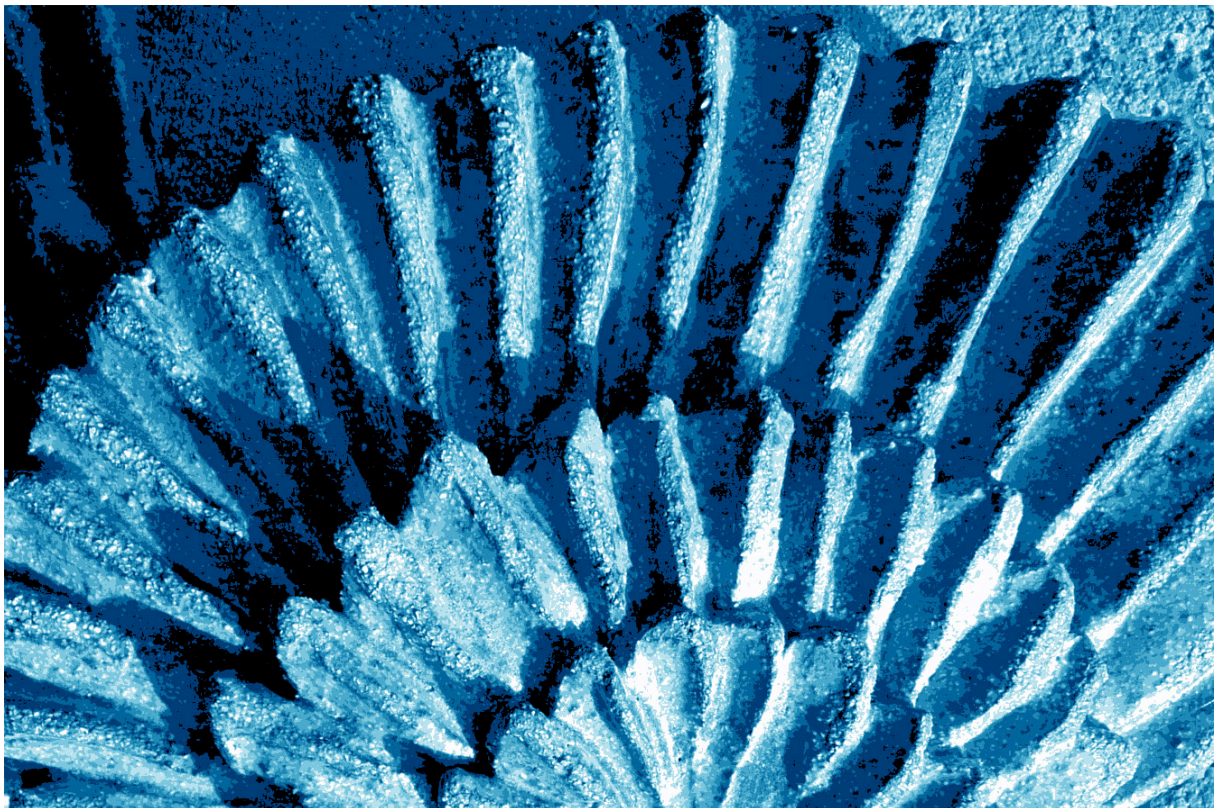


# UK National Ecosystem Assessment

Understanding nature's value to society

## UK NEA Scenarios: Narratives



### CEM Working Paper No 5



The University of  
**Nottingham**



Centre for Environmental  
Management

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**Notes:**

This document is the original longer version of the NEA scenario narratives. They are finalised in the final scenario chapter (CEM working paper No 6).

This document reflects the views of the authors and not those of the funders or other NEA partners.

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**NEA Scenario Coordinator:**

Prof Roy Haines-Young (PI), CEM, School of Geography, University of Nottingham, Nottingham, NG7 2RD, email: [Roy.Haines-Young@Nottingham.ac.uk](mailto:Roy.Haines-Young@Nottingham.ac.uk), website: [www.Nottingham.ac.uk/CEM](http://www.Nottingham.ac.uk/CEM)

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Appendix 1: (Approximate) correspondence between Global, European and British scenarios

# Executive Summary

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The development of story-lines for scenario-building exercises is an increasingly essential part of any ecosystem assessment. They provide a bridge between the understanding of the current state and past trends in ecosystem services and the likely policy or management responses that might be appropriate given a range of plausible futures. For the UK NEA, scenarios will be used to explore how ecosystems and their services in the UK change in the future (in this case 2060), and to identify what the possible effects might be in terms of human well-being and who might be affected most. The development of the scenarios for the NEA have been heavily influenced by current and recent UK and European scenarios from other projects; however, they are also the product of extensive consultation with NEA stakeholders as well as reviews of academic papers examining futures across a broad range of subjects. This document provides a thorough outline of six story-lines that are intended to offer plausible, thought-provoking, coherent and internally consistent outlines of the future for ecosystem services in the UK.

The six story-lines that have been developed attempt to cover a range of socio-political and economic ideologies: Green and Pleasant Land is a scenario where the conservation of traditional landscapes is a dominant driving force in society. This aesthetic imperative drives a renewal in tourism and recreation but also has clear benefits (and a few disadvantages) for biodiversity. In contrast, in Nature at Work, conflicts with biodiversity conservation can arise if the provision of a given ecosystem service is reduced by the presence of a particular species or habitat. Adapting to climate change is also a priority and which means that some non-native species may be introduced to provide food, energy or shade. Similarly, biotechnology solutions are adopted to provide drought or flood resistant cultivars of food crops.

In the World Markets story-line unfettered economic growth through the complete liberalisation of trade is the main goal. International trade barriers dissolve, agriculture subsidies disappear and farming, for example, is now industrial and large-scale. Consumption in society is high which results in greater resource use and imports. Demand for land is very competitive and coupled with reduced rural and urban planning restrictions housing, agriculture and industry fight it out - biodiversity is often the loser. Technological development in all industries is mainly privately funded but nevertheless is burgeoning. Food is cheap and plentiful but of low quality. In National Security UK industry is protected from foreign investors and imports. Trade barriers and tariffs are increased to protect jobs and livelihoods in the UK; immigration is also very tightly controlled. Technological development is state funded and many industries are subsidised by the state (including agriculture). Food, fuel, timber and mineral resources are prioritised over biodiversity conservation.

Local Stewardship has elements of National Security is but far more environmentally benign and although localism is the dominant paradigm, people are less jingoistic and nationalistic. Political power has been devolved and many major issues are decided at a regional or local level (except crucial national aspects like defence); local timber and energy production is encouraged and there is great pride in the numerous local food products. This scenario focuses on optimising resources and consumption is reduced to more sustainable (and healthy) levels - GDP is low but sustainable. Business as Usual is essentially a following-on from current (socio-political, economic, etc) trends. It has elements of all the above although perhaps is closer to World Markets than any other.

# 1.Scenario construction and comparison

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## Scenarios - origins

Scenarios are an essential part of the ecosystem assessments (Carpenter, Bennett & Peterson, 2006a; Henrichs et al., 2010). They provide a bridge between the understanding of the current state and past trends in ecosystem services and the likely policy or management responses that might be appropriate given a range of plausible futures (Bennett et al., 2003). In the context of the UK NEA, the aim is to use them to explore how ecosystems and their services in the UK change in the future, and to identify what the possible effects might be in terms of human well-being and who might be affected most. The timeline to be considered extends to 2060.

A work plan for scenarios was agreed following a meeting with the different NEA interest groups in November 2009. Its main elements included: (1) taking stock of existing scenario studies to review how useful they might be for the purposes of the NEA and to identify the range of projections that others have made on relevant drivers of change; (2) examining what kinds of questions that potential users of the NEA were asking about the future; and, (3) exploring how the scenario programme can best be integrated with the science and valuation components of the assessment.

Despite the strengths of many previous scenario studies<sup>1</sup> none were found to fulfil the needs of the NEA in terms of making a detailed and systematic analysis of future changes in the output of ecosystem service under a range of relevant and plausible futures that might face the UK. Although those of the Millennium Ecosystem Assessment (Carpenter et al., 2006b) are clearly relevant, it was felt that even these needed to be examined closely to ensure that they were relevant in the present context. The various scenario studies identified in our preliminary review were used to inform discussions about potential scenario story-lines and the future projections of the key indirect and direct drivers of change that are relevant to the NEA. The scenarios outlined below are therefore partly based on existing scenarios and use a number of their elements.

Feedback from the potential users of the NEA also helped identify a set of focal questions that was used to shape the design of scenarios. To do this we reviewed documentary material collected through consultation by Defra prior to the start of the NEA, and analysed the results of an on-line questionnaire for members of the current NEA community. The character of some questions posed suggested that within the NEA programme there is a need to help users understand the mechanisms underpinning the delivery of ecosystem services and relationships between services and the factors that drive change. While the scenarios can help in promoting this type of understanding, this aspect of 'community learning' may only be fully achieved by looking at how the outputs from all components of the NEA can be used to promote awareness and understanding (Groves & Lempert, 2007).

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<sup>1</sup> See Paterson, J.S.; Haines-Young, R.; Potschin, M.; Moore, K. and G. Silfwerbrand (2010): The utility of existing scenario frameworks for the National Ecosystem Assessment. Interim Report, May 2010, CEM Working Paper No 2, 11 pp. <http://www.nottingham.ac.uk/ceM/WorkingPapers.html>

Despite the broad and diverse range of issues posed by the user community, the survey suggested there was a clear need to use scenarios to explore alternative strategies, policy options and the impact of changing circumstances on ecosystems and their associated services. It became apparent that a more subtle and multi-dimensional approach to scenario construction was needed to achieve this, hence we adopted a 'morphological approach' to scenario construction (Ritchey, 2010a, b). This was used to identify a range of plausible projections for the main indirect and direct drivers of change. We adopted this approach with stakeholders to define a set of scenarios to be used for the NEA, and to develop a framework in which the mechanisms linking drivers and service outputs can be represented in a transparent way. Bayesian Belief Networks (McCann, Marcot & Ellis, 2006) were used to represent and make operational the links between the drivers that define the different scenarios and service output (often entailing fairly complex causal chains), using 'service output' and 'marginal benefit' functions. This approach allowed the consequences of different assumptions about the future to be traced, and helped make some scenario outputs spatially explicit.

A quantitative description of the changes outlined in the scenarios is provided in this document, both as summary tables and as text. To populate each story-line the materials have, where possible, been derived from peer-reviewed literature, government statistics and expert opinion (see appendix for list of sources). The time-line considered by the NEA extends to 2060. Only final outcomes are described rather than the transition paths.



## 2. Major Issues explored in the scenarios

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### 2.1 User needs and Focal Questions

The survey of focal questions from potential users of the NEA highlighted a number of areas to explore. In particular, they survey highlighted the main drivers that users wanted to consider, namely: climate change, policy issues (e.g., CAP), population growth, management, and global markets and trade<sup>2</sup>. Surprisingly, technology garnered the fewest responses which greatly with many of the published scenarios which assumed that technology will be a major driver of change.

When asked about Ecosystem Services, most respondents expressed an interest in seeing provisioning and regulation services explored over cultural (although cross-cutting issues across all ecosystem services also received a good response). This was seen through greater response for energy, food, water, carbon ecosystem services whilst biodiversity, leisure and recreation had fewer.

A number of the focal questions supplied by the users have helped us define the strategic approach to some of the story-lines; for example: “What happens if you implement all the sustainable management option chapters in the NEA?” and “What will be the consequences of recasting biodiversity targets in terms of ecosystem services?” were clearly useful in helping create an *Nature@Work* story-line. Furthermore, questions highlighting potential contrast between a *Nature@Work* and a *Biodiversity* approach to policy proved useful in deciding to create a landscape preservation/biodiversity story-line.

Policy questions also provided useful source material to populate the story-lines. For example, questions like “How could CAP reform help delivery of services other than ‘provisioning’ from farmland?” allowed us to provide policy contrasts in the story-lines. A further avenue to explore was the effect of external global actors and market forces on the UK’s future. Here, questions like, “What would 70% food security mean for UK’s ecosystems?” were extremely useful. Finally, a number of questions raised issues of the relationships between biophysical and socio-political/economic factors. These often expressed themselves as questions about trade-offs between ecosystem services - an issue that clearly needs to be explored in the story-lines.

### 2.2 Projections and plausible connections derived from published scenarios

Most of the published scenarios (Appendix 1) placed a strong emphasis on the five main indirect drivers (also identified by the NEA Drivers chapter): socio-political; economic; science and technological; cultural and religious; and, demographic. In comparison, cultural and religious drivers were explored the least but they are still evident themes in many of the scenarios.

A review of the direct drivers in the published scenarios reveals that climate change (in 100% of scenarios), resource consumption (95%) and land use change (80%) are dominant issues; surprisingly, biotic drivers like invasive species occur in only 40% of the scenarios. Additionally, one socio-political driver that is not

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<sup>2</sup> Moore, K.; Haines-Young, R.; Paterson, J.; Potschin, M.; and G. Silfwerbrand (2010): Assessing User Needs Of the NEA Scenarios through Focal Questions. [CEM Working Paper No 4](#)

mentioned anywhere is property rights, which has clear implications for a range of ecosystem services. It was, however, raised in the focal questions from users and as a result has been included in the story-lines developed for the NEA. Focus on ecosystem services (or more importantly the effects on ecosystem services) in most of the scenarios reviewed was comparatively rare with two exceptions though: the Foresight Futures Land Use (Foresight Land Use Futures, 2010) and the MA analysis (Bennett et al., 2006). However, despite this paucity reviewing existing scenarios helped distil the connections between drivers of change and the consequences for the environment and hence ecosystem services.

Nearly all the scenario studies followed a fairly generic pattern of differentiation with four basic story-lines: a free market model (corresponding to the SRES A1 scenario; MA Global Orchestration); a national security model (SRES A2, MA Order From Strength); a sustainable or green vision model (SRES B1, MA Techno-Garden); and, a local stewardship model (SRES B2, MA Adaptive Mosaic) (Cork et al., 2006; Nakićenović et al., 2009). Through the use of the morphological approach (which allows expansion of the 2x2 model) six plausible and contrasting story-lines were developed that allowed a greater range of assumptions about the drivers of change and their potential impact on ecosystem services to be examined.

The six story-lines proposed for the NEA are: Green & Pleasant Land (GPL), Nature at Work (N@W), World Markets (WM), National Security (NS), Local Stewardship (LS), and Business as Usual (BAU). Their main characteristics are summarised in Part 3, and the story-lines are described more fully in Part 4.

## 2.3 Dealing with climate change

Both the published scenarios and the focal question placed a heavy emphasis on climate change. Clearly we need to include climate change impacts in the story-lines (as well as variations in adaptation and mitigation measures). We decided to adopt two levels of climate change impact for all the story-lines based on an assumption that whichever approach to mitigation the planet takes now will have little effect on the effects of climate change in 2060 (i.e., there is a considerable time-lag between our mitigation activities and the effects of climate change) - (Hulme, Turnpenny & Jenkins, 2002; Caldeira, Jain & Hoffert, 2003).

We have used 8 climate change variables that are considered to have important affects on ecosystem service output (see table 1) that roughly correspond with two extremes (or probability levels) of the UKCIP09 scenarios<sup>3</sup>. However, each of the scenarios will respond differently to climate change (i.e., though mitigation and adaptation activities) and these are outlined in the story-line chapter (e.g., in the World Market scenario climate change mitigation is seen as a waste of resources; in the Nature@Work scenario the opposite holds true).

The increase in annual mean temperatures in the UK is likely to be higher than the global mean figure; annual temperatures may rise by between 2°C and 4°C by the 2060s, depending on the UKCIP scenario; the south-east will receive more warming than the north-west of the UK, with summer and autumn warming more than winter and spring. Normal spring temperatures will start between one and three weeks earlier by 2050 and conversely winter temperatures may start later by one to three weeks. Annual average precipitation will possibly decrease by 2060 although there will be regional differences; but, as for the rest

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<sup>3</sup> <http://www.ukcip.org.uk/>



of Europe, winters will be wetter and summers will be drier. Snowfall in winter across the UK will decrease and the duration of snow cover will decrease also.

As well as the noted changes in mean climatic variables there are predicted to be changes to the frequencies of extreme events in Europe and the UK. The results of the European PRUDENCE model (Beniston et al., 2007) suggest that the same frequency and intensity of heat waves currently experienced in southern Europe will be experienced by central Europe in the future. Heavy winter rain events will increase in central Europe; winter storms will increase in northern Europe as will North Sea storms resulting in more sea inundation in coastal areas (Beniston et al., 2007; Christensen & Christensen, 2007).

