Scottish Natural Heritage
Dualchas Nàdair na h-Alba
All of nature for all of Scotland
Nàdar air fad airson Alba air fad

Background to our Position Statement on Bioenergy and the Natural Heritage (August 2013)

Introduction

1. Bioenergy is produced whenever organic non-fossil material of biological origin is converted into energy. Several types of biomass, including forest products, crops, algae and residual organic waste are potential sources of bioenergy. Peat has been a form of biomass traditionally used for energy in some areas of Scotland, but the very slow rate of accumulation makes it in effect a non-renewable resource and unsuitable for extensive use as a source of bioenergy.

2. Biomass can provide a renewable source of energy (referred to as bioenergy) and help mitigate climate change. It has the potential to be carbon neutral depending on the way it is produced and in principle can reduce carbon dioxide emissions across all the energy sectors (electricity, transport and heat). Bioenergy does not have the disadvantage of intermittency associated with some other types of renewable energy. Interest in bioenergy is also being driven by concerns for energy security, and the desire for diversification in farming and forestry, and rural development.

3. Biomass can be used directly to generate heat or electricity - domestically in stoves or woodfuel boilers, or at a community/regional level in biomass electricity plants and Combined Heat and Power (CHP) schemes. Biomass materials (or feedstocks) can be used in co-firing in existing fossil fuel power stations and through the use of liquid biofuels in the transport sector. Waste to energy schemes can generate heat and/or electricity, either through thermal processes or anaerobic digestion, though the potential mixed nature of some wastes used (which can for example include plastics) means that this cannot always be classed as renewable. Some waste materials can also be used to produce biofuels.

Policy context

4. Climate change is acting as a driver to change energy generation and consumption patterns in Europe and around the globe. A central aim is to reduce greenhouse gas (GHG) emissions, especially carbon dioxide from the burning of fossil fuels. The UK Climate Change Act 2008 introduced a legally binding target of at least an 80% cut in greenhouse gas emissions by 2050. The Climate Change (Scotland) Act 2009 set a statutory target of reducing emissions by 80% by 2050. It also set an interim target for a 42% cut in emissions by 2020. Within this context, renewables have a key role to play in providing an alternative energy source. The 2020 Renewable Energy Routemap for Scotland established a target to generate the equivalent of 100% of Scotland's own electricity demand from renewable resources by 2020, along with at least 11% renewable heat.

5. A number of policy measures have been implemented to support the development of a bioenergy industry. The Renewables Obligation Scotland (ROS), which is the main driver behind renewable electricity development in Scotland, supports the development of dedicated bioenergy plants and co-firing with biomass. The Feed-in Tariffs (FITs) scheme, which was introduced to encourage deployment of additional small-scale (less than 5MW) low-carbon electricity generation, supports small scale electricity from biomass. In 2013, the government set the support level for woodfuel electricity in Scotland whereby wood-fuelled biomass stations with an installed capacity greater than 15MW will only receive support under the Renewables Obligation if they operate as combined heat and power (CHP) stations.

6. The Renewable Heat Incentive is a long-term tariff support currently targeted at the larger emitters in the non-domestic sector, and applies to a range of biomass-based heat technologies. A household scheme is also planned. Biomass is to play an important role in meeting the renewable heat target. In the Electricity Policy Statement, the Scottish Government advocates the deployment of biomass in heat-only or combined heat and power (CHP) schemes, generally prioritised in off-gas-grid areas, at a scale appropriate to make best use of both the available heat, and of local supply.

7. Capital grants schemes were made available over the last few years to support the establishment of heat installations. Grants to support the production of some bioenergy feedstocks are available under the Scotland Rural Development Programme. The Scottish Forestry Strategy set out the ambition to increase woodland cover in Scotland, from 17% to 25% by the second half of the century. Woodland expansion would increase the availability of a long term resource for woodfuel. Under Scotland's Zero Waste Plan, Scotland has a target of 70% waste recycling and a maximum of 5% to landfill by 2025 for all of Scotland's waste. The Plan encourages the use of residual waste for energy generation as part of its overall waste policy.

8. At the EU level, the Directive 2009/28 on the promotion of the use of energy from renewable sources requires that renewable fuels (including but not limited to biofuels) represent a 10% share of transport fuels (by energy content) by 2020. Under the Directive, only biofuels that fulfil sustainability criteria (outlined in article 17) and meet a minimum 35% GHG emissions reduction threshold (rising to 50% from 2017) are taken into account for compliance with the target. The structure of the target and GHG thresholds for new installations are currently under review. In addition, the Directive requires the Commission to develop a methodology to minimise GHG emissions caused by indirect land-use change (ILUC). A substantial amount of work has been carried out to model ILUC and several options have been discussed to address the problem. ILUC is the object of considerable debate and the introduction of a policy mechanism is still awaited. Policy mechanisms that aim to address ILUC may affect the respective share of different bioenergy feedstocks in the overall biofuel supply. The requirements for biofuels are implemented in the UK under the Renewables Transport Fuel Obligation (RTFO).

9. The Directive also requires that a sustainability scheme be considered for solid and gaseous biomass for heating, electricity and cooling. An EC proposal has been drafted but no EU-wide sustainability framework has yet been introduced. In the UK, the Scottish Government, alongside DECC, have introduced sustainability criteria for woodfuel for electricity which are based on the Government's UK Timber Procurement Policy Principles. Similar proposals have been made for woodfuel heat under the Renewable Heat Incentive.

