptable than eucalyptus as their form, colour and texture is closer to that of our native broad-leaved species. The scale and visibility of planting are also key issues with SRF more likely to be accommodated in lowland areas where plantations will be less visible due to the lower relief.

Biodiversity

3.35. Research undertaken by LTS International (February 2006) indicates that the exotic species such as eucalyptus and nothofagus generally have lower biodiversity potential than native species.

Habitats

3.36. The understorey vegetation beneath dense stands of SRF trees can provide a suitable habitat for a number of common species. The understorey vegetation is however dependent on the density of the canopy as this determines the light level reaching the ground and hence the abundance of the vegetation layer and the rate of litter breakdown. In general, sycamore, eucalyptus and nothofagus have the densest canopies and the slowest rates of litter breakdown (LTS, 2006).

3.37. Apart from a small number of bryophytes, the LTS research (2006) suggests that no particularly rare or threatened plants are likely to benefit from the establishment of SRF, although this is likely to depend on where the crop is planted as there may be opportunities for SRF to play a beneficial role in expanding and buffering existing vulnerable habitats. SRF is however likely to contain a greater abundance and diversity of non-crop vascular plants compared with both cropland and improved grassland.

3.38. SRF can also be used for the purpose of restoring forest land to other, non-forest, habitat types such as heathland (Brierly *et al*, 2004).

Birds

3.39. The LTS research (2006) suggests that in general, SRF and the associated unplanted zones are likely to support a greater abundance and species richness of birds than intensively managed agricultural land, and the addition of SRF to a landscape will probably provide suitable habitat for additional bird species. Some rare bird species adapted to open habitats could however be threatened by the addition of SRF to a landscape, and could become locally extinct if significant areas of SRF were planted. Consideration therefore needs to be given to provision and maintenance of open spaces within or adjacent to these areas.

3.40. Trees with the densest canopies are likely to discourage ground feeding birds but may encourage insectivorous birds feeding in the canopy. The LTS research (2006) suggests that there is little evidence to suggest that exotic broadleaved trees provide poor habitats for UK birds and that it is not yet possible to make predictions as to how birds would fare in exotic SRF plantations, e.g. of eucalyptus spp.

Invertebrates

3.41. The LTS study (2006) suggests that SRF can provide habitats for a more abundant and more species-rich assemblage of invertebrates than intensively managed farmland. As many invertebrates feed directly on the SRF trees, the species of tree used will have a large influence on the number and abundance of invertebrates associated with the tree canopy. It is suggested that in general exotic species are likely to support less diverse invertebrate assemblages than the other SRF trees as they are not adapted to them.

Mammals

3.42. The establishment of SRF in an agricultural landscape can potentially benefit most species of mammal due to the provision of additional cover by the tree crop and by the herbaceous vegetation associated with unplanted zones. Much like set-aside, these zones will also provide forage for both large and small mammals, and cover for smaller species (LTS, 2006).

Water

3.43. Depending on the type of species used and the existing site conditions Hall (2003) states that SRF crops are likely to use less water than SRC willow crops but their impact on the hydrology of a site will be similar. As with SRC, as the trees become older and more structurally complex they intercept and subsequently evaporate a greater proportion of incipient rainfall, and thus reduce the net amount of water reaching the soil. In addition, their greater leaf area index enables higher potential water uptake from the site (LTS, 2006).

3.44. Cannell *et al* (1999) suggests that if the trees have no access to the water table and they are therefore dependent on soil water recharge via local precipitation, their water consumption is likely to be similar to that of agricultural crops in drier areas of the UK, but may exceed that of agricultural crops in areas of higher rainfall. However, at sites where deeper-rooted trees are able to gain access to soil water not available to the more shallow-rooted agricultural crops, overall water extraction of the tree crop is likely to be greater. This is likely to be particularly true for tree species, such as eucalyptus, which can consume significant volumes of water, particularly in semi-arid conditions. Concern has been expressed that eucalyptus could have a significant impact on local hydrological regimes and reduce groundwater availability (EEA, 2006).

3.45. In general, (Perry *et al*, 2001) state that water use by SRF is likely to be higher than that of most agricultural crops, slightly higher than that for SRC willow, similar to that of broadleaved forests, and slightly lower than that of coniferous forests. The net impacts on hydrology of conversion from agricultural use to SRF production of biomass is, as in the case of SRC, likely to be: reduced percolation to aquifers; reduction in plant-available soil water; and reduced surface run-off from site (LTS, 2006).

3.46. In terms of nitrate pollution, when compared to current arable farming practices, where fertilisers, pesticides and fungicides are often applied annually, SRF crops, as with SRC have lower and less frequent chemical requirements. Since nitrate applications are lower and water-use by SRF trees is greater than that of annual crops, water-assisted nutrient pollution from the site is likely to be low (LTS, 1996).

Soil

3.47. Compared with arable land use, Makeschin (1994) states that SRF is likely to have a stabilising effect on the soil, due to the relative infrequency of soil cultivation. Soil compaction and the potential for gully erosion is reduced as there is no need for multiple mechanized applications of agrochemicals and fertiliser. In addition, the provision of year-round soil cover and the network of fine roots in the upper soil layer improve water infiltration, and, together with leaf litter, resists the impacts of water droplets and thus reduces sheet erosion (Kort *et al*, 1998). The planting and establishment of woodland can in fact be used as an effective approach to reducing sediment loss in problem areas. A study looking at the role of woodlands within the catchments of Bassenthwaite Lake in the Lake District found that the establishment of targeted woodland planting has the potential to significantly reduce soil erosion and sedimentation problems (Forest Research, 2004).

3.48. As previously outlined, the LTS study (2006) notes that there are some differences between species in the rate of decomposition of the leaf litter with the litter of non-deciduous broadleaves such as Eucalyptus spp. taking longer to decompose (Cornelissen, 1996). In general, the litter of deciduous broadleaved trees is known to have a beneficial effect on soil chemistry and structure but there is very little research on nothofagus or eucalyptus litter and the impact on soil chemistry. Quicker-growing tree species grown on shorter rotations will also require more frequent establishment operations, and will therefore have a less positive impact on soil (LTS, 2006).

Archaeology

3.49. SRF may have a direct impact on the physical integrity of sites of archaeological interest either through ground disturbance or by affecting the character of the landscape or the setting of a site. The LTS study (2006) suggests that the potential impacts of SRF on archaeology would appear to be comparable with other intensive land uses such as commercial forestry and intensive arable cultivation, both of which involve ploughing, drainage and other activities which could have a significant impact on the archaeological resource.

Management measures

3.50. A summary of the main management recommendations outlined in the literature in relation to SRF is set out in **Table 3.2** below. **Please note that these are not the recommendations of the Wildlife and Countryside Link.**

3.51. There is no existing best practice guidance relating to SRF but it should be noted that many of the management measures identified in relation to SRC and woodland creation are equally applicable to SRF. Existing guidance on the creation of new woodlands is provided in the UK Forestry Standard and the UK Woodland Assurance Scheme (UKWAS).

Table 3.2: Summary of Establishment and Management Recommendations for SRF as Identified from the Literature Review

SRF Management Recommendations
Landscape
• **Sensitivity**: there should be a presumption against extensive SRF planting in the most sensitive open landscapes. • **Shape**: careful consideration should be given to the shape of any new planting e.g. avoiding geometric plantations with straight edges in favour of more 'natural' formations. • **Scale**: the plantation size should be in scale with the established landscape framework. • **Landform**: the planting should relate to the natural landform and should respect existing field patterns where appropriate. • **Diversity**: consideration should be given to the species, colours, textures and form of new planting. Where possible a varied age structure should also be used to give visual diversity. • **Retention**: existing native trees and hedgerows should be retained wherever possible. The above general guidelines are drawn from existing guidelines set out in the *Forest Landscape Design Guidelines* (Forestry Commission, 1989); *Lowland Landscape Design Guidelines* (Forestry Commission, 1992); and *Forest Design Planning: A Guide to Good Practice* (Forestry Commission, 1998).
Biodiversity
• **Ecological value**: SRF should not be planted on land of high conservation value. • **Rides and other open spaces**: should be incorporated into the design of new plantations. It is suggested that a minimum of 15% of the gross area of SRF plantations should be open space. • **Mature trees**: a certain area (eg 15%) should be left with minimum intervention to allow the trees to mature to old age to enhance the biodiversity value of the woodland for certain species (eg bats). • **Scale**: the establishment of plantations in smaller blocks (10 to 50ha) should be encouraged as they are likely to support greater species diversity and abundance. • **Linking habitats**: linking corridors should be provided between SRF blocks in the form of hedges, unplanted areas and existing trees (e.g. for bats). • **Diversity**: stands of different ages should be planted to provide alternative habitats for animals. • **Buffers**: buffer zones should be left between SRF and existing woodlands or hedges to avoid the loss of edge habitat due to shading. • **Species type:** light canopied native species should be used in preference to dense canopied exotic species. The above recommendations are drawn from LTS International, (February 2006), *A review of the potential impacts of Short Rotation Forestry* and IEA, (1995), *Short Rotation Forestry Handbook* and are **not** the recommendations of the Wildlife and Countryside Link.

SRF Management Recommendations
Water and Soil
Impacts on hydrology and soil can be managed through careful consideration of the following factors: • **Soil type and texture**: careful consideration should be given to the existing soil type and texture before deciding on suitable locations for SRF. • **Hydrological regime**: rainfall levels and drainage should be assessed in detail. • **Tree species**: some species such as eucalyptus require significant quantities of water and should not be planted if less water intensive options are available. • **Silviculture**: careful consideration should be given to the timing of planting and harvesting and care should be taken when thinning and felling is undertaken.
Archaeology
• **Identified sites**: prior to the establishment of a SRF plantation, consultation with the county archaeologist and or local planning authority should be undertaken. • **Avoidance**: features of archaeological interest should be avoided wherever possible. Further guidance is contained in the Forestry Commission's publication *Forests and Archaeology Guidelines* (1995).

FOREST RESIDUES AND LOW GRADE TIMBER

Overview

Forest Residues and Low Grade Timber

There is no single definition of **Forest Residues** but the term most commonly applies to the non-economic arisings from commercial forestry management practices (most commonly associated with single species forestry plantations). These residues include: harvesting residues (i.e. 'the lop and top' or 'brash'); small roundwood (i.e. small stems of no commercial value); and poor quality final crop (i.e. stems of sufficient diameter to be used commercially but of such poor form that they are usually left on site). However, the main opportunity offered by energy production from wood is the creation of a market for **Low Grade Timber**. Currently little of the UK's semi-natural woodland resource is managed as there has been no market for low grade timber. Nevertheless, demand for woodfuel has the potential to create an economic rationale for the re-introduction of traditional sustainable woodland management of our semi-natural woodland resource. Indeed, in most instances, the development of a woodfuel market offers the only economic opportunity for the management of existing (and new) semi-natural woodlands.

As identified by the Forestry Commission, aspects of woodland management for woodfuel that would bring significant environmental benefits are:

- Thinning of Plantations on Ancient Woodland Sites (PAWS)[29], especially mixed crops where broadleaves are favoured.
- Felling of mature PAWS (although usually this will need to be done gradually and/or selectively to avoid clear felling).
- Restoration of neglected coppice woodlands which still contain species dependent on the coppice cycle for their survival (this includes restoration of sweet chestnut coppice).
- Thinning of even-aged native woodlands to diversify the structure of both the understorey and the canopy.
- Removal of rhododendron and other invasive species from native woodland.
- Felling of conifer plantations which are otherwise uneconomic and their potential conversion to semi-natural woodland (where this does not conflict with other habitat objectives.
- Removal of invasive scrub and trees from open habitats such as heathland, moorland and semi-natural grasslands.

(in all cases deadwood should be left in the woodland for the benefit of biodiversity, as set out in UKWAS).

A contributory reason for the lack of management of many smaller woodlands in the UK is their relative inaccessibility. Such woodlands may still not be economic for woodfuel production serving distant power plants but may have a very important role in providing an energy source for small-scale community CHP stations.

Environmental impacts of forest residues & low grade timber

3.52. There is a very large and separate body of literature covering the benefits of reinstating traditional woodland management in existing woodlands, especially in terms of enhancing landscape and biodiversity; reinstating local traditions and contributing to the local economy and employment. This literature has not been specifically reviewed as part of this study but key points are brought out below.

Landscape

3.53. In a recent response to the Government's Biofuels Strategy, the Forestry Commission (2006) identified that the reintroduction of woodland management stimulated by biofuel production would, in the main, produce very strong environmental benefits as identified above. In addition, diversifying the age structure of woodlands through management could reduce the extent of any future storm damage. On the negative side, it was recognised that local people could be opposed to any rapid change in woodland structure resulting from the reintroduction of

[29] Since the 1930s many ancient woodlands have been clear-felled and replanted as single species conifer plantations. This has greatly reduced their landscape and biodiversity value and there is now a strong call in many landscape strategies, Local Biodiversity Action Plans and Regional Forestry Frameworks, for these woodlands to be converted back to their ancient woodland form through the gradual removal of the conifer crop to allow the natural regeneration of ancient woodland species that lie dormant in the soil.

woodland management and could resist the introduction of new access tracks. With appropriate demonstration, consultation and informed debate, however, the Forestry Commission (2006) believes that these concerns can be addressed and that there should be no significant adverse impacts on the wider landscape. Clear felling of woodlands or the removal of all trees under a certain size (which makes a woodland more uniform in structure) would generally not be seen as beneficial, nor would the removal of broadleaves from mixed broadleaf/conifer stands, e.g. cleaning out invasive birch from conifer stands). In many woodlands where management is reintroduced there could also be problems of deer damage with the potential to prevent natural regeneration following woodland extraction

3.54. The fundamental point is that semi-natural woodland is regarded as a central characteristic of the UK landscape, as acknowledged in nearly all Landscape Character Assessments. The reintroduction of traditional woodland management is important in maintaining woodland structure and potentially longevity, with avoidance of potential adverse effects guided by Woodland Management Plans. Furthermore, the expansion and relinking of such woodlands is now increasingly identified as a means of strengthening landscape character, increasing the ability of these woodland habitats to adapt to the effects of climate change, and assisting with carbon sequestration.

Biodiversity

3.55. While there are few studies which have looked specifically at the impacts of the removal of forest residues on biodiversity, there is a huge body of information on the biodiversity benefits of bringing semi-natural and ancient woodlands back under traditional management.

3.56. With reference to **Forest Residues**, a review undertaken by the Scottish Executive (2006) suggests that the removal of forest residues could have an adverse effect on local biodiversity. A study undertaken by Bengtsson *et al* (1998) found that the removal of residues during whole-tree harvesting at two sites in Sweden led to a reduction in the population of spiders and other predatory insects (30-60% reduction). Brierly *et al* (2004) also states that brash removal may lead to a local depletion of nutrients and deprive small vertebrates, invertebrates and fungi of important habitat and food resources, leading to decreased biodiversity.

3.57. The local depletion of nutrients caused by brash removal may also affect biodiversity indirectly. For example Green *et al* (1998) reports that there has been a 7-10 % thinning of egg shells since 1850, which has been attributed to the reduced nesting success of European birds in recent decades. This effect could be caused by the nutrient withdrawal from sites with whole tree harvesting. A certain amount of deadwood per hectare is recognised as an important factor in the protection of the biodiversity in forests (Humphreys *et al*, 2003). When extracting forest residues it is therefore important that a certain proportion of residues, deadwood and old trees are left behind (EEA, 2006). Nevertheless, the removal of brash from clear-felled areas in conifer plantations can benefit birds by establishing clear ground where they can forage or nest (British Biogen, 1999).

3.58. The real potential for biodiversity, however, rests in the reintroduction of traditional management in areas of semi-natural and ancient woodland through the development of a market for **Low Grade Timber**. The Forest Commission (2006) states that the areas where woodfuel would bring the greatest environmental benefits, especially for biodiversity, are those areas with a high density of traditional coppice woodland; areas with high concentrations of PAWS; and landscapes where the restoration of open habitats is a priority, especially heathland, moorland and calcareous grassland.

3.59. As already identified, so long as principles of sustainable woodland management are applied, the harvesting of low grade timber from existing woodlands can deliver very substantial biodiversity benefits through the diversification of woodland structure and the removal of non-native species (especially from PAWS) and from other semi-natural open BAP habitats. In all cases the woodland management needs to take account of and adapt to the needs of the key species that the woodland supports, again emphasising the importance of ensuring that woodland management is guided by a woodland management plan that takes account of biodiversity objectives and reflects the priorities in the Local Biodiversity Action Plan.