So what does this mean for the UK's ecosystem services? Climate change has affected the autoecology of species in various ways including their phenology (timing events like bud burst, senescence, etc), growth, reproduction, germination, establishment, competition between species and response to herbivory (Parmesan, 2006; Rosenzweig et al., 2008; Morecroft et al., 2009). These impacts not only affect species and their populations but can have serious implications for community structures and ultimately ecosystem function (McCarty, 2001; Neilson et al., 2005). The evidence for impacts of climate change on species is now very conclusive and in recent years a number of comprehensive reviews of the impacts of climate change on biodiversity have been produced summarising effects across different taxonomic groups, biological systems, regions and type of response (Hickling et al., 2005; Menzel et al., 2006; Thomas, Franco & Hill, 2006).

The complexity of most natural communities means that it is extraordinarily difficult to predict outcomes - for example, biotic interactions (competition, facilitation, herbivory, mutualisms) between species at different trophic levels are all likely to be affected by physiological, phenological and migratory responses (Aerts, Cornelissen & Dorrepaal, 2006). However, we can infer some pathways through evidence of climate impacts on existing habitats. In Spain, where many European plant species are at the limits of their southern distribution, climate change is having a dramatic affect on plant communities (Peñuelas & Boada, 2003; Sanz-Elorza et al., 2003; Peñuelas et al., 2007). At the other extreme there is also evidence that alpine communities are changing too (Klanderud & Birks, 2003; Walther, Beißner & Burga, 2005).

Are there deeper consequences of community change? Perhaps of greatest concern is that changes in community composition will result in a change in ecosystem function -and hence ecosystem service provision (Schroter et al., 2005). For example, changes to climate affecting phenology in species may disrupt long-standing synchronous ecological relationships (Sherry et al., 2007; Rich, Breshears & White, 2008).

Focussing on just one habitat highlights how climate change may have serious repercussions for a range of ecosystem functions. For example, woodlands provide a range of ecosystem services which may be affected: productivity Running (Boisvenue & Running, 2006), carbon sequestration (Nabuurs et al., 2003) soil protection (which has implications for flood resilience) (Bradshaw et al., 2007), air filtering (Karl et al., 2010), climate regulation (Bonan, 2008), timber production (Kirilenko & Sedjo, 2007), avalanche control in mountainous areas (Kulakowski, Rixen & Bebi, 2006), pest regulation (Volney & Fleming, 2000; Chapin et al., 2007) and leisure and recreation (Lacaze, 2000).

Similarly, climate change will have major consequences for ecosystem services in other sectors. In farming there will be changes in productivity (good and bad) as well as changes to crop and animal production areas (Rounsevell et al., 2005); marine fish and invertebrates will shift their distribution and depth ranges (Cheung et al., 2009) and ocean acidification from increasing CO<sub>2</sub> levels is, and will, affect calcification processes in coral as well as reduce the capacity of marine ecosystems to act as a carbon sink (Hoegh-Guldberg & Bruno, 2010).

*Table 1: Summarised impacts of Low and High climate change scenarios*

| Climate change scenario | Change in climate change factor in 2060 |                   |                     |                     |                                      |                    |                 |           |
|-------------------------|---|-------------------|---------------------|---------------------|--------------------------------------|--------------------|-----------------|-----------|
|                         | Mean Summer Temp.                       | Mean Winter Temp. | Mean Summer Precip. | Mean Winter Precip. | Drought events                       | Storm events       | CO <sub>2</sub> | Sea level |
| Low                     | +1.0°C to +2.0°C                        | +1.0°C to +2.0°C  | -5% to -10%         | +5% to +10%         | One prolonged drought every 10 years | One every 5 years  | 450ppm          | +15cm     |
| High                    | +3.0°C to +4.°C                         | +3.0°C to +4.0°C  | -15% to -30%        | +15% to +20%        | 2 consecutive droughts every 5 years | One every 15 years | 550ppm          | +45cm     |

## 3. Summary Tables and Figures

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The following figures and tables provide a summary of the most aspects of the six story-lines outlined in Section 4. Figure 1 outlines the key characteristics of the story-lines and their differences and similarities. The Tables also give a detailed picture of other key aspects as well as some quantification of important elements such as population and growth.

The six story-lines (Figure 1) can be grouped in a number of ways depending on the outcomes for ecosystem services, habitats, social equity and governance. All the story-lines share a growing decline in global resource availability and an ageing UK population. The story-lines also include some degree of technological innovation but this is focussed in different areas. In terms of contrasts between the story-lines, there are clear differences between the degree of consumerism (high: WM, NS, BAU) and community spirit (high: GPL, N@W, LS), interdependence (WM, BAU, N@W) and autonomy (GPL, NS, LS), overseas ecological footprint (high: WM, BAU), landscape heterogeneity (high: GPL, N@W, LS) and habitat fragmentation (high: WM, NS, BAU) as well as response to climate change through mitigation and adaptation efforts (high: N@W, GPL, LS).

The development of settlement also differs between the story-lines (Tables 2 and 6). In WM, N@W and BAU there is a strong south-east UK focus and in GPL and NS it is focussed in current urban areas throughout the UK. Transport and mobility also vary: in WM, BAU and NS there is a greater dependence on fossil fuels, air and car travel and continued investment and expansion of the road network; in GPL car use stays high but no new roads are built; in N@W and LS the whole transport system is more sustainable, low-cost flights are reduced, cycling and walking to work is easier and alternative fuels like electricity and hydrogen are promoted.

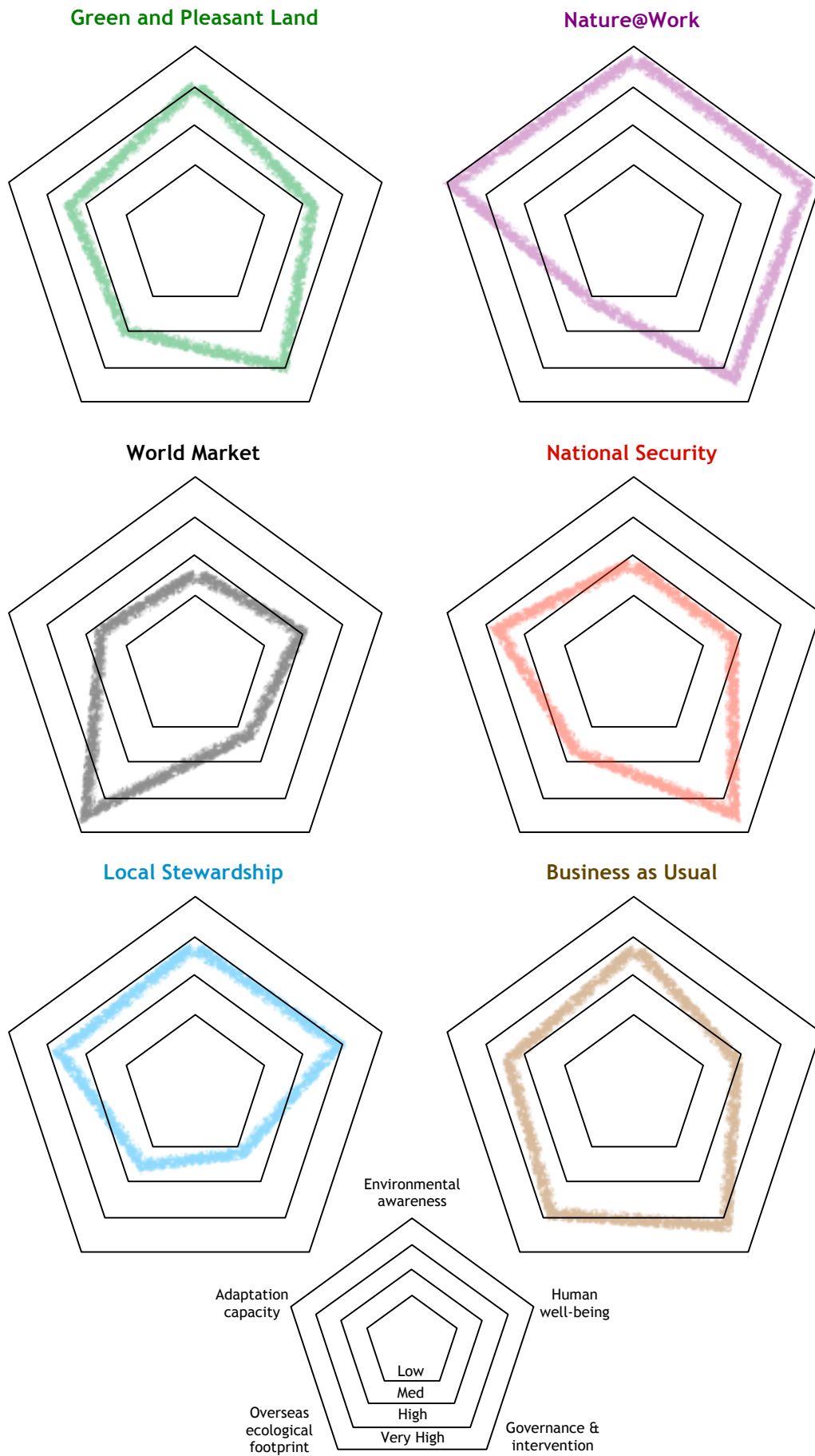


Figure 1: Simplified spider diagrams of story-line characteristics

Table 2: Key story-line attributes for the UK NEA scenarios<sup>4</sup>

|   | Green & Pleasant Land   | Ecosystem Service   | World Market  | National Security  | Local Stewardship  | Business as Usual   |
|---|---|---|---|--|--|---|
| <b>GDP growth of UK</b>   | 2% increase since 2010  | 3% increase   | 2% increase, but numerous crashes   | 1% increase,   | 0.5% increase, but sustainable   | 1.5% increase. Pattern of recession and boom.   |
| <b>Population</b>   | 65 million  | 68 million; many new immigrants from southern EU escaping CC  | 77 million; nearly 30% ethnic minority  | 70 million   | 65 million   | 75 million; 24% ethnic minority   |
| <b>Av. UK wheat yield (other crops, milk and meat products follow similar trends)</b> | 8.5 tonnes/ha   | 10.5 tonnes/ha  | 11 tonnes/ha  | 10 tonnes/ha   | 8.5 tonnes/ha  | 9 tonnes/ha   |
| <b>R&amp;D investment</b>   | 1.5% GDP  | 3% GDP  | 2.0% GDP  | 1.9% GDP   | 1.4% GDP   | 1.5% GDP  |
| <b>World Food Prices (FAO Food Price Index - 2002-2004=100)</b>                       | 560   | 200   | 560   | 560  | 160  | 350   |
| <b>Regional factors</b>   | SE dominates finance and service industry. Other regions boost tourism and tech development.                        | Greater spread of GDP across regions. Renewed urban and rural areas   | London and SE dominate: most jobs and housing development   | Regional development strongly backed by govt.  | Most regions are healthy and diverse; fairly equal spread in GDP among them                    | SE domination; central England competitive too  |
| <b>External World Scenario</b>  | Continued expansion of global free-market enterprise alongside further increases in global environmental standards. | Continued expansion of global free-market enterprise alongside further increases in global environmental standards. | Massive expansion and adoption of free market enterprise globally. Stronger faith in technological solutions to environmental problems. | Global resources are in short supply hence the need to focus on home-grown production and sustainable use. | Global free-market enterprise slows down; further increases in global environmental standards. | Continued expansion of global free-market enterprise alongside further increases in global environmental standards              |
| <b>Urban growth &amp; change</b>  | Brown-field development. More rental flats  | Emphasis on improving building energy efficiency and urban greening   | Continued urban growth and ribbon development   | Urban development on Brown field; small-holdings and allotments increase but less space for leisure        | Reverse; housing stock diminishes, more green space  | Urban growth and redevelopment. More congestion in towns. Gradual push to better public transport                               |
| <b>Rural growth &amp; change</b>  | Farming provides more jobs; other rural service industry grows  | Countryside restoration includes farming, leisure and tourism   | Loss in pop. Rise in exclusive gated communities.   | Heavy push for energy and food prod. More people working in land-based industry                            | Radical changes. Revitalised and burgeoning. Diverse.  | Static. Fewer people working in rural industry. Farming more industrial   |
| <b>Transport demand &amp; supply</b>  | Well maintained road network but reliable and comfortable rail too  | Large investment in rail network and cycle lanes. Less car use but electric and hydrogen popular                    | Continuation of road building, congestion. Short-hop flights  | Car use increases as does internal flights. Fossil fuels and biofuels dominate.                            | National decline; emphasis on local bus, cycle networks. some mono-rail                        | Move towards road tolls and privatisation of motorways. Rail network struggles to keep up with demand. Air travel still popular |

<sup>4</sup> See appendix for sources of information.

|   |   |  |  |  |  |  |
|---|---|--|--|--|--|--|
| <b>Urban &amp; rural policy</b>               | Rigid planning - aesthetic & nature dominates                 | Urban regen. Local neighbourhoods flourish. Rural areas seen as major ES providers                           | Loss of planning powers. Slow blurring or rural/urban                  | State controlled; emphasis on protecting and expanding agri and energy prod.                   | Based on equality of resources. Food prod just as likely to come from urban area                                 | Maintenance of countryside preservation (in terms of planning); rise in demand of 1 or 2 bedroom dwellings |
| <b>Rural &amp; environmental economy</b>      | Subsidised agri and forestry provides reasonable income       | Flourishing, based on ES; IT well established across UK too  | Declines slightly, industrial farming maintains profit                 | Slight increase in % of national economy but not equally shared. Env given backseat.           | Slow and low but sustainable and healthy. High levels of equality  | Dwindling. Fewer farmers and larger farms.   |
| <b>Institutional &amp; governance factors</b> | Private property mixed with public owned NPs etc              | Land with key ES is public. Many land owners become 'stewards'   | Govt backs away and lets markets run free                              | Very strong national govt. Less power with LAs and EU  | National Govt underpins localism. Local govt. more important (think Cantons)                                     | Move towards more privatisation of public services. Continued love/hate relationship with EU               |
| <b>Leisure &amp; tourism</b>                  | Very important part of economy & high investment & management | Increased access to countryside (open access in most places)   | Traditional areas under greater pressure; increase in south coast      | Less important and less attractive UK. Luxury that most people less concerned with             | Local. Different. Outdoors. Historical. More festivals   | Resurgence in south. More privately sponsored events.  |
| <b>Land use &amp; landscape</b>               | Highly protected, diverse, local character                    | Highly protected; 'optimised' balance of ES provision  | More homogenous and industrial   | For production. Food and energy come first. Homogenised  | Very diverse, different regional characters.   | Token efforts towards bioD protection doesn't hide further homogenisation of countryside                   |
| <b>Energy mix &amp; renewables</b>            | Nuclear, imported   | Massive development of Renewables; nuclear also major source   | Fossil fuels, nuclear and biomass                                      | Drive to secure UK-based energy includes fossil f, renewable, gas and nuclear                  | Localised. Based on optimising national resources. Small-scale   | Imports of gas and fossil fuels maintained. 15% renewables and nuclear                                     |
| <b>Climate change adaptation</b>              | Focus on biodiversity and flood                               | Major part of societal focus. Involves EbA as much as possible   | Areas of high investment protected. Otherwise little attention         | Taken seriously and seeks tech solutions   | Yes, agri-adapt in full swing. Strong co-op between regions though   | Adaptation in agri and private sector.   |
| <b>Water management</b>                       | Public sector, high water quality                             | Public sector; heavy investment involving education on use and managing storage, leaks etc                   | Private sector ownership. Little investment. frequent water shortages. | Public sector management. Increase in desalination and recycled water plants in south and east | Regions focus on maintaining their own supply and conservation. Some trans-country delivery from NW & W to east. | Private control. Expansion of desalination plants in south and east  |
| <b>Agriculture &amp; forestry</b>             | Extensive farming low-input, agri-environment schemes popular | Reduction in meat - replaced by crop protein. more sustainable, precision techniques. More woodlands managed | Industrialised and GM dominate   | Heavily subsidised. Tech advances pus yields; GM adopted.                                      | Localised, value added, regional products. Woodlands managed for timber, firewood and NTFPs                      | Increasingly industrialised. Forestry industry dead - pulp and timber imported.                            |
| <b>Ecosystems management</b>                  | Co-benefit of landscape preservation                          | Underlying concept. Includes education.  | Some trading of ES (mostly energy) otherwise little regard             | Little regard. Other things over-ride it   | Full understanding of how to maintain ES. Local pride in management  | Some landscape management in flood areas.  |



|   |   |  |   |  |  |  |
|---|---|--|---|--|--|--|
| <b>Governance</b>   | National                                | National with strong EU (& global) influence                                   | National but small govt.  | Strong national. Outside the EU  | Local decision rule.   | EU and National, increase in private sector control of public services |
| <b>Role of family</b>                                     | Traditional                             | Evolved. More emphasis on community involvement in family roles                | More divorce, disparate, breakdown of 'traditional values'                                | Government incentive to stay traditional nuclear family                  | Strong family units, children stay local.                                  | Higher rates of divorce, single unit households common.                |
| <b>State of the environment</b>                           | Good, protected landscapes              | Very good. Provisioning optimised but careful balance with regulation and BioD | Poor in most places   | Agri and energy decrease bioD few areas protected                        | Optimised' landscape but high BioD   | Many habitats in favourable cond. Loss of some spp to CC though        |
| <b>What do people eat</b>                                 | Traditional                             | More crop protein; less meat. more fresh food                                  | Fast food, processed meals  | Fast food, processed meals; less meat though                             | Different regional and local products. Fresh, meat, fish etc               | Convenience food for poor and overworked.                              |
| <b>What technologies are in use?</b>                      | IT, Biotech etc all strong              | IT, Biotech, Sustainable Tech  | IT, transport, military, pharmaceutical, GM   | GM, biotech.   | Sustainable tech. Increase energy efficiency etc                           | IT, vehicle,   |
| <b>Are people mobile? How do they travel?</b>             | Yes, car and very good public transport | Yes, better use of public transport systems                                    | Yes, car dominates, flying too  | Yes, but expensive.  | Not very, at least nationally. Major use of bicycles and buses             | Yes, car and flying  |
| <b>Nature of education</b>                                | State and private                       | Heavy investment in state education. Greater emphasis on languages, env.       | State sector in poor cond. More people take out mortgage to send children to private sch. | Traditional. Focus on science and vocational. Loss of languages and arts | Vocational emphasis alongside traditional subjects. LA control and funding | Mix of state and private. Increase in faith-based schools              |
| <b>Dominant cultural norm (art, philosophy, religion)</b> | Aestheticism                            | Utilitarianism and pragmatism.   | 'Low art' and consumerist movements.  | 'Low art' and consumerist movements.                                     | Pragmatism and strong local emphasis                                       | Cross section: consumerist but also increasingly environmentalist      |