10. The amended Fuel Quality Directive, which requires suppliers of fuels to reduce life cycle GHG emissions per unit of energy to at least 6% by 2020 (from 2010), also drive demand for biofuels. The sustainability requirements for biofuels apply under the Fuel Quality Directive. Currently, the way fuel suppliers report GHG reductions is through

reporting on the GHG performance of the biofuels they supply as an agreement is yet to be reached on an EU methodology for the calculation of GHG emissions of fuels other than biofuels.

11. Under the Kyoto Protocol, bioenergy has been considered carbon neutral in the energy sector and emissions from land use where feedstocks are grown are not taken into account. Following an EC consultation in 2011 and the Durban decision on LULUCF (Land Use Land Use Change and Forestry), the European Commission put forward a legislative proposal which was adopted in 2013, to harmonise accounting rules for GHG emissions and removals from soils and forests. This will result in the real emissions from bioenergy being accounted for in the EU. The first step is to harmonise rules to account for forests and agricultural soil emissions across the EU before seeking to incorporate these sectors into the EU's reduction efforts. However, for feedstocks produced in non-Annex I countries which are eventually used in the EU, emissions are not accounted for under Kyoto, and as bioenergy is otherwise considered carbon neutral, accounting remains incomplete.

12. The UK Bioenergy Strategy published in 2012 describes the UK Government approach to bioenergy and the circumstances in which the government is likely to be willing to support bioenergy, with regards to impacts on the economy, the environment, food production and food prices and relative potential for carbon reduction. It is proposed to review the analysis underpinning this framework to take account of new evidence every five years.

Types of bioenergy feedstocks and uses

13. The main types of bioenergy feedstocks can be divided into forestry materials, energy crops (including perennial crops e.g. short rotation coppice, grasses and arable crops), residues and waste products. Seaweeds and microalgae are other resources which are being developed for bioenergy applications.

14. Traditional arable crops, including oilseed crops (e.g. oilseed rape), sugar crops and starch crops (e.g. wheat), can be grown for the transport biofuel market. In the UK, the main crops grown for biofuels are wheat, sugar beet and oilseed rape. Statistics gathered under the RTFO show that the majority of biofuels are from imports, though the proportion of UK biofuels has grown over the years. Most biodiesel is from waste cooking oil[i].

15. Research to develop advanced biofuels (from woody biomass, residues, waste or algae), testing different technologies and biofuel feedstocks has been progressing. Advanced biofuels have the potential to offer greater energy yields and GHG savings per hectare than current biofuel production pathways.

16. There is interest in microalgae which can be farmed in open ponds or closed systems to produce liquid fuels. Microalgae production systems are land based but significantly less land intensive than crops and forestry[ii][iii]. Commercial scale applications are being started. Seaweed biomass is another potential source of energy. Seaweeds could be harvested or farmed offshore to produce biogas or turned into ethanol[iv].

17. Wood fibre is currently used for heat and power generation and is expected to become another potential feedstock in the commercial production of transport biofuels. Wood fibre can include virgin wood (from felling, thinning, coppicing) and forest residues (top, branches, stumps) from harvest. At UK level, domestic forestry supplies are expected to peak in 2027-31 with a maximum potential availability of 15m green tonnes. However there will be in parallel a significant increase in demand for wood fibre, mostly driven by

large scale biomass electricity or CHP installations. Though those estimates have to be reviewed regularly, this could translate into millions of tonnes in additional demand at UK level[v]. In Scotland, the Woodfuel Task Force had identified that, once existing markets were taken into account, about a fifth of the estimated resource in Scotland (>5 millions tonnes) would be available in 2017-2021[vi]. The same report highlighted that this resource could make a significant contribution towards the 11% renewable heat target, particularly if used in heat-only applications. There has been a significant rise in woodfuel demand[vii] in Scotland (1.2m green tonnes in 2011) largely drawn from the forest resource with no obvious negative impacts. There are positive benefits for the economics of forestry and rural development associated with such domestic production. This increase coincides with forecasts that indicate greater potential availability of softwood in Scotland over the next twenty years. While the UK has been historically a significant importer of timber and timber products, Scotland is not currently a significant importer of woodfuel.

18. Land managers could also diversify into Short Rotation Forestry (SRF), which could make use of poorer quality land. SRF involves the cultivation of fast growing tree species such as alder, ash, birch or Eucalyptus amongst others. Forest Research is undertaking 20 years trials on SRF at six sites across Scotland.

19. On agricultural land, crop residues (e.g. straw) could be used and there are options to produce wood fibre through Short Rotation Coppice (SRC willow or poplar) or grow perennial grasses (Miscanthus, switch grass or reed canary grass). These feedstocks can be used for heat and power generation, and could in theory be used for the production of advanced biofuels. Agricultural crop residues (e.g. straw from cereal crops) are also a potential feedstock. These crops would involve a change of cropping practice, predominantly on good quality agricultural land. Business barriers such as the 3-year delay before the first crop for SRC, the greater margins and flexibility offered by arable crops on good quality land have resulted in a limited uptake of SRC and little interest in any other lignocellulosic crops in Scotland.