3.60. One particular aspect of the management of semi-natural and ancient woodlands is the restoration of neglected coppice woodlands which still contain species dependent on the coppice cycle. A diverse array of plants and animals has survived in coppiced woodlands over the centuries that are adapted to the coppice cycle management system. In recent years, interruption of the coppice cycle as a result of market collapse for small diameter timber has led to a rapid ecological decline of many these woods. For example, the heath fritillary butterfly requires the open sunny habitats produced by coppicing to breed. Its number has declined by over 90% in the last 30 years primarily as a result of the reduction in the level of coppicing being practiced (Butterfly Conservation, 2001). The reinstatement of coppicing in such woodlands across landscapes in which these coppice-dependent species still occur could therefore help to reverse the ecological decline of some of our most important habitats.

3.61. There is some concern that bringing some woodlands back into management could be detrimental to important BAP species such as bats (particularly the Bechstein bat and barbastelle, both of which are woodland specialists bats). Greater and lesser horseshoes and common and soprano pipistrelles are also known to use woodlands and/ or woodland edges. To avoid impacts on these species it has been recommended by the Bat Conservation Trust that checks should be undertaken and felling plans should be modified to protect bat habitats and avoid disturbance to these species.

3.62. Whilst the focus is generally on the re-introduction of management to semi-natural woodland, appropriate management can also bring biodiversity benefits to commercial forestry plantations. Thinning for biomass utilisation can provide an opportunity to open up very dense forest plantations and therefore improve the development of ground flora so that native species can thrive, while the creation and/or reinstatement of rides can lead to an increase in edge and ride habitats.

Water

3.63. The removal of forest residues and the bringing of existing semi-natural woodlands under productive management does not involve the additional application of fertilisers or pesticides and therefore is not likely to affect water quality through increased nutrient inputs. The removal of residues can however leave soils more susceptible to erosion and lead to increased sedimentation of water courses (Scottish Executive, 2006).

3.64. Logging residue and deadwood have a role to play in regulating the waterflows through the woodland ecosystem and can act as filters to improve water quality. They do this by capturing and storing significant amounts of water and reducing runoff on slopes. The harvesting of woodfuel may therefore reduce the potential to regulate waterflows (EEA, 2006), although this should not be a concern if this is a clear consideration in woodland management plans.

Soil

3.65. Clear felling and the use of heavy forest machinery, as in the management of commercial forestry plantations, can lead to soil compaction and higher levels of soil erosion. The extent of this impact is dependent on the mode and intensity of harvesting as well as the soil type (Brierly *et al*, 2004), with peatland soils, for example, facing a higher risk of damage then podzolic soils or shallow gley soils.

3.66. Soil erosion is related to soil properties, topography, rainfall and vegetation cover. Carling *et al* (2001) reported that there is little consensus on the effects of commercial harvesting operations on soil erosion in the UK; some considering soil losses to be minor and others significant. Rosen *et al*. (1996) compared runoff from 50% cleared and 95% cleared forest catchments with an unharvested control area. The increase over the control area was 85% and 110% respectively. Logging residues however decrease the direct exposure of the soil to rainwater and therefore reduce the risk of erosion.

3.67. A recent study for the DTI (Brierly *et al*, 2004) looked at the suitability of different woodland sites in the UK for extraction of forest residues based on a set of different environmental criteria – including the impact on soil fertility, nutrient leaching, soil compaction and erosion. The study found that there are only limited opportunities for forest residue extraction in Scotland's upland soils due to high compaction of Scotland's wet peaty soils and in the West of Scotland, high acidification impacts (Scottish Executive, 2006).

3.68. Much less research has been done on the effects of traditional woodland management on soils. Generally the view is that traditional woodland management practices have little adverse impact on soils as they involve relatively traditional approaches and do not result in clear felling. However, it is probable that further mechanisation would need to be introduced to make this form of woodland management economically viable under modern conditions. It is understood that a range of research is currently on-going looking into the use of light-weight machinery for this purpose and it will be important to follow up on this research when it is complete.

Archaeology

3.69. There is no known literature on the potential impacts of removing forest residues (as opposed to commercial timber) on sites of archaeological or cultural heritage importance, although it is clear that the use of heavy harvesting machinery and the creation of forest rides pose a very significant threat to archaeological sties.

3.70. In the case of the semi-natural woodland resource, it is increasingly realised that these woodlands are a major repository of archaeology as they have suffered little ground disturbance, especially when compared to areas under arable production. To-date archaeological investigations have tended to concentrate on open field locations and therefore this woodland archaeological resource, whilst now recognised, is very poorly recorded.

3.71. If woodland management is reintroduced to these semi-natural woodlands it will be important to ensure that the location of archaeological sites is known so that damage from extraction machinery can be avoided.

Management measures

3.72. A summary of some of the key management recommendations outlined in the literature in relation to the extraction of forest residues and the re-introduction of traditional woodland management is set out in **Table 3.3** below. **Please note that these are not the recommendations of the Wildlife and Countryside Link.** Existing guidance on the sustainable management of woodlands is provided in the UK Forestry Standard and guidelines. The UK Woodland Assurance Scheme (UKWAS) offers a certification standard providing independent reassurance of responsible forest management and as such provides the most assured method of delivering best practice. Harvesting activity is also regulated under the Felling Licensing Regulations and through the approval process for forest plans.

Table 3.3: Summary of Establishment and Management Recommendations for Forest Residues and Low Grade Timber as Identified from the Literature

Forest Residues and Low Grade Timber Management Recommendations
Landscape
• **Edges**: the edge structure of planting and natural regeneration should be adjusted where possible, to improve its appearance in the landscape. • **Fencing**: where fencing is necessary this should be erected on alignments which respect the landscape, public rights of way and other routes.
Biodiversity
• **Diversity**: where possible, develop distinct age classes to increase the structural and ecological diversity of the woodland. This will include the development of coppice stands of different age classes in the same wood. • **Protected species**: checks for the presence of protected and priority species, e.g. bats, should be undertaken and if necessary management proposals should be modified to protect their habitat and avoid disturbance to the species. • **Open spaces**: ride and open space management regimes should promote or be sympathetic to wildlife conservation. • **Nutrient supply**: forest residues supply the ecosystem with nutrients so foliage

Forest Residues and Low Grade Timber Management Recommendations
should be left in the forest and the residue extraction rate should be adapted to suit the soil nutrient balance. • **Deadwood**: deadwood should be left in situ to maximise biodiversity. • **Species**: species mixtures should be adjusted by selective thinning. • **Coppicing**: the cutting cycle for coppice woods should be appropriate to the species and communities of that woodland. • **Deer**: deer control may need to be focused and enhanced in areas where woodfuel harvesting takes place to ensure the success of natural regeneration. • **Disturbance**: care should be taken to ensure that management activities avoid the breeding seasons of protected or priority species. • **Machinery**: machinery with low ground impact should be used especially for winter harvesting and wet sites. • **Roads and loading facilitates**: should be carefully located, ideally outside the woodlands (this may require greater flexibility in CAP cross-compliance conditions). • **Regeneration**: consideration should be given to the need for regeneration to improve or preserve structural diversity 10-15% is the maximum proportion of woodland that should be regenerated at any time. • **Linking or expanding woods**: opportunities to expand or link semi-natural woodlands should be encouraged. • **Restoration of Plantations on Ancient Woodland Sites (PAWS)**: through the phased removal of conifer stands and promotion of natural regeneration. • **Restoration of open ground habitats**: the removal of invading scrub provides the opportunity to restore habitats such as heathland and chalk and limestone grassland while producing a woodland residue.
Water
• **Water regime**: the wood extraction rate should be adapted to the soil water regime. • **Water supplies**: any public or private water supplies should be protected. • **Timber staking**: all timber should be stacked away from watercourses and care should be taken to avoid blocking roadside drainage. • **Watercourse crossings**: the extraction should be planned to minimise the number of stream and drain crossings. • **Consultees**: liaison with the EA or SEPA and water companies should be undertaken at the early planning stages when harvesting in water supply catchments. • **Machinery**: the best machine combination for the ground conditions should be used including appropriate traction or flotation aids. • **Inspections**: local watercourses should be inspected regularly for evidence of discoloration or sediment deposition, particularly at drainage outlets from harvesting sites. If there is any erosion risk associated with the operation of machinery on temporary tracks, the ground surface should be protected with brash or stone aggregate. • **Pollution**: fuel spillages should be avoided and buried pipelines or conduits should be protected from damage by machinery. More detailed consultation arrangements and management practices are detailed in the *FC Forests and water guidelines* (2003b).

Forest Residues and Low Grade Timber Management Recommendations
Soil
• **Slope**: the extraction rate should be adapted in relation to local steepness to minimise the risk of erosion. • **Roots:** roots should not be extracted to minimise the potential for erosion. • **Brash mats**: brash mats should be used on soft soils to help minimise erosion and nutrient depletion during harvesting (Brierly *et al*, 2004). • **Culverts**: where appropriate, culverts should be used to prevent rutting and blocked drains. • **Weather**: on sites prone to erosion, work should be undertaken during spells of good weather. • **Silt traps**: silt traps or pools should be installed where there is a high risk of erosion. • **Compaction**: tracked machines should not be used for long distances on forest roads.
Archaeology
• **Identified sites**: prior to the reintroduction of woodland management, consultation with the county archaeologist and or local planning authority should be undertaken where scheduled archaeological sites may be at risk. • **Avoidance**: features of archaeological interest should be kept clear of natural regeneration of trees and shrubs. Further guidance is contained in the Forestry Commission's publication *Forests and Archaeology Guidelines* (1995).

PERENNIAL GRASSES

Overview

Perennial Grasses

The most common form of perennial grass used for biomass production in the UK is miscanthus, but other examples include reed canary grass or switchgrass.

Miscanthus at varies stages of growth (Source: Bical)

Perennial Grasses

Miscanthus *(Miscanthus sp.)*: Miscanthus or elephant grass is a perennial, rhizomatous grass originating from Asia that once established can be harvested every year for 15 years. It grows to about 3 metres in height and can produce very high yields with little pesticide or fertiliser. Herbicides are needed pre and post-planting to aid establishment but are unlikely to be needed once the crop is established. High stand density and the presence of lower leaves effectively prevent weed growth. Miscanthus differs from SRC in that it can be harvested annually. By the third year harvestable yields are between 10-13 tonnes per hectare. Peak harvestable yields of 20 tonnes per hectare have been recorded.

Reed Canary Grass *(Phalaris arundinaceae)*: This species is a robust coarse perennial. It grows to between 60cm and 2m high and can be harvested 2 to 4 times a year. Reed canary grass spreads naturally by creeping rhizomes, but plants can be raised from seed. It is a native species and provides a quicker harvest and full yield, but is a lighter yielding crop than miscanthus at about 12 tonnes per hectare. The crop grows extremely quickly in the spring to about seven feet becoming a dense mass and can be harvested from late summer through to mid-winter. The crop is particularly suited to wetter land and provided it can be harvested in the early autumn, will withstand large amounts of flooding. The life span of the crops is significantly shorter than miscanthus at around 5 years and then re-sowing is required. As it is resistant to excessive water (i.e. it can easily adapt to poor wet soils), it can be used to remove nutrients from waste waters and to reduce soil erosion.

Switchgrass: Switchgrass (*Panicum virgatum L.*) is a native of North America where it occurs naturally. Both in America and Europe it can be found as an ornamental plant. It grows fast (up to 3 meters), producing high amounts of cellulose that can be liquefied, gasified, or burned directly. It also reaches deep into the soil for water, and uses the water it finds very efficiently. A study co-ordinated by Dr Elbersen from the agrotechnical research institute in Wageningen (Netherlands) showed that between the UK, Germany and the Netherlands, the UK had the highest yield for switchgrass as an energy crop. Switch Grass has similar yields to Reed Canary Grass but has an extended life of up to eight years yield, compared to five years for Reed Canary Grass.

Other perennial grasses which are native or naturalised in the UK and can be used for bioenergy production include reed (Phragmites australis), cord grass (Spartina spp.) and sedge (Cyperus spp.).

Environmental impacts of perennial grasses

Landscape

3.73. No specific studies have been identified looking at the landscape and visual impacts of miscanthus, reed canary grass or any other perennial grasses. Although most lowland sites in England are able to grow perennial grass energy crops, there is believed to be a decreasing indicative yield with increasing latitude and altitude (Centre for Ecology and Hydrology, 2004). The old 'maize growing zone' south of a line drawn between the Bristol Channel and the Wash, will satisfy the environmental requirements for high yields, but many lowland sites north of this line will also be suitable (Defra, 2001).

3.74. Miscanthus and switchgrass are non-native and are unfamiliar to the UK countryside although it is suggested that miscanthus is not dissimilar in character to that of forage maize although it is taller (Turley, 2003). Once established it can grow to approximately 3m in height, and so it has the potential to have a significant visual impact in the countryside. The impact on the landscape will however depend on the species used, scale of planting and where the crop is grown.

3.75. Reed canary grass is, however, a native species and, as long as it is grown in its natural habitat and does not displace unimproved wet grasslands or other important flood plain habitats, is has the potential to bring positive landscape benefits, especially if replacing arable or ley pasture.

Biodiversity

Habitats

3.76. Semere and Slater (2006) have undertaken the most detailed study to date of the effects of young miscanthus and reed grass plantations on biodiversity. This involved the monitoring of wildlife within two miscanthus and two reed canary fields in Herefordshire, England over 2002, 2003 and 2004. They found that young miscanthus crops and to a lesser extent reed canary grass can benefit native wildlife. Miscanthus fields during the establishment years (years 1-3) were found to have a richer diversity of weed vegetation than reed canary grass. Both miscanthus and reed canary grass were in turn found to have a wider diversity of weeds than wheat crops. This was attributed to the energy crop's initial slow growth and development early in the season, coupled with the agronomic practice of planting the crop in wide rows and at a very low plant density leaving plenty of space for weeds to establish with little competition for soil nutrient and light resources. The diversity of weeds within the crops were, however, found to decrease as the crop canopy cover and dominance of a few weed species increased, and as the age of the crop increased. This suggests that species richness is likely to be substantially lowered in fully mature crops.

3.77. **It is important to highlight that the study undertaken by Semere and Slater (2006) only involved the monitoring of four energy crop fields and that the miscanthus in the study only related to young crops in the establishment phase as opposed to mature stands. The findings of the study must therefore be treated with caution.** As miscanthus does not reach maximum canopy cover until at least year three, it is not known how wildlife abundance and diversity will change as the crop ages and the canopy starts to close. As concluded by Semere and Slater (2006), this illustrates the need to establish long term monitoring of miscanthus crops grown to full maturity, in order to assess the biodiversity implications of older crops.

3.78. Turley *et al*, (2004) suggest that short rotation coppice is likely to be more beneficial than energy grasses such as miscanthus and canary grass, as their dense shade is likely to exclude other flora. Gove (2006) also concurs that the dense shading along with the use of herbicides during establishment are likely to lead to species-poor ground flora communities within miscanthus. No detailed information is given within these sources about what research these conclusions draw upon.

Birds

3.79. Semere and Slater (2006) found that bird use of the grass energy crops varied depending on the crop species. Considerably more open-ground bird species such as skylarks, meadow pipits and lapwings were found in the miscanthus than in the reed canary-grass fields. This is believed to be because the miscanthus canopy takes several seasons to close. Miscanthus fields were also found to not only provide foraging habitat for ground nesting species but also a winter foraging habitat for the wide range of species that exploit crop fields for invertebrates, seeds and cover. Reed canary grass was also found to be valuable as a foraging area for seed eating birds in winter, with flocks of linnets and wrens observed foraging the seed heads. With the exception of skylarks, meadow pipits and lapwings, a larger abundance of bird species were found within the hedges than in the crop fields, indicating the importance of retaining field structure when planting perennial grass crops.

3.80. The most common species using the biomass crop fields during the breeding season were goldfinches, skylarks, stock doves and lapwings. In the non-breeding season, the most common species were linnets, meadow pipits, skylarks, grey partridges and pheasants. Woodland type warblers commonly found in SRC such as willow warbler and chiffchaff were not recorded in the study. Sage *et al* (2006) conclude that the Semere and Slater (2006) data suggest that miscanthus may attract the quantity of birds that SRC does and that reed canary grass may not. The low number and density of species recorded in reed canary grass may be the first indication that the value of this crop to UK birds is not as good as miscanthus or SRC, although further work is needed to assess the effects on bird species naturally associated with this habitat. Anderson *et al* (2004) also suggest that the rapid growth of miscanthus from May onwards may act as a breeding trap for ground nesting species allowing the establishment of nests but becoming impenetrable before the chicks can fledge.