Table 3: UK GDP growth and regional UK Gross Added Value<sup>1</sup> quantification for the NEA story-lines

|  |                  | Green & Pleasant Land  | Ecosystem Service | World Market                      | National Security | Local Stewardship              | Business as Usual <sup>2</sup>           |
|--|------------------|------------------------|-------------------|-----------------------------------|-------------------|--------------------------------|--|
| GDP growth of UK   |                  | 2% increase since 2010 | 3% increase       | 2% increase, but numerous crashes | 1% increase       | 0.5% increase, but sustainable | 1.5% increase. Pattern of boom and bust. |
| Gross Added Value by region and country (as % of total UK GVA) | North East       | 4.5                    | 4                 | 2.5                               | 4                 | 5.5                            | 3.1                                      |
|  | North West       | 11                     | 8.5               | 8                                 | 6                 | 6                              | 9.7                                      |
|  | Yorkshire Humber | 8                      | 6                 | 7                                 | 8                 | 6.5                            | 7.3                                      |
|  | East Midlands    | 7                      | 7.5               | 6                                 | 9                 | 9                              | 6.5                                      |
|  | West Midlands    | 6                      | 7                 | 8                                 | 7                 | 10                             | 8.1                                      |
|  | East             | 8.5                    | 8                 | 7.5                               | 10                | 9.5                            | 8.2                                      |
|  | London           | 13                     | 14                | 27                                | 19                | 8                              | 24                                       |
|  | South East       | 8                      | 9                 | 20                                | 13                | 8.2                            | 16.6                                     |
|  | South West       | 7                      | 6                 | 5                                 | 6                 | 6.5                            | 6.5                                      |
|  | England          | 73                     | 70                | 91                                | 82                | 65                             | 90                                       |
|  | Wales            | 7                      | 10                | 2                                 | 5                 | 10                             | 3  |
| Scotland   | 15               | 13                     | 6                 | 10                                | 18                | 5.5                            |  |
| Northern Ireland   | 5                | 7                      | 1                 | 3                                 | 7                 | 1.5                            |  |

1. Gross Value Added is a metric the Office of National Statistics use to measure the contribution of any given sector or region to the UK economy; it is essential GDP without taxation or subsidy figures included.
2. Based on current % contribution of each region to total UK GVA - see ONS Annual Abstract of Statistics <http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=94>

Table 4: UK sectoral Gross Added Value for the NEA story-lines

|  | Sector   | Green Pleasant Land & Ecosystem Service <sup>1</sup> | World Market | National Security | Local Stewardship | Business as Usual <sup>2</sup> |      |
|--|--|--|--------------|-------------------|-------------------|--------------------------------|------|
| % contribution of each industry to total UK GVA (excludes state or LA run) | Agriculture, hunting and forestry and fishing                  | 0.5  | 16           | 0.6               | 10                | 12                             | 0.8  |
|  | Mining & quarrying   | 1.2  | 4            | 3.2               | 7                 | 5                              | 2.8  |
|  | Manufacturing  | 14   | 12           | 11                | 20                | 18                             | 13.4 |
|  | Electricity, gas and water supply                              | 1.9  | 4            | 2.1               | 7.1               | 1.5                            | 1.8  |
|  | Construction   | 4  | 6            | 7.5               | 5                 | 8                              | 7    |
|  | Trade & repair of motor vehicles, personal and household goods | 13   | 9            | 13.2              | 6.2               | 10                             | 12.3 |
|  | Hotels and restaurants   | 8.2  | 5            | 2.1               | 1.6               | 2.5                            | 3.1  |
|  | Transport, storage and communication                           | 5.3  | 5            | 5.2               | 3.5               | 4                              | 4.7  |
|  | Financial intermediation                                       | 13   | 8            | 12                | 6                 | 5                              | 9    |
|  | Real estate, renting and business activities.                  | 23.6   | 21           | 20                | 22                | 23                             | 25.6 |
|  | Education <sup>3</sup>   | 5.3  | 2            | 8                 | 4                 | 3                              | 6.4  |
|  | Health and social work <sup>3</sup>                            | 6  | 4            | 12                | 4                 | 4                              | 7.7  |
| Other community, social and personal services <sup>3</sup>                 | 4  | 4  | 3.1          | 3.6               | 4                 | 5.4                            |      |

1. Based on extrapolation of % contribution of each industry to total UK GVA in 2007 - see table 12.6 and 16.4 of the ONS Annual Abstract of Statistics  
<http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=94>
2. Assumption that all ecosystem services are contributing to GVA
3. This only includes private sector provision.

Table 5: UK Energy consumption for each NEA story-lines

|  |                                | Green & Pleasant Land | Ecosystem Service | World Market | National Security | Local Stewardship | Business as Usual |
|--|--------------------------------|-----------------------|-------------------|--------------|-------------------|-------------------|-------------------|
| UK energy balance <sup>1</sup><br>(as a % of Primary Demand) | Indigenous production          | 45                    | 80                | 50           | 85                | 70                | 74                |
|  | Import                         | 75                    | 40                | 90           | 35                | 60                | 66                |
|  | (Export)                       | -20                   | -20               | -40          | -20               | -30               | -40               |
|  | Primary Demand <sup>2</sup>    | 238550                | 249560            | 282590       | 256900            | 238550            | 220062            |
| Energy consumption by fuel (%)                               | Coal                           | 8                     | 8                 | 20           | 13                | 12                | 17                |
|  | Petroleum                      | 30                    | 20                | 26           | 40                | 35                | 32                |
|  | Primary electricity            | 15                    | 30                | 20           | 25                | 5                 | 9                 |
|  | Renewables and waste           | 6                     | 20                | 4            | 12                | 15                | 2                 |
|  | Natural Gas <sup>3</sup>       | 41                    | 22                | 30           | 10                | 33                | 40                |
| Energy consumption by sector (% of total UK consumption)     | Transport                      | 43                    | 35                | 43           | 40                | 28                | 40                |
|  | Industry                       | 11                    | 16                | 12           | 16                | 23                | 13                |
|  | Residential                    | 26                    | 22                | 33           | 30                | 28                | 28                |
|  | Agriculture & forestry         | 1                     | 6                 | 1            | 4                 | 8                 | 1                 |
|  | Commercial and public services | 13                    | 15                | 5            | 5                 | 7                 | 11                |
|  | Non-specified                  | 1                     | 1                 | 1            | 1                 | 1                 | 1                 |
|  | Non-energy uses                | 5                     | 5                 | 6            | 4                 | 5                 | 6                 |

1. thousand tonnes of oil equivalent (ktoe) on a net calorific value basis. 2. Very crudely based on relationship between today's Primary demand and UK population. 3. Assumed that UK supplies will have considerably diminished and now importing. Source:

<http://www.decc.gov.uk/en/content/cms/statistics/publications/publications.aspx>

Table 6: Regional population breakdown for the NEA story-lines

|                               |                          | Green & Pleasant Land | Ecosystem Service | World Market | National Security | Local Stewardship | Business as Usual |
|-------------------------------|--------------------------|-----------------------|-------------------|--------------|-------------------|-------------------|-------------------|
| UK population                 |                          | 65 million            | 68 million        | 77 million   | 70 million        | 65 million        | 75 million        |
| Population (as % of UK total) | North East               | 4                     | 4                 | 3.8          | 3.9               | 4.8               | 4.2               |
|                               | North West               | 10.9                  | 11                | 8.2          | 11.3              | 12                | 11.2              |
|                               | Yorkshire Humber         | 8                     | 9                 | 8            | 8.7               | 9                 | 8.5               |
|                               | East Midlands            | 7                     | 7.5               | 6            | 7.4               | 8                 | 7.2               |
|                               | West Midlands            | 9.1                   | 9                 | 8            | 9                 | 10                | 8.8               |
|                               | East                     | 9.2                   | 9.5               | 7            | 9.7               | 10                | 9.3               |
|                               | London                   | 13                    | 11                | 18.1         | 11                | 10                | 12.5              |
|                               | South East               | 13.7                  | 10.5              | 16           | 13.8              | 8                 | 13.6              |
|                               | South West               | 8.5                   | 10                | 9.2          | 8.8               | 9                 | 8.5               |
|                               | England                  | 83.4                  | 81.5              | 54.2         | 83.6              | 81                | 83.8              |
|                               | Wales                    | 5.1                   | 5.5               | 3.5          | 4.9               | 6                 | 4.9               |
|                               | Scotland                 | 8.5                   | 10                | 9.5          | 8.5               | 10                | 8.4               |
|                               | Northern Ireland         | 3                     | 3                 | 2.7          | 3                 | 3.2               | 2.9               |
|                               | Pop % in Urban (>10,000) | 85                    | 76                | 90           | 76                | 70                | 80                |

## 4. Scenario Narratives

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### 4.1 Green and Pleasant Land

#### **Origin**

This storyline arose from two main influences - the popularity of a green storyline in many of the published scenarios and a demand from the focal question responses to include biodiversity or landscape elements. A number of additional focal questions helped to refine it, e.g., *'How would reversing habitat fragmentation affect ecosystem services?'*, and *'What are the implications of a continuing growth in leisure use in the countryside?'* Originally the emphasis was more on biodiversity underpinning national and regional policies; however, feedback from the discussion sessions with the country groups resulted in this storyline developing a more preservationist focus, albeit one that emphasised the importance of biodiversity. While this may appear a green storyline, the heavy dependence on overseas ecosystem services to maintain a high quality of life in the UK tends to contradict this. The underlying theme is one of enhancing cultural services in the UK at a cost to others: whilst attaining this sometimes benefits regulating services it involves trade-offs with provisioning services, and as a consequence we see declines in the area of more intensively managed enclosed farmland, for example, and expansion in semi-natural habitats.

#### **Rationale**

The preservationist attitude that characterizes this scenario comes about because the UK can afford to look after its own backyard without diminishing the increases in standards of living. The countryside is very much a managed and cultural space but the focus is on trying to maintain, protect and improve its aesthetic appeal. Tourism and leisure is consequently boosted by this drive and increases its share of overall UK GDP - this is boosted further by the loss in tourist revenue to many late-20th century destinations because of climate change (e.g., France, Spain, and Italy). The gradual results of the changes in drivers produce a greener countryside – this comes about through a reduction in productive farmland (more is converted through agri-environment schemes to semi-natural grassland and woodland). Climate change adaptation for biodiversity is also a dominant driver of land use change and results in greater connectivity between semi-natural landscapes and a softening of the landscape. There is also a greater emphasis on habitat restoration and recreation in areas with existing high levels of biodiversity (e.g., areas with high concentrations of ancient semi-natural woodland). The drive towards conservation is so strong that even the best quality agricultural land is occasionally targeted for agri-environment schemes.

Climate change is a high priority under this scenario because it is recognised that not only could it affect habitats (and hence landscapes) but also the economy; this is reflected in numerous adaptation programmes. Many of those are biodiversity focussed or use biodiversity as a means of delivering other adaptation aims.

In general, landscape preservation often coincides with biodiversity conservation although one major source of conflict is between the importance of recognising habitat and ecosystem change and the maintenance of landscape character. A range of legislation has enabled the higher protection of landscape and biodiversity, and the UK has willingly adopted many EU Environmental Directives and often gone further with UK legislation. Biodiversity and landscape conservation legislation is underpinned by a strong emphasis in the education system and backed up by a well-funded body of advisory and research groups (government and NGO).

#### **Main Drivers**

Arguably the dominant drivers in this storyline are a change in the cultural appreciation of the UK's natural attributes as well as a rise in affluence in society. Economic growth is assumed to be strong (2% of GDP/year) but is less immune to economic slumps. However, the UK is also sufficiently healthy economically to instigate a long-term change in the rural economy that, whilst damaging for traditional



agricultural and forestry industries, provides greater opportunities for recreation and conservation. This loss of agricultural productivity comes at a price though: national debt exists mainly due to a reliance of imported foodstuffs and other resources although this is tempered by an increasing emphasis on financial and service industry. The UK imports large amounts of raw materials but also exports high-quality goods. Employment is high but is mainly within the tertiary and quaternary industries. The UK population increases very slowly through ageing and tighter controls on immigration exist; the majority of the UK's population still live in the south-east of England. Clearly then, land use change is a major driver in this storyline although one that is now beneficial for biodiversity.

The energy industry is heavily funded for the development of renewable conversion technologies. Despite the UK's wealth of wind, wave and tidal power new energy plant development can only proceed after passing stringent environmental impact assessments; however, as for biomass, much of the UK's energy is imported from overseas.

Adaptation to climate change is led through government initiatives although the emphasis is on ecosystem-based adaptation programmes. Less money is spent on mitigation directly or reserved for autonomous adaptation. The higher climate change impacts results in a further reduction in arable and improved grassland area in the south east because it becomes more difficult to farm without recourse to irrigation which is problematic given reduced water; the consequence of this loss of agricultural land is further expansion of semi-natural grassland. Broadleaf woodland also declines slightly with transfers to semi-natural grassland too; the preference for native species is strong, so unlike *Nature@Work*, southern European tree species are not used to maintain woodland cover).

Planning is strictly controlled in rural, urban and coastal areas. Housing development is all but impossible in rural areas and urban (re)development is the norm to meet the demand for dwellings. The transport network is invested in heavily and road pricing schemes are common. The rail network has been improved and new high-speed lines are replacing the old routes.

Globally, the US, EU, China, India and Brazil are the dominant economic forces in the world and most countries appear to have embraced capitalism in various forms. International trade increases each year and new markets are created as more countries strive for a western standard of living and climate change affect some traditional production areas. Global environmentalism is, however, stronger than ever before but still struggles in places to make progress in a world where a free market economy is dominant. One success is the burgeoning use of products which are sustainably certified (timber, biofuel, many foodstuffs) and increasingly these products dominate the western markets. For wealthier people, the UK becomes a desirable country to live in even if ultimately its continued economic growth is heavily – and unsustainably – dependent on the provision of key ecosystem services from overseas.

### ***Land and Sea Use***

Pressure to improve the conservation and landscape value of the countryside results in an enclosed farmland area decreasing in area in 2060. As a consequence major biodiversity and climate change corridor projects are established which help to connect habitats or soften the landscape enough to ease the dispersal of species. The 'softening' of the landscape is also a major focus and the remaining rural land use industries have a strong focus on sustainable management. For example, many farmed landscapes have long since converted to organic production and all farms are encouraged to adopt various farmland conservation options.

