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# FUTURE CHALLENGES FOR UK BIODIVERSITY: 2011-2020

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**JOINT NATURE CONSERVATION COMMITTEE**

# FUTURE CHALLENGES FOR UK BIODIVERSITY: 2011-2020

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## 1. Capsule

1.1 2011 is a critical year for environmental and biodiversity policy development. The mix of new policy direction, societal change, changes to resource availability and costs, and technology developments is likely to bring about significant change in the way we manage our countryside and seas over the next 10-20 years. We present a non-systematic review of the developing environmental policies in the UK, technology trends, and a selection of scenarios and societal statistics; this is summarised in a 2020 scenario, or narrative. Likely significant transformations over the next 10 years are identified along with a broad view on evidence needs to support and monitor change.

## 2. Possible transformations over next 10 years

2.1 The following changes in resource management approaches or developments could undergo a step-change in intensity over the next 10 year resulting in impacts, some negative, some positive, on the environment and biodiversity.

2.2 To meet demands for domestic energy production it is likely that wind energy and biomass production will increase rapidly. Biomass sourcing will diversify to include algal production (freshwater and marine), novel and GM crops, woodlands, and novel non-native species. Significant changes in patterns of land use are possible, especially via conversion of non-production lands, pasture, marginal grazing land and uplands for biomass production. Other forms of energy production – wave/ ocean current, solar and nuclear – are unlikely to have a significant impact on UK generation in the next 10 years, but beyond 2020 marine and nuclear may become key sources.

2.3 Domestic food production may continue to intensify and become increasingly specialised on cereal and vegetable protein crops, resulting in increased conversion of non-production lands and pasture and larger farm units. Pressure to make use of urban non-production lands (green-space and brown-field) is likely to result in significant change in use, including food production alongside increased residential and business development. Strong measures to significant reduce food waste are likely, ultimately influencing patterns of production.

2.4 The future of aquaculture is likely to be mixed depending on affordability of feed, but it is possible that significant increases in both coastal and freshwater aquaculture could happen over the next 10 years.

2.5 Pressure to increase domestic fibre production, alongside biomass volume, is likely to result in changes to patterns of forestry; redistribution is likely with

significant new planting over the next 10 years, which is likely to be targeted on marginal pastures and uplands.

2.6 Water management will become an increasingly critical issue as costs associated with supply increase; this will impact on all aspects of living. Ecosystem approaches to flood management are likely to become an increasingly frequent adaptation strategy over the next 10 years resulting in relatively significant changes in land use patterns. Patterns of food production will be increasingly influenced by affordability of irrigation and result not only in changes in land use, but also changes to local water management that could change water flows and quality through wetland systems. Biomass production is also likely to drive change in water management, especially from abstraction and local cycling for freshwater algal production. Urban demands for water will increase with likely significant impacts on wetland systems due to abstraction and local water cycling.

2.7 Demands for energy efficiency and to meet climate change mitigation needs will have an additive effect as patterns of land use change become influenced increasingly by a broader range of economic considerations, including payments for ecosystem services.

2.8 The role of society and businesses in land use management is likely to change over the next 10 years linked to payments that will enable communities and businesses, especially in partnerships, to invest in and control land management at a local level. A range of economic instruments and financial incentives, including subsidies, green taxes, green investment loans, etc, will support this significant change in societal involvement in local landscapes. Amongst other things, wind energy production, urban food production, woodland management and local water management are all areas that could have significant community/ business involvement.

2.9 The likelihood of transformative land use change and its rate depends on complex economic and societal factors. However, stochastic events, or shocks, can force a profound shift in direction. At the time of writing and in addition to large-scale natural disasters, global economic instability, national debt and energy costs are all major issues that could create shock-waves that cause a significant shift in financial viability of major land use; scenarios are complex and consideration of their potential impacts is beyond the scope of this review.

## 3. Evidence to support sustainable development

3.1 The transformations in management of the land and sea that unfold over the next 10 years, including those that account for ecosystem services, will present challenges and opportunities for securing biodiversity. Evidence will be required to assess changes in ecosystems, habitats and biodiversity and to understand underlying ecological processes. Targeted evidence will also be needed to assess and modify policy approaches, including incentives that enable change. The following broad suggestions for evidence needs relate to the UK only, but the key drivers of change are global and a review of international evidence needs to support UK policy development is needed. A risk-based approach to defining specific and high priority evidence needs is one option, linked to actively occurring or most likely imminent transformations (or transformative policies).

3.2 A better understanding of ecosystem functioning is still required, including how this translates to habitat character and condition and how we can effectively and efficiently monitor change. There is a wealth of ecological information that needs to be used more effectively and a need to develop more holistic approaches to ecological research (system-level); such research is expensive, but seems essential to create successful cost-effective solutions to land-use and marine management. Linked to improved understanding of ecosystem functioning is the need for better characterisation of ecosystem services and both improved understanding of how changes in ecosystems/ habitat condition affect service provision and how they can be measured and monitored. The specific role of biodiversity surveys in detecting change in ecosystem status and services requires review.

3.3 Evidence on direct and indirect pressures on the environment is required and improved understanding of how management choices at different scales contribute to the character and magnitude of these pressures is essential as transformations occur. Linked to better understanding of ecosystem functioning is evidence for the effects of pressures, especially on service provision. Specific evidence needs include understanding the role of and/ or impacts on ecosystems, habitats and species of the following: changing patterns of land use, especially linked to food and biomass production and including changes to nutrient management; water management changes, especially linked to abstraction and local cycling for agriculture/ aquaculture and urban development; woodland management to optimise a range of services, including carbon capture and biomass/fuel provision; financial instruments for land and marine management.

3.4 To support effective management approaches that integrate ecosystem services accounting, models and tools for practitioners (including advanced tools such as predictive modelling) are required urgently. Sensitivity mapping is one such tool and should aim to demonstrate sensitivity of ecosystems and habitats/ goods and services to different management choices; underpinning models are a key evidence requirement. The practitioner community is likely to diversify with financial incentives that enable communities and businesses to gain more involvement in landscape management; tools will need to be developed by this broader range of practitioners thus also requiring involvement of a broader range of science disciplines to ensure success and efficiency.

## 4. A 2011 Review

### *Introduction*

4.1 2011 is a critical year for environmental and biodiversity policy development; the outcomes of the 10th Conference of Parties to the Convention on Biological Diversity, including the new 2020 targets, will be reflected in a refreshed EU biodiversity strategy and action plan. In turn, the four countries of the UK are responding to these changing frameworks and developing new environmental and biodiversity strategies.