3.81. No studies of birds in mature miscanthus or any other energy grass plantations have been undertaken in the UK. American studies of bird use of mature switch grass (Murray and Best, 2003 and Murray *et al*, 2003) have shown that grassland birds use the crop for nesting. However, this research is not necessarily transferable to the UK situation.

Invertebrates

3.82. Semere and Slater (2006) found that ground beetles, butterflies, bumble bees, hoverflies and other invertebrates were more abundant and diverse in the floristically diverse habitats of the energy crop fields than in the surrounding arable fields. Gove (2006) suggests that biomass energy crops which are native to the UK, such as reed canary grass, are likely to support a greater diversity of native invertebrate species. The Semere and Slater (2006) study however found that the greater diversity of weed flora within miscanthus had a greater positive effect on invertebrates. Ground beetles, butterflies and arboreal invertebrates were more abundant and diverse in the more floristically diverse miscanthus fields compared to reed canary grass. The miscanthus crops themselves however supported very small invertebrate numbers compared to the native reed canary grass but the number of invertebrates found in the weed vegetation within miscanthus was far greater than in the reed canary grass. The invertebrate fauna might be expected to decrease however as the crops get dense and the canopy closes, favouring the reed canary grass in the longer term.

3.83. In addition to the indirect impact of weed vegetation, the Semere and Slater (2006) study found that the diversity and abundance of invertebrates was directly linked to the absence of insecticide application. Due to the lack of insect pests, the widespread use of insecticides for these crops is considered unnecessary and unlikely (Bullard, 2000). The lack of disturbance with a single initial planting and related tillage also means that the fields can be used as over wintering sites for invertebrates, suggesting additional benefits for biodiversity (Semere and Slater, 2006).

Mammals

3.84. Miscanthus and reed canary grass were found to provide suitable habitat for small mammals in the form of good ground cover and minimal land disturbance (Semere and Slater, 2006). There was no particular crop preference by the small mammals, although, the field margins a had consistently higher small mammal abundance than cropped areas of energy crops.

Water

3.85. There have been few studies of the water use of energy grasses and consequently there is much more uncertainty regarding their water consumption compared with traditional crops and SRC. Hall (2003) states that the water requirements for perennial grasses are expected to be higher than that of traditional annual crops but less than the water use of short rotation coppice. This is because the transpiration losses from energy grasses are believed to be more than from traditional crops as the grasses grow quickly, transpire rapidly, and develop large leaf areas, and on suitable soils, deep root systems (up to 2m in depth). However a more recent study undertaken on behalf of the DTI by the Centre for Ecology and Hydrology (2004) found that for the same rainfall and soils, the water use of the energy grasses is likely to be less, or comparable to, that of the existing land cover where it is grass or tilled land and less if the existing land cover is woodland or heathland. This indicates that further research is needed on energy grasses in order to reduce the uncertainties arising from the existing research.

3.86. The highest risk of water shortage will be during the summer on small, heavily planted catchments, because of their smaller storage potential. Springs and ephemeral streams may dry up sooner and for longer than before the grasses were planted (Hall, 2003). The high water use of energy grasses may be used to advantage to reduce peak flows and delay the onset of local flooding. Using them to dry the soil profile on deep soils with large potential water storage would result in the soil accepting more winter rainfall before reaching saturation. Reed canary grass, as a wetland species, is better able to cope with water logging over prolonged periods. It is therefore better suited than the other grasses to planting in fields subject to rising or perched water tables, or in areas prone to flooding (Hall, 2003).

3.87. The impact of energy crops on surface and groundwater quality will depend on many factors including the previous land-use, soil type, hydrological regime and the past and future use of fertilizers and pesticides. At present the information available on nutrient uptake by energy grasses is sparse but what there is indicates that in general water quality should not be adversely affected (Hall, 2003).

3.88. After establishment, the annual fertiliser demands of perennial grasses are low (CCW, 2006). Weed control in the establishment phase of the crop is considered to be necessary, but once the crop is mature (from the third year), competition from weeds is effectively suppressed and herbicides are not needed (English Nature, 2003). Research undertaken by Hall (2003), Murphy and Helal (1996) and Christian and Riche (1998) has shown that once established, miscanthus can lead to low levels of nitrate leaching and can improve groundwater quality compared with arable crops.

3.89. Bical Energy state that if 1000 ha of miscanthus were grown in an area, it would remove the following agricultural inputs compared to average use for current crops:

- reduction in nitrogen fertiliser: 140 tonnes;
- reduction in fungicide use: 2000 litres;
- reduction in insecticide use: 100 litres; and
- reduction in growth regulator: 1000 litres.

3.90. Geber (2000) also suggests that nitrate-rich groundwater can be ameliorated by continued cropping with reed canary grass. As with SRC, energy grasses offer opportunities for improving water quality by planting buffer strips along water courses and for the remediation of waste waters, although further research is required on the effect of the crops on local hydrology before their use can be recommended as a buffer crop along watercourses (CCW, 2006).

Soil

3.91. No specific studies have been identified related to growing perennial energy crops and soil. As with SRC, there is a high risk of erosion on susceptible soils in the first year because the plants are typically planted in wide row spacings and crop establishment is slow (Turley *et al*, 2003). Once established, erosion risk is likely to be low (Murphy and Helal, 1996).

3.92. There is a high risk of soil compaction during harvesting as heavy machinery is required to harvest the crop in winter (Turley *et al*, 2003). Miscanthus in particular has a requirement for well-aerated soils and generally does not grow well on wet compacted soils. Harvesting the crop under wet conditions can therefore potentially damage the rhizomes (Schwarz and Greef, 1996).

Archaeology

3.93. Energy grasses should not be planted close to, nor surround, archaeological sites. There is great uncertainty as to the appropriate separation, but Hall (2003) suggests that it would be prudent not to plant closer than 50m to archaeological remains taking account of hydrological considerations. However, the requirement for heavy machinery to be able to turn and approach the plantation may require a larger separation distance.

Management measures

3.94. There is very little existing guidance on the management of perennial energy crops such as miscanthus, reed canary grass or switch grass. The only specific guidance document is *Planting and Growing Miscanthus: The Best Practice Guidelines for Applicants to Defra's Energy Crops Scheme* (Defra, 2001) and this focuses predominately on practical planting and establishment issues as opposed to environmental control measures. A summary of the key management recommendations outlined in this publication and other relevant literature is set out in **Table 3.4** below. **Please note that these are not the recommendations of the Wildlife and Countryside Link.**

Table 3.4: Summary of Establishment and Management Recommendations for Perennial Grasses as Identified from the Literature

Perennial Grasses Management Recommendations
Landscape
• **Visual impact**: careful consideration should be given to the siting of the crop as it can grow to up to 3.5m in height. This may have impacts on both landscape character and key views. The use of reed canary grass in flood plain locations may positively enhance the landscape where it is replacing arable cropping or grass leys.
Biodiversity
• **Diversity**: perennial energy crops should be grown as one component of a mixed cropping pattern. • **Linking**: opportunities for the crop to form buffers and links between habitats should be investigated. • **Rides and Headlands**: rides and headlands should be established to enhance the value of perennial crops for wildlife. The use of grass headlands around the crop will protect edge habitats which are particularly important for wildlife by preventing shading to existing habitat. Headlands may also act as a sacrificial crop for rabbits or deer to feed on and thus reduce any damage they may cause to the newly established crop. • **Hedgerows**: where possible, hedgerows should be incorporated into the design of perennial grass plantations as they can provide shelter for the crop whilst providing valuable habitat for bats, songbirds, game, wildflowers and insects. This may include

Perennial Grasses Management Recommendations
the reinstatement of former hedgerows. • **Inputs**: the amounts of fertiliser, pesticides and herbicides should be kept to a minimum. • **Siting**: crops should be planted on sites of low conservation value and should not be planted close to sensitive habitats (especially wetland habitats). However, reed canary grass naturally forms a mosaic with other wetland habitats and could be valuable in replacing more intensive agricultural crops.
Water
• **Inputs**: as above to minimise nitrate leaching the amount of fertiliser applied should be kept to a minimum. • **Scale**: area planted with crops within small catchments should be carefully controlled.
Soil
• **Soil type**: wet compacted soils are unlikely to be suitable for crops such as miscanthus. • **Machinery**: care should be taken when using heavy machinery to harvest the crops to avoid soil compaction.
Archaeology
• **Buffers**: energy grasses should not be planted close to, nor surround, archaeological sites.

CONVENTIONAL CROPS

Overview

Conventional Crops

There are a wide range of conventional crops which can also be used to produce biofuels – in the form of either bioethanol or biodisesel.

Bioethanol: The most common crops used to produce bioethanol are sugar beet, cereal crops, sorghum and potato. In the UK, the crops which are most likely to be used are sugar beet, wheat and sorghum.

Sugar Beet: Sugar beet (*Beta vulgaris*) is primarily grown in the UK for sugar production. Its cultivation for energy purposes is no different to that for sugar production. It has a two year cycle, but is usually harvested at the end of the first year, when the root is most swollen. This crop can be used for the production of bioethanol after fermentation. It has a very good ethanol yield, as one hectare of sugar beet can be converted into 2,860 litres of bioethanol per year.

Cereal Crops: The term 'cereal crops' includes wheat, rye and barley. Again, their production as energy resources is no different to their production for food purposes. The ethanol yield from wheat is far lower than that of sugar beet, but it is still of value, as one hectare worth of wheat can be transformed into 1,344 litres of bioethanol per year. Straw from cereal crops can also be used as a form of biomass used to generate heat and/or electricity.

Sorghum: sorghum has the potential to be a major producer of bioethanol because of its high lignocellulosic mass, and its flexibility of adaptation to both tropical and temperate climatic regions, as well as areas with poor soils. The agronomy of sweet sorghum is similar to that of corn except that its grains are stored in a panicle, rather than an ear. Sorghum is a crop grown extensively in the United States and Africa, increasingly in Europe but not as yet in Great Britain.

Conventional Crops

Biodiesel: The most common crop used for producing biodiesel is oilseed rape, although increasingly proposals are being forward to use both linseed and sunflower.

Oilseed rape *(Brassica napus):* Oilseed rape is the most commonly used crop for biodiesel production in the UK. It is cultivated on a yearly basis. It has been calculated that one hectare of rapeseed could produce up to 1,322 litres of biodiesel per year.

Linseed: Linseed is an annual plant, with a fast stem growth (it can reach up to 1 meter in height). Because of its tendency to exhaust the soil, it is recommended that it is cultivated in a rotational system, where 6 to 7 years are left before a new linseed culture is planted on the same agricultural parcel. In 2005, 33,000 ha were cultivated in the UK. It has a yield of 1.7 tonnes/ha, and the seed's oil content is around 38%.

Sunflower: Sunflower is not very well adapted to growing in the UK. However, there are estimates that 60,000 ha could be grown in southern England and climate change means that more areas are likely to become available. Sunflower has a crop yield of around 1.7 tonnes/ha and one hectare of sunflower could produce around 1200 litres of biodiesel per year.

Environmental impacts of conventional crops

Landscape

3.95. Many of the crops outlined above are already grown in the UK and are a familiar sight within the countryside. The landscape impacts of growing these crops for bioenergy is dependent on the extent to which the demand for these crops increases and the associated land use implications of this increased demand. As expressed by Tipper (2006) there is a fear that the new market for biofuels will lead to the establishment of 'wall to wall' wheat, sugar or rape. The expansion of the use of oilseed rape, with its vivid yellow flowers is considered to be of particular concern in areas where these crops are currently not grown (Turley *et al*, 2002).

3.96. If very large areas are committed to certain crop types there is a fear that biofuel cropping will increase the establishment of monocultures; with the landscape dominated by a select number of crops. Maintaining and if possible enhancing crop diversity is therefore, considered to be essential for an acceptable biofuel programme (Murphy and Helal, 1996). There is also a concern that market forces will encourage the growth of crops in marginal areas where the ambition is to encourage habitat restoration, such as conversion of arable lands back to chalk grassland (pers. com).

Biodiversity

3.97. There is already a good understanding of the environmental impacts of growing major food crops that can be used to produce biofuels. Less is known however, about the environmental implications of growing some of the crops such as sorghum, linseed oil and sunflowers in the UK.

3.98. *Sugar beet*: The literature suggests that there are substantial benefits to wildlife from growing sugar beet compared to cereals and oilseed rape in the UK. Sugar beet provides important nesting and foraging habitat for birds by virtue of being spring-sown, being broad leaved and including winter stubbles in the rotation. Its wildlife value is however reduced if it is intensively managed (both mechanically and chemically) and there is evidence that in recent years sugar beet crops are being managed more intensively (RSPB, 2006). A study undertaken by Defra (2002) found that sugar beet provides important food and habitat resources for a number of important species such as stone curlew, finches, buntings, lapwing and skylark. After beet is harvested in the autumn and winter, many bird species such as pink footed geese, swans, skylarks, golden plover, lapwing, pied wagtail and meadow pipit use the stubble and remaining beet tops for food and also forage for invertebrates. Up to half the world's population of pink–footed geese winter on sugar fields in northwest Norfolk and the Broads.

3.99. *Wheat:* Some species, including yellowhammer, skylark, quail and grey partridge are found in high numbers in wheat, but this may be a reflection of the amount of habitat available, rather than crop preference (Wilson 2001; Holland *et al.* 2002). Many species appear to avoid wheat during the winter. Wheat commonly has high numbers of invertebrates, but these may be adversely affected by pesticide treatments (Moreby *et al.* 1992) and the timing of sowing (Reddersen 1994). Insect availability and suitability for nesting also tends to decrease as the crop matures during the summer (Lack 1992).

3.100. *Oilseed Rape:* English Nature (2003) has stated that rape crops provide resources for a variety of farmland birds, including shelter and nesting sites as well as food (both seeds and a wide range of invertebrates). Studies have shown that the presence of oilseed rape positively influences the number of bird species found in adjacent hedgerows compared with wheat and other crops (Green, 1994), and increases the frequency of nesting sites for particular species (Mason & Macdonald, 2000). Green (1994) studied the distribution of passerines in hedgerows in relation to adjacent crop types. Crop types in order of preference were: oilseed rape>potatoes>autumn-sown cereal>peas>beans>sugar beet>spring cereal. Lack (1992) also found preferences by farmland birds for oilseed rape over all other arable crops. Food availability (invertebrates) may be an important factor in this preference (Green, 1994; Holland *et al.* 2002). Holland *et al.* (2002) found that oilseed rape, peas and beans tended to have higher densities of invertebrates compared to cereals, potatoes and sugar beet had lower densities.

3.101. Oilseed rape crops often have higher levels of broadleaved weeds than cereals because the herbicides available for use in oilseed rape to control broad-leaved weeds are not as effective as those used in cereals, and the presence of weeds late in the season has little effect on rape yield (Lutman, 1993). Some commentators however suggest that a key problem affecting the biodiversity value of oilseed rape is that insecticides are often applied during the flowering period. When a crop attracts in the pollination fauna from a wide area, a badly timed spray can destroy populations of threatened species from habitats some distance (over 0.5 miles) from the crop.

3.102. *Sorghum and Sunflower:* No known studies have been undertaken to date looking at the impacts on biodiversity of growing sorghum or sunflowers in the UK. There also appears to be little literature available on the biodiversity impacts of *linseed*, although it is known to be a desirable forage for deer and birds, either as herbage or seed. It may also provide some cover for selected small bird species.

3.103. Replacement of natural regeneration set-aside with oilseed rape or cereals would have a detrimental impact on some farmland birds, although some species that may use oilseed rape as a food source in summer would benefit (Turley *et al.* 2004). Replacement of set-aside for winter oilseed rape would also reduce the availability of stubble that many birds depend on during the winter season. Some of these detrimental impacts on biodiversity could be mitigated, however, by positive management practices such as the maintenance of field margins.

Water

3.104. Using oilseed rape for biodiesel or cereals for bioethanol production offers little opportunity to reduce fertilizer and pesticide inputs compared to their management for food (Turley *et al.* 2004; St Clair 2006). Replacement of natural regeneration set-aside land with these crop alternatives is likely to lead to increased inputs of pesticides and fertilizers and also to higher nitrate leaching levels. However, nitrate leaching rates are not determined by fertilizer rates alone, and typically set-aside has higher residual nitrogen levels which are subject to over winter loss (Turley *et al.* 2004). In general, cereals are more efficient in terms of fertilizer use, compared to root crops and oilseed rape and consequently have lower nitrate leaching rates (see **Table 3.5**). Oilseed rape may represent a higher risk of nitrate leaching relative to other arable crops, due to high levels of residual nitrate left in the soil following harvest (Turley *et al.* 2004).