20. Waste and by-products can also be used for heat and electricity generation. Feedstocks can include residues from sawmills and other wood-processing industries, wet waste such as manures or food waste, sludge from paper or pulp mills, the biomass content of residual municipal, commercial or industrial waste. Conversion pathways include thermochemical conversion (e.g. incineration, gasification, pyrolysis), generally known as 'energy from waste or efw' and non-thermal technologies, mostly anaerobic digestion (suited to high moisture feedstocks). Landfill gas (methane) is a waste-derived fuel which can be combusted or injected into the grid. It is estimated that waste could contribute around 3% of heat and electricity needs in Scotland[viii].

21. Bioenergy developments offer new markets for agricultural and forestry products and provide farmers and land managers with diversification opportunities. Local economic benefits can also be realised from installation, maintenance, and electricity and/or heat sales.

Impacts of bioenergy upon the natural heritage

22. Bioenergy can deliver benefits for the environment, in terms of GHG savings and enhancing biodiversity and landscapes, but it can also result in negative effects, which, cumulatively, could be significant.

23. The most significant impacts are those associated with feedstocks production. These depend predominately on the type of feedstock used, crop or forest management practices,

the land use which bioenergy feedstocks production is replacing, and ultimately on the level of demand for materials.

24. It is necessary to consider the impact of the demand for feedstocks on markets. The growth in demand for biomass may affect other non-energy sectors which rely on the same materials. For bioenergy alone, insufficient resources in the UK are expected to increase demand for imports. This demand translates into an additional requirement for overseas land, with potential impacts on non-UK ecosystems.

Global impacts of increase in demand

25. The production of bioenergy feedstocks can lead to the loss of habitats and species, changes in species populations, habitat quality, and affect ecosystem diversity and function. This can occur through changes in land use primarily and will also be influenced by land management practices[ix]. Carbon losses following vegetation clearing in tropical ecosystems or cultivation of carbon-rich soils can be very significant and negate any subsequent savings from bioenergy. It has been shown that change in land use from habitats with high above- and below-ground carbon stocks, such as rainforest or peatland habitats, results in large amounts of carbon emissions that will offset any carbon savings delivered by biofuels and lead to greater carbon dioxide emissions than using an equivalent amount of fossil fuel (per energy content) for decades or even centuries[x] [xi].

26. To alleviate these risks, sustainability criteria were introduced under Directive 2009/28. The development of sustainable supply chains based on sustainability criteria will limit adverse land use change on land where feedstocks are produced. However sustainability criteria do not address yet the consequences of the additional demand for agricultural commodities and forest products, and the resulting land use displacements effects.

27. Land use displacement can occur locally and between global regions, whereby production of bioenergy feedstocks replaces another land use and produces a shift in land use elsewhere. This can cause additional GHG emissions and diminish the potential of bioenergy to deliver GHG savings[xii] . The effects of indirect land use change (ILUC) represent a threat to remaining natural habitats. Though habitat clearance for agriculture has occurred for millennia, it has accelerated[xiii], worsening the current biodiversity crisis and damage to ecosystems.

28. There is evidence that the development of the bioenergy sector is adding pressure on land globally[xiv] [xv]. The report by AEA on the UK and Global Bioenergy Resource suggested a significant increase in the availability of biomass internationally between 2010 and 2030 and then a decline in 2050[xvi]. Much of this increase would be due to the planting of energy crops, which implies changes in land uses either directly or by displacement. JNCC estimated that the 52 million tonnes of materials of biological origin (food, feed, fibre etc.) imported in 2008 in the UK translates into 14 million hectares of overseas land. The overseas land requirement for UK biofuels consumption was calculated as approximately 1.4 million hectares of land in 2008[xvii]. The area of global land required to meet UK consumption might increase significantly as a result of the additional biomass required for energy end uses. UK consumption needs to be put in the context of a growing demand from the rest of the world and the cumulative effects this will have.

29. The development in woodfuel trade globally could pose a risk to forest ecosystems from unsustainable forest management where forest governance is weak. Levels of state-led forest governance are variable and have been judged as very inadequate in some instances. The UK government introduced criteria for sustainable forest management based on the UK

Timber Procurement Policy Principles[1] to address those concerns. There exists a range of voluntary certification standards to promote responsible forest management, with the majority of them falling under the Programme for the Endorsement of Forest Certification (PEFC) or Forest Stewardship Council (FSC). The application of certification systems and type of schemes (PEFC, FSC and others) is variable across different global regions. A large percentage of Western European and North American forests are certified while the uptake remains low in the rest of the world (on average as this will vary between countries)[xviii]. There is an ongoing debate on their relative performance in achieving sustainable forest management goals on the ground. Plantations may be certified provided they meet the requirements under those schemes. However there is no provision for preventing the certification of plantations that were established on areas converted from open habitats of high biodiversity value.

Potential of bioenergy for climate change mitigation

30. Biomass for heat and power can offer considerable GHG savings relative to fossil fuel based systems. As a general rule, biomass heat will deliver higher GHG savings than electricity[xix], while electricity from CHP plant generally has lower emissions/MWh than power only plant[xx].