Societal and environmental pressures on intensive livestock farming mounted in 2020 and the consumption of cheap meat declined; it resulted in a reduction in specialised (grain-fed) livestock farms but the number of mixed farms increased (this helps to increase landscape heterogeneity and boost biodiversity levels in rural areas). A loss of agricultural area in lowland and upland rural UK results in greater conversion to nature conservation and woodlands. Landscape heterogeneity increases, but more so in areas with high concentrations of Ancient Semi-Natural Woodlands (ASNW) or in other landscapes whose character is heavily influenced by trees. The changes in woodland cover suggested by the analysis based on land cover

transition matrices are shown in Figure 5. In upland rural areas there is a loss of livestock farming with concomitant rises in moorland, native woodlands and semi-natural grassland habitats. Restoration and the creation of native woodlands is a major land use driver in uplands areas of the UK – as a consequence, and due to the lack of support for home-grown goods, conifer plantations are slowly converted to broadleaf woods. Particular attention is paid to the removal of invasive exotic species in freshwater systems. A programme of sustainable river management has introduced greater structural heterogeneity by increasing the number of bends, shallows, pools, riffles; this improves biodiversity and helps flood alleviation.

Marine ecosystems are given a high priority and the UK adopts all global, EU and many new national biodiversity and sustainable fishing laws and protocols. Sea fish stocks are given far better protection and a small rise in sustainably farmed off-shore fisheries partly meets our demands for quality British fish (but most fish is sourced from overseas). A few areas of biodiversity importance around the coast of Britain are given better conservation designations and very little fishing or other harmful activity is allowed. Sea level rise is combated by a programme of widespread managed retreat which results in more coastal habitats and less farmland. Where possible, ecosystem-based adaptation strategies are also adopted rather than hard defences traditionally applied. Off-shore wind turbines are sited in a few places around the UK which result in creating additional sea habitats.

Despite stringent controls on rural housing development and a general acceptance that almost all new housing will be within existing urban boundaries, new urban green-space is created and increases by 10%; however, there is a stronger focus on developing semi-natural green-space as well as public parks and gardens and other amenity spaces. Urban housing development follows similar ‘green’ lines by adopting environmental techniques like green roofs. In peri-urban zones tree planting increases near existing woodland areas. Smaller organic farms selling direct to the public via organic box schemes or in farm shops increase. Most housing remains much as in 2010 except for an increase in urban areas to meet population demand. New developments are kept to brownfield sites – the further decline in primary industries frees up a number of sites. The lack of new housing and rise in rental costs results in more young people living with their parents until marriage; multi-occupancy flat sharing is common too.

### ***Human well-being***

Despite a large societal concern for the environment and biodiversity, in terms of *material needs* many people still enjoy a consumer lifestyle although there is certainly more conspicuous consumption of ethical and sustainable goods. Eating out patterns change slightly and there is a greater emphasis on local, quality food and drink for those that can afford it. The increase in jobs in service and professional sectors results in a greater average income in the UK than most other storylines.

Health improves across all social groups in the UK although the wealthiest still lead healthier lifestyles. Cleaner air, water, and food (greater percentage of organic products) as well as a switch from junk food to more balanced diets (through education schemes) leads to overall health gains. The State continues to provide free healthcare for all although the wealthier opt for private care. Mental health is also improved - the benefits of increasing biodiversity habitats throughout urban and rural UK is paying in terms of the wider social benefits they can offer.

In terms of social relations and security people are generally more relaxed and friendly which partly reflects living in a more attractive environment. Communication systems are more advanced and people are better connected too. Literacy levels are higher and more children attain higher levels of performance at school. Local communities experience more ‘togetherness’, partly due to shared pride in the environment. There is also less vandalism, people feel safer. Thus in relation to freedom and choice, there is a greater tolerance of different attitudes (except, perhaps, for non-environmentally friendly viewpoints). On the whole, there is a live and let-live attitude, an increase in civil liberties (there is a ban on CCTV) as well as access to information and expression of views; however, freedom and choice is arguably greater for the richer than the poor.

### ***Effect on UK ecosystem services, goods and benefits***

The main outcome of this storyline is a strong emphasis on preserving cultural services at the expense of provisioning. Regulating services often coincide with the main cultural service objectives although they can sometimes clash. For example, areas prone to flooding may be better served by creating woodlands, but, if the existing habitat is diverse wet grassland, afforestation would be unlikely.

#### Provisioning

- Timber production – minimal increase despite much greater area of broadleaf woodland as most woods are managed for conservation or fuelwood (i.e., through coppice). Small pockets of quality timber production woods are encouraged, and these mainly supply a very small high-quality furniture industry.
- Fuel wood production – stimulated by the increases in woodland areas coupled with wide-scale use of wood-fuel energy boilers or log-burners; a return to traditional coppice management is encouraged to engage rural employment, improve biodiversity and reduce fossil fuel use for heating. Sales to urban areas increase also with the use of clean wood burners.
- Crop yields – increase from 2010 yields due to climate change and agronomic improvements; however, these yield increases cannot compensate for the large decrease in crop area. Crop-based food production is one of the biggest losers in this storyline and the UK depends heavily on food imports.
- Fisheries – natural ocean stocks are strictly controlled and protected. Fish farms increase but are carefully managed to ensure they do not harm the surrounding ecosystems. Locally abundant but unfashionable fish are caught and markets for them developed.
- Animal products – there is reduction in overall national production and there are no significant improvements in breeding. Traditional, hardier beef and dairy breeds make a comeback (partly to help manage semi-natural grasslands) but imports of milk, beef, pork and other livestock products are higher than ever before.

#### Regulation

- Carbon – overall gain due to land use change and better management; soil carbon increases mainly due to the conversion of land from arable to semi-natural habitats (mostly grasslands and woodlands or scrub) and adoption of mixed and sustainable farming systems. Also, external nutrient inputs are lowered because of the greater utilisation of leguminous break crops in the rotation. Organic and low-till systems have increased soil carbon stocks too.
- Flood alleviation – is helped immensely mainly due to the greater area of semi-natural vegetation or grassland (vs arable). Coastal flooding is dealt with by encouraging managed retreat.
- Water quality – increases, incidents of pollution and diffuse pollution dramatically declines due to smaller farmland area and better management. Watercourses are given higher protection control from industry too.
- Erosion control – is improved due to agri-environment schemes like field margins and conversion to woodland; also, better soil management is more common (use of no-till, better use of farm yard manure and other compost).

#### Cultural

- Recreation – there are improved opportunities in peri-urban and rural areas, although even urban areas are more appealing. The countryside as a whole is more attractive and more people use it for weekends and longer breaks; taking a holiday in rural Britain is very common now too, partly as Spain, Italy and southern France are too hot for most people. A Sunday walk in the country has become a very common pastime – partly due to the scenery but also because walking has been promoted as a healthy national pastime. Some conflicts arise where visitor numbers can conflict with conservation aims but generally this is carefully managed and understood by a sympathetic public.
- Historical – a strong shift in cultural appreciation of local history is developed and many historical and archaeological monuments, buildings etc are conserved. This historical interest even extends to long-since extinct species and re-introduction schemes are encouraged and well supported (e.g., beavers).

### ***Ecosystem service trade-offs and changes since today***

The main gains in ecosystem service provision in this scenario compared to today are in the rise in the output of cultural services (driven by the availability of a more preserved, accessible and scenic countryside) and regulating services (Figure 6). The prioritisation of cultural services in this storyline does have a clear effect in terms of reducing the area devoted to provisioning services, particularly food from enclosed farmlands (Figure 7). Despite some gains in improving crop and livestock yields (and hence productivity per unit area), loss of agricultural area reduces overall UK productivity; to counter this food supply in the UK becomes more dependent on imports from overseas. The shifts to semi-natural grassland, mountain, moor and heath and broadleaf woodland brings with it benefits for many regulating services including maintaining soil quality, flood alleviation, air quality, water quality, etc. These changes also help to ameliorate the impacts of climate change although the higher impact scenario starts to reduce some regulating service provision by affecting woodland habitats in the south (e.g., climate and hazard regulation). It is difficult to estimate how the overall balance in service output would change, however because we lack any clear indication of how the output of services varies per unit area of each habitat type, either under present conditions or in the future. The implications of this knowledge gap for the interpretation of the scenario outcomes generally will be considered in Part 4.

## **4.2 Nature@Work**

### ***Origin***

This scenario arose from the need identified in the consultation work for a green storyline that relates to increased interest in ecosystem services as their management as a paradigm for sustainability. It attempts to outline a future where balancing trade-offs in delivering ecosystem services are one of the main challenges in society, and the overall goal is to create a ***multifunctional landscape***. As the title of this scenario suggests people have a utilitarian outlook on nature. They value it because of what it provides or does. Many of the focal questions asked about the trade-offs that would have to be made with ecosystem services and this storyline attempts to provide a pragmatic approach to balancing multiple aims; there is no attempt to prioritise any one ecosystem service group over another.

### ***Rationale***

The belief that the promotion of ecosystem services through the creation of multifunctional landscapes is essential for maintaining the quality of life in the UK is widely accepted after years of heavily promoted education programmes and a growing awareness in society that a more sustainable UK is a necessity. Society accepts and understands that some trade-offs have to be made and as a result becomes more environmentally aware. Habitat restoration and creation is seen as an important component of this campaign but the explicit conservation of species is sometimes overruled by a 'greater' ecosystem service benefit; this sometimes results in habitat conversion (e.g., semi-natural grassland to woodland). Climate change excepted as very important driver of change so as well as carbon mitigation, an important focus is the enhancement of societies' resilience to climate change through 'ecosystem-based adaptation'. Modern technology is used where appropriate though and even GM biotechnology is adopted if it can be shown to enhance ecosystem services. This includes the use of drought-tolerant crops to maintain production and reduce soil erosion.

This storyline is a heavily 'top-down' in terms of how the countries ecosystems are managed - policy prescription through legislation and incentive is strong (ecosystem services have influenced legislation in many different sectors) and environmental schemes abound (not just for farmers). Education is a strong part of this shift towards sustainability and is a consistent part of the curricula in all schools. Backing for maintaining the balance between different ecosystem services is provided by regional planning teams made up of experts in different fields – this feeds into a national ecosystem services accounting system and to ensure a balance at the national level.

'Optimal Service Provision' is key and many ecosystem services in the landscape are a result of careful examination of the trade-offs through scientific review: this entails in careful examination of the needs at a local, landscape and regional level. Areas with a strong potential to produce high-yield crops sustainably

are maintained and kept in arable production for example. Areas known to be at high flood risk would have mitigation plans instigated (e.g., conversion of arable of intensive grazing to woodland).

### **Main Drivers**

Population increases steadily through ageing and immigration and is one of the main drivers in this scenario. Economic growth is strong (3% of GDP/year), sustainable and increasingly based on the green economy. National debt is low (but exists) and the balance of trade is slightly negative (despite an emphasis on more sustainable consumerism) due to a continuation of some food imports. This scenario is one in which science and technology are embraced, and in which most of society are appreciative of public funding in these sectors. There is a drive to develop technologies that solve environmental problems, and this includes a widespread adoption of many different form of GM biotechnology (e.g., pathogen, drought, flood, salt tolerance in crops). The national government has introduced ecosystem services as the dominant policy paradigm, which is backed up by a fully integrated national 'Ecosystem Service Account.'

As in other storylines, land cover change is an important driver of ecosystem service output; in this vision semi-natural and wooded land covers generally increase at the expense of improved grassland. This is a radical but important change to the UK and is a result of a slow change in societal attitudes towards meat production (not necessarily meat consumption); meat becomes more of a luxury good and dependence on crop-based protein is far higher than ever before.

The energy industry is heavily funded for the development of renewable conversion technologies as well as nuclear power. However, despite the UK's wealth of wind, wave and tidal power new energy plant developments only go ahead if their impact on ecosystems is minimal. This results in a greater number of small-scale plants and domestic energy systems become very popular.

The national response to climate change is a well-funded programme of carbon mitigation schemes alongside planned adaptation programmes (also increasing the resilience of communities to better able to adapt autonomously). Invasive species are a constant threat to ecosystem service delivery in many areas throughout the UK but a huge and well-funded national programme to screen and manage them has been very successful. Of all the storylines this is the best adapted to climate change and changes in land cover between the low and high impact scenarios are marginal.

This scenario sits into a world where the business-as-usual has evolved into green business-as-usual; global environmentalism is stronger than ever before. Sustainable development is finally beginning to mean something tangible to people. The US, EU, China, India and Brazil are dominant economic forces but many other countries with the capacity to export vitally important ecosystem services are gaining importance globally. Global trade increases each year and includes trade in ecosystem services.

### **Land and Sea use**

Farmers are paid to provide services based on locally determined payment rates for ecosystem services. Soil erosion, water storage, water quality improvement, flood alleviation, carbon sequestration, recreation as well as food and fuel provision are all targeted throughout the country. As meat production decreases the nation's protein requirements are easily met by an increase in pulse production in the UK; large areas grassland are converted to biofuels or woodland resulting in a higher percentage of woodland in the north and western parts of the country where beef, sheep and dairy production dominated. Floodplain woods are encouraged in the main river landscapes in the UK (e.g., Thames, Severn, Trent). However, ecosystem service provision is ubiquitous throughout the UK so most regions see an increase in woodland area (to meet carbon mitigation, recreation and shade needs). Organic farming as well as no-till cultivation increases in usage as soil management is very important. Lowland rural farmed areas become slightly more heterogeneous; woodland area increases and there is some increase in mixed farming in eastern counties. Many areas with high concentrations of ASNW or with major river networks also increase woodland cover.

Woodlands are seen as a potential solution to many problems and the conservation of existing ANSWs is maintained; mixed-plantation woods are almost equally important though and home-grown timber

production is encouraged (although clear-cut systems are rare and more sophisticated shelterwood or selection systems are common). New woodland creation is also heavily supported, especially near to where people live. Some localised woody biomass (Short Rotation Coppice, SRC) production is found on large estates wanting to mechanise as much as possible (large harvester as opposed to men with chainsaws) and similar projects crop up where villages and towns have started community heat generation systems. New floodplain woodlands utilise willow, alder, birch and poplar but also ash and oak. Livestock farms in the west and north diversify and reduce their beef and sheep enterprises. More land is used for recreation too and many large privately owned estates are opened up for free public access.

Most semi-natural grasslands are protected from woodland or farmland encroachment but they are also utilised for service provision. This includes traditional uses such as grazing land for sheep and beef breeds but increasingly payments for recreation and education services are seen. Areas of traditional species-rich grasslands are restored (e.g., chalk grasslands) often taking poor quality arable land out of production (this is a good example of optimising ecosystem services). Wet grasslands are conserved for floodplain health; in mountain regions wind farms are often deemed more important than other uses.

The conservation and protection of freshwater is one of the highest priority aims - in the case of farming, this includes 25 metre buffer strips bordering rivers for any potentially damaging operation (including organic farming systems).

Coastal areas are particularly protected from development and in certain areas coastal erosion is allowed to progress through a system of managed retreat. Marine habitats are given greater conservation protection through a number of European and British laws; however, as in terrestrial ecosystems, there are trade-offs between biodiversity, food provision and energy. The UK's marine energy resources are particularly valuable and are developed considerably to the point where some energy is exported. A co-benefit here though is an increase in marine habitats around energy farms as they cease to become fishing grounds as well as the conservation of carbon-rich sea-beds. Sustainable fishing is very important but investment in research into farmed species increases to maintain supply for the UK market (another benefit of increased R&D are marine biotechnology spin-offs).

In urban areas there is an emphasis on the role of urban trees, gardens, urban farms and green roofs; urban green-space increases by nearly 6% but a large percentage of that is in semi-natural habitats. The housing stock stays static with an emphasis on restoring and upgrading old stock to improve energy efficiency. A more holistic approach to town planning is taken which incorporates energy use and transmission, waste removal, transport and dwellings. Many towns have been 'greened' so that they become net exporters of some ecosystem services, e.g., water purification. Similarly, urban food production becomes common and takes advantage of allotment and park space as well as roof space. This increase in small market producers, urban farms and forest gardens helps meet the demand for produce with low food-miles. The south-east still has the largest proportion of people in the UK although this is mainly due to a fairly static building construction programme in the UK.

A precondition of this scenario is that an extensive programme of developing renewable energy across the UK to harness wind, sea, solar and biomass resources in the most optimal manner is implemented. Conflicts between landscape aesthetics and energy are much rarer with most people accepting the 'necessary evil' of a local wind farms etc. Nuclear power is also a major provider of energy.