Table 3.5: Nitrate Leaching Loss from Arable Crops

Crop	Amount of NO_3 N leached (kg ha $^{-1}$ yr $^{-1}$)
Oilseed rape	74
Sugar Beet	30
Cereals	30
Unfertilized grass	10

Source: Turley *et al.* 2004.

3.105. Water quality can also be compromised by pesticide application. Cereals typically require greater pesticide applications than oilseed rape, but both crops require substantially more than natural regeneration set-aside.

Soil

3.106. The frequent tillage of annual crops such as oilseed rape or wheat results in a higher soil erosion risk than cultivation of energy crops. Evans (2002) devised a classification for the erosion risk posed by individual crop types in which the percentage of observed channel erosion was expressed as a fraction of the percentage of arable land cover of the crop for England and Wales. Results from this analysis are shown in **Table 3.6**.

Table 3.6: Index of Channel Erosion of Possible Biofuel Crops

Crop	% erosion occurrence/ % arable area
Sugar beet	4.05
Spring cereals	0.83
Winter cereals	0.69
Winter oilseed rape	0.29

Source: Turley *et al.* (2004), based on Evans (2002).

3.107. As shown in the table, the overall erosion risk of winter cereals and oilseeds is relatively small in comparison to root crops such as sugar beet, although the ultimate erosion risk is heavily influenced by topography and soil type. Oil seed crops, if they replace other arable crops, will yield little benefit for soil structure and may have negative impacts if they replace long term set aside (Scottish Executive, 2006).

Management measures

3.108. There is no existing guidance on the sustainable production of biofuels. A study has recently been completed on behalf of the Local Carbon Vehicle Partnership looking at developing draft environmental standards for biofuels (2006).

3.109. Within the UK, the Assured Food Standard (AFS, the Little Red Tractor) covers a large proportion of the UK crops grown (80% in the case of the Assured Combinable Crop Scheme). The Assured standards and associated environmental criteria have however been described by the Sustainable Development Commission and the RSPB as weak. More comprehensive standards and guidance is contained in the Linking Environment and Farming (LEAF) scheme, which is aimed at promoting environmentally friendly farming practices. With regard to sugar beet, WWF is promoting the Better Sugarcane Initiative (BSI), although this is in the early stages of development.

3.110. **Table 3.7** summarises the principle management measures identified in the literature relating to the sustainable production of conventional crops. Please note that this does not form a comprehensive list of all the relevant management measures but rather an overview of the main management principles.

Table 3.7: Summary of Management Recommendations for Conventional Crops

Conventional Crop Management Recommendations
Landscape
• **Sensitivity**: cropping should avoid sensitive habitats that contribute to landscape character such as remaining areas of semi-natural grassland and areas with the potential to be restored to these habitats, so relinking now isolated habitat fragments. • **Diversity**: diversity in crop rotations should be encouraged, avoiding extensive monocultures of crops that are highly visible in the landscape, such as oilseed rape and linseed. • **Boundary features**: crop cultivation should not lead to the further loss of characteristic boundary features and buffer strips adjacent to boundary features and field tracks should be used to visually strengthen the field boundary.
Biodiversity
• **Conservation**: protected species and habitats of high conservation value should be identified and protected. • **Hedgerows**: hedgerows should be retained and where possible former boundary features should be reinstated. • **Inputs**: appropriate crop management practices should be implemented to assist in the conservation of important habitats or species where present. This may include timing of field operations to avoid harm, avoiding crop spray within defined areas and minimising inputs of fertilisers, pesticides and herbicides. • **Enhancement**: measures should be identified to encourage wildlife and restore degraded natural ecosystems.
Water
• **Water resource assessment**: an assessment should be undertaken of the available water resources. • **Abstraction**: valid abstraction licences or permits should be obtained where required and should comply with the Environment Agency's Catchment Abstraction Management Strategies (CAMS). • **Conservation**: evidence should be provided of appropriate water management and conservation measures. • **Pollution**: growers should show compliance with prevailing legislation and codes of practice relating to diffuse pollution. • **Inputs**: growers should show compliance with prevailing legislation when using irrigation, fertilisers and/or pesticides. • **Waste**: waste management plans and waste disposal activity should comply with the regulations and should show how waste is minimised.
Soil
• **Conserving soil**: soils with high organic matter should be identified and appropriate measure adopted to conserve organic matter. • **Ploughing**: no deep ploughing should be undertaken (i.e. >30cm). • **Conversion**: no conversion to crop production should take place on soils where there is a high risk of soil carbon loss.

Conventional Crop Management Recommendations
• **Management plan**: a soil management plan should be prepared which reviews erosion risk. • **Nutrient plan**: a farm nutrient plan should be prepared which details fertilizer and manure management activities.
Archaeology
• **Deep ploughing**: deep ploughing should be avoided over known areas of buried archaeology. • **Cultivations**: all forms of cultivation should be avoided over surface archaeology and earthworks with conversion to a grassland cover.

SUMMARY OF THE ENVIRONMENTAL IMPACTS OF BIOENERGY

3.111. The following table provides a summary of the key threats and opportunities associated with each form of bioenergy as identified from the literature. Please note that this is not a comprehensive list of all the environmental issues associated with each form of bioenergy but rather a summary of the headline issues.

Table 3.8: Summary of threats and opportunities of different forms of bioenergy

	Threats	Opportunities
Short Rotation Coppice		
Landscape	• Planting of extensive areas of SRC could lead to a reduction in landscape variety and a change in landscape character as SRC does not look like natural woodland. Landscape change results from rapid uniform growth and large scale harvesting operations. • Height of mature SRC crops could obscure landscape features, e.g. stone walls, hedgerows and key views and in an open landscape could adversely affect sense of openness.	• If designed appropriately SRC has the potential to add structural diversity to existing agricultural landscapes. • May provide an opportunity for the restoration and reinstatement of boundary features, e.g. hedgerows and the expansion of woodland areas.
Biodiversity	• Some evidence suggests that SRC could displace open farmland bird species, e.g. grey partridge, lapwing, skylark and corn bunting. • If located in inappropriate areas, SRC could have a negative impact on sensitive wetland and marginal habitats.	• If native species and low impact management strategies are used, SRC has the potential to increase the abundance and diversity of ground flora (including stable perennials), farmland bird species and invertebrates compared with grassland and arable crops – particularly in the early stages of crop growth. • SRC is believed to provide suitable habitat for small mammals in the form of good ground cover and minimal land disturbance. • SRC could be used to buffer woodlands and vulnerable habitats from more intensive forms of agricultural production.
Water	• SRC has high water requirements which could exacerbate water shortages, particularly in areas with low rainfall.	• As SRC is effective at absorbing available nitrogen, it has the potential to be used to improve water quality, tackle nitrate pollution problems, buffer vulnerable habitats and treat wastewater and landfill leachate.
Soil	• Due to the need for relatively heavy harvesting machinery, there could be a risk of soil compaction during the harvesting of SRC crops.	• SRC has the potential to have a stabilising impact on soils and could be used to reduce soil erosion and sedimentation problems.
Archaeology	• Ploughing and sub-soiling of root growth of SRC could damage archaeological sites and deposits.	
Short Rotation Forestry		
Landscape	• Planting of species such as eucalyptus could have a significant impact on landscape character as it is non-native to the UK. • Planting of SRF in sensitive open landscapes could have a detrimental impact on landscape character. • New woodland planting may affect perceptual aspects, such as sense of enclosure.	• SRF could provide a market opportunity for the creation of new native broadleaved woodlands or the expansion of existing woodlands.

	Threats	Opportunities
Biodiversity	• Trees with the densest canopies e.g. eucalyptus and nothofagus could discourage ground feeding birds. • Bird species adapted to open habitats could be threatened if significant areas of SRF are planted.	• SRF could have a positive impact on biodiversity if native species are used and if it replaces arable or improved grassland. In particular: ➢ the understorey vegetation can provide suitable habits for a number of invertebrate and mammal species ➢ native woodlands can support a greater abundance and species richness of birds than intensively managed agricultural land.
Water	• SRF and in particular non-native species can have high water requirements which could have a significant impact on local hydrological regimes and groundwater availability.	• SRF (as with SRC) has lower input requirements compared with other energy crops and is therefore likely to reduce nitrate pollution compared with arable and grassland areas.
Soil		• Tree planting could have a stabilising impact on soils due to the infrequency of soil cultivation and could be used to reduce soil erosion and sedimentation problems.
Archaeo-logy	• Root growth of SRF could have a direct impact on the physical integrity of sites of archaeological interest comparable with other intensive landuses such as commercial forestry and intensive arable cultivation.	
Forest Residues		
Landscape	• Creation of new access tracks could have a negative landscape impact if inappropriately located. • Perception of rapid rates of change to landscape.	• Felling and thinning of even age woods could help to diversify the age structure of woodlands – reducing the extent of future storm damage. • Could create a market for the restoration of historic coppiced landscapes.
Biodiversity	• Removal of forest residues could lead to the depletion of nutrients and deprive small vertebrates, invertebrates and fungi of important habitat and food resources – particularly if the following takes place: ➢ whole tree harvesting ➢ clear felling or uniform thinning of native woodland ➢ removal of broadleaf trees from mixed broadleaved/conifer stands • Removal of forest residues could have an impact on some important BAP species such as bats.	• Could provide an opportunity for the diversification of the woodland structure and the removal of non-native species from PAWs, semi-natural and open BAP habitats. • Thinning can open up dense plantations and improve development of ground flora. • Removal of brash from clear felled areas in conifer plantations may benefit birds in open areas. • Creation of new rides could lead to an increase in edge and ride habitats. • Could aid the restoration of neglected coppice woodlands which still contain species dependent on coppice cycle, e.g. butterflies.
Water	• Removal of forest residues could increase the sedimentation of water courses. • Harvesting of wood could reduce the potential to regulate water flow as deadwood captures and stores significant amounts of water reducing run off on slopes.	

	Threats	Opportunities
Soil	• Removal of forest residues could lead to an increase in the susceptibility of soils to erosion and remove nutrients. • The use of heavy machinery for harvesting forest residues could lead to greater soil compaction.	• Could counter 20th century increases in nitrogen and potassium levels in soils.
Archaeology	• The use of harvesting machinery and the creation of woodland tracks has the potential to impact on archaeological remains if appropriate mitigation is not put in place.	
Perennial Grasses		
Landscape	• Miscanthus and switchgrass are non-native in the UK and can grow to up to 3m in height, which could have a significant impact on landscape character as a result of rapid growth rates and large scale harvesting operations. • Presence of non-native crops could adversely affect the `naturalistic' character of the landscape. • Growth of crops could impose rigid geometric patterns into unenclosed landscapes such as chalk grassland or moorland.	• Reed canary grass is native in the UK and if grown in its natural habitat and in a location which doesn't displace unimproved wet grassland – it could bring positive landscape benefits if replacing arable or ley pasture.
Biodiversity	• Mature perennial grass stands could have a negative impact on open farmland species such as skylarks, meadow pipits and lapwings. • Research suggests that reed canary grass does not attract the same density of species of flora and fauna as miscanthus and SRC. • Little research has been undertaken looking at the impact of mature stands of perennial crops on biodiversity.	• Young miscanthus stands and to a lesser extend reed canary grass, could potentially benefit native weeds if inputs are kept to a minimum. • Young miscanthus crops could provide foraging habitat for ground nesting bird species and for a wide range of species that exploit crops for invertebrates, seeds and cover. • Young miscanthus crops could support a more diverse and abundant array of native invertebrate species than arable fields (if the use of pesticides is avoided). • Miscanthus is believed to provide suitable habitat for small mammals in the form of good ground cover and minimal land disturbance.
Water	• There is a lack of uncertainty regarding the potential impact of growing perennial grasses on water use and water quality.	• Mature stands of perennial grasses do not require the application of herbicides of fertilisers and could therefore improve ground water quality if planted on former arable sites. • Perennial grasses offer opportunities for improving ground water quality by planting buffer strips along watercourses and for the remediation of waste waters.
Soil	• There could be a high risk of soil erosion on susceptible soils in the establishment year. • There could be a high risk of soil compaction during harvesting as heavy machinery is required to harvest the crop during winter.	
Archaeology	• The use of harvesting machinery and root growth has the potential to impact on archaeological remains if appropriate mitigation is not put in place.	

	Threats	Opportunities
Conventional Crops		
Landscape	• An increase in the demand for conventional crops for bioenergy could lead to an expansion in mono-cultures. • Market forces could encourage the growth of crops in marginal areas where the aim is to encourage habitat restoration and the conversion of arable land back to other semi-natural habitats.	
Biodiversity	• An expansion in the establishment of some crops, e.g. wheat, could have a negative impact on biodiversity as it generally has a low abundance of invertebrates and farmland birds compared with other crops. • Conventional crops typically require greater inputs of fertiliser, herbicide and pesticide, which can have a negative impact on biodiversity. • The replacement of natural regeneration set-aside with oil seed rape of cereals would have a detrimental impact on some farmland birds • Little research has been undertaken looking at the impacts on biodiversity of growing sorghum and sunflowers in the UK.	• Some crops such as sugar beet and oilseed rape could potentially benefit a number of farmland bird species and invertebrates.
Water	• The use of conventional crops such as cereals sand oilseed rape require significant inputs of fertiliser, pesticides and herbicides which can have a negative impact on water quality as a result of nitrate leaching.	
Soil	• The frequent tillage of annual crops such as sugar beet wheat or oilseed rape could lead to a higher risk of soil erosion than the cultivation of energy crops.	
Archaeology	• Deep ploughing and root growth has the potential to impact on archaeological remains if appropriate mitigation is not put in place. Care therefore needs to be taken to site crops away from sites of archaeological or cultural heritage importance.	

4. CONSULTATION FINDINGS

INTRODUCTION

4.1. To supplement the information gathered from the policy literature review, telephone consultations were undertaken with a range of key experts within the bioenergy field. The consultees included representatives from key Government departments/ agencies, non government organisations, land management organisations and the bioenergy industry. A list of the consultees and their involvement in bioenergy issues is provided in **Appendix 2.**

METHODOLOGY

4.2. The purpose of the consultations was fivefold:

- to identify any existing research or information relating to the potential impacts of bioenergy on the environment;
- to identify any policy, fiscal or technological developments which will influence the future development of bioenergy;
- to discuss the potential positive and negative impacts of bioenergy production on biodiversity, soil, water and landscape etc;
- to gather opinions on what policy or practical measures are required to minimise or enhance the projected negative and positive impacts of bioenergy production and use; and
- to identify any potential case studies that may be suitable for further investigation.

4.3. The interviews were carried out using a pre-scripted set of questions formulated to elicit information relating to the five areas identified above. A copy of the interview questions is provided in **Appendix 3.**

4.4. The comments and information expressed in the interviews is summarised in the following section and is set out under the broad themes of the interview questions.

CONCLUSIONS FROM CONSULTATIONS

Summary of the key drivers behind the production and use of bioenergy in the UK

4.5. The majority of consultees agreed that the primary driver behind the production and use of bioenergy is tackling climate change through carbon savings and greenhouse gas reductions. Energy security was identified as the second key driver, although it was pointed out that this is perhaps an issue of greater significance in other countries, notably the US and some EU countries. The potential for bioenergy to stimulate rural economies / development and as a form of farm diversification was also raised by a number of the consultees, as was the rising costs of energy prices.

Key Government policies and support measures driving bioenergy development

4.6. The consultees identified a wide range of government policies and fiscal support measures that they saw as influencing the future development of bioenergy in the UK.

4.7. Several consultees mentioned that the Renewables Obligation is the key policy driving bioenergy, although to date the workings of this policy has been more influential in encouraging large scale co-firing projects as opposed to stand-alone bioenergy schemes. As outlined in **Chapter 2**, it was mentioned that the Government is currently consulting on further changes to the Renewables Order ,with the proposal that future obligations will be 'banded' enabling the Government to encourage certain renewables technologies at the expense of others. It is anticipated that if this takes place it will significantly encourage the development and uptake of emerging technologies such as biomass.

4.8. It was highlighted that at present the current Renewables Obligation only supports electrical as opposed to heat generation, which considering the difference in conversion efficiencies is a major weakness. Defra stated that there are no plans to develop a Renewables Heat Obligation as recommended by the EFRA Committee but instead efforts are going to be focused on encouraging the development of combined heat and energy projects through the capital grants. The 2nd tranche of the bioenergy infrastructure scheme is about to be launched shortly. The UK Government is also in the process of preparing a bioenergy strategy which will set out a strategy for optimising the use of bioenergy for heat, electricity and transport fuels.