31. Savings in GHG emissions from current transport biofuel technologies are highly variable, even assuming no land use change. The conversion to biofuels can generate co-products (e.g. rape meal used as animal feed). Co-products can be accounted for on the basis that they can be used instead of other commodities. Assumptions on what product is displaced and where and how this displaced product would have been produced will affect the outcomes of GHG savings calculations and can also alter the extent of indirect land use change driven by a given feedstock[xxi].

32. There can be emissions from land use change for biofuels from feedstocks grown on land. Emissions resulting from land use change can considerably affect the net GHG emissions of bioenergy. Assuming no direct land use change, as a result of indirect land use change, bioenergy can generate additional GHG emissions. An analysis of the European National Renewable Action Plans suggested that use of biofuels in the European Union in 2020 will result in significantly more GHG emissions than if fossil fuels were used to meet the same need[xxii].

33. A fundamental issue is that bioenergy is a land intensive form of energy[xxiii] where feedstocks are produced on land (i.e. except where from waste, by-products and residues). There are large discrepancies in GHG savings (and consequently in land area per unit of energy) between feedstocks depending on the type, methods of production and end uses.

34. The carbon benefits of bioenergy relative to alternative land uses, or alternative end uses for feedstocks also have to be considered. The influence of forest bioenergy on climate change reduction efforts is particularly complex to determine. Biomass removal and use as woodfuel will result in GHG emissions. It is often assumed that they will be compensated for by the carbon sequestration of growing trees. At the level of a stand, emissions from woodfuel combustion can cause climate change mitigation to be significantly delayed. However the climate significance of a forest stand in temporal and spatial terms will depend on the landscape context of the forest. In a dynamic forest ecosystem, the total carbon stock should remain stable when the harvest of some trees is compensated by the growth of others in the same period, provided sustainable forest management principles are adhered to[xxiv] [xxv]. GHG emissions will be less if thinnings and residues are used, as opposed to roundwood from dedicated harvesting.

[1] http://www.cpet.org.uk/uk-government-timber-procurement-policy

35. Climate change benefits will also depend on the counterfactual scenario (i.e. what the most likely alternative use for wood and the most likely alternative source of energy are), as well as other factors including initial forest carbon stock, frequency and intensity of biomass harvest and future growth rate of the forest, as well as the relevance of the timeframes considered to emission reduction objectives[xxvi].

36. The Committee on Climate Change argued that the use of woody biomass as construction materials should be prioritised[xxvii]. Optimal use will depend on whether the wood products are sawlogs, roundwood or residues. Using roundwood and sawlogs for materials is preferable while forest residues can be used for bioenergy and residues from wood processing can be used alternatively for bioenergy or materials[xxviii].

37. The way GHG emissions from bioenergy are accounted for is important in assessing its actual potential to mitigate climate change. Two significant accounting issues with policy consequences have been identified. The first accounting error occurred under the Kyoto Protocol whereby emissions associated with LULUCF were not accounted while combustion emissions were considered to be zero due to fossil fuel displacement[xxix]; this error has now been partly addressed in the EU thanks to the new accounting rules for LULUCF, though overseas emissions are still unaccounted for. A second issue that was raised relates to additionality, whereby using land to produce bioenergy feedstocks typically means that this land is not producing plants for other purposes, including carbon otherwise sequestered. Searchinger[xxx] explained this matter in a paper on biofuels[2]. The Scientific Committee of the European Environmental Agency published an opinion[xxxi] in 2011 on this issue, also supporting that the additionality concept should be applied to bioenergy. This highlights the need to consider Indirect Land Use Change in the calculation of GHG emissions.

Production and extraction of bioenergy feedstocks in Scotland

Forestry sources

38. Bioenergy offers a market for forest products that were not merchantable (stumps, branches, low quality trees). Forestry products are a readily available bioenergy feedstock, with the potential to enhance the economics of forestry and lead to long-term improvements in forest management. With the right precautions, the extraction of forestry residues and thinnings from managed forests should not impact on the natural heritage, and will offer an opportunity to utilise material previously considered unusable, with additional extraction of roundwood also possible up to a sustainable yield. Currently extensive thinning is not a viable option in some plantations and the woodfuel market brings opportunities for uneconomic thinning to take place and bring woodlands back into management. The

[2] Abstract from Searchinger's paper: 'Use of biofuels does not reduce emissions from energy combustion but may offset emissions by increasing plant growth or by reducing plant residue or other non-energy emissions. To do so, biofuel production must generate and use `additional carbon', which means carbon that plants would not otherwise absorb or that would be emitted to the atmosphere anyway. When biofuels cause no direct land use change, they use crops that would grow regardless of biofuels so they do not directly absorb additional carbon. All potential greenhouse gas reductions from such biofuels, as well as many potential emission increases, result from indirect effects, including reduced crop consumption, price-induced yield gains and land conversion. If lifecycle analyses ignore indirect effects of biofuels, they therefore cannot properly find greenhouse gas reductions. Uncertainties in estimating indirect emission reductions and increases are largely symmetrical. The failure to distinguish `additional' carbon from carbon already absorbed or withheld from the atmosphere also leads to large overestimates of global bioenergy potential. Reasonable confidence in greenhouse gas reductions requires a precautionary approach to estimating indirect effects that does not rely on any single model. Reductions can be more directly assured, and other adverse indirect effects avoided, by focusing on biofuels from directly additional carbon.'

growing issues with tree diseases and pests have to be taken into consideration. Further information and biosecurity guidance can be found on the Forestry Commission website http://www.forestry.gov.uk/pestsanddiseases.