4.2 The mix of new policy direction, societal change, changes to resource availability and costs, and technology developments is likely to bring about significant change in the way we manage our countryside and seas over the next 10-20 years. In an attempt to predict the direction in which all of these factors will take us over the next 10 years we have reviewed the developing

environmental policies in the UK, technology trends, and a selection of scenarios and societal statistics; we present conclusions in the form of a 2020 narrative (Appendix one). Based on the review and our 2020 scenario, we have also proposed a number of transformations in land and sea use; these are likely to demand new evidence to both monitor change and support further policy development, and we present a list of broad research areas in which increased effort may be beneficial over the next 10 years (transformations and evidence are described in earlier sections).

## *5. Part One: Environmental policy developments in 2011*

### *Policy trends common to all countries of UK*

5.1 The following policy changes are common to two or more of the country environment strategies; some have a clear link directly to the CBD Strategy and 2020 targets and the 2011 EU Biodiversity Strategy, whilst others more closely reflect national priorities or opportunities.

5.2 Development of a 'green economy' is identified as the key mechanism for mainstreaming biodiversity conservation. In simple terms this is the sustainable management of production and services, both within the UK and globally. The key changes emerging from the environmental strategies that will realise this ambition are: the development of new financial mechanisms and accounting approaches; and, new ways to gain significantly greater involvement by communities and businesses in delivering sustainable management.

5.3 An important element of green economy will be valuing and accounting for the goods and services provided by ecosystems[1], and new financial instruments will be developed to realise this approach. Alongside this is the recognition that ecosystem restoration is required and a new approach to large-scale management is proposed.

5.4 Green infrastructure is an approach identified by all country strategies to support sustainable management, enhance ecosystem services and provide resilience to climate change. Green Infrastructure (GI) is a strategically planned and managed network of high quality green spaces and other environmental features that conserve ecosystem values and functions (providing resilience) and provide benefits to society. Features include: corridors to connect protected areas; measures and areas to improve landscape permeability for species, including in urban environments; multifunctional areas where land uses that help maintain or restore healthy ecosystems are favoured over other uses; and features focussed on climate change adaptation and mitigation.

5.5 All governments place local action at the heart of emerging environmental policy and will seek much greater involvement of local communities, businesses and civil society in achieving sustainable management and protection of biodiversity, the countryside and marine environment. Enhancement of the voluntary sector is part of this approach.

5.6 Associated with optimising ecosystem services is the recognition of the value of the countryside to well-being and the strategies hint at new approaches for

[1] An alternative terminology to ecosystem services used in policy documents is 'multiple land use'.

improving access to the countryside, including as a health management measure and for enhancing education.

5.7 All the strategies are clear about the need for increased domestic food, fibre and energy production.

5.8 A more integrated approach to water is common to all strategies, with an emphasis on larger scale approaches (catchment), and more naturalistic approaches to floodplain management. The term Blue Infrastructure is sometimes used to describe integrated water management and follows the same principles as green infrastructure.

5.9 An important common theme is the issue of waste, especially in food; strong measures are proposed to cut waste and this is likely to have longer term impacts on production.

5.10 The need for new indicators to track policy change is highlighted in all the strategies, with gaps in ecosystem condition, ecosystem services, sustainable management and economics.

***Policy divergence between countries of the UK***

5.11 There are, perhaps unsurprisingly given the international and EU frameworks, few differences between the countries of the UK in the scope and intentions of the new environmental strategies. However, there are a few differences worth mentioning, but ultimately the more detailed implementation plans that deliver the strategies may provide proposals on these issues.

5.12 The risks associated with novel disease outbreaks is recognised most specifically in England with potential for new approaches to controls, surveillance and horizon-scanning to manage risk from animal and plant diseases (Defra[2]). Linked to this is risk-based regulation of farming, with shared responsibility on animal disease management (Defra). Invasive non-native species management is mentioned explicitly in the Scottish Land Use Strategy, which may overlap with disease management, but is recognised in its own right as requiring action.

5.13 Alongside aspirations for more involvement by communities and businesses in sustainable management is the intention to devolve powers to local levels in England and Scotland (Defra; Scottish Land Use Strategy). Reform of planning policies to provide a more strategic approach to nature is one mechanism for empowering local governance highlighted by Defra.

5.14 In England, mention is made of developing a voluntary approach to biodiversity offsets, with testing through pilot schemes.

5.15 Restoration of derelict or vacant land to economic, social or environmentally productive uses is mentioned explicitly in the Scottish Land Use Strategy. 'Community growing' to enhance food production, especially in urban areas, is also mentioned as a specific aspiration.

5.16 The Scottish approach is more specific on delivery of some ecosystem services, especially carbon storage. Targets for woodland planting are

[2] Defra Business Plan 2011-15

explicit with an intention to increase cover from 17% to 25% by 2050 (10,000 ha per annum), but ensuring planting away from peat soils to ensure good carbon management and ensuring all deforestation is compensated by new planting. Restoration of soils to deliver services, such as carbon storage, including re-wetting peat land and lower-impact agricultural and forestry practices are also highlighted in Scotland.

## 6. Part Two: Technology trends

6.1 Advances in bio-identification technology, in particular physiochemical and genetic testing using hand-held devices and applications for communication devices, are being achieved, but relatively slowly. However, such advances will enable not only specialist recorders, but the general public to make greater contributions on biodiversity evidence.

6.2 Research to improve the use of remote sensing for monitoring habitats and condition, and hence mapping and modelling ecosystems and services, is underway and derived tools are likely to be critically important for taking forward new ecosystem management approaches.

6.3 Advances in computing could have a significant impact on resource management approaches. A new phase in internet development to make data more accessible and re-usable is likely (the 'web of data'), which when coupled with new modelling techniques, like predictive modelling, new user and sensor networks, artificial intelligence systems, and remote surveillance could provide opportunities for tool development based on far more complex data sources. Cloud computing, or context-aware computing systems (personalised systems spanning networks in working and home environments), and possibly even neural interface systems could facilitate significant flows of data, especially real-time human behavioural data (Foresight 2010b). Holographic science is a rapidly advancing field with potential to create new interfaces with systems and networks, and the existing kinetic sensor technology that translates movement into digital information could herald a new era in virtual management of resources (New Scientist 2010).