Most of the UK sees far greater recreation in rural and urban areas. Urban areas, in particular, have increased green space and many cities have seen increases in visitor numbers. Traditional high visitor number rural areas continue to attract many people (although more use extended public transport systems to get there) but most rural counties develop recreation activities and consequently boost visitor numbers. The decarbonisation of the road transport system is all but complete. New technologies and improvements in electric vehicle systems mean that air pollution from the internal combustion engine does not plague the towns and cities of the UK. Aviation, shipping and heavy transport now use biofuels, much of which is grown in the UK and the EU. Short-hop air travel has disappeared from the UK (replaced by rail); short-



distance travel is largely undertaken by bicycle and cycle lane networks are extensive, well maintained and easy to use.

In summary, the main land cover changes are a huge decline in improved grassland cover, a slight decline in arable cover and increases in woodland (broadleaf and conifer), upland (mountain, moor and heath) and semi-natural grassland.

### ***Human well-being***

Compared to 2010 societies material needs are lower and less sophisticated; there is still a strong demand for electrical goods for domestic and leisure purposes but most aspects people are happier to get by with possessions that work well and last longer. Locally produced items are very important and in many parts of the UK regional variations in clothing style can be seen.

Society in the UK benefits from improved nutrition; cleaner air, water, and food; better access to information about health and medicine; reduced stress; and better mental health. The concept of the green gym takes off and is a common prescription for many people; more importantly, it is seen as a preventative measure and heavily promoted too. Technological improvements have also advanced surgical techniques and drug development; the UK, US and other EU countries inject considerable funding into a global initiative to developing 'drugs for all' that allow even the poorest access to the latest medicines. Bioprospecting for pharmaceuticals is considered a global good for all and patents are not allowed (funding is provided by public tax).

Society is more secure mainly due to greater equality and better standards of living for all. People are more connected with each other both within the UK and overseas. Cheap communication systems are universal and high-speed internet connection is ubiquitous throughout urban and rural UK (indeed, a large part of the economy is utterly dependent on it).

Tolerance, live and let live are the main credos. Increased political freedom, civil liberties, information flow, movement, expression, and association are values held highly and rarely contravened. All environmental data are available to everyone to ensure that supplies of ecosystem services are equitable and justifiable. Flow of ecosystem services to the poor as well as the rich is an important part of ecosystem service provision.

### ***Effect on UK ecosystem services, goods and benefits***

The essence of this storyline is the development of an understanding of how to balance trade-offs between ecosystem services. Inevitably some ecosystem services will become less common 'luxuries'. Climate Change also dominates the environmental agenda and service provision incorporates mitigation and adaptation heavily.

### ***Provisioning***

- Timber production – home-grown timber is encouraged and supported by the public - everyone wants to live in a house 'made in Britain'; large plantations (sustainably managed) in the traditional areas (Wales, Borders) are joined by new woodland planting in (carefully chosen) sites in the north of Scotland. Broadleaf timber is also utilised (and more importantly managed properly) and becomes an increasingly common building material.
- Fuel-wood production – as with Green and Pleasant Land, increases considerably due to Short Rotation Coppice production as well as from conservation coppice woodlands. The area of woodland is also much higher than in 2010 helping to meet the nation's timber requirements.
- Biofuels from cropped land considerably to meet energy requirements; however, biofuels are only ever grown on poor quality agricultural grade land and do not displace high yielding food crops.
- Crop production – overall production declines slightly as the cropped area reduces; however, technological advances in agronomy and a warmer climate maintain the trend of increasing yields and due to a major switch from meat production to legumes the UK's supply of protein for human consumption increases.

- Animal production – meat consumption declines and the super-high yielding dairy and beef breeds of 2010 have almost disappeared to make way for better adapted animals and a focus on flavour, not quantity. Meat and dairy production still exists, but is focussed more on quality rather than quantity.
- Marine – natural (sea and freshwater) stocks are strictly protected and only harvested under a regime of sustainable catch - the total natural catch is far lower than today's. Farmed fisheries proliferate (off-shore) but follow careful management guidelines so they don't affect natural ecosystems. Energy from marine ecosystems is hugely important and a network of windfarms, but also wave energy, is widespread.

### **Regulation**

- Carbon - overall gains in lowland areas previously dominated by arable; soil carbon increases mainly due to the conversion of land from arable to semi-natural habitats (mostly grasslands and woodlands or scrub) and adoption of mixed farming systems. Also, external nutrient inputs are lowered because of the greater utilisation of leguminous break crops in the rotation. Organic and low-till systems have increased soil carbon stocks dramatically. Upland areas also improve above and below-ground carbon through better management and habitat restoration.
- Flood alleviation - the restoration and creation of floodplain woodlands becomes a major factor in reducing flood impacts throughout the UK. This involves conversion of vulnerable areas from intensive arable or improved grassland use to appropriate alternatives (often woodland but also semi-natural grassland).
- Erosion control – problem areas throughout the UK are targeted and controlled by implementing new management regimes (e.g., change to woodland, grassland or no-till cultivation). This is one of the main success stories.
- Water quality – vastly improved everywhere; polluters are fined heavily so rarely make mistakes; sustainable land management in farmland also reduces pollution from fertiliser and pesticides.

### **Cultural**

- Recreation – becomes more popular in urban, peri-urban and rural areas. The countryside as a whole is more attractive and more people use it for weekend and longer breaks. A Sunday walk in the country has become a very common pastime - partly due to the scenery but also because walking has been promoted as a healthy national pastime. Some key areas have been nationalised in order to maintain them for public use. Urban regeneration has transformed many cities making them more attractive places to live and visit.

### ***Ecosystem service trade-offs and changes since today***

The goal in this storyline is to balance the needs of all ecosystem services within a region and indeed nationally. Maintenance and promotion of multifunctionality is the key. In terms of projected land cover changes, there is also a more even gain of area across the woodland, semi-natural grassland, mountain moor and heathland, and freshwater categories for *Nature@Work* compared to *Green and Pleasant Land*. Inevitably, in some areas certain ecosystem services will be reduced in favour of others but the emphasis is on achieving a balance and where possible no net loss. Within the enclosed farm landscape there will probably be a greater loss of improved pasture to semi-natural grasslands under this scenario compared to *Green and Pleasant Land*. Perhaps one crucial element to the goal represented in the *Nature@Work* scenario is that *although* is that biodiversity that is valued for its intrinsic worth can sometimes clash with the greater ecosystem service worth. For example, in some parts of the southeast, climate change may slowly change the structural composition of woodlands, even to the point that they become more scrub than woodland. In certain circumstances, tree species from southern Europe that are drought tolerant may be used to maintain a woodland structure and function (but would clearly be an anathema to contemporary conservation ideals).

This storyline, along with *Local Stewardship*, shows the starkest difference with the current suite of ecosystem service provision in the UK. As the dominant paradigm in society and government policy, the goal of improving provisioning, regulating and cultural services is taken very seriously and largely succeeds in improving them all. Climate change mitigation and adaptation is a high priority policy (and societal) goal

and many habitats are managed to cope with extremes of temperature and precipitation (both wetter winters and drier summers). In areas of particular vulnerability to climate change impacts (e.g., drought in the southeast, sea-level rise in low lying coastal areas) the appropriate response to optimise ecosystem service provision is taken (e.g., the adoption of drought and heat tolerant crops or coastal retreat schemes). However, as with the discussion of *Green and Pleasant Land*, it is difficult to estimate how the overall balance in service output would change, because we lack any clear indication of how the output of services varies per unit area of each habitat type.

### 4.3 World Markets

#### **Origin**

This storyline is a very common one in many published scenarios studies, and provides an opportunity to examine how a suite of dominant socio-economic and demographic drivers could affect the UK's ecosystem services. It also reflects the desire from some potential users of the NEA to see how a relaxation in rural and green belt regulation (and hence a spread of urbanisation) would affect ecosystem services in the UK. Other influencing focal questions raised issues of increasing dependence on commodities from overseas, rises in global food prices, a societal rejection of the importance of climate change, continuing increases in atmospheric Nitrogen pollution, increases in housing density.

#### **Rationale**

High economic growth with a greater focus on removing barriers to trade is the fundamental characteristic of this scenario. International trade barriers are assumed to dissolve or have limited impact as markets are liberalised. Agriculture declines slightly (in area, mostly improved grassland, arable increases) but becomes more industrial and large-scale. Demand for land is very competitive and housing or small-scale industrial units are often the winners; however, food production is still deemed more important than many other (uneconomic) land uses (albeit in a highly industrial manner).

As in land-based food production, food supplies from the seas are equally seen as source for exploitation without recourse to any sustainable management. Fish stocks plummet and a few species have been wiped out in the North Sea. Most fish is imported from Asia now. Desalination plants are built in areas along the east coast to meet water demand for the south and eastern counties. 'Home-grown' fossil fuel energy production is dwindling and has been overtaken by imports of gas from Eastern Europe and privately funded nuclear industry in the UK. Consequently, coastal areas are built upon to accommodate power plants and gas pipeline stations. Supplies of other ecosystem services increasingly become privatised.

The underlying policy prescription in this storyline is essentially 'hands off' approach, i.e., there is very little legislation or incentive geared towards ecosystem service delivery in the UK. Market forces dominate and along with population are one of the main drivers of change. Legislation relating to land planning is greatly diminished. The consequence of this is a radical change in rural and urban fabric of the UK: urban areas continue to grow with very little curbing them, traditional conservation and landscape areas do not have the same restrictions on development, and threats to land cover (floods, sea-level rise) are only targeted if considerable financial loss is at risk.

#### **Main Drivers**

The UK's population rises through immigration and an increase in the 60+ age cohort; also, more people wish to live alone and the average household is smaller than 2010. As a consequence there is a strong demand for new housing and planning restrictions on green belt and rural areas are relaxed throughout the UK often resulting in conversion of agricultural, woodland and grassland habitats to housing development. In this scenario it is assumed that the UK is determined to be part of an expanding global trade system. New business models that maximise some ecosystem service provision (but not most) are created. Economics becomes the 'go to' paradigm for solving environmental problems that urgently need addressing (this way at least some ecosystem services are conserved). Investments in technology are mostly privately-funded and the state plays a smaller role in everyday life. There are large differences in

income levels among society and divisions in equality are higher than ever.

There is strong centralised government but there is an emphasis on allowing people freedom to choose many of the important aspects of life (health, education, etc). There are minimal sets of environmental standards that maintain important aspects of urban life (e.g., air quality) but otherwise there are few restrictions on economic growth unless a market is created to protect some services (e.g., the rural beauty of some charismatic areas). Climate change is hardly given any attention in national policy; there is limited investment in mitigation; climate change is considered 'natural' and that the market will take care of responses. Thus adaptation is mostly local and autonomous (and often led by business innovators and early adopters). Any recourse to renewable energy production is solely down to a decline in fossil fuel resources rather than concern for the environment. The consequences of this attitude is that climate change effects the greatest land use transitions in this storyline - arable and improved grassland is lost to semi-natural grassland through abandonment and even some broadleaf woodland suffers dieback.

The influence of local groups and rural communities on development is somewhat limited and large business often gets its own way with little effective opposition. Many small towns are either subsumed by larger neighbours or become part of ribbon developments.

This scenario sits into a world where the business-as-usual continues apace. The US, EU, China, India and Brazil are dominant economic forces and global trade increases each year; global environmental legislation and conventions have become somewhat toothless and are rarely adopted by governments.

### ***Land and Sea use***

All land-based subsidies are removed and the agricultural industry is dominated by large agri-businesses (which includes the large retail supermarkets). Technological advances in agriculture push yields to new heights; GM is very much part of this. Specialisation is normal in farming and there are very few mixed farms; farm size continues to increase, as does the average field size. Large factory pig/dairy/beef/poultry units, which produce cheap meat efficiently, rise up throughout lowland, and increasingly in northern areas (cooler in the summer). UK petroleum prices rocket so woody biomass cropping and other cropped biofuels increase to meet demand. Agricultural production intensifies on the best land but lower grade land is utilised for biofuels where it has escaped pressure from housing development. Climate change presents a problem but advanced husbandry, air-conditioned livestock units and GM crop-breeding result in high adaptation in the sector (possibly the only sector where adaptation to climate change is taken seriously).

Modern arable farms are industrialised and homogeneous, with large fields of cereal or protein crops; this trend has resulted in hedges and some woodlands being grubbed out. Apart from a huge increase in willow for short-rotation coppice, most surviving woods have become replanted with exotic species to maintain timber production. Woodlands maintained for conservation and recreation have minimal importance. Intensive management of existing woodlands is promoted (including coppicing ASNWs). Semi-natural grasslands are not considered a high priority and many are consequently converted to biofuel cropping or housing. Some grassland on steep slopes gradually reverts to scrub and woodland. Lowland rural areas see a decrease in existing woodland but woody biofuel area increases. Housing stock increases with new towns being built, and this results in an overall loss of farm area. In upland rural areas the cooler climate is utilised for housed livestock production in valley bottoms – most feed is imported. Overall there is still a decline in farm area though. Improved grassland area declines as more livestock is housed in larger feedlot complexes.

Some parts of mountains areas are maintained for the best services they supply (i.e., freshwater provision, wind for energy generation and also for recreation near large conurbations). However, in many mountainous areas, deregulation and lack of environmental protection have resulted in development or conversion to woodland in the warmer climate - large conifer and even eucalyptus have begun to appear in many hilly areas on the UK.

The UK's rivers are in poor condition in terms of biodiversity, water quality and the presence of invasive species. Farmers do not have to consider water quality and can spray pesticides and fertiliser near water-

courses with impunity.

Coastal erosion is a continuing problem in many areas and does involve state intervention except where there is huge investment threatened (affluent housing, major ports, desalination plants). Since the removal of the Common Fisheries Policy the seas around the UK have become a free-for-all, except the Exclusive Economic Zone (EEZ) of 200 nautical miles from the coast. Even within the EEZ the UK seas are more open to resource consumption and fishing and aggregate consumption increase with little nod to sustainable management. Most commercial fish populations have been over-harvested and marine aggregate extraction has also increased in many areas. Shipping increases due to greater trade with other countries particularly from countries where the UK has entered into exclusive trade agreements for resource harvesting.

An expansion of housing into green belts and parks and gardens results in a loss of nearly 30% of green space (resulting in only 39% of urban cover) and built-on surfaces increase by nearly 80% to represent 1/3 of all urban cover. Street trees are replaced as they die but otherwise there is little urban woodland planting. Urban space has diminished considerably as the demand for housing targets every space available. In peri-urban areas there is a large decrease in woodland and farmland due to housing expansion and small-scale industry.

Dependency on nuclear power and fossil fuels continues and there is very little use of renewable energy (with the exception of biofuels). One other exception is a large tidal barrage system across the Severn estuary that provides energy for 5% of the UK's needs. Technology continues to improve efficiencies in most energy sectors.

The UK sees a huge decline in internal and overseas tourism partly due to a gradual erosion of the country's cultural services (both in rural and urban areas); the wealthy middle classes around the globe still travel extensively but the UK is losing out as a tourism destination. Recreation in the UK is now more home-based.

The transport network is heavily biased in favour of cars and air travel - motorway-widening schemes reduce farmland area more and a few new toll motorways are created between London and the Manchester-Leeds belt. Nearly all the major airports expand including Heathrow and Birmingham - in east London an airport is built in the Thames Estuary. The major land use winner in this scenario is urban - large increases in urban cover throughout the UK occur although there is a stronger growth in the south-east. The main losers are semi-natural grasslands and upland habitats.

### ***Human well-being***

People strive for personal wealth and material possessions or experiences. This is truly the age of mass consumerism. Mean income is higher than ever before and the poor have higher incomes too (but see below); the private education sector has increased considerably, as state-funded schooling is under-funded and in decline. Many services are provided by private companies.

Health standards are very high for those that can afford it; the NHS survives but struggles to cope with quality service provision. Obesity increases due to poorer diets and less exercise (linked to more people spending their leisure time at home in virtual worlds). There is a rise in diabetes, cancers, stress, and other 'affluenzic' diseases. There is an increase in human health pandemics every decade in the UK. Increasingly, sick people are forced to pay for their health care if it can be shown they are responsible for their decline (e.g., smoking, drug and drinking related diseases).

This is a disjointed and unfriendly society. People feel secure if they can afford to pay for security services or live in gated communities. Despite a higher standard of living for the poor there is great resentment of the rich who almost live in a different world. Street violence, mass protest and other civil unrest is common. Further afield, the UK is increasing 'strong-arming' itself towards other developing countries in a struggle for diminishing resources.

Freedom is more restricted for all although the rich have more access, more say and more influence than the poor. Many goods that were once public are now private - this affects access for recreation, food and decision-making. Increasingly, politics is becoming a commercial enterprise and it becomes more difficult for someone to enter national politics without funding. Underground political movements spring up but are suppressed on a regular basis by the government under 'state terrorism' laws.