39. Longer term, the demand will also be met from the increase in woodland cover. The implications for the natural heritage will depend on the type of woodlands and their location. Afforestation above a threshold (from 0 hectare to 5 hectares depending on the sensitivity of the site) is regulated under the Environmental Impact Assessment (Forestry) (Scotland) Regulations 1999, though non-designated priority habitats are not always well identified. Work is underway to improve habitat mapping. The 2012 report to the Scottish Government by the Woodland Expansion Advisory Group supported the Scottish Government's ambition for woodland expansion, and recommended new woodlands are created in an integrated way. Guidance is being produced to support decision-making.

40. There is no commercial Short Rotation Forestry (SRF) in Scotland but the development of a bioenergy industry could be a driver for expansion. The environmental implications of large scale SRF are not fully understood. Potential impacts are likely to depend on the species used, the site and previous land use, planting pattern and management[xxxii]. Forest Research currently undertakes field trials into the impacts of SRF, including native and non-native species. The introduction of non-native species is regulated under the Wildlife and Countryside Act 1981 and the Wildlife and Natural Environment (Scotland) Act 2011.

41. Compliance with the UK Forestry Standard and associated guidelines will help mitigate potential adverse impacts on soil quality and the water environment, and ensure that woodland creation proposals take account of biodiversity considerations. The revised version of the standard makes reference to carbon; it advises against planting on soil with peat >50 cm and recommends the conservation and enhancement of carbon stocks medium to long term. Any public support for woodland creation requires adherence to the UK Forestry Standard and is subject to statutory consultation. Any felling licenses issued by the Forestry Commission on private land have to comply with the Nature Conservation (Scotland) Act 2004. The UK Woodland Assurance Standard provides a voluntary certification process for forest owners and promotes high standards in sustainable woodland management.

Impacts on soil and water quality

42. The demand for woodfuel could intensify harvesting and increase the removal of residues. Biomass recovery should be limited to sustainable levels. The propensity for damage will depend on the sensitivity of the site and guidance is available from Forest Research[xxxiii] . While brash and undergrowth can provide a valuable biomass resource, in some situations its extraction could disturb local ecosystems, and affect nutrient levels. A significant loss of undergrowth might also affect forest regeneration by removing seedlings, though it is expected that managed forests will be re-planted cyclically.

43. It is important to avoid soil compaction through the use of heavy extraction equipment e.g. for chipping on site. Brash mats fulfil an essential function in forest harvesting by helping to prevent compaction. Compaction is particularly likely in wet or peaty soils, which are common in Scotland. The ability to extract residue material on upland sites may be significantly limited by the risks of compaction or acidification[xxxiv].

44. The application of wood ash may help to compensate for loss of nutrients and counteract soil acidity where these might be an obstacle to re-establishing a felled woodland. Recycling of wood ash must be properly monitored, with controls on contaminants, to ensure

there is no build-up of pollutants in the soil or adjacent watercourses. Potential impacts on water quality are closely linked to effects on the soil and are controlled by the Water Environment (Controlled Activities Scotland) Regulations 2011 (as amended) and General Binding Rules for Controlling Diffuse Pollution.

45. Whole tree harvesting (WTH) is an intensive harvest technique, as it involves the removal of all materials above ground and sometimes stumps. This practice might result in nutrient losses and soil compaction. Impacts are dependent on site-specific characteristics and guidance is available from the Forestry Commission [xxxv].

46. 'De-stumping' can cause significant soil disturbance, increased soil erosion, compaction, removal of base cations and depletion of nutrients. The risks depend on the type of site, and in Scotland, will increase in the uplands due to the topography and the nutrient poor, carbon-rich and acidic soils. Interim guidance is available from Forest Research[xxxvi].

47. The need for access can affect the type and use of biomass resources. The wider use of forestry products or residues is likely to lead to a need for new forest tracks, and this can have natural heritage impacts associated with construction and ongoing use. Changes in access may open up new forest areas, previously remote and uneconomical. In some cases, harvesting of these unmanaged forests should be avoided, on account of their natural heritage value.

Impacts on biodiversity

48. The biodiversity value of forests varies, and not all are suitable for biomass extraction. Native woodlands of high biodiversity value, such as SSSI / Natura woodlands, and ancient or historic woodlands (which tend to be limited or fragmented) are not considered suitable for biomass extraction. They are of significant natural heritage value, and minimal intervention is to be encouraged. Currently many native woodland sites have insufficient amounts of deadwood, and even extraction of this should be avoided, as the deadwood provides a valuable ecosystem function.

49. Provided good woodland practice is followed, there are unlikely to be any significant adverse impacts on biodiversity from the use of roundwood from managed forestry. Some thinning and felling practices could help to encourage the development of a ground cover ecosystem on the forest floor, with better regeneration and an increase in biodiversity. An irregular thinning pattern is preferable to encourage structural diversity.

50. Some residues should be retained on the site to provide microhabitats. Removal of brash from existing forestry alters habitats for invertebrates, plants and fungi leading to changes in community structure and loss of species which utilised this material[xxxvii]. The UK Forestry standard recommends that residues be retained unless removal is necessary for management and all impacts have been considered.