4.9. A number of consultees welcomed the capital grant schemes, both in terms of the support they provide to growers, particularly during the period of establishment when perennial crops provide no financial return, as well as for infrastructure. Defra noted that the New Rural Development Programmes is likely to include additional incentives for biomass and that the Energy Crop Scheme, which is currently closed, will be continued in some form. This required producers to undertake an EIA and follow best practice guidance. The details of the new energy crop scheme have yet to be finalised and will need to be agreed with both Europe and UK ministers. Consultees from Wales pointed out that the Energy Crops Scheme has never been implemented there, and that this form of funding was needed and sorely lacking in Wales. One consultee suggested that there should be some provision for the growing of certain energy crops as part of the Environmental Stewardship.

4.10. In relation to the RTFO, Defra acknowledged that a considerable proportion of the target (for fuel providers to secure 5% (by volume) of the total fuel supply from biofuels by 2010) will be met from foreign imports, e.g. sugar cane, palm oil etc. It was suggested however that when looking at the life cycle analyses of importing biofuels, very little energy is used to transport the product - as it usually travels by sea. Concerns were expressed by some consultees regarding the fact that biofuels are being produced in the tropical countries and that environmental safeguards need to be put in place to ensure that they are produced in a sustainable manner. It was suggested that there are three factors which will help to ensure that overseas production is sustainable - 1) pressure from NGOs, 2) corporate responsibility from the large companies and 3) appropriate environmental controls. Defra are also in the process of developing a carbon and sustainability assurance scheme as part of the RTFO, although this is only likely to relate to UK based production. SNH pointed out that the RTFO will have less impact on first generation biofuels in Scotland due to the fact that SRC / forestry has the most potential there.

4.11. Several consultees noted the lack of policy and fiscal support measures for bioenergy within the forestry sector, in particular a lack of incentives for SRF, or for the management of PAWS or ancient woodland. CCW noted that SRC was now supported under the Welsh WGS called 'Better Woodlands for Wales'.

4.12. Finally, planning policy was identified as a key recent driver of bioenergy. Representatives from the bioenergy industry pointed out the example being set by the London Borough Merton, whose revised Development Plan policy requires that '*All new non-residential development above a threshold of 1,000 sqm will be expected to incorporate renewable energy production equipment to provide at least 10% of predicted energy requirements*.' This policy approach is now being adopted by a large number of local authorities across the country and it is anticipated that it will have a significant impact on the uptake of small scale renewable energy (including bioenergy) schemes within England.

Perceived key technological developments and implications

4.13. Consultees identified a wide range of technological developments that have the potential to impact on the production and use of bioenergy at different scales. One of the technological developments that was most commonly cited as having a significant impact on the production of bioenergy was the development of new crop varieties which are seeking to improve crop yields, increase plant photosynthetic and water efficiencies and reduce the application of chemicals. It was suggested that improved varieties could mean that there is greater potential to grow crops in locations not currently viable and that impacts on water resources and soil quality could be reduced.

4.14. Several consultees noted the potential for technological developments in processing bioenergy crops for energy conversion. This includes more efficient ways of processing fuels in terms of the products used (i.e. creating fuel pellets) and in terms of emerging processing technologies such as lignocellulose conversion using enzyme technology and bio-refineries using microbes. The development of second generation biofuels using of woody biomass was seen as having potentially huge positive impacts, although the emergence of this technology was estimated to be between 5-10 years away.

4.15. In relation to harvesting equipment, it was noted that there are trends towards machinery generally increasing in size for efficiency purposes. It was noted however that the application of such large industrial scale machinery is problematic in certain areas of the UK due to smaller enclosed fields and sloping terrain. Concerns were expressed that larger machines require larger turning circles and the weight of machinery may increase potential disturbance to soils and damage to buried archaeology.

4.16. The continued development and potential future distribution of more efficient small scale woodchip boilers and power generators could, it was suggested, lead to significant impacts on the scale and location of bioenergy production in the UK. Representatives from the bioenergy industry stated that at present the majority of small scale boilers are imported from Sweden, and that technology within the 40-500KW scale is still being tested and is in the research and development stage.

The potential positive and negative impacts of bioenergy on the environment

Overview

4.17. Most consultees pointed out that there were several key factors to take into account when trying to assess the potential environmental impacts of bioenergy. These include:

- the type of crop that is being grown and the management processes undertaken in growing it;
- the nature of the land that it replaces; and
- the geographical location, scale of development and spatial distribution of the crop.

4.18. With regards to the last point, it was noted that there is a gap in existing research on the impacts of large scale bioenergy production.

Biodiversity

4.19. Several general comments were made about the global benefits for biodiversity resulting from an increase in bioenergy in terms of reducing green house gases. Local potential benefits were identified where intensive agricultural land use could be replaced by crops with lower inputs of fertilisers, pesticides etc. Concerns were however expressed about the potential loss of semi-natural and unimproved grassland. Some consultees also expressed concern about the loss of improved grassland. Although improved grassland is of little value for rare and endangered species, concern was expressed that an EIA system (like that used under the former energy crops scheme) may not able to adequately distinguish between good and poor ecological quality grassland.

4.20. A number of consultees also raised concerns about the genotype of the crops used and that this will have a significant impact on the pros and cons of each crop species for biodiversity. Some existing amenity and other plantings are non-native and seemingly can be relatively poor for native insects. Re-assurance about use of native genetic stock could make a big difference as there is a real potential that GM variants may be used to increase resistance to pests and disease and for improved burning qualities.

4.21. Further comments relating to biodiversity for each particular form of bioenergy are provided below:

SRC / SRF

4.22. Consultees commented that the majority of the research undertaken to date has generally found that SRC, in particular Willow, has the potential to deliver the most positive impacts for biodiversity, particularly if it is carefully managed (i.e. headlands and rides, age class breaks, planting mixed species, avoidance of large plots, allowing certain stands to develop into woodland etc.). It is favoured for its high diversity of soil invertebrates; ability to support birdlife (although generally not BAP species); and scope to increase habitat variety in the landscape.

4.23. SRF using native species was generally supported to the same degree as SRC, although it was suggested the longer time frame had greater biodiversity benefits as it allowed development towards more stable ecological communities. The Woodland Trust, commented that SRF has the potential to encourage native broadleaf woodland which could help to deliver HAP and woodland creation targets.

4.24. It was urged that care should be taken in determining where new sites are located, i.e. growing SRC on semi-natural heathland, heathland, peaty soils, chalk moorland or areas which have important bird populations are likely to be unsuitable. It was suggested that for SRF, Forestry Commission guidelines should be adhered to thus ensuring that management is appropriate. Several consultees additionally commented that using eucalyptus – a non native species would be inappropriate.

4.25. One consultee expressed concern that monocultures of willow or polar may carry a high risk of ecological imbalance and pest outbreaks. If significant pest problems do develop, it is currently not clear whether ground spraying would be effective within dense coppice stands, and as a result sprays may have to be applied from the air.

Forest residues

4.26. The use of forest residues was identified as having significant benefits. Ancient woodlands in particular contain low quality wood which bioenergy developments could provide a market for, leading to the restoration of these important priority habitats. The opportunities for the reintroduction of coppicing and the opening up of woods was cited as having significant benefits both for flora and fauna, some of which may include a number of BAP species. Several consultees however noted that it is important that appropriate machinery is used and that harvesting works are timed to avoid disturbance (e.g. in the bird breeding season).

4.27. Bioenergy was also identified by the Woodland Trust as having the potential to assist with PAWS restoration, as long as it enables the gradual removal of conifers rather than clear felling. In reality, it was suggested that woodland residues would only to be cost effective to extract from large woodland sites rather than small woodlands. English Nature did however suggest that there may be an opportunity for the rotational restoration of PAWs sites – i.e. with swathes harvested out of a number of different sites on a rotational basis, rather than the clear felling of one particular site.

4.28. The main additional potential benefit highlighted by consultees was the opportunity, through the restoration of our woodlands (e.g. through the use of forest residues) to provide greater public access and to reconnect people with their local woodlands.

4.29. Wood waste was also identified by the Forestry Commission as a key resource as approximately half a million tonnes of arboricultural arisings are sent to landfill every year from street trees in England alone. Significant amounts of sawmill residues could also make a substantial contribution to bioenergy generation.

Perennial energy grasses

4.30. It was noted by a number of consultees that there is little information or research on the production of miscanthus within the UK. Current research that is available is generally based on young plantations, some of which are grown for rhizome production and therefore do not resemble fully productive commercial scale plantations. As such it was urged that the research undertaken to date should be treated with caution.

Conventional crops

4.31. Several consultees pointed out that if conventional crops are spring sown, rather than in late autumn and are allowed to stand longer before drilling, then winter stubbles can be left resulting in benefits to biodiversity, particularly birdlife. This can also lead to a more diverse crop structure - allowing late nesting, in July-August as opposed to April-May (e.g. for skylarks). Spring sown crops also tend to need less herbicides as there is less time for weeds to compete. BAP farmland bird species associated with arable land tend to thrive in open crops – therefore low density biofuel plantings would also be beneficial.

4.32. One consultee expressed concern that the creation of a market for biofuels may impact on efforts to recreate and restore vulnerable habitats. Conservation organisations are trying to buy up large areas of drained wetland to restore them to wildlife habitat such as the Great Fen Project of Cambridgeshire. With the prospect of drained wetland about to have high economic value for biofuel production (in the national interest), wildlife restoration ambitions could be foiled.

Soil

4.33. Consultees made reference to a range of potential positive impacts on soil as a result of increased bioenergy production, again dependent on what land use/cover is being replaced. It was noted that biomass crops and SRC require lower chemical inputs in terms of fertiliser and pesticides, although herbicide applications are still often required to remove weeds before establishing crops.

4.34. The Wales Biomass Centre noted that SRC and biomass crops were much more efficient nutrient users, e.g. the leaf litter turnover from SRC tends to result in rich soil. Miscanthus plants also translocate nitrogen to their rhizomes, and therefore don't require the application of fertilisers once established. Research has found that energy grasses that have not received any pesticides and only minimal levels of fertilizer, have experienced only small reductions in yields. Herbicides are also not considered necessary after establishment due to the competitiveness of grass crops.

4.35. Several consultees mentioned that greater investment should be made in plant and equipment and management practices that lighten the impact of harvesting machinery on soils. Related concerns were also expressed by the Council for British

Archaeology regarding the potential damage from machinery and roots breaking up the structure of buried archaeology.

4.36. Energy crops and SRC were recognised as having the potential to reduce soil erosion and sedimentation in areas which are prone to flooding or erosion. However several consultees raised concerns about water intensive biomass crops and SRC being planted on, or near, previously waterlogged soils (e.g. peats) where it could cause them to dry out leading to the oxidisation of organic material and the release of stored carbon. It was suggested that this impact could potentially be experienced over a much wider area than the actual cropped land.

Water

4.37. Several consultees highlighted that SRC and miscanthus can help to improve water quality as they require much lower inputs of fertilisers than traditional crops, resulting in less nitrate leaching. The crops can also be used as riparian buffers helping to reduce nutrient loads from agricultural runoff. There is also potential for the use of the energy crops for biofiltration and the treatment of waste waters, and bioremediation, i.e. the treatment of contaminated land. Again consultees noted the benefits of the substantial root mats of bioenergy crops and the potential for reducing soil erosion and the sedimentation of watercourses. Some concern was expressed that bioenergy crops such as SRC and perennial energy can have high water requirements, and this may have a significant impact in areas such as the South and East at risk of drought.

4.38. In terms of biofuel crops, it was suggested that if they replace current set aside or perennial grasslands then they could increase siltation and nutrient leaching. An increase in the areas of oilseed rape and sugarbeet was considered to be potentially negative as both require large amounts of fertiliser. Wheat was noted for its high water requirements, however it was recognised that wheat for bioethanol have lower nitrate requirements than high protein wheats and therefore there is less potential nitrate leaching.

4.39. In summary SRC, SRF and grass perennials were seen has having the greatest potential benefits in relation to water resources compared with biofuels. The NFU also stated that producer investment in precision farming technology should better equip farmers for more precise targeting and application of plant nutrition and crop protection products, reducing the chance for nitrates to leach into the water.

Landscape

4.40. There were mixed views on the potential impacts of bioenergy crops on the landscape. Generally it was agreed that bioenergy can have positive impacts on the landscape but it depends on where the crop is planted, how it is planted, and its scale and size. If miscanthus replaces maize then it was suggested that the landscape impacts would be insignificant.

4.41. Many consultees noted the importance of undertaking appropriate assessments prior to the planting of any crops and that due consideration is given to issues such as landscape character, landscape features and landform. Dorset County Council has recently commissioned a study to identify the landscape sensitivity of different landscape areas within Dorset to bioenergy. Natural England is also discussing how to map the impact of bioenergy on the landscape with the aim of producing better guidance.

4.42. In terms of those landscapes where bioenergy may not be appropriate, it was suggested that energy crops may not be suitable in some traditional small scale farming landscapes - e.g. pastoral landscapes or in historic landscapes where the planting of a taller woody crop could result in the obscuring of traditional features such as hedges and walls. However it was noted by Natural England that existing arable and improved grasslands are more likely to be targeted, and are more likely to be suitable in landscape terms.

4.43. Other potential negative impacts included the occlusion of views from public footpaths, the movement of large vehicles along narrow country lanes and concerns over the spread of monocultures and non-native species such as miscanthus and eucalyptus.

Archaeology

4.44. The Council for British Archaeology noted that they are concerned about the potential impact on buried archaeology, especially on land that has been permanent grassland or subject to shallow cultivation. In particular, damage below traditional 'plough soil level' (often 8-10") risks disturbing virgin soil containing archaeology. Mechanical ground preparation, especially sub-soiling in preparation for planting SRC and miscanthus, and the mechanical removal of miscanthus rhizomes and SRC stools at the end of cropping period and (in case of miscanthus) for propagation, were highlighted as potential concerns. Due to roots breaking up the structure of buried archaeology, willow and poplar were considered to be the most damaging due to their root depth.

Other environmental issues

4.45. Several consultees commented on the potential negative effects on air quality. Comments from the Centre for Ecology and Hydrology pointed out the lack of research and knowledge on the wider chemical / climatic effects of crop production. It was noted that an increase in the production of bioenergy could lead to the greater production of Volatile Organic Compounds (VOCs), which all plants produce, and are known to be indirect greenhouse gases which act by producing organic aerosols in the atmosphere, like ozone.

4.46. The Environment Agency also highlighted that certain species of trees produce higher levels of isoprenes and monoterpenes, which are also thought to be the precursors to ground level ozone creation. This issue therefore also has implications for the production of SRC and SRF and is being looked into by the FC.

4.47. Most of the consultees agreed that there needs to be some form of carbon / energy lifecycle analysis in order to identify the most the environmentally appropriate options. A further issue raised by several consultees is that there should be a requirement for bioenergy crops to be grown organically. This would fit in with the general ethos of it being a sustainable form of energy. If fertilisers derived from petrochemicals are used, then that will not aid the carbon footprint/use of fossil fuels. An organic approach would also enhance the benefits for biodiversity.

Conclusions on which form of bioenergy has the potential to deliver the greatest benefits

4.48. Consultees highlighted that this was a complex question and it was difficult to generalise with so many different crops and production methods. The majority of consultees thought that there was still a lack of effective methods of assessing the overall net environmental benefits of each bioenergy crop, and that there was a need to take a neutral perspective.

4.49. Despite this, most consultees favoured the extensive low impact management of existing woodlands and forests. Forest residues and other wood industry by-products such as sawdust and slabwood were cited as being the most likely to deliver the greatest environmental benefits as biofuels. Similarly, excess straw from agricultural enterprises was highlighted as a potential low-impact biofuel.

4.50. Biomass from SRC and SRF were thought to deliver greater energy savings than transport biofuels and, depending on scale, were believed to be the best form of new planted bioenergy crops. However, consultees emphasised the need to take careful consideration of the scale and location of new plantings, particularly in terms of their impacts on, or the loss of, existing land uses.

4.51. Of the energy grasses, miscanthus and reed canary received most mention. However, most consultees felt that more research is needed to prove their effectiveness and understand the potential impacts of large scale planting.

4.52. Several consultees believed that a mixture of bioenergy crops could offer a range of benefits. The Environment Agency suggested that government should be promoting a transparent system where information is available on which fuels and supply chains offer the greatest net environmental benefits. At present, landowners and managers can choose themselves which crops to grow, with Defra encouraging both biomass and biofuel production.