### ***Effect on UK ecosystem services, goods and benefits***

Ecosystem services that have monetary value and are easy to trade are protected, but many others are not in this unregulated, urbanising world. The major transfer is to developed land, driven mainly by the larger population size anticipated under this storyline. The growth is uneven geographically, with the major changes occurring in England, in the southeast and the midlands, although there is also growth around existing urban centres elsewhere.

### **Provisioning**

- Timber production – despite a similar land cover to 2010, very little timber production is UK-based with a high dependence on imports from Eastern Europe (despite high transport costs). Many woods are neglected or end up privately owned.
- Fuelwood production – increase due to high fossil fuel costs. More efficient boiler designs means that some (affluent) local communities adopt fuelwood as their energy source for heating.
- Crop production – increase dramatically, free market enterprise has increased R&D and arable area has also increased; a large proportion of crop production is animal feed.
- Animal production – similar increase in yield per head but overall national production stays the same as 2010 levels because of the demand for cheap, low quality meat. The vast majority of meat and dairy production systems are indoors.

### **Regulation**

- Carbon – land carbon stocks decrease due to loss of semi-natural and upland habitat and conversion of improved grassland to housing. A decline in good soil management also diminishes soil carbon levels further.
- Flood alleviation – nothing is done to prevent the impacts of flood events in vulnerable communities. Those that can afford it move away, otherwise people cope as best they can. Land management in surrounding countryside does not change to help mitigate flood impact.
- Erosion control – neglected problem, increases in some areas due to lack of vegetation or inappropriate land management.
- Water quality – declines to mid-1980s levels in the UK due to lower environmental standards across industry and agriculture.
- Invasive species numbers increase due to more un-regulated trade with other countries, an increase in traffic (a main vector for many species) and climate change; very little is done to control species except in affluent areas.

### **Cultural**

- Recreation – there are declining opportunities for woodland, upland and farmland recreation. Most woods are privately owned or managed for fuel to supply local heat generation systems; farming has reduced the beauty of much of the countryside. Upland areas are often privately controlled and the right to roam statute has been repealed. 'High quality' rural recreation remains an expensive past-time - game shooting and even a day in the country is an exclusive treat for the few.
- Historic and spiritual – values throughout the UK have been degraded or lost. These are seen as non-tangible, pointless and not worth conserving. Beautiful landscapes remain in areas almost exclusively utilised by the wealthy (i.e., homes, services are too costly for most people).

### ***Ecosystem service trade-offs and changes since today***

The emphasis on provisioning services at the expense of almost all others is the notable pattern that arises in this storyline although even food and timber production in the UK has to compete in a market driven by value (hence a reliance on cheaper food imports from overseas). Thus the loss enclosed farmland under this scenario is much less than that assumed for *Green and Pleasant Land*, and *Nature@Work*. Sustainable



land and sea management is not always followed which results in losses of regulating and cultural services.

The pattern of large-scale loss of semi-natural habitat as well as the unsustainable management of land and sea resources in this storyline explains the overall Ecosystem Service provision compared to 2010. Whilst there are potential for increases (technology driving crop and livestock yields for example) the demand for land for housing and industrial development results in further overall decline in provisioning, regulating and cultural services. Climate change significantly reduces the already eroding ecosystem services in this storyline: worst hit are provisioning (loss of food production) and regulating (from a decline in woodland cover). Once again, however, although we can project potential changes in the area of the different habitats, it is difficult to estimate how the overall balance in service output will change because we lack information on how the output of services varies per unit area.

## 4.4 National Security

### **Origin**

This storyline is also very common in the published scenarios. The focal questions also highlighted a number of areas useful for its creation including: where the UK will get its ecosystem services from, the impacts of trying to secure national food, fibre and bioenergy supplies, an increase to 70% food security and its consequences for ecosystem services, maximising domestic food production to protect overseas ecosystems, the future of CAP. Many of these questions helped to design a storyline that shared a lot of aspects of the World Markets storyline except that global trade would be much reduced and there would be an emphasis on home-grown provisioning services.

### **Rationale**

Under this scenario it is assumed that climate change results in increases in global energy prices forcing many countries to attempt greater self-sufficiency (and efficiency) in many of their core industries. The UK is no exception and agricultural and other primary industries intensify accordingly. Society understands that a move towards sustainable resource management is a desirable way forward although something that is not always attainable. For example, many farmers are better at maintaining good soil quality but this is out of a desire to maintain food production rather than for any long-term environmental goals. Food and energy production to meet UK demands is the main priority and often comes at an environmental price if it ensures the UK's self-reliance.

This storyline relies on a heavy government hand in setting and policy for the provision of ecosystem services; it also reduces the scope of market-driven forces (at least externally to the UK) to have an effect. Trade-barriers provide a relatively competition-free environment for industry within the UK; subsidies for food and timber production exist also to encourage their growth. Removal or weakening of environmental legislation results in a greater switch from semi-natural and woodland habitats to arable and improved grassland; conifer plantations also make huge gains in upland areas.

### **Main Drivers**

Society is UK-focussed. Immigration is strictly controlled and allows only the most skilled workers. The housing stock increases to meet the demand for single-occupancy households but this is mainly concentrated in brown-belt development and results in an increase in new flat complexes. Population growth is 0.5% year. Economic growth is lower than the *World Markets* scenario. Planning is strongly controlled by the state and although it allows for the expansion of home-grown industry (if it provides jobs and benefits for the wider community), it does not threaten green belt or rural land. Every last resource in the UK is utilised for the provision of services: this sees the resurrection of the many coalmines; greater protection of the UK's fisheries and the conversion of non-productive land to farming. Resource consumption is somewhat curbed and a slightly more sustainable and less profligate society arises. Protectionism and trade barriers are put in place to secure the health of the UK's industries.

The drive towards self-sufficiency is seen as a necessary step forward by many countries throughout the world although trade still exists. Diminishing energy and freshwater resources have resulted in countries

refocusing their efforts towards ensuring sustainable supplies of their own ecosystem services (albeit mainly regulatory and provisioning). No longer can countries guarantee supplies of many goods although, of course, some countries will still export were they have an excess in supply.

Climate change is a driver of change in this storyline but its greatest impact is felt in a reduction in arable area in the high impact a scenario although technology plays a major role in this storyline the insularity of the country results in a lower adoption of better adapted crop cultivars. In other habitats, climate change adaptation is more developed, e.g., suitable drought and heat tolerant conifer species are planted.

### ***Land and Sea use***

Precision farming and other sustainable techniques are promoted and constantly evolve; GM crops are also heavily utilised and are considered essential to sustainable land management. Plant-based protein is a more optimal use of agricultural land and meat production is heavily taxed with a climate change levy (and thus declines becoming a food for the affluent); this results in some surplus grassland becoming available for arable, SRC bio-ethanol production as well as new forest plantations for timber. Forestry is an important sector and home-grown timber production is promoted. Climate change has put pay to the promotion of conserving native species and foresters are free to experiment with exotic trees (with the exception of some potentially problematic species). Ancient semi-natural woodlands are managed for fuelwood but in some cases for quality timber or furniture products (although in places conservation objectives are met too). Plantations are the by far the dominant woodland type though and increases on conifer plantation cover are seen through the UK (but especially in the uplands in Wales and Scotland).

Semi-natural grassland becomes a conservation luxury that society cannot afford and it is now either harvested for bio-ethanol or converted to woodland if the topography is too difficult for farm machinery. Many of these mountain, moor and heathland habitats have increased woodland cover to accommodate the drive for home-grown timber. Overseas conifer species are widely used (Monterey and Corsican pines cope well with the climate and soils). Freshwater resources are protected and use is governed by licence, e.g., for irrigation or drinking water. New desalination plants are built along the east coast; more reservoirs for potable water are built also.

Coastal resources are protected if they are important for the economic growth of the UK; desalination plants, nuclear power stations and some built on areas are given priority for sea-rise defence. In other areas high value farmland is also protected from sea intrusion. The fish resources of the waters around the UK are harvested as before but under strict sustainable catch quotas and protection measures. However, low trophic-level aquaculture (subsidised too) has developed into an important food resource and is pursued in many areas around the UK. Renewable energy schemes are also heavily promoted and include a huge programme of off-shore wind farms and wave energy units. Large tidal barrage scheme provide 5% of the UK's energy requirements.

Large market-gardens, urban-gardens (not just allotments) and even urban 'forest gardens' are developed and represent nearly 20% of all urban green-space in the UK. However, as a consequence, green-space for recreation (public parks and gardens and amenity areas) declines dramatically (although these do provide areas for relaxation despite their prime food producing role). The housing stock is maintained and improved for energy efficiency; new housing is built to high-energy standards but is small and uninviting. Peri-urban zones are similar to urban but small agricultural fields also dominate; market gardens thrive and even previously large private gardens are converted to food production.

Wind energy is heavily subsidised and much of the coast around the UK is utilised; nuclear power is also developed through a programme of developed world control of uranium resources. However, uranium is one of the few overseas resources required for energy production and much of the UK relies on a continuation of fossil fuels use from North Sea gas beds and the remaining coal seams. The major road networks are maintained and car use increases in the UK. Internal flights remain, although more people use rail travel to commute too. Fossil fuels are in decline and are rationed, electric and biofuels dominate.

### ***Human well-being***

Consumerism is down largely due to lack of supply rather than personal preference but there is also a trend towards local crafts and high quality (long lasting) goods over cheap, disposable wares; many people return to more traditional past-times including reading. Technology has not been abandoned though and most people are connected through the internet.

The NHS is heavily funded by the government and a programme of education improves health throughout the UK. A move to more manual labour employment also has health benefits and obesity is declining. Junk food is comparatively rare and although the average diet is not inspiring it is fairly well-balanced. Meat consumption declines due to the high cost of production, this also has health benefits for the nation.

A shared feeling of responsibility and pride in the UK provides a strong backbone for social togetherness and contentedness. The more affluent still enjoy a higher standard of living than the less well off but the poor have a higher standard of living due to lower unemployment. Crime reduces slightly.

A decrease in availability of many luxury goods and even some staple foods increases inequality and the affluent manage to maintain a relatively higher standard of living. The government takes more power away from citizens (this is seen almost as a time of war) and the media is also heavily monitored and censored. A rise in nationalism follows the drive towards self-sufficiency.

### ***Effect on UK ecosystem services, goods and benefits***

The goal of self-sufficiency and security of supply dominate in this future. Provisioning services are prioritised over the other ecosystem service types. A key feature of the changes is the transfer of land (mainly semi-natural grasslands and mountain moor and heathland) to woodland, especially conifer.

### **Provisioning**

- Timber production – increases dramatically due to larger area but also because of better adapted species to a changing climate, high adoption of tree breeding technology and better forestry management.
- Fuelwood production – also increases, it provides a relatively easy fuel to source as well as providing home-grown jobs.
- Food production – a huge increase in arable area coupled with gains in crop yields result in higher crop production than at any time in the UK's history. Protein-based crops as well as more traditional grain and starch crops increase to off-set a reduction in meat production.
- Marine fish stocks – dwindling wild fish stocks are protected and the UK's fishing territory is vigilantly controlled. Aquaculture becomes a vitally important source of fish-based food for the UK.
- Marine energy – increases dramatically to help meet the demands for self-sufficient energy supplies through the use of wind and tidal power.

### **Regulation**

- Carbon – increases in above and below-ground mainly due to biofuel and woodland expansion. A reduction in meat production also reduces carbon emissions.
- Flood alleviation – rural flood-prone areas are afforded protection against flood if they are major agricultural production areas. This is done through a series of better soil management, river-re-channelling and hard defence systems. Afforestation also improves flood mitigation provision in some areas.
- Erosion control – strict control in the agricultural sector and good practice reduces erosion incidences.
- Water quality – declines to mid-1980s levels due to high use of pesticides and fertilisers and increase in arable area.
- New incidents of invasive species decrease due to a reduction in overseas trade, current species are controlled in areas where they pose the largest threat to provision of food.

### **Cultural**

- Recreation – decreases significantly, people have less time to visit the countryside and are more likely to spend time close to home in gardens etc. Rural UK is a less attractive and many scenic

areas have lost their aesthetic appeal through further agricultural expansion or large-scale coniferous planting.

- Historic and spiritual values throughout the UK are preserved and celebrated however. Some beautiful and iconic landscapes that have not been altered too much by the drive towards production and remain the most popular places to visit.

#### ***Ecosystem service trade-offs and changes since today***

This storyline heavily emphasises provisioning services in the UK and results in a decline in regulating and cultural service provision. In some circumstances (e.g., increase in broadleaf woodland) benefits for regulating services are made (although little for cultural except to increase landscape aesthetic value by adding more woodland). An increase in food and timber production in this storyline results in gains in provisioning services compared to contemporary UK; however, in nearly all other instances, regulating and cultural services decline. It is difficult to estimate how the overall balance in service output would change, however, because we lack any clear indication of how the output of services varies per unit area of each habitat type. It would, nevertheless seem that climate change would have the severest impact in arable land - with a significant reduction in area under the high impact scenario due to poor adaptation capacity, which is largely converted or abandoned to semi-natural grassland.

## **4.5 Local Stewardship**

### ***Origin***

This storyline is a twist on the *National Security* narrative, which emphasises an effort to maintain economic development and living current patterns of consumption despite external pressures. The *Local Stewardship* storyline, in contrast, is an inherently greener world that assumes a more conscious acceptance that a reduction in the intensity of economic activity and the high levels of consumption that had characterised the earlier part of the century is needed; it also assumes a migration pattern of counter-urbanisation. Many of the focal questions influencing the *Nature@Work* storyline where also relevant here, however, aspects influencing the *National Security* storyline are also relevant. In particular, this storyline tries to address issues raised about the future importance of localism and balancing ecosystem service delivery, but it also seeks to describe a future where economic growth has not continued unabated. It is arguably the most challenging and difficult storyline to envisage, nevertheless, it provides us with a picture of how the UK could evolve sustainably under a global decline in economic growth and access to dwindling resources.

### ***Rationale***

*Local Stewardship* defines a future where society is more concerned with the immediate surroundings (community, land, etc) and strives to maintain a sustainable focus on life within that area. However, unlike the *National Security* storyline, and despite the local focus, people are more connected and have more solidarity with communities in other countries.

This scenario assumes that societal equity goes alongside environmental equity. People travel less and depend more on local resources; more of our food and leisure activities take place in our immediate surroundings. The implementation of the sustainable management of resources is emphasised and society relies less on technological innovation compared to the other scenarios. Low carbon economies spring up everywhere and there is a greater use of alternative economies such as LETS (Local Exchange Trading Systems) schemes. Waste is considered an anathema: very little food is wasted, and, for example, farmers and small-holders utilise every last part of the animal. Many families keep chickens, pigs or geese.

Self-sufficiency is a key concept and many exports and imports are reduced considerably (but exist for commodities not produced in the UK); agricultural land, however, declines only slightly from 2010 although the population in this storyline is the lowest of all the scenarios. The overall levels of biodiversity increase though and many ecosystems, including farmland and woodland, are managed more sustainably. Climate change is taken seriously and mitigation (an example of the 'think global' aspect) and adaptation projects spring up around the country. The main land cover changes due to climate change are seen in arable and

grassland (small declines in area with concomitant rises in semi-natural grassland and broadleaf woodland); however, the low input and heterogeneous nature of the farm enterprises in *Local Stewardship* increase the adaptation capacity so losses are minimal.

Through local specialisation the UK becomes less homogenised – the landscapes become more distinct and even local economies vary considerably. Technological development occurs in localised areas due to private innovation and a government initiative for developing sustainable technology. Social and environmental regulation has advanced though, particularly in workers welfare and rights and in environmental protection. Policy encourages smaller enterprises and SMEs proliferate. Although economic growth is slower compared to some storylines, the economy is more stable and does suffer periodic dips and crashes. The localism aspect of this storyline is enabled by a reduction in government interference in the everyday life of society. The UK government has largely devolved much of the day-to-day running of many aspects of life (e.g., education, health) but it still plays a role in the environmental governance through legislation. Most environmental Acts are related to environmental protection of semi-natural habitats and wildlife, other than this, there are no incentives for environmental management. Instead, the national government helps to provide education on sustainability and other environmental issues; otherwise, environmentalism is generally quite driven by a ‘bottom up’ approach.

Land cover transitions are driven by a greater appreciation and desire for sustainability but are also permitted to a large extent because of a lower demand for food provision due to smaller national population. Biodiversity is afforded greater protection locally and the desire to produce food locally results in greater heterogeneity in the landscape, which also improves the conservation value.