6.4 New infrastructure to support exchange of digital information – sensor networks – is likely and will facilitate creation of smart grids, or intelligent infrastructure, for fine-tuned water, waste, energy and fuel management. Fully integrated systems that adapt to real-time data flows will be possible, leading to far more efficient use of resources; this will impact on all aspects of life. The term 'urban metabolism' describes an intelligent infrastructure approach in which utility and transport systems are constantly adapting to data flow through decision models, the latter ultimately supported by artificial intelligence. Some farming systems are already highly computerised, but intelligent infrastructure and more sophisticated modelling could lead to increasingly remote farm management approaches. Directed energy technology will find applications in more technical farm systems for pest control, for example, lasers and microwaves (New Scientist 2010). Water management will benefit from smart grids and new technologies for low-energy desalination and recycling of grey water locally will be developed. The development of intelligent infrastructures to support developing energy and transport needs (e.g. electric cars, hydrogen vehicles, private rail vehicles) is likely to result in land take and possibly increased landscape fragmentation. Energy micro-generation technologies and new battery technology will

support smart grids, with increasing demands for new materials and potential for new pollutants (Foresight 2010b).

6.5 Such advances in computing could herald 'Servicisation' in land-based industry; customers order and pay for a product irrespective of the supplier. The method of delivering products is left to a contractor who provides all the servicing needed to underpin production. For example, you could sign a contract with a provider who then supplies all food to your home (raw and cooked, possibly including hot foods). We are already moving towards this approach, but will we ever achieve the *Star Trek* image of getting food from a single service point in the home? The impact of servicisation will be in the provision chain and could increase the ownership of productive lands by large service providers (supermarkets) rather than farmers, as they move towards potentially more energy efficient 'whole' system (from field to fork) models (Foresight 2010b).

6.6 Manufacturing on demand, *i.e.* personalised products, is likely to increase. This could extend beyond smaller personal items to all aspects of manufacturing, for example modules to build cheap but unique housing. With servicisation, this could lead to greater variation in solutions to any given manufacturing demand and result in greater reliance on local sourcing of materials (Foresight 2010b); for example, in the building sector it could stimulate local markets related to timber and wool insulation supply.

6.7 New building and engineering materials are in development, for example, fibrous composite materials, self-healing surfaces on materials, nanomaterials and metamaterials. Advances in genetic engineering are rapid: 3rd generation Genetically Modified food and biomass crops will be available soon; smart and biomimetic materials, synthetic organisms and industrial biotechnology will all be developed rapidly over the next 10 years (Foresight 2010b).

6.8 In the next 5 to 10 years, biological sensors to detect toxins and heavy metals in environment will be developed, and could be coupled with engineered bacteria capable of neutralising toxins and metals. This could have significant application in managing water quality, and in the longer term be enhanced by synthetic sensors and 'cleaners'. Synthetic bacteria and yeasts (in contained systems) could have a role in biofuel production, with large scale production likely in the longer term. Bio-materials under development could be used for carbon capture, for example artificial leaf technology and paints. A new generation of pesticides is under development; synthetic pesticides will have high specificity and be system friendly (life cycle not harmful to non-target species including soil biodiversity). Synthetic genetics will in the longer term impact on GM to further enhance multiple-use of crops (food plus energy) and increase environmental tolerance (growing range). Also in the longer term (25 year horizon) synthetic enzymes (especially for biofuel production and biomass conversion) and bio-plastics will be available (Royal Academy of Engineering 2009).

6.9 Carbon-dioxide removal (CDR) methods will be a focus for development over the next 20 years, but some simple measures are available now such as land use change (increased afforestation), biomass production for fuel, biochar and biomass burial, and ocean fertilisation. Far horizon applications might include enhancing natural weathering processes, *e.g.* adding silicates to agricultural soils, and carbon capture via air capture technology. Solar radiation management (SRM) techniques that might have a future in the

longer term include: land use change to increase reflectivity of earth's surface – i.e. different crop/ vegetation choices; injecting sulphate aerosols into the stratosphere (impacts precipitation patterns); and, inserting light-scattering materials in space (Royal Society 2009).

## *7.* Part Three: Scenarios

7.1 There are a range of environmental scenarios available at country, UK, EU and global scales that when viewed in the context of known policy trends, can provide an inkling of how the next 10 years might unfold. We summarise key messages from a few of these.

**The UK National Ecosystem Assessment** (UK NEA; 2011) presents six plausible futures for 2060: green and pleasant land; nature at work; local stewardship; business as usual; national security; and, world markets.

The main messages are:

i. People regard nature and natural places as separate from their urban surroundings, but green and blue spaces are important to the majority of surveyed people (about 90%);
ii. Local stewardship produces increased afforestation;
iii. All scenarios produce significant increases in woodland cover, especially in urban areas;
iv. The area of freshwater systems stays the same or increases in all scenarios;
v. All scenarios produce increased urban greening, but of differing types depending on scenario.

7.2 Each scenario is based on various social and economic assumptions and the impacts of these are then described in the context of environmental pressures and change. Each can be very briefly summarised as follows:

i. **Green and pleasant land:** conservation of biodiversity main driving force; intrinsic value of biodiversity afforded prominence in policy. Tourism and leisure boosted, bringing significant economic benefits (domestic holidays increase). Conflict from desire to preserve landscapes and recognition of ecosystem change (under climate change), but preservationist. Only possible with continued economic growth (GDP increase 2% or more) and slow population growth. Significant reliance on imports for food, fuel, etc, which means that domestic food production not a major driver of habitat change.

ii. **Nature@work:** ecosystem services approach in which biodiversity conservation is in context of goods and services and not a separate priority. Climate change adaptation a priority and non-natives are introduced to provide food, energy or shade, or ensure services maintenance. Multifunctional landscapes are mainstreamed across all sectors. Ecosystem restoration a major driver of habitat management, but less emphasis on species except in relation to ecosystem functioning. Climate change adaptation delivered through ecosystems. Good recognition of value of ecosystems by society. Technology embraced to support this agenda, including GM. Optimal service provision is objective. Dynamic ecosystems (neo-ecosystems where nativeness is given less importance). Renewable energy production is

important – proliferation of small-scale approaches, but major development of marine energy. Strong national level regulation needed. Assumptions: population growth moderate, strong economic growth (GDP >3%), green economy, sustainable growth. Decline in improved grassland with lower meat production and greater dependence on vegetable proteins; forest and woodland increases in marginal grassland areas, lowland grasslands protected. Invasive aliens well managed. Fish farming gains importance and UK fish supplies well managed. Urban green space increases.