51. The deadwood resource should not be depleted or prevented from building up. As a minimum requirement, it is recommended that deadwood (both standing and lying) should amount to a minimum of 5% of the stand volume or 20m3 (whichever is the least). Where managed woodland provides a habitat for key species, such as capercaillie, use should be restricted to maintain the habitat. Some managed native woodlands may have structures that are better suited for exploitation for bioenergy, though this should not compromise the objectives of encouraging natural regeneration.

52. Overall, where managed forestry is of limited natural heritage value, there is scope for biomass exploitation to deliver net associated benefits for biodiversity. This could help

promote one of the Scottish Forestry Strategy's priorities, which is to encourage the restructuring of woodlands to increase structural and species diversity.

53. Change in woodland structure, land use and infrastructure (e.g. tracks) could modify the connectivity of woodland and open ground habitats. There is potential for new woodland and trees in hedges and pastures to improve connectivity.

54. Woodfuel seems to be leading to a renewed interest in coppicing. It would not be advisable in all woods. In the lowlands, coppicing can have value for ground flora and birds, but it could have adverse impacts in the uplands and the west of Scotland, where there are important epiphytes communities. The potential of coppicing should be explored in recent woods of no commercial or conservation value.

Impacts on climate change

55. The extraction and planting of trees cause soil disturbance which results in emissions of carbon dioxide. Conversely carbon will be sequestered by tree growth. Hence the carbon balance of the system will depend on the relative rate of absorption and emissions post afforestation (see also para 35).

56. Whether biomass growth and extraction effectively mitigate climate change will depend on the carbon payback time. Soil type is one factor that will influence carbon payback time. In Scotland, a large proportion of soils have a high carbon content, accounting for over 50% of total UK carbon soil content[xxxviii]. New planting on carbon-rich soils is not recommended as it can change the soil from a carbon sink to a carbon source. Though soil carbon losses will eventually be compensated by carbon uptake by trees[xxxix], the carbon payback time means that it is an inappropriate land use change in relation to the timescales for climate change mitigation. Afforestation on mineral soils provides better opportunities for carbon sequestration.

57. Removing forestry as part of a peatland habitat restoration programme could be beneficial by providing long term carbon storage benefits that would outweigh short term losses. There are however insufficient data on the carbon dynamics of forest soils. The impact of reversal of afforestation and peatland restoration on soil carbon budgets is not fully understood and is still being investigated. The impact on carbon budgets of restocking after harvest on previously drained peatlands is not understood either.

58. Thinning operations for use as woodfuel should improve the overall carbon benefits of managed plantations. While the removal of brash can cause net emissions of carbon dioxide from the soil, this should be short term[xl]. In soils with a high carbon content, 'de-stumping' will result in carbon dioxide emissions that could offset the carbon savings achieved by replacing fossil fuels with woodfuel[xli].

60. Bringing unmanaged woodland back into production will result in a reduction in long-term carbon stocks[xlii]. There is here a potential conflict between carbon reduction objectives and other objectives. Old-growth woodlands can offer a valuable function as a carbon store (both below and above ground) whilst continuing to capture carbon[xliii]. Habitats that also offer a valuable function as a carbon sink will make an immediate contribution to mitigation against climate change and as such need to be protected and enhanced.

Impacts on landscape and visual amenity

61. Provided existing forest management practices continues, such as shielding of felled sites and a move away from monoculture plantations, there should be no significant landscape impacts from the extraction of biomass material from managed forests. The

Scottish Forestry Strategy recognises the importance of forestry in the landscape, which has been delivered through mechanisms such as Landscape Character Assessments, landscape designations such as National Scenic Areas and the UK Forestry Standard and associated guidelines.

Energy crops

Perennial crops

62. The potential impacts on the natural heritage from energy crops will depend on what land use is being replaced and how they are managed. There has been a very limited uptake of perennial crops in Scotland.

Impacts on soil and water quality

63. If harvested cyclically, Short Rotation Coppice (SRC) willow is unlikely to be associated with soil erosion because it tends to be grown on heavy soils and provides better wind protection than arable crops. Harvest normally takes place in winter when wet weather and high soil water contents are more likely. Under these conditions, harvesting machinery can cause soil compaction[xliv].

64. Willow coppice has a particularly high water requirement, and needs to be located in where there is adequate rainfall and the soil is deep enough and retentive enough to avoid depletion of the water table and the disruption of drainage patterns[xlv]. Willow plantations should not be located in or adjacent to areas of wetlands or wet meadows of conservation value.

65. Willow offers the advantage of tolerating high levels of heavy metals, and can have a role in bioremediation of contaminated land or waste treatment[xlvi xlvii]. When used in this way for bioremediation, the ash from the combustion of willow needs to be disposed of in a way that prevents soil or water contamination from any accumulated heavy metal content.

66. Changes in the end use of the crop can affect management practices. If the crop is not to be used as food, there will be fewer restrictions imposed as a result of health concerns. This may facilitate the use of sewage sludge (biosolids) as a fertiliser. This could lead to a risk of soil contamination, though sewage sludge could also be used for the improvement of derelict land. The application of sewage sludge to agricultural land is controlled by SEPA under the terms of the Sewage Sludge (Use in Agriculture) Regulations 1989 (as amended) and the Waste Management Licensing (Scotland) Regulations 2011.