### ***Main Drivers***

Immigration is reduced and internal migration between regions falls dramatically too. Population growth from 2010 is very small mainly due to a government policy of rewarding one-child families; however, the population continues to age (although the age of retirement reflects greater health at old age and rises to 70). A focus on sustainable households results in more people living together under one roof. As a result, there is no housing crisis and as a consequence much poor quality housing from the 20<sup>th</sup> century is destroyed to make way for green space.

One consequence of this scenario is lower overall GDP; however, the country as a whole is healthier, happier and the environment is better protected. Unemployment is much lower than 2010 and although average income is reduced there is much greater employment security and more people are engaged in labour-intensive jobs.

An investment in water and energy efficiency is one area where some technological advancement is made; coupled with a greater desire to develop diverse energy resources locally means that the energy industry is radically changed; domestically, more houses take up a mix of solar, ground-source heat and wind. Fossil fuel is still used; some abandoned coalmines are reworked and energy is generated using cleaner technologies and carbon storage.

The drive towards self-sufficiency is seen as a necessary step forward by many countries throughout the world although trade still exists. Diminishing energy and freshwater resources have resulted in countries refocusing their efforts towards ensuring sustainable supplies of their own ecosystem services (albeit mainly regulatory and provisioning). No longer can countries guarantee supplies of many goods although, of course, some countries will still export goods were they have an excess of supply.

### ***Land and Sea use***

Agriculture changes considerably as a consequence of two factors: the drive towards self-sufficiency means that some crops are reduced in area (e.g., wheat-exports reduce) to be replaced by more protein and vegetable crops; mixed farms (many organic or low-input) become more common too. One major difference with many of the other storylines is the continued presence of improved grassland to maintain livestock production; however, whilst the overall land cover may stay the same, the location of improved

grassland has changed and many arable farmers have become mixed. These changes are largely (local) market driven. Some meat production becomes more extensive and traditional British breeds do well, although increasingly species with a high tolerance to heat are kept. The second factor is the promotion, through market forces and policy, of a distinct local or regional character for food production. Traditional areas for specialist foods return. Agriculture is subsidised by the government and entails a programme of biodiversity conservation and sustainable management practices.

Most woodlands have a similar woodland composition to today's but are better managed through coppice (used for local domestic energy or other craft products) and other (sustainable - like shelterwood) high forest silvicultural systems; lower grade agricultural land is converted to woody biofuel in peri-urban areas and in lowland rural counties. Overall agricultural land area declines only slightly since 2010 but changes considerably in type (more heterogeneous) and in average farm size (smaller). Perhaps the most significant change is a large increase in semi-natural-grassland ecosystems that are maintained by grazing and provide an opportunity for recreation and biodiversity too. Mountain habitats are protected from development and provide grazing for sheep and hardy cattle breeds. Recreation is important but often locally based.

The quality of water in all freshwater habitats improves as a result of better agricultural management and more extensive production systems. A reduction in freshwater provision in the southeast due to climate change is partly met by better water use efficiency and delivery from western and northern parts of the UK. Invasive species are controlled and new introductions from overseas decline due to greater border control. In coastal areas managed retreat is common (landowners are well compensated) and hard defences are actively removed in favour of 'softer' approaches. Areas of valuable agricultural land are protected but some farm systems are changed from highly drained farmland to wetland farm systems (e.g., rice production). Coastal development for shipping, oil and gas is reduced and the UK's coastline and marine habitats reap the benefits. Renewable energy from the sea is encouraged and backed by government schemes - wave and tidal energy sources become common (but do not conflict with areas of high biodiversity). Marine bio-resources are managed sustainably (local quotas are implemented) and the numbers of small fishing vessels increases. Local fish-based cuisine is very popular; mobile fish populations (i.e., trans-boundary) are managed by national quota systems and a new fisheries committee. Despite a lower overall fish haul than in 2010, fish catches are more diverse. Carbon sequestration in marine environments is also taken seriously - local marine areas are rewarded by the national government for maintaining carbon stocks.

A pattern of counter-urbanisation occurs in many urban areas; the housing stock diminishes to make way for more green space (gardens both for leisure and food production) and the total green-space is the second highest proportion of urban cover after *Green and Pleasant Land* (57%). Street trees are planted and maintained and urban farms crop up throughout the UK. In peri-urban areas there is a large increase in (working) woodlands and conservation areas due to a housing contraction. Small farms (mostly tenanted) arise from the break-up of larger units.

The UK settlement pattern is very similar to 2010 except in areas prone to flooding, where some of the housing stock has been removed. Existing housing development occurs only in relatively safe and 'climate proof' areas. There is a small outflow of people from urban to rural areas.

Domestic energy supply is very important in this scenario and many houses are installed with a combination of wind, solar and ground-source heat systems. Energy efficiency is also improved across the national housing stock. Transport adopts a combination of bio-fuel, electric and fossil fuels. Large-scale renewable energy also plays an important part but only where it does not conflict with biodiversity: e.g., wind farms crop up around the coast but avoid major bird migratory routes as well as important marine habitats.

### ***Human well-being***

The belief in sustainable production systems pervades attitudes towards consumption and lifestyles; most people do not want or miss high-tech goods and enjoy a more relaxed pace to life. Simple things provide simple and rewarding pleasures. Food is very important though and many people pride themselves on their

cooking abilities - local food is easily sourced.

The health of the nation increases due to lower stress lifestyle, better nutrition, better education, more outdoor work and better housing standards although technological developments in medicine have not progressed as much in other storylines. Mental health is also much higher than ever before.

The UK is a much happier place. There are lower incidences of crime and aggressive behaviour toward others; tolerance of minorities and different viewpoints is high and many local communities are so well connected and supported that any transgression are easily dealt with if they arise. Community pride and peer pressure to 'behave' is strong.

Localism does not mean inconsistent standards in law or freedom; everyone in the UK has a voice, a vote and freedom to do what they want within the laws of a civil society. Many local customs are maintained but these do not encroach on equality and civility. Access to land and production systems is good and anyone has the opportunity to do well in life if they work hard.

### ***Effect on UK ecosystem services, goods and benefits***

The goal of using resources in a more sustainable way, and managing them at local scales, is reflected in the outcomes, in that habitats and services are regarded as important across the board, and most show improving trends. The less intensive approaches to land management are reflected in the expansion of semi-natural grasslands, compared to the present.

### **Provisioning**

- Timber production – there are huge increases in some areas (i.e., traditional wooded regions like south east) due to an emphasis in restoring silvicultural systems and a slight increase in woodland area; many farm woods are also renovated to working woods again. Local wooden products are easy to find in shops (everything from spoons to broom handles to tables and joists).
- Fuelwood production – increases due to high fossil fuel costs and more woods being restored or worked for underwood. More efficient boiler designs means that many local communities adopt fuelwood as their energy source for heating.
- Crop production – declines slightly where old varieties have been adopted; there is less use of pesticides and inorganic fertilisers but the rise in sustainable and diverse farming systems means many farmers are far better adapted to climate change extremes.
- Animal production – there is a similar decline in yield to crops although the land area used and total livestock numbers remains fairly constant.
- Marine – popular wild fish species from the 20<sup>th</sup> century are largely unharvested and replaced by sustainable catches of local species.

### **Regulation**

- Carbon – terrestrial carbon stocks increase due to better management of woodlands, farms and grasslands. Marine carbon stocks are protected.
- Flood alleviation – locally designed adaptation plans are implemented often resulting land cover change to woodlands or other semi-natural habitats. Planned adaptation is widespread and housing developments in floodplains have been removed and returned to natural ecosystems.
- Erosion control – the main problem areas on farmland are managed to control or prevent soil erosion.
- Water quality – improves to almost complete UK-wide favourable status as a result of more sustainable agricultural practice and tighter environmental legislation.

### **Cultural**

- Recreation – there are increasing opportunities for woodland and farmland recreation and local service provision is key. Fewer people travel far for leisure and pride in local landscapes runs high. Most woods are intensively managed for fuel to supply local heat generation systems but also incorporate trails and paths for recreation. The traditional English landscapes of pre-war times are



returning and many people love walking in the countryside.

### **Ecosystem service trade-offs and changes since today**

*Local Stewardship* has more in common with *Nature@Work* than *National Security* with regard to trade-offs for ecosystem service. However, despite the focus on local food production this would never over-ride regulating or cultural service provision. In this sense, *Local Stewardship* also sits slightly closer to *Green and Pleasant Land* too (in as much as biodiversity is regarded as very important). It must also be remembered that it is easier than *Nature@Work* to balance service provision because the overall impact from the drivers of change are lower (e.g., population). All ecosystem service provision in this storyline improve over the current status – food provisioning stays constant or increases slightly but regulating and cultural services increase quite dramatically. However, as before it is difficult to estimate the changing balance overall and the extent to which the gains compensate for the losses. Climate change reduces provisioning services slightly in farmland, which is particularly evident in the southeast (where temperatures and drought are most extreme). This farmland loss is broadleaf woodland's gain as more drought tolerant native species are planted.

## **4.6 Business as Usual**

### **Origin**

This storyline attempts to imagine how current trends or targets will carry forward; in one sense it is a kind of comparator, but it is perhaps best viewed as a scenario in its own right because it does explore a particular set of assumptions about the processes that drive change and the responses to them. A number of the focal questions identified in the stakeholder consultation raised issues of about the effectiveness of current environmental and socio-economic policies.

### **Rationale**

This scenario is essentially a qualitative projection based on current trends and societal attitudes and results in a future UK that is loosely based on today's ideals and targets; it leans towards improving environmental performance and sustainability in the UK. Thus many current ideas being discussed in academic, government and the business sectors have been used as the basis of this narrative. The scenario assumes that environmental improvements are still important in the national vision for a future UK, but that the public are somewhat reluctant to adopt many global or national environmental standards if it challenges living standards (business and industry even less so). In this scenario, this stand-off continues to dominate and a lot of environmental progress is hindered.

Policy development in this storyline continues the current pattern of improving and tightening environmental legislation and incentives, backed up by more awareness of environmental issues in society and a more comprehensive extension service ready to support and advise farmers and other land owners. Land cover changes largely follow the patterns of the last few decades also: broadleaf woodland continues to slowly increase through agri-environment grants, more semi-natural grassland is restored, and urban development continues very slowly and expands into target areas (e.g., ex-farmland near good transport links).

### **Main Drivers**

The average household size of 2.4 persons in 2010 declines slightly as more people enjoy living alone, the divorce rate continues to rise and the birth rate declines. Immigration is controlled and only skilled migrants are allowed entry (it falls to 250,000/year although emigration rises to 350,000/year). Population growth slows but *Business as Usual* is second only to *World Markets* for total UK population size. A slow progression towards a low-carbon economy and better environmental standards across industry and society is maintained, albeit with bumps along the way. There are brief spurts and setbacks depending on the government at the time but climate change mitigation and adaptation is kept on the agenda.

The employment rate increases from 72% in 2010 to 77%; unemployment falls from 7.9% to 3%. Export of goods to the EU and other countries grows to a value of £30 billion in 2060. The UK follows the same

pattern of privatisation of public institutions as now.

Technology and science are considered important aspects for a developing society and are maintained although private sector investment is encouraged. The UK's gross domestic expenditure on R&D has increased from £25.6 billion in 2008 to £35 billion in 2060; this represents 1.5% of GDP.

The global context is the same as in *Green and Pleasant Land*: this scenario sits in a world where the business-as-usual paradigm continues. The US, EU, China, India and Brazil are the dominant economic forces in the world and capitalism drives the economy in 99% of countries. Global trade increases each year but new markets are created as more countries strive for a western standard of living and climate change affects some traditional production areas. Global environmentalism is stronger than ever but still struggles in places to make any headway into a world where a free market economy is dominant. One success is the burgeoning use of products that are sustainably certified (timber, biofuel, many foodstuffs) and increasingly these products dominate the western markets.

### ***Land and Sea Use***

The current area of agricultural land in the UK of 17.5 million hectares stays the same although cropping changes to reflect the impacts of climate change (new crop species, more perennial crops and biofuels). Agriculture is a varied and changing industry – in some parts of the country large, factor farm units supply cheap milk, pork and beef to the supermarkets; in others, there is greater emphasis on organic farming and quality beef, lamb and pork production. The area of grassland declines slightly as more livestock is housed under roof (much of the remaining is converted to woody biomass). Arable production starts to encroach into traditional animal production areas in the western and northern parts of the UK due to climate change. The woodland area in the United Kingdom in 2010 increases reflecting 50 years of agri-environmental support for woodland creation; of this a large percentage is sustainably managed. Greater public access to woodlands is achieved through an amendment to the CRoW Act. All conservation-designated grassland are maintained, mainly by local conservation organisations as the emphasis of government conservation programmes shifts to focus on ecosystem service delivery and climate change adaptation schemes. Mountain and heath ecosystems are threatened by afforestation and localised grazing pressure but continues to be a dominant sink for soil carbon in the UK. Upland peat soils, in particular, are protected from land use change. Recreation increases in mountain areas although traditional mountain communities (farm based) are in decline and more people are engaged in the tourism and leisure industry. Mountain biodiversity shows a steady decline from 2010 for the next few decades primarily due to climate change; conservation programmes to curb this are expensive and largely unsuccessful.

One success story in this storyline is the continued successes in cleaning the rivers of the UK; however, all is not rosy and invasive species number rise and prove difficult to control with the limited funding the government offers.

In 2060 UK ports handle 750 million tonnes of freight, up from 562 million in 2008. The vast majority is inward. Some areas of coastland are placed under managed retreat regimes but on the whole hard-sea defences are employed to hold back rising sea levels. The UK sea fish (including shellfish) catch is down to 270 thousand tonnes in 2060, almost half the 2010 figure. Development of offshore wind farms has slowly picked up and threatens some marine ecosystems.

Government plans to build a quarter of million new houses every year until 2030 (when the UK will reach 27.8 million households) are extended indefinitely and housing development continues for the next 20 years; this results in an average density of 50 dwellings per hectare (up from 45 in 2010). Most of this housing is concentrated in the southeast but all major conurbations in the UK see a rise. Building in greenbelt areas rises and about 15% changes to residential use since 2010. Development in areas of high flood risk also continues and in 2060 twenty % of all dwellings built since 2010 are found within high flood risk areas.

The UK pushes its 2010 target of 3% of energy sourced from renewables to 8%; a focus on nuclear energy

was promoted in 2020 to help alleviate dwindling fossil fuel resources available to the UK. Biofuels from cropped land is also heavily promoted. Energy efficiency continues to improve at a steady pace and cars with poor fuel economy are heavily taxed. New high-speed rail networks are developed greatly reducing travel time. Car use also continues although the vast majority of vehicles in 2060 do not use non-fossil fuels (hydrogen, bioethanol and electric cars are common).

### ***Human well-being***

UK society is divided between the have and have-nots. Mean income is higher than in 2010 but so is the gap between rich and poor; there is still a glass ceiling for some sectors in society (although things have improved for women). Most people have access to cheap electrical goods and a range of foodstuffs (although niche products become prohibitively expensive for most people).

More of the NHS is funded through private finance initiatives which has a serious detrimental affect on national health (i.e., the needs of patients are not always met). The affluent sections of society are generally healthy due to access to the best medical care and better education (smoking, drinking and obesity all mainly lower class issues). An increase in human health pandemics throughout the world results in large occasional mortality events across the UK.

The standard of policing is very patchy in the UK, partly as a result of the police force coming under the management of Public Private Partnerships; some areas (i.e., affluent) have good policing, many others do not however. This breeds resentment and creates a divisive society.

Freedom is more restricted than in 2010. Human rights are squeezed further in the name of protecting democracy. The biggest fear remains terrorism and threats from fundamentalist religions continue to rise. Many goods that were once public are now private - this affects access for recreation, food and decision-making.

### ***Effect on UK ecosystem services, goods and benefits***

The theme of this scenario is a continuation of today's aims and objectives. Thus ecosystem services that have monetary value and are easy to trade are protected, many others are not. Enclosed farmland declines in area and there are small increases in woodland, semi-natural and mountain moor and heathland.

### **Provisioning**

- Timber production – very little timber is produced in the UK as imports from Eastern Europe are cheaper for the UK consumer. The area of conifer plantation declines slightly and although broadleaf woodlands increase in area very little is managed for timber.
- Fuelwood production – increases due to high fossil fuel costs and the larger broadleaf woodland area; some local communities adopt fuelwood as their energy source for heating.
- Crop production – increases steadily, government and private R&D has pushed yields higher despite climate change; overall national production in cereals and protein crops increases.
- Animal products – milk, beef and pork yields continue to increase due to demand for cheap, low quality meat; much of it is reared indoors.