National and regional policy initiatives and assurance

General Governmental policy

4.53. Most consultees felt that a strategic approach was needed to address the fragmented bioenergy sector, creating a framework to guide the number of policies and strategies already in place for encouraging appropriate planting, and links to local demand. Some felt that this overarching framework should be steered from a national level, filtering down through regional policy. Landscape assessments should then be used as an effective tool for selecting appropriate locations for planting. The need to get incentives right and give a clear lead early on was advocated.

4.54. Several consultees thought there should be EIAs for any significant energy crop production proposals, with the suggestion that an EIA scheme similar to that in place under ECS would be appropriate.

Research

4.55. Several consultees pointed out the need for more research to assess the nature and location of land available and suitable for bioenergy crop planting. Funding should be provided for appropriate feasibility studies and landscape character assessments to be undertaken specifically looking at the impacts of bioenergy planting. Several consultees made reference to the Defra Environmental Constraints Mapping project which could be an effective tool for this.

Assurance schemes

4.56. Opinions were split on the application of assurance schemes to the bioenergy sector. A number of consultees argued against placing too much of a regulatory burden on the industry at this early stage. Reinforcing this point, the NFU felt that existing measures under cross compliance were already delivering high environmental standards, and that the majority of biomass is likely to be planted on farms that are already in crop assurance schemes. They felt that another scheme would lead to *'further additional bureaucracy for bionenergy production'*. Defra also echoed this view, quoting the Assured Combinable Crop Scheme (ACCS), UK Forestry Standard and the Responsible Palm Oil Partnership as successful schemes already in place. They did, however, note the current lack of assurance schemes for sugar beet, which is currently being looked into by the HGCA. Both the Wildlife and Woodland Trusts also raised concerns over the effectiveness of ACCS (which is likely to be used by most bioenergy crop producers) in terms of its environmental coverage.

4.57. Other consultees such as Natural England believed that bioenergy is already a big enough sector to warrant its own Assurance Scheme, whether at EU or UK level. The Environment Agency highlighted the need to take account of entire bioenergy lifecycle with a national or international methodology allowing comparable analysis of greenhouse gases and other environmental impacts for different types of crop.

4.58. Many consultees suggested building on the existing UK Woodland Assurance Scheme (UKWAS) to incorporate bioenergy crop production. This could be used to provide assurance that the timber used to produce the bioenergy is from sustainably managed woodlands. One drawback of UKWAS is that whilst it does cover small woodlands, work is currently being undertaken to make it more appropriate to smaller woodland sites. It is anticipated that the revised guidance will be published within the next year or two.

4.59. In terms of the nature of an assurance scheme for bioenergy producers, the Woodland Trust suggested that there could be different tiers of compliance. They also highlighted the need for market incentives for producers – without which an assurance scheme would not be successful. The Trust also emphasised the need for the enforcement of any assurance scheme – guidance and legislation alone would not be sufficient.

Carbon standards

4.60. Natural England pointed out that the Biofuels Directive's main aim is to reduce carbon emissions, and there therefore needs to be an assessment of the entire carbon cost of biofuels from growth, through processing to burning. Other consultees agreed – suggesting that this approach would prevent the establishment of systems that would release higher net greenhouse gases from production compared to those that are saved.

4.61. Several consultees mentioned the draft environmental standards for biofuels, which was commissioned by the LowCVP and is previously discussed in **Chapter 2**. HGCA noted that field trials tackling carbon accreditation were underway and likely to be adopted into ACCS. These have involved carbon questionnaires being completed on all farm management processes, allowing the assessment of GHG production.

4.62. Econergy mentioned the need for fuel quality standards, in particular for biomass heat and power. Most current boilers (most of which are imported) are dictated by Austrian standards that lack mention of heavy metals and particle size emissions.

4.63. Consultees noted there is a strong international incentive to undertake such assessments, such as targets under the Kyoto Protocol. The question of whether this should be implemented at a government or market level was uncertain.

Other policy measures

4.64. Many consultees pointed out the need for widely publicised and readily available best practice guidance on all aspects of the bioenergy sector.

4.65. The Council for British Archaeology advocated the need for guidance that incorporates the need for early advice to farmers on the presence of archaeological features on proposed planting sites. They stated that this should be undertaken at the first stages of a proposal, before consultation on grant applications.

4.66. Finally, several consultees believed that the government should lead by example and fit public buildings with biomass heating systems.

5. CONCLUSIONS AND RECOMMENDATIONS

INTRODUCTION

5.1. The following chapter sets out the conclusions and recommendations that have been drawn from the findings of the study outlined in **Chapters 2-4**.

5.2. The threat of climate change is the key driver behind the development of renewable energy. Faced with the problem of global warming, the UK Government has pledged to reduce national CO_2 emissions by 60% by 2050 and generate 10% of our electricity from renewables sources by 2010, increasing to 20% by 2020. To meet these targets, it is anticipated that 1 GW of electricity will need to be generated from biomass sources. The current available resource of straw, waste wood and woodfuel could potentially meet the 1 GW target, although not by 2010. Similarly current oilseed rape and wheat production could potentially achieve the target of supplying 5% of transport fuels by 2010. However, in the longer term (to 2020 and beyond), greatest potential comes from the emerging conversion technologies that could see the priority move to biomass crops with large increases in the area of short rotation coppice, miscanthus, and the use of forest residues and low grade timber.

5.3. Substantially increasing the production of bioenergy from agricultural and forest resources offers real potential to reduce greenhouse gas emissions. However, it also has the risk of placing environmental pressures on our limited natural resources, unless there is strong political support for obtaining much of this energy from the management of existing woodlands. The extent of these pressures will depend on how the market and production of bioenergy develops and in particular what types of crop are grown, how the crops are managed, what kind of landuse they replace, the proportion of energy that comes from the management of the existing woodland resource, and the size and location of the processing/ generation plant.

5.4. Wildlife and Countryside Link support the development of the bioenergy industry and believe that it has the potential to make a substantial contribution to the renewable energy mix and deliver wider environmental priorities. However to realise these opportunities, it must be produced sustainably – with real carbon savings, avoiding negative impacts on the natural and historic environment and wherever possible delivering positive environmental benefits. To realise these goals however requires action at the national, regional and local level.

CONCLUSIONS AND RECOMMENDATIONS

Principle 1: Delivering Sustainable Bioenergy

Key Outcomes for Sustainable Bioenergy Development

Bioenergy developments *should*:

Woodlands and semi-natural habitats

- **assist in converting Plantations on Ancient Woodland Sites (PAWS) back to semi-natural woodland** through the gradual removal of conifers;
- **facilitate the restoration of certain priority non-woodland habitats** such as heathlands, moorlands and unimproved grasslands through the removal of trees as appropriate.
- **seek to reinvigorate the sensitive management of the semi-natural woodland resource,** with woodland management guided by Woodland Management Plans, that take account of potential environmental impacts including conservation of archaeology and specific species.

Bioenergy crops

- **ensure that the scale and location of planting is appropriate** both in terms of its impact on landscape character and the environment;
- **be managed in ways that have been demonstrated to benefit biodiversity** e.g. including the establishment of rides, conservation headlands and retention and creation of boundary hedgerows;
- **increase habitat and landscape diversity through the use of different varieties and age stands of crops** to avoid extensive monocultures that are both highly visible in the landscape and of lower biodiversity value;
- **use native species or species traditionally used in the UK,** to maximise the benefits for biodiversity;
- **maximise the opportunities for buffering, extending and relinking vulnerable semi-natural habitats;**
- **maximise carbon savings and benefits for biodiversity and water quality by minimising the use of fertilisers, herbicides and pesticides.** Where inputs are required, organic fertilisers should be used to reduce the carbon-footprint;
- **maximise the opportunities for community involvement and public access.**

Bioenergy developments *should not:*

- **be located in environmentally sensitive areas** such as wetlands, wet meadows, extensively managed semi-natural grassland or scrub and marginal habitats;
- **replace, or be maintained on, land uses that are known to support greater levels of biodiversity** (e.g. semi-natural/ priority habitat) or areas which have the potential to be **restored** to these habitats;
- be grown in locations which could:
  - adversely affect **soil structure** or increase **erosion and sedimentation;**
  - lead to a negative impact on the **carbon balance** (because of the presence of high carbon soils);
  - adversely affect the **quality or quantity of water** resources and the **biodiversity of aquatic environments;**
- involve the **use of any GM strains** to minimise the risk of contamination.

Wildlife and Countryside Link recommend that all plans, programmes and projects for bioenergy should, be consistent with, and seek to deliver the key outcomes outlined above.

Action: As a priority, the Government should ensure that any emerging national bioenergy plans and programmes such as those outlined below are consistent with the principals of sustainable bioenergy development as summarised in the key outcomes.

- **The forthcoming UK Biomass Strategy (which Defra is due to publish in 2007).**
- **The revised energy crops scheme (which will be introduced by Defra under the new Rural Development Programme in 2007).**
- **The Scottish Biomass Action Plan and Scottish Biomass Support Scheme (which is being prepared by the Scottish Executive and is due to be published in early 2007).**
- **The Renewable Energy Transport Obligation (which is due to come into effect in April 2008).**
- **The Woodfuel Strategy and Implementation Plan (which is due to be published by Defra/ Forestry Commission in 2007).**

5.5. In the UK much of our biodiversity is closely associated with both our agricultural systems and our semi-natural woodland resource. Over the last century these have suffered very different fates, both to the detriment of landscape and biodiversity. Our agricultural systems have been greatly intensified through increased mechanization and the application of greater quantities of chemicals. As a result many species of farmland birds, butterflies and plants having declined dramatically over the past 30 years. Landscapes, water quality and soil health have been adversely affected by intensive agricultural practices. Conversely, the majority of our semi-natural woodland resource has fallen out of management with the loss of markets for low grade timber. This has resulted in a loss of structural diversity, a significant reduction in woodland biodiversity, and a decline in species adapted to traditional woodland management cycles. This existing semi-natural woodland resource offers a significant opportunity for the sustainable development of bioenergy. There is also the potential through sustainable cropping to enhance biodiversity and landscape by restoring Plantations on Ancient Woodland Sites – that is ancient woodland sites that were clear felled and planted with conifers, back to their original semi-natural woodland form.

5.6. Developing sustainable bioenergy production therefore faces two significant challenges:

- to make positive use of the existing woodland resource which is currently economically dormant, thereby bringing positive benefits for landscape and biodiversity, as well as contributing to renewable energy production by utilizing an existing and currently undervalued resource;
- to assist in reversing the agricultural decline in biodiversity by accommodating the introduction of new bioenergy crops which clearly adopt environmentally sustainable farming practices. Management practices for bioenergy crops must minimise any adverse impacts on the environment whilst enhancing any positive benefits, if mistakes of the past are to be avoided.

5.7. Based on the evidence set out in this report, to encourage the development of a sustainable bioenergy industry, Wildlife and Countryside Link recommend that the key outcomes outlined above should inform future bioenergy policy, programmes and projects. With the Government due to publish a number of a plans and programmes on bioenergy in the near future, it is essential that these documents and initiatives are based on the principles of sustainable bioenergy production and use.

Principle 2: Maximising Carbon Savings

Wildlife and Countryside Link recommend that increased Government support should be given to those technologies and forms of bioenergy that maximise green house gas savings whilst protecting and enhancing the environment.

Action: It is recommended that the DTI/Defra should provide clear guidance on the carbon savings associated with each form of bioenergy, including the various production pathways. This guidance should be used by the Government to redress the balance between heat, fuel and power in the forthcoming Biomass Strategy. If, as existing studies suggest, biomass holds greater potential for carbon savings per hectare of cultivated land and has the ability to deliver greater environmental benefits, the Government should prioritise the production of biomass over arable biofuels. Likewise the Strategy should reflect the greater carbon savings that can be offered by biomass heat.

As biomass heat has the potential to deliver the greatest carbon savings, the Government should urgently review the support measures available for biomass heat projects (such as the Renewables Heat Obligation (RHO)). The development of any support programmes should however be based on a comprehensive understanding of their social and environmental impacts, bearing in mind that we have a finite land resource.

5.8. The main driver behind the move towards the greater production and use of bioenergy is to reduce carbon emissions. Bioenergy holds significant potential for carbon savings as a source of heat, electricity and biofuels. Recent studies have indicated that the greatest potential green house gas savings can be gained through the use of biomass as a source of heat, the gasification of biomass to produce electricity, and the use of second generation biofuels produced from biomass. If the Government is to meet its ambitious targets for renewable energy and carbon savings, then biomass must be exploited to its full potential. It is therefore essential that full government support is given to the development and uptake of the most efficient technologies. With their superior carbon savings it is suggested that the Government should increase its support for renewable heat and second generation biofuels technologies.

5.9. It is also apparent that some forms of bioenergy can produce greater carbon savings than others. In a recent assessment undertaken by English Nature (2006), it was calculated that growing a mixture of sugar beet, oilseed rape and wheat over 1 million hectares could potentially reduce UK GHG emissions by 2.5 million tonnes per year. This is equivalent to 0.37% of the total UK greenhouse gas emissions for 2003. In contrast, an area of just 0.5 million ha of willow SRC could reduce around 5 million tonnes of CO_2 per year, or 0.75% of total UK emissions. Studies therefore appear to indicate that biomass crops can save significantly more GHG emissions per hectare than arable biofuels. This was also reiterated in the recent EFRA Committee report (2006) which noted that, in their current state of development and with limitations on land capacity in the UK, existing biofuels produced from crops such oilseed rape and wheat do not present the most effective or efficient way of making a significant difference to the UK's carbon emissions in the long term.

5.10. Whilst a number of studies have been undertaken looking at the potential reduction in greenhouse gas savings associated with different sources of bioenergy and using different production pathways, there appears to be considerable variation in the results of these studies depending on the methodology and assumptions used. It is therefore recommended that the DTI/ Defra undertake a comprehensive review of the existing studies and where necessary commission research to plug any information gaps. Using the results of this review, the Government should publish guidance on the carbon savings associated with each type of bioenergy and form of production. This review will need to consider four key variables – what the crop is replacing, the initial soil carbon content, the form of biomass production and the conversion technology.

5.11. The review of the potential impacts of different sources of bioenergy in **Chapter 3** indicates that the impacts of growing biofuel crops are greater than for biomass crops. Biofuels crops such as oilseed rape, sugar beet or cereals require higher levels of fertilizer and pesticide inputs, are at higher risk of soil erosion and release higher quantities of soil carbon due to the frequent tillage of the crops, and do not deliver the same potential opportunities for conservation gains as SRC and the harvesting of low grade timber (as a stimulus to the reintroduction of woodland management). Whilst it is recognised that biofuels represent one of the few means of tackling carbon emission from transport, given the availability of land and the demands on it (both for food production and biodiversity), biomass production would appear to deliver greater benefits both in terms of carbon savings and environmental protection.

5.12. In summary therefore:

- within the bioenergy sector the greatest potential green house gas savings can be gained through the use of biomass as a source of heat, the gasification of biomass to produce electricity, and the use of second generation biofuels produced from biomass.
- biomass, and especially the management of the existing woodland resource, appears to be better for the environment when compared to the growing of biofuels.

5.13. Against this background, it is recommended that Government support for bioenergy should be contingent on rewarding those forms of bioenergy that deliver the greatest carbon savings and the best deal for the environment. At present, for example, there is very little Government support for the development of biomass heat and the Government has recently rejected calls for a Biomass Heat Obligation. A much more informed understanding of the most sustainable forms of bioenergy is therefore needed along with a clearer strategic support framework for their development. It is important however that the development of any future support programmes are based on a thorough understanding of the social and environmental impacts of any proposed programme.

Principle 3: Benchmarking and Environmental Assurance for Bioenergy

Wildlife and Countryside Link recommend that Government should work with industry to roll out assurance schemes to accredit all bioenergy feedstocks and processes to minimum standards of environmental practice. These should be based on industry quality assurance schemes where they exist, underpinned by a set of 'meta-standards' that ensure sufficient coverage across all feedstocks and all environmental domains. The energy generating sector should be required to report on the environmental and social sustainability of the renewable energy sources it uses, matching the requirement to be placed on the transport fuel sector.

Action: Work to develop sustainability standards for the biofuel supply chain (being led by the Low Carbon Vehicle Partnership) should be broadened to encompass protection of the historic environment and the visual landscape, ensuring that equivalent standards apply to feed stocks from all provenances.

In the absence of equivalent standards for biomass crops, Defra should commission work on sustainability standards for this sector, using the approach taken in the UK Woodland Assurance Scheme as the basis for this work.

OFGEM should require energy generators to report on the environmental and social sustainability of the renewable energy sources it uses to meet the Governments renewable energy targets, matching the requirement for the biofuels industry.