iii. **Local stewardship:** elements of national security scenario (see below), but more environmentally benign; localism strong and society less nationalistic. Local self-sufficiency and branding of products. Focus on optimisation – land use more sustainable. Less travel, local innovation through private funding, but less reliance on technological advance. Low-carbon economies bloom and local exchange schemes become important. Landscape becomes more locally distinct. Afforestation increases with loss of open-habitat upland areas. Local energy solutions also lead to loss of open upland habitats. Assumes: Counter-urban population shift, very slow population increase (reduced immigration), and more people living together so there is only slow housing increase and brown-fields are increased through removal of urban housing. Focus is sustainable growth at local levels, so levels of consumerism decline and economy grows very slowly. Waste is reduced dramatically. Water and energy technologies supported; greater reliance on renewable energy production, but some fossil fuels still used and mining increases. Imports reduced – less reliance – but exports also reduced. Agricultural extensification through subsidy; smaller farms. Improved water management and reduced threat from non-natives due to more controlled imports. Fisheries sustainable with national and local management. Urban farming. Large wind farms in right places avoiding biodiversity hot spots.

iv. **Business as usual:** current policies and regulatory burden persist. Environment still important, but funding diminishes and progress is hindered. Scenario based on qualitative projection of current trends and attitudes; leans towards more sustainable future. Moderate population growth; people continue to live more independently with smaller households on average. Some progress on renewable energy and low-carbon economy, but not concerted. Privatisation of public bodies. Low growth in GDP. Science and technology well funded with increase in private funding. Sustainable certification grows and these products come to dominate markets. Farming more industrial with more indoor rearing of livestock and increase in arable. Non-natives insufficiently controlled. Large wind farms built, including on some sensitive areas. Fish stocks half of 2010 baseline. Housing increase in SE and into green belt areas across UK. Biofuels promoted and most cars not using fossil fuels. Ecosystem services that have very obvious value are protected, but others not. Timber is imported, so little additional commercial forestry. Woodlands increase for fuel wood. Arable increase. Fish imports overtake domestic production. Gas remains key fossil fuel, with only moderate investment in renewable energy.

vi. **National security:** UK industry protected; trade barriers and tariffs increase; immigration tightly controlled. State subsidies of industry and technical development. Biodiversity loses out as domestic food, fuel and timber, and minerals prioritised. Fuel prices increase driving greater self-sufficiency but optimal approaches to agriculture rather than intensification. Lower economic growth. Tight controls on planning with focus on developing brown field sites. Resource use maximised – coal mines re-established, etc. Fisheries protected. Technology embraced, including GM. Meat production heavily taxed – shift to plant proteins. Forestry increases – especially conifers and non-natives at expense of natives. Desalination plants built in east. Urban food production and woodlands established – gardens given over to production under private or community initiatives. Aquaculture increases, especially around English coasts.

vii **World markets:** liberal markets; priority is economic growth. No subsidies for farming – farming becomes 'industrial' (loss of farmland heterogeneity). Land use regulation relaxed – planning restrictions relaxed – urban sprawl. No sustainable management of fisheries – fish stocks collapse. Desalination required in SE England. Gas imports and domestic nuclear provide most energy – biomass decline. Other ecosystem services in private hands. Major reliance on imported goods. Assumptions: population increase and desire to live in smaller family units/alone; strong demand for new housing. Some models to maximise ecosystem services adopted. State funded activities decline – privatisation dominates. Strong central government, but choices increased. Intrinsic value of biodiversity of minimal importance – restricted to a few areas. No recognition of climate change – little mitigation or adaptation – renewable energy only as fuel supply to offset loss of fossil fuels. Some land abandonment. Large business dominates, with little opposition. Community-based activities minimal. Global MEAs decline.

7.3 Three of the scenarios (green and pleasant, local, and nature at work) are based on no significant rise in UK population (65); the others all assume a population of at least 75 million in 2060 (ONS projections indicate that if past demographic trends continue the population will rise to 72 million by 2034). Key issues related to population growth are energy/ fuels and foods (including imports). Key considerations for developing the scenarios are: consumerism trends; community cohesion; settlement patterns; transport and mobility; interdependence; autonomy; overseas footprint; landscape heterogeneity; habitat fragmentation; response to climate change through mitigation and adaptation.

7.4 Output of ecosystem services is highest for green, nature at work and local scenarios. Business as usual is less than these, but slightly higher than today. World market and national security have negative impact on ecosystem services. The link between habitat condition and service provision is poorly know and requires study to allow the prediction of likely impacts of different scenarios on ecosystem services to be better understood. Future change s in land use may have as large an impact on ecosystem services as the direct effects of climate change.

7.5 Woodland ecosystems undergo different patterns of change under each scenario, but increase in cover is common to all. There is a trade-off between

multiple-services, including climate change (deciduous domination – natives and new non-natives from southern Europe), and focussed fibre/ fuel production (conifers). There is also a significant trade-off with food production on lower value lands, complicated by the need for increased vegetable protein production rather than meat. Urban areas become more wooded in all scenarios, but there is also a trade-off between this and urban food production.

7.6 For marine ecosystems and services world markets and local stewardship are very damaging scenarios (tragedy of commons), the latter for not allowing recovery of commercial stocks and for allowing fishing of new species. Some scenarios that place biodiversity at heart of consideration are benign or lead to improvements in marine. However, the nature at work and local scenarios demand greater use of marine for energy production.

7.7 The UK NEA concludes that the UK cannot support itself on current consumption patterns; access to international ecosystem services is essential (30% of biomass used currently by the UK is sourced from overseas). Food and wood products account for 90% of imported biomass, with bio-energy crops representing 10%; marine imports are only 2% by volume. Over half of imports are from Europe. Ongoing access to overseas biomass is a crucial factor in UK land-use futures. Waste reduction, increased domestic production and changes in consumption behaviour could reduce dependency on overseas biomass; this could be sufficient to compensate against increased demand from population growth. Increases in biomass for energy generation are likely to be significant creating a net increase demand over next 10 years. If biomass import demand is not mitigated by increased domestic production and reduced waste then overseas volume (by land area) is likely to double by 2030.

7.8 ***Foresight*** has undertaken a range of futures analyses that are relevant to environmental change in the UK; we have focussed on technology futures, land use and global food futures.

7.9 A shift in land-based business 'culture', with land-based businesses empowered to adopt new technologies for managing interests over long-term is likely leading to stronger, direct collaboration between land-based businesses, industry and research organisations. This presents an alternative model for government subsidy of farming. The outcome is likely to be marginalisation of biodiversity, creation of larger businesses, and an increase in multi-national investment (Foresight 2010b).