### **Regulation**

- Carbon – terrestrial carbon stocks slightly increase due to better carbon management across sectors (including agriculture); an increase in broadleaf woodland area also contributes.
- Flood alleviation – there are localised improvements, mostly in the southern counties of England; housing development continues in flood zones often with no or little flood mitigation programme implemented.
- Erosion control – slow improvement in management through concerted DEFRA & NFU efforts.
- Water quality – continues to improve throughout the UK through better farmland management and tighter environmental legislation.
- Invasive species numbers increase due to more un-regulated trade, an increase in traffic (a main vector for many species) and climate change; control methods are implemented but without real

- funding are fruitless.
- Marine fish stocks – some wild fish stocks have been all but depleted despite protection from the UK and EU. Aquaculture increases production to maintain local fish supplies but increasingly fish is imported from overseas.
  - Energy – the nuclear industry is renewed and along with gas imports is the main energy source for the UK. Renewables provide a token gesture with a mix of land a sea-based wind generation the main source.

### **Cultural**

- Recreation – there are increasing opportunities for countryside recreation in National Parks and other publicly managed landscapes; however, increasingly access to private land in the UK is more difficult.
- Some historic and spiritual ecosystem services in the UK have been degraded or lost due to a lack of government funding.

### ***Ecosystem service trade-offs and changes since today***

Trade-offs in this storyline are a constant struggle to achieve – whilst there is a gradual shift away from provisioning services to regulating and cultural (although not in all areas) there is a constant battle with other socio-economic forces to improve the UK's environment. There is also a large geographical element to ecosystem service delivery in this storyline – e.g., the south-east has a lower overall suite of services than many other parts of the UK.

Production in food increases due mainly to technological advances increasing crop and livestock yields; however, sustainably farming also is more popular (although there is still a widespread adoption of 'industrial' farming practice) and as a result regulating services also improve slightly.

The main difference to note in ecosystem service delivery compare to 2010 is that there is a marked improvement for all services; and whilst this storyline compares unfavourably with *Nature@ Work*, *Green and Pleasant Land* and *Local Stewardship* it is certainly an advance on today's situation as well as *World Markets* and *National Security*. Climate change adaptation is increasingly more important to society and the government and as a result of adopting greater technology and better management strategies, land cover change under the high climate change scenario are marginal (some loss of farmland in the most extreme climate zones in the southeast). However, sea-level rise does result in a loss of land area although this is partly due to a programme of managed retreat in some parts of the UK.

## 5. Discussion on ecosystem services and habitat outcomes

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The main aim of the scenarios is to address two questions:

- How might ecosystems and their services in the UK change in the future under plausible scenarios?
- What is the future possible effect of changes in ecosystems on human well-being and who might most be affected?

To do this, and it remains an ongoing task, we have created six (hopefully plausible) story-lines that offer a wide range of outcomes for the UK's ecosystem services (and habitats). These outcomes will be 'played out' by using the story-line characteristics as well as land cover data for the UK to create casual chain models in Bayesian Belief Network software. We attempted to populate a table of some of the major outcomes for habitats and land cover types (table 7). This helped to ensure that the story-lines provided sufficient contrast with each other (and yet still maintain plausibility). The modelling process then involves affecting changes in land-use that reflect each story-line characteristic (e.g., a reduction in arable area and management intensity in *GPL*) as well as other connecting factors that may influence any given ecosystem service (adoption of no-till farming methods on soil carbon levels). The Bayesian model can provide (if calibrated and populated with realistic data) an estimation of the amount of the ecosystem services (or more importantly the range of outputs under the six different story-lines). By exporting data back into a GIS programme we can also partially address the second question (i.e., who?) assuming *who?* correlates to *where?*

The other crucial element is then to apply the climate change impacts into the model; this will of course have a range of possible effects including affecting plant growth (and survival), population location, flood impacts, etc. To do this we have attempted to anticipate how climate change would affect ecosystem service output by working through the implications of each story-line (table 8). However, this will also be guided by the outputs of the Bayesian model and further expert input.

The two climate change scenarios will have dramatic affects on many ecosystem services in all the socio-economic scenarios discussed above but clearly the High CC scenario will have a greater impact on crop yields, coastal erosion, habitat composition and carbon sequestration to name but a few. These direct impacts will be the same across the story-lines, however, they will be further compounded (or not) by the effects of other drivers in each story-line (which also includes the different adaptation strategies). For example, the *World Market* story-line dismisses adaptation as a waste of time, and coupled with a lack of ecosystem management (e.g., no 'soil-friendly' management practice in agriculture) will likely suffer negative effects on many ecosystem services in the both climate change scenarios.

Two scenarios will deal with climate change better than the rest: *Green and Pleasant Land* and *Nature@Work* which both place a strong emphasis on adaptation to climate change throughout industries, land use types and habitats. In agriculture, *Nature@Work* will be better placed to adapt though as it is more likely to adopt new crop species, new technologies and even GM crops that are more CC tolerant. In

contrast, *Green and Pleasant Land* has a greater emphasis on adapting to CC in the conservation sector through programmes like species translocation, habitat corridors and use of low-latitude genotypes.

Table 7: Major land cover and marine changes in 2060

|                        | Green & Pleasant Land  | Ecosystem Service   | World Market  | National Security   | Local Stewardship   | Business as Usual   |
|------------------------|--|---|---|---|---|---|
| Urban                  | Increase in green cover through trees, parks and gardens and green roofs                             | Increase in green cover through trees, parks and gardens and green roofs. Improve energy efficiency of old housing stock  | Street trees replaced at death; many gardens and parks converted to housing.                          | Increase in urban farms and allotments. Loss of parks and gardens for leisure.                      | Loss of housing reflecting greater sharing. More green space and urban farms                            | Urban expansion continues at slow pace. Some infilling in green space.                        |
| Farmland               | Reduction in area but more sustainable practice. Mixed farms increase                                | Change in farm practice to control erosion and increase soil carbon. Some land lost to woodland.                          | No subsidy; farming becomes more industrial, large-scale and more specialised.                        | Optimisation: new tech, GM and switch to crop protein.  | Farm areas as in 2010; increase in mixed, organic and low-input farms. More on-farm processing.         | CAP remains, farms get bigger as small farms sell up.   |
| Woodland               | Restoration of ASNWs and PAWS; new woodland planting helps connect ASNWs                             | Woodland restoration programme combines conservation and fuelwood prod. Huge increase in woodland cover.                  | Some woods grubbed out for housing and other development. Conservation efforts reduced.               | Woodlands managed intensively for timber and fuel. New fast-growing species introduced.             | Conservation woodlands managed sympathetically but also for woodland products (timber, fuel, NTWP, etc) | New woodland planting continues at slow pace. Few ASNWs restored or managed for conservation. |
| Grassland              | Restoration or rare chalk grass habitats prioritised. Other conservation grasslands protected.       | Conservation grasslands protected for amenity, biodiversity and carbon uses.  | More loss of chalk grassland to arable and biofuels.  | Loss of grasslands to SRC where possible. Some is converted to arable.                              | Chalk grassland is restored and grazed with traditional species   | Most grassland remains although some threatened by external inputs.                           |
| Mountain, moor & heath | Species translocation project helps to adapt to CC   | Carbon stock and water provision in MMH is protected. Amenity encouraged.   | Loss of MMH habitat to agriculture. Reduced conservation protection.                                  | Lower slopes are converted to plantation forests using exotic species.                              | Some adoption of mixed farms on the lower slopes of mountains. Otherwise managed for conservation.      | Recreation is popular in Mountains. Slow removal of plantations.                              |
| Coastal margins        | Managed retreat leading to new habitat creation is promoted. Other coastal habitats protected.       | Protected from development and managed retreat encouraged.  | Development continues into biodiverse coastal habitats. New ports and housing spoils many ecosystems. | Development of desalination plants on east coast. Some managed retreat. New nuclear plants.         | Managed retreat is common except on valuable agri land.   | Mostly protected from development except major energy plants (nuclear and hydro).             |
| Marine                 | Fish stocks protected and habitats given conservation legislation                                    | Sustainable fishing restores fish populations.  | Oceans become commons: fish stocks continue to fall   | UK sea fish stocks harvested unsustainably and protected from foreign fishing boats.                | Food resources managed sustainably. Habitats protected.   | Some fish populations thrive but others have all but disappeared.                             |
| Freshwater             | Tighter legislation on pollutants and invasive species management. 'De-straightening of some rivers. | Rivers and streams cleaned up and invasive species controlled. Renewed interest in natural swimming and other recreation. | Reduction in water quality. Rise in invasive species.   | Given little protection. No new invasive species but existing spp increase. Water quality declines. | Improvement in water quality continues. Invasive spp controlled.  | Slow improvement in water quality but invasive species increase.                              |

The levels of overall adaptation will be greater in the GPL and ES scenarios compared to the other socio-economic scenarios in the High climate change scenario than in the Low climate change scenario. Whilst the two other scenarios are less committed to adaptation (NS and BAU all reasonably accommodating without having the same levels of commitment as GPL and N@W) they are more likely to cope with the Low climate change scenario in most sectors. However, under the High climate change scenario some ecosystem services are likely to decline considerably (carbon mitigation, recreation) whilst others will receive societies' attention (agricultural production).

*Table 8: Ecosystem service delivery for six socio-economic scenarios under two different climate change scenarios (from best to worst, left to right)*

|                            | Nature@Work |      | Green and Pleasant Land |      | Local Stewardship |      | Business as Usual |      | National Security |      | World Market |      |
|----------------------------|-------------|------|-------------------------|------|-------------------|------|-------------------|------|-------------------|------|--------------|------|
| Carbon sequestration       | ↑           | ↗    | ↑                       | ↗    | ↗                 | →    | →                 | ↘    | →                 | ↘    | ↓            | ↓    |
| Carbon emissions           | ↑           | ↗    | ↑                       | ↗    | ↗                 | ↗    | ↗                 | ↘    | ↘                 | ↓    | ↓            | ↓    |
| Crop yield                 | ↗           | ↗    | →                       | ↘    | ↓                 | ↓    | ↗                 | →    | ↑                 | ↗    | ↑            | ↗    |
| Prevention of soil erosion | ↑           | ↑    | ↑                       | ↗    | ↗                 | ↗    | ↗                 | →    | →                 | ↘    | ↓            | ↓    |
| Flood alleviation          | ↑           | ↑    | ↗                       | ↗    | ↘                 | ↓    | ↘                 | ↓    | →                 | ↘    | ↓            | ↓    |
| Meaningful places          | ↑           | ↑    | ↑                       | ↑    | ↑                 | ↗    | ↘                 | ↓    | ↘                 | ↓    | ↓            | ↓    |
| Freshwater provision       | ↑           | ↑    | ↗                       | ↗    | ↗                 | →    | ↗                 | →    | ↓                 | ↓    | ↓            | ↓    |
| Pollination                | ↑           | ↗    | ↑                       | ↑    | ↗                 | →    | ↘                 | ↘    | →                 | ↓    | ↓            | ↓    |
| <i>Climate Change</i>      | Low         | High | Low                     | High | Low               | High | Low               | High | Low               | High | Low          | High |

Key: ↑ large increase in ecosystems' ability to provide the service; ↗ small increase in ecosystems' ability to provide the service; → ability of ecosystem to provide the service remains the same as in 2010; ↘ small decrease in ecosystems' ability to provide the service; ↓ large decrease in ecosystems' ability to provide the service.

Table 9: Proportional land cover projections for GB for six scenarios based on generalised Land Cover (%)

|                          | 2010 | GPL  | N@W  | WM   | NS   | LS   | BAU  |
|--------------------------|------|------|------|------|------|------|------|
| <b>LCM2010</b>           |      |      |      |      |      |      |      |
| Arable and horticulture  | 23.4 | 17.5 | 22.6 | 20.6 | 25.1 | 23.1 | 22   |
| Improved grass           | 19.9 | 15   | 17.9 | 18   | 21.7 | 18.7 | 16.9 |
| Broadleaved woodland     | 6.3  | 11.9 | 8.4  | 7.2  | 6.5  | 7.3  | 9.4  |
| Coniferous woodlands     | 5.3  | 4.5  | 5.5  | 5.4  | 5.3  | 4.5  | 4.8  |
| Built-up land            | 6.7  | 6.7  | 6.5  | 12.0 | 6.5  | 6.5  | 6.9  |
| Semi-natural habitats    | 16.5 | 21.8 | 17.2 | 15.4 | 13.2 | 17.2 | 17.6 |
| Upland habitats          | 15.4 | 15.4 | 15.1 | 14.0 | 15.1 | 16.0 | 15.6 |
| Water                    | 0.9  | 1.6  | 1.1  | 0.9  | 0.9  | 0.9  | 0.9  |
| Coast                    | 1.4  | 1.3  | 1.2  | 2.1  | 1.4  | 1.4  | 1.5  |
| Sea                      | 4.3  | 4.4  | 4.5  | 4.5  | 4.3  | 4.5  | 4.4  |
| <b>NEA Habitat Types</b> |      |      |      |      |      |      |      |
| Enclosed Farmland        | 43.3 | 32.5 | 40.5 | 38.6 | 41.8 | 46.9 | 39.0 |
| Woodland                 | 11.6 | 16.4 | 13.9 | 12.6 | 11.8 | 11.8 | 14.2 |
| Urban                    | 6.7  | 6.7  | 6.5  | 12.0 | 6.5  | 6.5  | 6.9  |
| SNG                      | 16.5 | 21.8 | 17.2 | 15.4 | 17.2 | 13.2 | 17.6 |
| MMH                      | 15.4 | 15.4 | 15.1 | 14.0 | 16.0 | 15.1 | 15.6 |
| Freshwater               | 0.9  | 1.6  | 1.1  | 0.9  | 0.9  | 0.9  | 0.9  |
| Coastal Margins          | 1.4  | 1.3  | 1.2  | 2.1  | 1.4  | 1.4  | 1.5  |
| Marine                   | 4.3  | 4.4  | 4.5  | 4.5  | 4.5  | 4.3  | 4.4  |



## 6. Incorporating the UK's overseas ecological footprint

A further element of NEA scenarios chapter is to consider the UK's overseas ecological footprint partly as it helps to define the reality of each of the story-lines but also because it could be incorporated into the Bayesian model and will help provide some quantification of the overall impact on global ecosystem services for each story-line.

The ecological footprint is a relatively new concept that is designed to provide some comparative measure of the human demand on Earth. It calculates the amount of productive land and sea to generate the resources we consume and to manage the waste we produce. Various attempts to produce figures for countries of the world have been made and in the UK we have even had estimates for each local authority. Here, by referring to published data we have tried to further enhance the realism of the story-lines by focussing on their resource impacts overseas or Ecological Deficit (Table 10). The table is derived from the latest Global Footprint Network<sup>5</sup> as published by the WWF (2010). The current ecological footprint is estimated to be around 6.1 gHa per capita. We have assumed that this does not change significantly under the BAU scenario (the higher population is balanced by more sustainable energy use and better food yields). The rest of the table was populated by other story-lines

Table 10 highlights areas of potential environmental conflict (i.e., between supposed green living in the UK but less so elsewhere) with the obvious example here being Green and Pleasant Land with comparatively high energy and food imports to compensate for lower indigenous production. In contrast, the Nature at Work story-line tries to deliver on improved indigenous food and energy production but will still require some reliance on overseas resources to maintain a comfortable lifestyle for the population. National Security sets out to be as self-sufficient as possible but would be happy to export waste whilst Local Stewardship not only focuses on self-sufficiency but is generally a lower consumption society too. The World Market story-line shows the highest increase in overseas global footprint overall. With all of the components increasing relative to the BAU case.

Table 10: Story-line overseas ecological footprints (after: WWF, 2010)

| Component                  | Green & Pleasant Land | Nature@Work | World Market | National Security | Local Stewardship | Business as Usual |
|----------------------------|-----------------------|-------------|--------------|-------------------|-------------------|-------------------|
| Food                       | 1.4                   | 0.8         | 1.4          | 0.6               | 0.6               | 1.0               |
| Energy                     | 1.6                   | 1.0         | 1.2          | 0.8               | 0.9               | 1.2               |
| Consumption and waste      | 0.9                   | 0.4         | 1.6          | 1.0               | 0.4               | 1.0               |
| Non-food bio raw materials | 0.9                   | 0.8         | 1.4          | 0.8               | 0.6               | 1.0               |
| Inorganic raw materials    | 1.2                   | 1.0         | 1.4          | 0.8               | 0.6               | 0.8               |
| Total score                | 6.0                   | 4.0         | 7.0          | 4.0               | 3.0               | 5.0               |

<sup>5</sup> <http://www.footprintnetwork.org/en/index.php/GFN/>

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