Impacts on biodiversity

67. Planting of Short Rotation Coppice (SRC) within arable agricultural land could provide biodiversity benefits by increasing habitat heterogeneity. It has been shown that SRC willow plantations can support a diverse invertebrate community in the canopy and tend to contain a higher diversity of plants than intensively managed grasslands though plant communities will vary with (e.g.) the age of the stand, previous land use and management. There is some evidence that commercial SRC willow in the UK can benefit bird species characteristic of scrub and woodland edge-type habitats and is used by a range of farmland bird species. However, as the crop matures, the interior of large plots holds fewer birds than the edges or cut SRC. Some open ground specialists such as grey partridge do not seem to use SRC. It has therefore been suggested that open farmland birds might be displaced by SRC particularly as the crop height and density increases[xlviii xlix]. Harvesting of SRC should avoid the nesting season. Ensuring a wide range of stand ages and thus some degree of

cyclical harvesting should enhance benefits for farmland biodiversity. SRC, as a woody crop, falls within the scope of the Environmental Impact Assessment (Forestry) (Scotland) Regulations 1999.

68. Mixtures of different species and hybrids will enhance structural and functional diversity. By ensuring a mix of varieties within the coppice, a greater range of wildlife may be supported than with a single variety. Mixtures will also help to limit damage from pests and diseases.

70. Perennial grasses also offer a different habitat from open farmland. It has been suggested that Miscanthus within the first years of establishment may benefit birds in intensively managed lowland landscapes[l]. Further research suggests that bird use is likely to be variable depending on weediness, presence of open patches and crop structure[li]. Miscanthus seems to offer more biodiversity benefits than reed canary grass[lii].

Impacts on climate change

72. SRC would offer advantages over annual crops for carbon sequestration due to a more extensive root system, longer growth cycle and a lesser need for inputs. The greatest potential for carbon sequestration under SRC will be on previously arable soils where it is likely to increase soil carbon[liii]. SRC is a feedstock that can help deliver high GHG savings if best practice is followed, which implies avoiding land that had high carbon stocks.

Impacts on landscape and visual amenity

73. New coppice woodland, if well sited and managed in accordance with Forestry Commission guidance, can add to landscape diversity and compensate for past woodland and hedgerow losses within agricultural landscapes. However, care is needed in harvesting, as the timescales involved for crop growth and clearance are much longer than the annual cycle required for arable crops, hence changes in the landscape resulting from harvesting can be more dramatic, with potential adverse effects on amenity. This can be mitigated in most areas by harvesting cyclically, so that extensive areas are not harvested at once but are sectionally harvested in rotation.

Impacts on access and recreation

74. It is important to ensure that any changes in land use do not restrict recreation or access opportunities. Establishment of corridors through SRC plantations should be designed to maintain access.

Arable / fodder crops

75. Growing arable crops successfully requires good agricultural land and the risk of direct land use change in Scotland is therefore limited. Arable crops are more input-intensive than perennial crops. The environmental impacts of growing first generation biofuels feedstocks are those of arable farming in general.

76. When producing transport biofuels from arable crops, fossil fuels are used throughout the process, from cultivation, through transportation to processing. Nitrous oxide is a potent greenhouse gas, which is emitted from soils following fertiliser application. The use of nitrogen fertiliser accounts for most of the GHG emissions in the production of oilseed rape in Scotland[liv].

77. In anaerobic digestion, waste can be co-digested with feedstocks from purpose grown crops such as maize. This could lead to an expansion of the area under maize, as

has occurred in Germany in some areas. Maize is a relatively poor crop for biodiversity - it is still not extensively grown in Scotland.

78. While crop residues can be used as a bioenergy feedstock, it is important that other uses are not neglected. Crop residues, can be incorporated into the soil, increasing organic matter content, reducing soil erosion and improving soil erosion. Residual straw can also help limit erosion if left after harvest. Straw is also used for animal bedding and additional roughage.

Waste and by-products

79. The agricultural, manufacturing, commerce and domestic sectors all generate large quantities of organic wastes and by-products. These feedstocks are not produced on purpose and therefore do not directly require land, unlike energy from dedicated biomass production. However some materials may already have other uses, in which case there should be an understanding of the indirect impacts of a switch from existing uses to bioenergy.

80. Using this material to produce energy can reduce the amount of waste going to landfill thus further contributing to offset GHG emissions. Energy from waste should fit within the waste management hierarchy, with highest priority being placed on waste reduction, reuse and recycling (as applicable to the particular type of organic waste).

Impacts on soil and water quality

81. Reducing the amount of waste going to landfill will lower the likelihood of soil and water contamination by leachates.

81. When organic waste is processed through anaerobic digestion to produce biogas, the organic by-products or digestate may then be returned to the soil as fertiliser and soil conditioner. Some of these may carry contaminants. The output from anaerobic digestion that is certified under the PAS110 quality assurance scheme, and which satisfies prescribed production and usage criteria, will not be subject to regulatory waste controls.

Impacts on biodiversity

83. Energy from waste and by-products does not have direct impacts on biodiversity. However, for by-products that already have uses, their diversion into energy could push other end users to use materials that are purpose grown. These market effects may lead to secondary impacts on biodiversity.