7.10 In the UK, demands for water in Eastern areas will become significant; a combined impact of rising population and climate change impacts. Incentives to encourage redistribution of population might be taken to help manage demands and impacts. Policies to support a significant increase in renewable energy generation will be adopted, especially large scale wind on land and inshore. Land release for development is likely, coupled with relaxation of planning policies. Incentives for multi-functional use of land will be developed; subsidies will be redirected. Nine sectors are considered: water, conservation, agriculture, woodlands and forestry, floods, energy, development, transport, and recreation (Foresight 2010a).

7.11 Integrated catchment management needed, alongside improved national infrastructure to move water to high demand areas; multi-sector land-

management partnerships will be an important mechanism for achieving sustainable water management. Local management of water will increase, including at the single property level (direct reuse and treatment). A better understanding of the role of habitat structure in flood management is required along with practical tools (including models).

7.12 Landscape scale management will be pursued to ensure effective protection of important conservation areas. Incentives for land management will be adapted to reflect multiple uses (ecosystem services) – especially carbon management, fuel production, low-carbon technologies, etc. Management of forests and woodlands will change to reflect value in providing multiple services, including support for integrated flood and water management; better incentives will be needed. Community led forest creation and management is likely. However, more research is needed on the role of woodland and forests in climate change mitigation and adaptation.

7.13 Increasing low-carbon energy supply through planning, pricing and new technologies will be a key change; a step-change in on-shore renewable energy generation is likely. Supplying about 10% of UK energy needs from biomass would require 25% of land; this will significantly limit domestic biomass capacity. Carbon trading becomes a reality, with improved pricing across sectors.

7.14 Research is needed on the value of different landscapes for recreation and tourism in different areas, including for health and prosperity, and to UK economy. Valuation and integration of intrinsic values of land need to become operationalised. The polluter pays principle also needs strengthened, but incentives and rewards also need to be more carefully considered. Values should be assessed on a consistent basis across scales and sectors; this might be done most effectively at a UK level activity. [Foresight 2010a]

7.15 Global food demands will also impact on UK production: there will be an increased demand for meat production to meet consumption needs in Asia; fishing pressure will intensify and there will be a greater reliance on aquaculture – Asia will become a major producer; the BRIC[3] nations are set to become 'food superpowers' supplying world with cheap vegetable proteins (Foresight 2011). Limiting factors on food production will include: cost of energy to produce fertilisers and for fishing; water demand for agriculture is already unsustainable – increasing demands for food production will create significant trade issues for water-dependent agriculture in drier countries and might result in water trading. The benefits of landscape scale management will be recognised increasingly with more integrated and optimised land-use choices being made to ensure that ecosystem services are maintained. Water management practices that secure flows critical to maintain ecosystem services will become important; this is especially important in irrigation-dependent agricultural systems, including aquaculture (Foresight 2011).

7.16 An additional perspective on growing international pressures is given in Sutherland *et al.* 2010: milk demand in Asia will increase rapidly (potential for increased UK exports); lithium prices might rise substantially and limit affordability of battery production with impacts on ability to harness renewable electricity; denial of need for /benefits of biodiversity (ecosystem approach)

[3] Brazil, Russia, India and China

due to increased remoteness of people from countryside (UN predicts that almost all people will live in cities by 2100); a significant rate of loss of protected areas to other uses and pressures like climate change; relaxation of animal disease controls and re-emergence of rare viral pathogens; loss of global governance mechanisms like climate change agreements and failure to create effective new mechanisms, *e.g.* carbon trading; rate of marine exploitation increases significantly (deep-sea fisheries, mineral extraction, energy capture); impact of European earthworms in North American ecosystems (significantly change to forest ecosystems); impact of rapidly increasing techniques for extracting 'new' fossil fuels (oil sands and shale basin gas), *e.g.* hydraulic fracturing, on natural fresh water reserves.

7.17 Finally, although not strictly a scenario, the Aldersgate Group has set out perspectives on greening the economy (Aldersgate Group 2011). They suggest that UK policy needs to focus on 3 things: building a globally competitive green economy; stimulating export; attracting investment from overseas. A green tax shift is required; the UK needs a strong and consistent green growth strategy. A sectoral basis will be most effective to avoid compounding barriers to change; some sectors need specific targeted funding to enable innovation. Green investment must be incentivised; taxation should be restructured and any Green Investment Bank must make a transformational impact. Skills development is crucial; this should be supported national through skills strategies that recognise the potential for green growth and support necessary training. Government R&D spend needs to be maintained. Public procurement needs to change to support the transition to a green economy; it needs higher priority and consistent and credible accreditation schemes need to be in place for domestic and global products. Planning reform is needed to support projects with net environmental gains and Local Enterprise Partnerships (LEPs) must play a leading role.

## *8.* Part Four: Changing pressures on the environment

8.1 Energy and food security are the main issues highlighted by UK governments and the EU, and emerging environmental policies are placed firmly in this context; this will result in changes, some transformative, in resource management decisions and hence pressures on biodiversity and ecosystems.

8.2 To meet demands for energy and fuel security, policies are likely to support significant increase in wind energy generation and biomass production and use, and microgeneration R&D (wave and tidal technology development better supported with a view to longer term up-scaled operation). Biomass sourcing will diversify to include algal production (freshwater and marine), novel and GM crops, woodlands, and novel non-native species. Other forms of energy production – wave/ ocean current, solar and nuclear – are unlikely to have a significant impact on UK generation in the next 10 years, but beyond 2020 marine and nuclear may become key sources. Longer term possibilities are hydrogen and synthetic gas (from a range of waste products including plastics) energy solutions. Any increase in wind energy infrastructure or biomass production will result in changes to patterns of land use, land take (including seabed) and conversion, and possibly increased landscape and habitat fragmentation. In particular, conversion of non-production lands, pasture, marginal grazing land and uplands is possible.

8.3 Any increased demand for domestic food production will mean land use change and, in order to increase crop yields, the use of GM crops. Energy efficient and low carbon agriculture will be a primary concern, especially in relation to chemical fertilisers and pesticides, and possibly in relation to the balance between crops and livestock; pressure to reduce some livestock production is likely. Continued agricultural intensification is likely along with increasing specialisation on cereal and vegetable protein crops, resulting in increased conversion of non-production lands and pasture, and larger farm units. Pressure to make use of urban non-production lands (green-space and brown-field) is likely to result in significant change in use, including food production and woodland planting alongside increased residential and business development. Strong measures to significant reduce food waste are likely, ultimately influencing patterns of production.