5.14. As already noted (paragraph 2.31), Government has required fuel suppliers to report on the carbon and wider social and environmental impacts of their biofuel supply chains each year. The background to this is the concern that has been expressed by NGOs and others over the negative environmental and social impact of some biofuels grown outside the EU (such as palm oil production in South East Asia) and of the high carbon cost of importing this. There appears to be less concern about the environmental impact of biofuel crops in the UK, at least under current conditions. However, should the area of biofuel crops grown in the UK increase beyond current projections (those needed to meet the 2010 Renewable Transport Fuel Obligation target), particularly to take in land currently under permanent pasture, the environmental implications of this increase could be significant.

5.15. It should be noted that the Government's requirement on the industry to report will simply records progress rather than requiring that supply chains meet minimum standards. Crucially, in relation to the biomass sector, there is no similar reporting requirement on the electricity generating sector (i.e. OFGEM do not require any such report through the Renewables Obligation Certificates).

5.16. The need for a more rigorous benchmarking approach for biofuels and the whole biofuel supply chain has been recognised. The research commissioned by Government and the Low Carbon Vehicle Partnership (LowCVP)[30] has proposed a methodology for drawing up standards for the production of biofuels that would apply across the globe. This methodology proposes 14 basic (i.e. baseline) criteria under the headings of six principles of conservation of carbon; conservation of biodiversity; sustainable use of water resources; soil fertility; good agricultural practice; and waste management. The methodology also suggested four enhanced criteria that could be used to identify biofuels produced to more exacting environmental standards. These standards do not cover social sustainability issues, nor do they address conservation of the historic environment. They can be considered relatively weak on impacts to the visual landscape. Nor are they intended to cover forestry management systems (although several of the principles and criteria could apply to these systems).

5.17. There is a close relationship between the existing crop assurance schemes operating in the UK and those proposed by the LowCVP study. One of the requirements of the study was that the proposed methodology should build on and not replace existing standards and schemes. The large majority of the current UK area of both crops that are expected to supply most of the UK's biofuel domestic production (oilseed rape and wheat) is already assured under the baseline Assured Combinable Combinable Crops (ACCS) scheme. The LowCVP study notes that ACCS already meets seven of its 14 basic criteria and provides partial compliance with a further six (the criteria on safe storage and segregation of waste is not addressed). The study also notes that all 14 of the basic criteria are met by the Linking Environmental and Farming (LEAF) standards adopted by a minority of UK growers. The study made no cross-referencing to any of the organic production standards.

5.18. Work to take forward these proposals for accreditation of UK grown biofuels is ongoing through a large stakeholder group. Previously referred to as environmental and social standards, these are now being called 'sustainability standards'.

5.19. There is much less activity taking place in relation to accreditation within the biomass supply chain. There has been discussion within the UK biomass sector about the benefits of a scheme to assure the quality of planting material supplied to growers (for instance certifying varietal quality, vigour of planting material, etc). The Biomass Task Force has recommended that the European standards which are being developed (CEN TC 335 for solid biofuels and CEN TC 343 for solid recovered fuels from waste) are adopted as the basis for the UK standard for these crops. However these European standards will concentrate on the physical and chemical composition of the fuel rather than the way it is produced and transported and will therefore be of less relevance to the accreditation of environmental practices.

[30] ECCM *et al,* (2006), Draft Environmental Standards for Biofuels. The Edinburgh Centre for Carbon Management, IIED, ADAS and Imperial College.

5.20. The UK Woodland Assurance Scheme (UKWAS) which is itself accredited by the international Forestry Standards Council provides the closest applicable model for benchmarking the production of SRC, SRF, forest arisings and low grade timber, but would be much less relevant for miscanthus. The guidance provided by the Forestry Commission on the growing of biomass crops (Forestry Commission, 2002) is also relevant. It is understood that the Environment Agency's Biomass Assessment Tool (BEAT) considers some of the environmental impacts of biomass production. From a regulatory point of view, the Environmental Impact Regulations place obligations on growers planning to convert uncultivated land to biomass production. Looking to the future and the likely scale of change in the area of biomass crops, there is a need to build on this work and develop a benchmark for the entire biomass supply chain to work to.

5.21. Consultees to this study emphasised that it will be important that any accreditation scheme is able to balance 'global' sustainability benefits (which can be defined in terms of lower carbon emissions and more equitable trading relations) with more 'local' sustainability impacts (which can be defined in terms of effects on biodiversity, natural resources, landscape, the historic environment, the viability of local supply chains, etc).

5.22. There is also a need to ensure that obligatory standards applied to growers and processors are proportionate and based on measured risks. The costs of administering an accreditation scheme can be significant and, as experience in the food sector demonstrates, the burden is often felt more by smaller businesses than larger ones. If there is a general principle that energy crop production should take place as close as possible to their processing plants and that, in landscape terms at least, smaller blocks are to be preferred to larger ones, it will be important to ensure that the cost and management time needed to meet accreditation standards does not disadvantage smaller producers or simply export energy production to other countries that are subject to less rigorous standards.

Principle 4: Promoting Small Scale Bioenergy Schemes

Wildlife and Countryside Link recommend that small scale local uses of bioenergy should be actively promoted as they provide greater opportunities for creating local bioenergy markets that are compatible with the protection of the local environment.

Action: It is recommended that the DTi and Defra should reaffirm their commitment to small scale projects by providing the necessary support and funding for a co-ordinated one-stop shop support and advice service for community and domestic renewables in England and Wales. This could be achieved through an expansion of the role and remit of existing programmes such as the Community Renewables Initiative.

5.23. As outlined in **Chapter 2**, the relatively high cost of transporting biomass crops means that crops are likely to be clustered around the energy plants. Although developments in primary processing of cropped material into denser pellets could see these transport distance lengthen, it is likely that large generating plants would result in upwards of 10% of the available agricultural land area used for energy cropping. This in turn could lead to the establishment of homogenous intensive agricultural landscapes which may in some cases have a significant negative environmental impact. It is therefore recommended that efforts should be made to promote small-scale use of bioenergy with farmers assisted in creating local bioenergy markets that are compatible with their local environment. This will have additional benefits of:

- reducing the need for long distance transportation of feedstuff;
- minimising the industrialisation of the countryside;
- reducing tranmission losses;
- improving public acceptability - with people connecting more closely with their energy supply.

5.24. Importantly, small scale bioenergy schemes may provide the best approach for bringing the existing semi-natural woodland resource back under management, with all the attendant environmental benefits that this could provide.

5.25. There are a number of existing initiatives which seek to encourage the development of small scale renewable energy scheme. The main programme is the DTi's UK-wide **Low Carbon Buildings Programme (LCBP)** which started on 1 April 2006 and supersedes the previous Clear Skies Initiative and Solar PV programmes. The new scheme provides grants for microgeneration technologies for householders, community organisations, schools, the public sector and businesses. A number of renewable technologies are supported, including biomass-fuelled stoves for space heating, central heating and hot water systems, Renewable CHP and MicroCHP.

5.26. The demand for the Low Carbon Buildings Programme has been significant with the £3.5m first year budget of the domestic stream of the Low Carbon Buildings Programme being fully allocated six months before 2007's funds were due to be made available. To meet this funding gap, in October 2006, the Government re-allocated a further £6.2m of the programme funding to the householder workstream.

5.27. In Northern Ireland, a £60million **Environment and Renewable Energy Fund** was announced by the Secretary of State in February 2006. £35m of this fund is being channelled into the Accelerated Deployment Programme which aims to achieve a step change in the use of renewable sources to provide heat, light and power requirements in domestic dwellings, commercial premises and public sector buildings. This includes providing grant assistance to householders, schools and other public sector organisations for renewable energy systems.

5.28. In addition to the Low Carbons Building Programme there is the **Community Renewables Initiative (CRI)** (covering England), the **Scottish Community and Householder Renewables Initiative** (SCHRI) and the **Action Renewables Programme** (covering Northern Ireland). These programmes seek to provide support and advice for community groups (and in Scotland and Northern Ireland communities and households) to help them devise and implement renewable energy developments in a sustainable and beneficial way.

5.29. The Community Renewables Initiative (CRI) was set up as a pilot scheme by the Countryside Agency in March 2002, to provide an expert advice and support service to communities wishing to develop local renewable energy projects. The scheme facilitates projects at a local and regional level through a network of ten Local Support Teams (LSTs) covering almost 70% of England. Work to date has been mainly funded by the DTI, Defra, Countryside Agency, and Forestry Commission, with each local support team receiving just under £35,000 per year in government funding. Between Spring 2002 and Autumn 2005, the CRI dealt with around 3700 enquiries, averaging around 1000 a year. Current enquiry levels are averaging at around 2000 a year. The pilot is however due to cease in March 2007 and there remains much uncertainly regarding future funding for the programme.

5.30. In Scotland the SCHRI is jointly run by the Energy Savings Trust and Highlands and Islands Enterprise (HIE) on behalf of the Scottish Executive. SCHRI is a one-stop shop offering grants, advice and project support to assist the development of new community and household renewable schemes in Scotland. The objectives of SCHRI are to support the development of community scale renewable projects; to support the installation of household renewables and to raise awareness of renewable technologies and their benefits to Scotland. A similar programme is in operation in Northern Ireland. The Action Renewables Programme in Northern Ireland is funded by the Department of Enterprise Trade and Investment (DETI). The programme provides an advisory service to a wide range of organisations and individuals such as householders, schools, community groups, local authorities and other non-for-profit organisations etc. Funding for this programme has been secured until March 2008.

5.31. There is real concern that the DTi in their quest to meet the Government's renewable energy targets are prioritising funding and resources for large scale renewable energy projects to the detriment of small scale renewable programmes. Whilst grants for small scale schemes are being made available through the LCBP, this programme does not provide advice and support for those seeking to design and install renewable schemes which is the key service provided by the CRI and SCHRI and Action Renewables. Funding has been secured for the SCHRI in Scotland and the Action Renewables Initiative in Northern Ireland, but there is no co-ordinated programme available in Wales. The CRI in England also does not cover household projects and the future of this programme is in question as no funding has been secured beyond March 2007. It is therefore recommended that Defra and the DTi should set out a clear strategy and funding stream for providing a co-ordinated support service for small scale renewable schemes in England and Wales. This could be achieved through the development of a successor programme to the Community Renewables Initiative which provides an independent advice service to households, community groups, local authorities, farmers and SMEs throughout England and Wales.

Principle 5: Exploiting Environmental Synergies

Wildlife and Countryside Link recommend that the development of bioenergy should be encouraged in ways that maximise the contribution made to other environmental priorities such as the UK Biodiversity Action Plan, the Water Framework Directive, the EU's Thematic Strategy for Soil Protection and delivery of the European Landscape Convention.

Action: It is recommended that Natural England, SNH, and CCW undertake a detailed review of the potential impacts and benefits of bioenergy production for the various Habitat Action Plans (HAPs) and Species Action Plans (SAPs). This may require further primary research, particularly for those crops such as miscanthus where existing information is limited. Following this review, a guidance note should be produced summarising how any negative impacts of bioenergy energy production can be avoided and how bioenergy could contribute towards the delivery of HAP and SAP targets. This habitat and species-specific guidance should be disseminated widely and used to inform the preparation of Local Biodiversity Action Plans (LBAPs).

It is recommended that the Environment Agency and the Scottish Environmental Protection Agency should actively explore the opportunities for using bioenergy production to meet the objectives set out in the Water Framework Directive. This will include identifying scope in the forthcoming River Basin Management Plans (which are due to be prepared 2007-2009) to create zones where bioenergy can be used to reduce nitrate levels and alleviate flood risk. It is also recommended that DEFRA should review the opportunities for bioenergy to contribute towards the delivery of the EU's Thematic Strategy for Soil Protection.

Finally, it is recommended that Natural England, SNH and CCW should develop landscape guidelines on how to address the potential landscape effects of bioenergy production on different landscape types, indicating key sensitivities and landscape opportunities. Landscape sensitivity studies should inform Strategic Guidance and Opportunity Statements for Bioenergy (as recommneded in Principle 5) assessing the sensitivity of different landscape typologies to different types of bioenergy production.

5.32. It is important that the policies put in place to deliver climate change targets, such as the promotion of bioenergy, does not reduce our ability to meet other environmental targets such as the Water Framework Directive, the UK Biodiversity Action Plan, the EU's Thematic Strategy for Soil Protection and our commitments under the European Landscape Convention. This study has found that rather than reducing the potential to meet these targets there are clear opportunities through the production of certain forms of bioenergy to positively contribute to these wider environmental priorities. As previously outlined, the development of short rotation forestry has the potential to encourage native broadleaf woodland which in turn can help deliver Habitat Action Plan (HAP) and woodland creation targets, and with careful planning can also make a positive contribution to landscape character.

5.33. Developing a market for the use of Low Grade Timber from existing woodland has great potential to encourage the management of the existing semi-natural woodland resource for the benefit of biodiversity (and the meeting of Biodiversity Action Plan targets) and landscape and could be used as an incentive to convert PAWS back to their previous semi-natural character.

5.34. In terms of the Water Framework and soil protection, the planting of SRC or woodland in the right locations can help to stabilize soils, reduce erosion, minimise nitrate pollution and alleviate flooding. In conclusion, if established and managed appropriately, bioenergy has the potential to create a market that delivers a range of wider public benefits.

5.35. At present however (other than a wide range of studies on the benefits of woodland management) there is little detailed research available on the means by which bioenergy can contribute towards the UK Biodiversity Action Plan targets, the conservation and enhancement of landscape character, soil protection and the Water Framework Directive. Further research is therefore required to ensure that the potential win-win opportunities for producing bioenergy whilst contributing to wider environmental objectives are realised.

Principle 6: Developing Strategic Spatial Guidance and Opportunity Statements for Bioenergy

Wildlife and Countryside Link recommend that detailed spatial guidance is prepared identifying the key constraints and opportunities for bioenergy developments at a sub-regional level.

Action: It is recommended that the DTI, DEFRA and Natural England should make funding available at a sub-regional level for strategic spatial assessments of the key constraints and opportunities for bioenergy development. This should lead to the publication of bioenergy opportunities statements which advise on the location and scale of opportunity for the establishment and management of bioenergy within a sub-region. A wide range of consultees including the Regional Government Offices, Regional Assemblies, Regional industry, government agencies and NGOs should be engaged in the studies.

The spatial assessments should consider the following key issues:

5. **The existing bioenergy resource within the area (i.e. woodland sites and their suitability for bioenergy production);**

6. **The key environmental constraints and opportunities for bioenergy crops in relation to:**

    - **landscape sensitivity -** i.e. undertake an assessment of the sensitivity of the landscape to bioenergy crops;
    - **biodiversity –** i.e. avoid environmentally sensitive areas such as designated sites and semi-natural habitats (including wetland, heathland and unimproved grassland) and identify opportunities for buffering, expanding and/or re-linking sensitive or fragmented habitats.

- **topography –** i.e. avoid steep gradients which may prevent access for planting and harvesting machinery;
- **geology and soils –** i.e. avoid best and most versatile land and identify opportunities for minimising soil erosion and sedimentation.
- **water –** i.e. avoid areas which may have a negative impact on water resources and identify opportunities to improve water quality and minimise flooding.
- **archaeology –** i.e. avoid impacts on sites or the setting of sites of archaeological or historical importance.
- **transport network –** i.e. assess the capacity of the existing road network to accommodate increases in traffic generation.

7. **The economic and market factors influencing the supply and demand for bioenergy in the area.**
8. **The scale of opportunity for bioenergy across the area, linked to land suitability, yield potential, sustainable management of natural resources and landscape capacity.**

Once prepared, the opportunity statement and accompanying constraints and opportunities mapping (in GIS format) should be disseminated widely to the bioenergy industry, local planning authorities and statutory and non statutory consultees.

5.36. It is apparent that there is little strategic spatial guidance available at a national, regional or local level on what types of bioenergy crops should be grown where and the key constraints and opportunities determining their suitability. It is understood that Defra is in the process of preparing a series of national opportunity and constraint maps for Bioenergy across the UK. These will highlight the broad areas where bioenergy production may be more problematic e.g. because of water constraints, and the areas of greatest opportunity. The maps are due to be published in early 2007.

5.37. These national maps will be broad and it is suggested that further detailed assessments are required at the sub-regional or local level. At a regional level, in 2001 the Government asked each region to set their own renewable energy targets, based on an assessment of the area's capacity to generate renewable energy. This led to the establishment of regional and sub-regional renewable energy targets, most of which have been adopted in the Regional Spatial Strategies and local development documents. Many of the regions are in the process of, or have completed strategies setting out how the regional targets are going to be delivered.