Impacts on climate change

84. The use of waste which is disposed of creates positive climate change mitigation effects, including indirect benefits. Using organic waste to produce energy reduces the amount of methane released into the atmosphere through natural degradation in anaerobic conditions in a landfill site. Anaerobic digestion of livestock manures enables farmers to reduce methane emissions from slurry storage. On the other hand, the use of waste and by-products which have existing uses could result in indirect GHG emissions[lv].

Impacts on landscape and visual amenity

85. By reducing the amount of waste going to landfill, there might be visual and landscape benefits for traditional landfill sites.

Processing and energy production

87. All forms of biomass will need transporting from source to processing plant and then on to the final point of use. The transport of feedstocks to the bioenergy plant has a carbon cost, which will vary depending on the mode of transport, the distance travelled, and the density of the feedstocks. There is a need to ensure that carbon dioxide emissions from transportation do not significantly reduce any carbon benefit derived from the use of biomass.

88. Biomass feedstocks used in heat and power plants can be converted into energy at different efficiency levels, which depends on the conversion technology, scale of plant, feedstocks and heat use. Using the heat generated in electricity production will raise the resource use efficiency[lvi]. Though achieving high efficiency should be an overall objective, there are other criteria that can be taken into account alongside efficiency e.g. scale of development and impact on demand for feedstocks, opportunities for local biomass electricity in remote locations where the potential for heat use will not be high.

89. The development of small scale bioenergy schemes to supply community energy needs could be of benefit by reducing domestic carbon dioxide emissions, reducing economic leakage and encouraging energy self-sufficiency.

90. Depending on the scale of the plant, many of the impacts will be similar to those of any industrial development. Impacts on the natural heritage could result from loss of green space if it is sited in a greenbelt area, or if it results in road expansion to accommodate the transport. There may also be some visual intrusion depending on where the plant is located. Care should be taken not to intrude on existing areas of amenity value such as public open space or green space or on areas of nature conservation value. There is also a need to assess any planned road widening and altered drainage. Sensitive land uses should be avoided e.g. routes through or alongside areas of natural heritage value that are used by the public for recreation. Smaller plants have the potential to be integrated into existing industrial and commercial developments for use as heat or electricity or into areas designated for future industrial, commercial, amenity or housing development without any significant local impacts on the natural heritage. There may be opportunities to co-locate bioenergy plants with other biomass processing industries.

91. Biomass combustion results in carbon dioxide emissions. Emissions that are of potential concern for air quality include nitrogen oxides (NOx), polycyclic aromatic hydrocarbons (PAH) and particulate matter (PM). Emissions from medium to large-scale bioenergy plants are controlled by SEPA under the Pollution Prevention and Control Regulations 2000 (PPC) (as amended). Energy production from waste must be in line with the emission standards contained in the European Waste Incineration Directive. Anaerobic digestion of waste is controlled under the Waste Management Licensing (Scotland) Regulations 2011 and the Pollution Prevention and Control (Scotland) Regulations 2000 (as amended). Waste ash arising from biomass incinerators, which can be landfilled, or be used in other industries e.g. construction, fertiliser, falls under the PPC permit and the Waste Management Licensing Regulations 1994 (as amended).

92. Small bioenergy applications are not regulated under PPC. Their emissions are regulated under the Clean Air Act 1993 (under review) and under the Renewable Heat Incentive from end 2013. There are planning restrictions in ‘smoke controlled areas’, which affect the siting of boilers for domestic or district heating schemes. Domestic users are only allowed to use authorised fuels or exempt appliances that enable the burning of smoky fuels without producing smoke. There have been concerns for air quality from the cumulative PM

emissions from small scale biomass installations, particularly in urban areas. A report for the Scottish Government on cumulative emissions suggested that boilers are unlikely to be a major source of pollutants but could lead to heightened pollution levels in some areas[lvii].

93. There are exhaust emissions from the end use of transport biofuels. Studies on exhaust emissions from biofuels show a high degree of variability, depending on engine type, vehicle age, drive cycle etc. In an advice note to the government, the Air Quality Expert Group suggested that biofuels as low strength blends up to 15% have little effect on air quality, but further research is required on the effects of high strength blends on emissions, on the effects of different strengths of biodiesel fuels on mass emissions of NOx, primary NO2 and PM and the characterisation of PM and chemical composition of organic compounds emitted[lviii].

Conclusions

94. The development of bioenergy in Scotland offers the opportunity to utilise land for forestry and energy crops in a way which could benefit both landscapes and wildlife and which can be accommodated alongside existing land management practices. The bioenergy industry provides opportunities for enhanced rural employment and can contribute to a sustainable and dynamic economy for Scotland.

95. However, except for bioenergy from waste, it is a land-intensive form of energy. Bioenergy creates additional demand for crop production and forest biomass, with potential knock-on effects on ecosystems and the loss of natural capital. Locally, the nature of impacts will depend on the land use being replaced, the feedstocks used, the management practices and the scale of the demand. In Scotland, the legislative framework and best practice guidance should help promote a good environmental standard of bioenergy production.

96. However, with some bioenergy feedstocks being globally traded commodities, increasing demand is adding pressure on land worldwide and environmental impacts can be far reaching. Bioenergy policy needs to address the consequences of the additional demand for biomass and the resulting potential land use displacement effects.

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