8.4 The future of aquaculture is likely to be mixed depending on affordability of feed, but it is possible that significant increases in both coastal and freshwater aquaculture could happen over the next 10 years. Exploitation of novel marine fisheries and changes to fishery policies on landing of non-target species, along with improved food waste management, could all boost non-food marine protein supplies (for animal and pet feeds) and support increases in aquaculture.

8.5 Domestic fibre production is also recognised as of importance with increases in forestry a likely policy-driven outcome; pressure to grow new forestry on marginal habitats is likely with conversion of a variety of semi-natural habitats of value to biodiversity, including marginal pastures and uplands.

8.6 Water management will become an increasingly critical issue as costs associated with supply increase; this will impact on all aspects of living. Ecosystem approaches to flood management are likely to become an increasingly frequent adaptation strategy over the next 10 years resulting in relatively significant changes in land use patterns. Patterns of food production will be increasingly influenced by affordability of irrigation and result not only in changes in land use, but also changes to local water management that could change water flows and quality through wetland systems. Biomass production is also likely to drive change in water management, especially from abstraction and local cycling for freshwater algal production. Urban demands for water will increase with likely significant impacts on wetland systems due to abstraction and local water cycling.

8.7 Demands for energy efficiency and to meet climate change mitigation needs will have an additive effect as patterns of land use change become influenced increasingly by a broader range of economic considerations, including payments for ecosystem services. Climate change mitigation through carbon management has stimulated a number of new policies that are likely to yield multiple societal benefits, but could have damaging impacts on biodiversity and ecosystems. In particular, significant increases in woodland planting are planned as a carbon capture method; the location of new plantings will need to be well planned to optimise benefits and avoid perverse impacts on other ecosystem services, including through conversion of habitats of cultural value.

8.8 The role of society and businesses in land use management is likely to change over the next 10 years linked to payments that will enable communities and businesses, especially in partnerships, to invest in and control land management at a local level. A range of economic instruments

and financial incentives, including subsidies, green taxes, green investment loans, etc, will support this significant change in societal involvement in local landscapes. Amongst other things, wind energy production, urban food production, woodland management and local water management are all areas that could have significant community/ business involvement.

8.9 The likelihood of transformative land use change and its rate depends on complex economic and societal factors. Natural capacity will limit the exact nature of land use change and tough decisions on land for food *v* land for energy *v* land for ecosystem services may be required. However, stochastic events, or shocks, can force a profound shift in direction. At the time of writing and in addition to large-scale natural disasters, global economic instability, national debt and energy costs are all major issues that could create shock-waves that cause a significant shift in financial viability of major land use and marine exploitation; scenarios are complex and consideration of their potential impacts is beyond the scope of this review.

## *9.* Part Five: UK evidence needs

9.1 There are many excellent publications on evidence needs to support current and developing land-use and marine management approaches; of particular note is the series of reviews published by the UK Biodiversity Research Advisory Group[4] (Defra 2007), the series of expert-opinion horizon scans led by Professor Bill Sutherland (2006; 2008; 2009 and 2011), and a number of strategies, work plans and papers from Europe (e.g. European Platform for Biodiversity Research Strategy 2010[5], BiodivERsA[6] and Pullin *et al.* 2009). Government evidence investment strategies also reflect current and future evidence needs.

9.2 Most of these have been developed from a biodiversity conservation perspective and, although they pose questions relating to ecosystem services, it may now be valuable to complement them by undertaking an in-depth review of needs in light of new policies and from an ecosystem services perspective. To do this successfully will require an inclusive approach that assesses issues in terms of economic and social implications; a multi-disciplinary and sectoral debate is needed.

9.3 We present a view on general evidence needs that might be most beneficial for managing biodiversity and ecosystems as new polices are implemented (see summary at top of document). The research needs to be both policy-relevant and applied, with greater emphasis on end-products that can be used by the full range of stakeholders; it also needs to make better use of existing evidence.

9.4 It might also be beneficial to consider better ways to identify more detailed UK evidence needs explicitly linked to common policy drivers, prioritise these (including to address highest current or near-horizon risks) and incorporate within the activities of the major research funders. There could be significant benefits (financial and temporal) from UK scale research that tackles the considerable commonality in country policies, whilst recognising that more localised solutions will be needed for some ecosystems. The development of

[4] http://jncc.defra.gov.uk/page-3901
[5] http://www.epbrs.org/PDF/EPBRS_StrategyBDResearch_May2010.pdf
[6] http://www.biodiversa.org/index.php?option=com_content&task=blogcategory&id=40&Itemid=130

the Intergovernmental Platform on Biodiversity and Ecosystem Services and the similar concept being developed at the EU level are both likely to demand an effective UK platform for multi-disciplinary research prioritised to societal needs (policy-relevant).

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**Appendix One**

**A 2020 NARRATIVE: THROUGH NEWS HEADLINES AND STORY**

i. **140 million footprints:** UK population rising faster than predicted with increase of 7 million over last ten years
ii. **1 in 4 over 65:** is 65 the new 55?
iii. **Kent droughts:** third year of no water, no local economy, no climate change?

1. A recent scan of personal data on the internet has revealed that the UK's population now stands at 70 million. Back in 2011, the Office of National Statistics (ONS) projections indicated that if demographic trends continued the UK population would rise to 72 million by 2034; it was 62 million in 2009, producing a 2020 prediction of about 67 million. But, immigration rate increases over last 10 years have resulted in a faster rate of increase. The UK is still in the EU and the economic status of several EU states declined in the first half of the decade resulting in increased movement within the Union. Also, instability in North Africa and the Middle East continued through the first half of the decade resulting in increased immigration, largely of refugees, into the EU. The population of India has risen rapidly over the last 10 years and their booming economy has led to greater movement, especially of skilled workers and students seeking to benefit from the UK's continuing strength in R&D.

2. We also have an ever ageing population as life expectancy has continued to increase slowly over the last decade; ONS predicted that 25% of the population is likely to be over 65 by 2034.