5.38. Planning Policy Statement 22: *Renewable Energy* (ODPM, 2004) allows regional planning bodies to identify broad areas at the regional and sub-regional level where the development of particular types of renewable energy may be appropriate. In response to this, several regional and sub-regional bodies such as the South West Regional Assembly have undertaken detailed resource assessments and capacity studies looking at where renewable energy (including bioenergy) developments can be accommodated. The parameters used in these studies vary but some have included assessments of the sensitivity of the landscape to accommodate bioenergy crops as well as other environmental issues.

5.39. It is suggested that greater efforts should be made to encourage regional and sub-regional authorities to undertake further detailed assessments of the constraints and opportunities for bioenergy developments within their area. It is envisaged that the results of the studies will have a number of potential benefits:

1) They will provide a source of strategic guidance for growers on what areas are likely to be appropriate or inappropriate for bioenergy development in terms of landscape sensitivity, archaeology, biodiversity, soil type and water resources etc.

2) They will provide an objective information baseline for local planners, statutory bodies and other stakeholders involved in the review of plans and/or EIAs for bioenergy crops (EIAs are required for biomass crops planted on semi-natural or uncultivated land and for SRC and miscanthus plantations over a certain size under the former energy crop scheme[31]).

3) They will enable local planners, statutory bodies and other stakeholders to proactively guide developers away from the most sensitive locations.

4) They may provide opportunities for the wider benefits of bioenergy to be maximised by identifying where bioenergy crops could contribute towards other environmental objectives such as reducing erosion, sedimentation or flooding or enhancing biodiversity.

5.40. It is recommended that funding for the development of Strategic Spatial Guidance and Opportunity Statements for Bioenergy should be provided by the DTI, Defra and Natural England. The DTI has historically made funding available to Government Offices and Regional Assemblies for studies relating to regional strategic planning and the delivery of sustainable energy agenda. It is understood that the DTI intends to withdraw this regional funding from April 2007. Given the importance the Government has placed in energy issues, including the development of the bioenergy industry, it is essential that the necessary funding is put in strategic spatial guidance for bioenergy based on a comprehensive understanding of the potential social, economic and environmental impacts.

[31] Defra have informed us that that the requirement for EIAs is likely to continue under the new energy crop scheme.

Principle 7: Disseminating Good Practice

Wildlife and Countryside Link recommend that the accompanying guidance *'Delivering Sustainable Bioenergy Projects: Good Practice Guidance'* (2007) should be disseminated to all those with an active involvement in implementing and regulating bioenergy projects.

Action: It is recommended that:

- **the guidance is endorsed by the statutory consultees (such as Natural England, Forestry Commission, Scottish Natural Heritage, Countryside Council for Wales, Environment Agency, Scottish Environmental Protection Agency and the Environment and Heritage Service (Northern Ireland));**
- **the guidance is circulated to the bioenergy industry via the Renewable Energy Association and the new Biomass Energy Centre which is being set up as a source of bio-energy advice and best practice for farmers, industry and the public.**

5.41. Wildlife and Countryside Link support the development of the bioenergy industry but advocate that the principles of sustainable land management practice should be used to maximise greenhouse gas savings while protecting and enhancing landscape, biodiversity, water quality and soils. To assist this, Widllife and Countryside Link have developed a good practice guidance document **-** *'Delivering Sustainable Bioenergy Projects: Good Practice Guidance'* (2007). To maximise the credibility and audience of this guidance it is recommended that the guidance is endorsed by the statutory consultees, and circulated via the industry trade associations and the new Biomass Energy Centre which is being set up by the Forestry Commission.

Principle 8: Research and Development

To inform the establishment of a strategic framework for the development of bioenergy and to monitor subsequent progress, Wildlife and Countryside Link recommend that further research and monitoring of the positive and negative impacts of bioenergy production and use should be undertaken as a matter of priority.

Action: It is recommended that Defra and statutory agencies such as the Forestry Commission, SNH, Natural England, SEPA, and EA should review the existing research gaps relating to bioenergy and commission further studies to ensure that the future development of the bioenergy industry is based on a thorough understanding of the key potential impacts and opportunities.

5.42. It is clear from the findings of the literature review and discussions with the expert consultees, that further research into the positive and negative impacts of bioenergy production and use is needed at a national level. The study has identified a number of notable information gaps including:

- **New crops:** There is limited information available on the potential environmental impacts of growing certain types of bioenergy crops in the UK such as miscanthus, reed canary grass, switchgrass, sorghum, linseed and sunflowers. For example, few studies have been undertaken in the UK looking at the potential impacts of mature stands of bioenergy crops such as miscanthus on biodiversity.

- **Management practices**: Further R&D is required on the management practices that can deliver both reductions in greenhouse gas savings and improve environmental sustainability of agricultural management.

- **Mammals:** very limited research has been undertaken looking at the impact of bioenergy crops on mammals.

- **Water requirements of energy grasses:** Few studies have been undertaken evaluating the water use of energy grasses and as such there is much greater uncertainty regarding their water consumption compared to traditional crops and SRC. This is of concern as water requirements for perennial energy grasses appear to be higher than that of traditional crops.

- **Landscape scale impacts:** No studies have been identified looking at the possible environmental impacts of bioenergy at the landscape scale. If the Government targets are to be met, very large areas of land will need to be used for growing biomass crops. This will inevitably have some effect on biodiversity at the landscape scale.

- **Regional impacts**: No comprehensive studies have been undertaken looking at the possible impacts on biodiversity of different types of bioenergy crops grown in different areas of the country, under different intensity levels and with different levels of inputs (i.e. fertilisers and pesticides).

- **Set-aside:** No detailed studies have been undertaken looking at the effects of replacing set-aside land with bioenergy crops. If large scale loss of rotational set-aside land is likely to occur then impacts on farmland biodiversity need to be predicted.

5.43. **Monitoring:** It is also suggested that a long term monitoring programme should be established with regular assessments reporting on the total area of land used for bioenergy; the type of land that is being replaced and indicators measuring the impacts on the environment, This will help to ensure the early identification of problems so that appropriate management and mitigation strategies can be put in place where necessary.

5.44. For all of the above it is clearly essential that the findings of any new research and monitoring work are quickly disseminated to the industry, growers and other relevant environmental agencies / bodies.

APPENDIX 1

References

APPENDIX 1: REFERENCES

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APPENDIX 2

List of Consultees

APPENDIX 2: LIST OF CONSULTEES

	Consultee	Organisation
1	Dr John Valentine	Institute of Grassland and Environmental Research
2	Dr Jon Finch	Centre for Ecology and Hydrology
3	Ian Tubby	Forest Research
4	Dr Simone Lowthe Thomas	University of Cardiff
5	Richard Tipper	Edinburgh Centre for Carbon Management
6	Alistair Dickie	Home Grown Cereals Authority
7	Sue Finley	DEFRA
8	Matt Georges	Environment Agency
9	Emma Jordan	Scottish Natural Heritage
10	Keith Kirby	English Nature – Woodland advisor
11	James Markwick	Natural England
12	Hilary Miller	Countryside Council for Wales
13	Tony Harris	Dorset County Council
14	Dr Rufus Sage	Game Conservancy Trust
15	Simon Pyror	Forestry Commission
16	Oliver Harwood	Country Land and Business Association
17	Chris Miles	Econergy
18	Peter Melchett	Soil Association
19	Guy Anderson	RSPB
20	Ian Woodhurst	CPRE
21	Tim Hodges	Woodland Trust
22	Frances Griffith	Council for British Archaeology
23	Nigel Bourn	Butterfly Conservation
24	Benedict Gove	Natural England
25	Nick Collinson	Woodland Trust
26	John Cousins	Wildlife Trusts
27	John Tucker	Woodland Trust
28	Guy Gagen	National Farmers Union
29	Professor David Poulson	Rothamsted Research
30	Rob Macklin	National Trust

APPENDIX 3

Consultation Proforma

APPENDIX 3: CONSULTATION PROFORMA

Land Use Consultants in association with the Kevin Lindegaard were commissioned in August 2006 by Wildlife and Countryside Link[32] to undertake a study looking at the potential environmental impacts of increased bioenergy production and use in the UK.

The study has three main aims:

4. To gain an informed understanding of the potential impacts of bioenergy production on the environment and the landscape.
5. To apply this knowledge to formulate policy recommendations which can be used to encourage the UK government and its associated agencies to pursue the sustainable production and use of biomass and biofuels.
6. To develop practical guidance for use by bioenergy developers and land managers on developing and implementing sustainable bioenergy projects.

As part of this study we are interviewing a range of key experts in the field of bioenergy including representatives from government agencies, the bioenergy industry and land management organisations. We are very grateful for your agreement to be interviewed as part of this study. A list of the questions that we would like to discuss with you is provided overleaf.

Scope of the Study
As you will be aware bioenergy can be generated from a number of different sources, from wood based fuels (e.g. short rotation coppice, forest residues), non-wood based crops (e.g. miscanthus, oil and cellulose crops) and animal waste. This study only considers the potential environmental impacts of bioenergy generated by wood based fuels and non-wood based energy crops (i.e. it does not cover bioenergy produced from animal waste). To aid discussions, a summary of the key forms of bioenergy that are covered in this study is provided in **Box 1** and **2.**

[32] Wildlife and Countryside Link brings together voluntary organisations concerned with the conservation and protection of wildlife and the countryside. Their members practise and advocate environmentally sensitive land management and food production and encourage respect for and enjoyment of natural landscapes and features, the historic environment and biodiversity. This project is being steered by a sub-group of Link members on behalf of the Link membership including representatives from Butterfly Conservation, the Wildlife Trust, Campaign to Protect Rural England, the Royal Society for the Protection of Birds, the National Trust, and the Woodland Trust.

Box 1: Bioenergy sources primarily used to generate heat and electricity

Wood based fuels

- ***Short Rotation Coppice*** (SRC): densely planted, high yielding varieties of either willow or popular harvested on average every 2-5 years.
- ***Short Rotation Forestry*** (SRF): plantations grown at such a spacing that they quickly fill a site and are felled when the trees reach a size that is easily harvested and handled. Varieties may include alder, ash, birch, poplar, eucalyptus, sycamore etc. SRF plantations are typically grown for between 8 and 20 years, much shorter than traditional forestry practice, but much longer than SRC.
- ***Forest Residues:*** poor quality stemwood, stem tips, branches and aboricultural cuttings obtained via the management and restoration of woodlands and other semi-natural habitats.

Non-wood based crops and residues

- ***Miscanthus*** *(Miscanthus sp.):* a woody grass from Asia. Once established it grows to 3.5m and can be harvested annually for at least 15 years. By the third year harvestable yields are between 10-13 tonnes per hectare. Peak harvestable yields of 20 tonnes per hectare have been recorded.
- ***Reed Canary Grass*** *(Phalaris arundinaceae*): a robust coarse perennial indigenous to the UK. It grows to between 60cm and 2m high and can be harvested 2 to 4 times a year. The life span of the crops is significantly shorter than miscanthus at around 5 years. Provides a quicker harvest and full yield, but is a lighter yielding crop than Miscanthus at about 12 tonnes per hectare.
- ***Switchgrass*** (*Panicum virgatum L.*): is native of North America It grows fast (up to 3m), producing high amounts of cellulose, that can be liquefied, gasified, or burned directly. Switch Grass has similar yields to Reed Canary Grass but has an extended life of up to 8 years' yield, compared to five years for Reed Canary Grass.
- ***Straw***: is produced as a by-product of a cereal crop grown for food. Varieties include wheat, barley and oats but could also include corn, maize, rye, etc. The UK produces around 15 million tonnes of straw each year of which approximately one half is used for animal feed and bedding. The remaining half could be used for energy production.

Box 2: Bioenergy sources primary used to produce transport fuels (i.e. bio-fuels)

Ethanol based fuels: Bioethanol refers to ethanol produced from biomass and/or the biodegradable fraction of waste, to be used as biofuel. The most common crops used to produce bioethanol are sugar beet, cane, sorghum, wheat, barley, rye, etc. In the UK, the crops used are sugar beet, wheat crops and sorghum.

- ***Sugar Beet*** (*Beta vulgaris*): is primarily grown in the UK for sugar production. Its cultivation for energy purposes is no different than for sugar production. It has a very good ethanol yield, as 1 hectare of sugar beet can be converted into 2,860 litres of bioethanol per year.
- ***Cereal Crops***: the term 'cereal crops' comprises triticale, wheat, rye and barley. Their production as energy resources is no different to their production for food purposes. The ethanol yield from wheat is however far lower than that of sugar beet, but it is still of value, as 1 hectare worth of wheat can be transformed into 1,344 litres of bioethanol per year.
- ***Sorghum*** (*Sorghum bicolor* (L.) [Moench.]): has the potential to be a major producer of bioethanol because of its high lignocellulosic mass, and its flexibility of adaptation to both tropical and temperate climatic regions, as well as areas with poor soils. It is thought that the potential bioethanol production from sweet sorghum will be realised within the next 5-10 years.

Oil based fuels: Biodiesel refers to the methyl-ether produced from vegetable or animal oil, of diesel quality, which can be used as biofuel. The most common crops used for producing biodiesel are oilseed rape, linseed and sunflower.

- ***Oilseed rape*** *(Brassica napus):* is the most commonly used crop for biodiesel production in the UK. 1 hectare of rapeseed can produce up to 1,350 litres of biodiesel per year.
- ***Linseed*** *(Linum usitatissimum)*: is an annual plant, with a fast stem growth (it can reach up to 1 meter in height). It has a yield of 1.7 tonnes/ ha, and the seed's oil content is around 38%.
- ***Sunflower*** *(Helianthus annus*): is not very well adapted to growing in the UK. Sunflower has a crop yield of around 1.7 tonnes/ha and one hectare of sunflower can produce around 1200 litres of biodiesel per year.

CONSULTATION QUESTIONS

When answering the following questions, we would be grateful if you could please be specific about what form of bioenergy you are referring to (i.e. see **Boxes 1** and **2**).

1. Please could you outline your involvement in bioenergy issues to date.

2. What do you think are main drivers behind the production and use of bioenergy?

3. Please could you summarise what you think are the key Government policy and/or fiscal support measures which will influence the future development of bioenergy in the UK? What impact do you think these measures will have on the level of biomass or biofuels produced and used in the UK?

4. What technological developments do you think could influence the supply and demand for bioenergy (e.g. new and improved technologies in crop breeding, farm management, harvesting, transportation and processing)? What impact do you think these technological developments will have on the scale and location of bioenergy produced and used in the UK?

5. To what extent can bioenergy production help contribute to the objectives of other policy measures e.g. Water Framework Directive, Biodiversity Action Plans (BAPs), carbon savings?

6. What are the potential **positive** impacts of bioenergy on:

   - biodiversity (habitats and species);
   - soil;
   - water;
   - landscape;
   - any other environmental issues.

   Where possible, please comment on the potential scale, location and timing of any impacts.

   Please also comment on what practical management measures could be used to enhance these positive impacts.

7. To what extent do you think there is scope for bioenergy production to:

   - reinvigorate the sensitive management and/or restoration of certain priority habitats e.g. ancient woodland, open habitats?
   - reduce the intensity of some land uses and aid the buffering and extension of vulnerable habitats?

8. Of the different forms of bioenergy listed in Boxes 1 and 2, which type(s) do you feel have the potential to deliver the greatest benefits for the environment?

9. What are the potential **negative** impacts of bioenergy on:

   - biodiversity (habitats and species);
   - soil;
   - water;
   - landscape;
   - any other environmental issues.

   Where possible, please comment on the potential scale, location and timing of any impacts.

   Please also comment on what practical management measures could be used to avoid or minimise these negative impacts.

10. What national or regional policy initiatives do you feel are necessary to minimise or enhance the projected negative and positive impacts of bioenergy production and use?

11. Do you think that an assurance scheme relating to the sustainable production of bioenergy is needed? If so, how would it work? Is there any scope to use any existing assurance schemes?

12. What affect do you think climate change will have on:

    a. the types of bioenergy crops that are grown in the future?

    b. the potential positive or negative impacts of bioenergy (as discussed in questions 6 and 8)?

13. What land use changes do you think an increase in bioenergy production will cause? What will be the impact on set-aside and the use of marginal land for production?

14. Are you aware of any existing research or information relating to the potential impacts of bioenergy on the environment? Please see Appendix 1 for a list of the literature gathered to date. Are there any key people you think we should be talking to?

15. Can you recommend any existing publications which include good practice management guidelines or measures relating to the sustainable production of bioenergy crops? As above, please see Appendix 1 for a list of the literature gathered to date.

16. Can you suggest any potential case studies examples which illustrate either good or bad practice on the sustainable production of bioenergy crops?

17. Are there any other key issues which you think this study needs to address?