3 Population increases are never evenly distributed and those over the last 10 years have been no exception despite policies to incentivise redistribution of businesses and population, alongside the growth of successful community-business partnerships (stimulated by market forces and the funded localism agenda that emerged at the start of the decade). And, of course, we have seen significant housing development around some of our cities and towns, with loss in some areas of urban green space, brown field and green belt land. There has been increased movement of people, especially the elderly, from the countryside into the growing urban sprawl and an increase in communal living. This has been driven in large part by increasing energy/fuel costs, which has reduced mobility and affordability of single-person homes. As we have seen the greatest population growth and resultant environmental pressure is occurring in SE England, the central belt of Scotland and the Severn Valley Conurbations. And of course, the droughts in Kent, Sussex and Essex over last three summers are a stark reminder of the real impact of added population pressure, the additive effects of climate change and the difficulty of integrated catchment management to sustain water supplies to people, businesses and ecosystems.

i. **Average household energy bill tops £5,000**
ii. **Our future is blowing in the wind**: 1,000 community wind farms now in operation
iii. **How do you get 10 ha of rain forest into a *Mini*?**
iv. **Plug and play:** sales of electric cars exceed biogas guzzlers
v. **Life's a gas:** UK dangerously dependent on natural gas imports

4 We have all seen rapid increases in energy and fuel costs within the home as well as for transport. Just to heat, light and feed a household has become prohibitively expensive for many – and has significantly increased domestic poverty. The result has been a change in the way we live, with people moving from rural to urban areas,

a greater demand for energy-efficient housing, and an increase in shared accommodation and facilities.

5 Back in 2011, some of the developing environmental policies, like those on renewable energy and localism, meant that, despite considerable controversy, many more large scale commercial wind farms developments have been built both inland and especially along the coast. Added to that, many smaller community-business partnership funded wind farms have cropped up as communities quickly sacrificed their 'back yards' to benefit from reduced energy costs – helped by government incentives and green loans. Overall, there has been significant land and seabed take for wind infrastructure over the last 10 years. One of the disadvantages of the more locally devolved planning system has been that there has been little ability to regulate cumulative impacts on habitats and ecosystems resulting in declining capacity of some landscapes to provide other valuable services. But, there is no doubt about the significant societal and economic benefits of wind development and many now consider these to outweigh the impacts on landscapes and habitats. Biodiversity research over last 10 years has demonstrated that some early concerns were misplaced, and significantly improved land-use modelling has allowed more precise ecosystem services sensitivity mapping and better planning.

6 Early in the decade, the transport sector - automotive and especially the airlines - continued to proactively respond to energy/fuel scenarios and put significant finance behind biofuel R&D. However, despite policies to encourage greater growth of domestic biomass and some volume increase, the food production conflict won out and the UK is still very dependent on imported biomass. Controversially, significant public money went into R&D from green investment banks – controversial because most people thought that more funds should have been focussed on community-business partnerships and not on major international companies. Interestingly, this shift in focus of R&D funding to support economically important research was seen across all sectors, including the environment.

7 Despite policies designed to increase domestic energy security, many believe that we haven't gone far enough, fast enough and should have sacrificed more food production and amenity land for biomass production to reduce dependence on both imported biomass and especially natural gas. So now in 2020, we are on the brink of a 'domestic energy drought' that could last 10 years, in which biomass availability will decline, wood-fuel will only begin to become available in any noticeable volume and of course nuclear… the Japanese Fukushima disaster in 2011 didn't slow progress in nuclear build, but this won't start generating until about 2025. Many commentators have recently asked why we didn't work faster to secure our energy future and why governments allowed environmentalists to dictate country energy policy. This is likely to have serious political and economic impacts over the next few years.

i. **Boundary wars:** England's county boundaries redrawn by river catchments
ii. **Power to the people:** River Dove Catchment first to be incorporated, with a little help from the Co-op Green Bank
iii. **Flushed with success:** waterways trust, community and businesses establish Europe's largest algal farm inside Severn barrage
iv. **Liverpool – the new market-garden city:** urban farms reach peak productivity

8 After years of heated argument, largely fuelled by political self-interest in setting electoral constituency boundaries (let's not forget the debacle that followed the alternative vote referendum in 2011), a new governance landscape has emerged that will help communities to build more effective partnerships with land owners and other businesses and create robust society management plans. Now the headache begins

to realign existing community- business partnerships, but with help of government funding and 'green loans' this is already being achieved by several smaller catchment communities; we now need to scale-up to larger catchments like the Severn Estuary.

9 Of course, and controversially, the governments' various green investment banks focussed primarily on funding support to independent R&D and big business. But, the limitations of this became very clear early in the decade and so banking regulation was tightened yet again to ensure 'green loans' (supported by government insurance schemes), became available for community-business partnerships too. Unpopular 'green taxes' are still with us in 2020, although they have become more sophisticated in an effort to penalise energy (or carbon) inefficiency, but rates haven't risen as fast as they were predicted to early in the decade. Commentators are calling for an urgent review of taxes to ensure that good behaviour, including 'green R&D', is being rewarded; the lack of transparency in the current system is believed to be hampering development of the UK's green economy, which could have significant impacts on our competitiveness and economy in the future.

10 One of the additional benefits of increased local/ community engagement, coupled with improved species identification through hand-held technology, means there has been a growth in interest in biodiversity and citizen science.

11 We all know that some of our urban areas have continued to decline over the last 10 years, with significant numbers of buildings and brown-field areas unused. Pressure to change planning laws to allow the unused land to be mobilised lead to radical national level regulations to release unused land for food or biomass production. This hasn't come cheap for the taxpayer, and whilst there have been benefits in some cities, it has lead to some poor local planning decisions that allowed take of green belt and urban green space for housing development.

i. **New model army:** Norfolk community uses predictive modelling in spatial planning
ii. **Meet Big Brother's much bigger brother**
iii. **The city never sleeps:** Boris's monster unchained as urban metabolism brought to life
iv. **In the house of the gods:** it's not a mirage, it's the real thing
v. **Something for the geekends:** 10 million gamers create alternative-reality sustainable planet in *Evoke 2*

12 We have touched on examples of localism in action – a major transformation over last 10 years - this has been enabled through a variety of technological advances. These advances have lead to significant changes in the way land-owners and users, businesses, developers, government – all sectors of society – view and interact with the environment. Predictive modelling isn't really a 2020 headline – it was very topical back in 2011, with some applications already in use (like flood planning) – but its local operational use, especially in adaptive management, is relatively new. It's surprising that it's taken so long to come into use as back in 2011 there was a clear policy trend toward risk-based land management, which is where predictive modelling would have come into its own. The delay has been driven largely by lack of knowledge on the societal benefits or values of different land-uses, and how management changes those benefits, coupled with the demand to get 'more for less' – maximising multiple use (services) of land. Unfortunately, the localism agenda was also partly responsible for slowing down the development of better planning approaches as the funding of knowledge of relevance to local needs wasn't given sufficient priority within local community-business partnerships.

13 The drive for energy efficiency has lead to significant investment in creating intelligent infrastructures. We now live with a high tech sensor system that collects information about behaviour, environmental conditions and status of supporting systems, and disseminates information to us to help decision making – the network came into its own in creating integrated water management systems and in enabling transport infrastructure change (especially in delivering the UK electric car-share system (ECaSS) – it wouldn't be possible without the sensor network). Of course, one of the major applications is in urban settlements – designed to efficiently manage energy, water, waste, etc. And, the Mayor of London recently switched on the city's fully integrated intelligent infrastructure, which combines cutting edge technology with sophisticated adaptive systems modelling (which utilises an artificial intelligence interface).

14 You might just remember the original Microsoft *Kinect* technology from the beginning of the decade – motion sensors allowing people to interface with computer games without using electronic devices. We have seen that technology develop and used in many different applications, especially in certain businesses (including recreation) and the home, but alongside that has been rapid development of holographic technology and the first interactive systems have just been launched – the *Star Trek holodeck* has arrived! It's early days, but there are now desk-top to room sized applications available that link into intelligent infrastructures and allow remote management of systems. A few of these applications are emerging in the farming sector and it's possible that they will have a significant role in managing landscapes over the next 10 years.

15 Of course, even back in 2011, the internet already represented a massive sensor network of kinds – especially with development of social networking - collecting vast quantities of real-time behavioural or social data. [The *Facebook* nation was 500-million users in July 2010]. Cloud computing was also developed at the beginning of the decade and allowed even more efficient access to behavioural data, and today our online interactions continue to provide valuable data for adaptive management and are actively scanned and analysed to contribute to intelligent systems. So, the behaviour of land-managers, farmers and tourists are all now easy to model, predict and manage! This has had enormous benefits across society and enabled people to become more actively involved in sustainable land and sea management.

i. **Old MacDonald sacked:** farming goes high tech
ii. **AI AI, Oh!** High tech farm systems learn on the job
iii. ***TESCO* largest land owner in England**
iv. **Ultimate table service:** *Enterprise* automated food station can be programmed to swear like Gordon Ramsay

16 Technology development has also had significant impacts on farming over the last 10 years – farming is driven by global markets, EU & national policy (including subsidies) and technology. It's worth reflecting on the two CAP reforms that have taken place over last 10 years. In 2013, you will remember that although sustainable management was still at the heart of policy the overriding driver for reform was EU food security; the new CAP that emerged was focused on ensuring maximum capacity for food and to a lesser extent biomass production – many felt we took a step backwards in terms of sustainability and biodiversity. But, the 2013 reform also placed greater emphasis on technological innovation, which has meant that high-tech solutions, including those designed to reduce carbon emissions, have been supported through EU funding mechanisms. Restriction on growing genetically modified crops were relaxed and these crops have been developed further, including

to increase production of oils and other biomass, and research on synthetic organisms has been supported. In 2013, the idea of multifunctional land use, based on ecosystem services valuation, was incorporated in CAP principles, but little was done to support development through funding mechanisms. The more recent CAP reform (2019) went further on multiple land-use (ecosystem services), partly due to better knowledge of services and values, but still places greatest emphasis on production. Attempts in both reforms to support local rural economies and small farmers achieved very little, largely due to rising energy and fuel costs.

17 Back in 2011 we already had some very high-tech farming systems emerging in the UK, for example fully automated milking parlours. But, we have seen automation take off in many systems, including increased use of robotics, with farming taking full advantage of developments in intelligent infrastructure to build energy, water and resource (particularly fertiliser) efficient systems. The latest advances are in directed energy solutions for pest management (laser and microwaves). As in other sectors we have also seen the development and adoption of artificial intelligence capability and predictive modelling in farming systems, which has increased efficiency even further. The size of farm units has increased across all systems, due to number of different factors, but partly due to automation capability.

18 SERVICISATION! An important development in the latter half of the decade has been increased 'servicisation' – the reliance by people on single service providers to provide all needs, including raw and cooked foods (cloud computing has helped this development). This has created a shift in logistics within the food industry and allowed different players to gain a greater stake; for example, supermarkets have become an even more dominant force in food production and distribution, and have acquired land in order to deliver more efficient production, reduce waste and increase profits.

i. **Waste not, want not**: shorter shelf-life reduces waste and increases profits
ii. **Last tree standing:** Thetford Forest reclaimed for agriculture
iii. **Alien liberates carbon stores:** killer mould rampages across Britain's uplands
iv. **Salmon virus tips scales:** Big 5 stop selling fresh fish

19 The recognition that we needed to dramatically reduce food waste began to gain prominence at the beginning of the decade and was reflected in environmental policy at the time. We have made some significant progress, which has reduced dependency on food and to a degree biomass imports. Servicisation has been beneficial in reducing waste in the home and hospitals, and intelligent infrastructure has helped food suppliers to reduce waste. Developments in biomass processing, including widespread build of anaerobic digestion plants, also means that the use of waste has improved. We may have less choice on the supermarket shelf, or in the Cloud (internet ordering), but food pricing hasn't risen as fast as it would have done without great improvements in waste management and the pressures on our environment from food production has been lessened.

20 Policy developments at the beginning of the decade, which focussed on food and energy security, as well as carbon capture and storage, lead to some redistribution of crops (for food and biomass), forestry and deciduous woodland. Mature lowland conifer plantations gave way to mainly biomass production, but also livestock production, and this was balanced by additional new plantings in open upland habitats. Semi-natural grasslands and lowland heaths came under significant pressure for release to food and biomass production and we have lost some areas. We have already mentioned conversion of brown-field to food production in some cities, but conversion to woodland has also happened with the duel aim of carbon

management and providing wood-fuel resources in the future. Early in the decade, additional and widespread planting of deciduous woodland took place, often at the expense of less productive pastures, and there has also been additional conversion of pasture to arable and biomass production. One of the beneficial changes to have come from the increasing demand for wood-fuel is that many poorly managed deciduous woods are now under active coppice management.

21 Of course, one of the factors influencing conversion of open heath and upland moorlands to other uses was the loss of habitat condition, and associated services, from the spread of non-native moulds *Phytophthora* spp. Despite the devastation from this, bio-security remained under-funded and of low priority. In 2016, this came back to bite us in a very noticeable way with the emergence of a non-native salmon pathogen that brought the UK farmed salmon industry to its knees in just three years and also seriously depleted wild salmon stocks. The impact of this, coupled with continued poor saltwater finfish harvests, has meant that the top supermarkets effectively now have just domestically farmed trout, tilapia and shellfish to market fresh – the majority of our fish supplies now come from farms in Asia, often in the form of various tinned or frozen products.