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The Development of Scenarios for the UK National Ecosystem Assessment Interim Report



CEM Working Papers No 1

Living With
Environmental Change
LWEC

UK National Ecosystem Assessment

Understanding nature's value to society

This is a document was produced for the NEA Scenario Expert Team.

The purpose of this document is to present it as a background paper to the NEA experts at an early stage. It will then on the base of discussions and feedback (from the Scenario Expert Workshop in London 26.5.2010 and topic specific telephone conferences be undated and presented as an Interim Report to the NEA overall expert meeting at end of June, 2010

Notes:

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

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For more information about the National Ecosystem Assessment follow: <http://uknea.unep-wcmc.org>

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In the context of the UK NEA, the aim of the scenario work 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.

1. **The key questions** that scenario work is seeking to explore are:
 - *How might ecosystems and their services in the UK change in the future under plausible scenarios?; and,*
 - *What are the future possible effects of changes in ecosystems on human well-being and who might most be affected?*

2. To do this we have:
 - a. **Undertaken a review of existing scenario studies** to determine 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. We are using the morphological approach to do this work. We conclude that:
 - despite their many strengths of previous studies non 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;
 - these studies do, however can be used to inform discussions about potential scenario storylines and the future projections of the key indirect and direct drivers of change that are relevant to the NEA.
 - b. **Worked with potential users to identify a set of focal questions that can be used to shape the design of scenarios for the NEA.** To do this we have 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. From this work we conclude that:
 - The character of some questions posed suggest that there is a need within the NEA programme to help users better understand **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 leaning’ 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.
 - 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.
 - On the basis of the survey of user questions it is apparent that if for the scenario exercise is to address the many perspectives and contrasting world views that the different interest groups bring to the table, then a more subtle and multi-dimensional approach to scenario construction is needed, compared to other recent studies.

3. **In response to the findings from the user survey we have adopted a morphological approach to scenario construction.** This has been used to identify for the main indirect and direct drivers of change and a range of plausible projections for them. We propose using 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 services outputs can be represented in a transparent way. To achieve this we have:

- Explored how Bayesian Belief Networks can be used represent and make operational the links between the drivers that define the different scenarios and service output, using 'service output' and 'marginal benefit' functions.
 - We have found that this approach allows the consequences of different assumptions about the future to be traced, and can help make some scenario outputs spatially explicit.
4. We have worked closely with the NEA economics team to ensure that the scenario outputs can integrate with their analysis, and have circulated a questionnaire to members of the economics team to identify the set of 'marginal benefit functions' needed in the analysis. We are presently making contact with the CLAs for the services and habitats to identify a set of functions linking changes in service output to the drivers used to define the scenarios.
5. In terms of the timetable, we propose:
- a. Preparing an interim report for circulation to the wider scenario group for discussion;
 - b. Presenting the revised interim report for review by the NEA expert Panel at its meeting on 24th-25th June, 2010, including recommendations on the candidate set of scenarios to be used for the NEA.
 - c. Undertaking and finalising the scenario analysis for use by response groups in September 2010 (following NEA expert panel, 17 September 2010).
 - d. Revision of scenarios given outputs from the 'response group' and other feedback, and preparation of scenarios chapter for review by NEA expert panel, January 2010

1.1 The role of scenarios within the NEA

Scenarios are an essential part of the ecosystem assessments. 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. 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 (Haines-Young and Potschin, 2010). Its main elements included taking stock of existing scenario studies and review how useful they might be for the purposes of the NEA, what kinds of question that potential users of the NEA were asking about the future, and how the scenario work can best be integrated with the science and valuation components of the assessment. The purpose of this Interim Report is to describe how the important methodological and practical issues surrounding scenario construction have been approached, and to present our recommendations on how the work might be taken forward to its conclusion. Key issues concern the identification of the questions potential users and how current scientific evidence can help our understanding of what the impacts of the different drivers of change might have. We have also considered how the economic assessment of past changes in the output of ecosystem services can be projected forward to better understand what some of the implications of alternative plausible futures might be, and present a flexible analytical framework that could be used in the discussion of response options by the wider NEA network.

1.2 Scenarios and Evolving Questions of Methodology

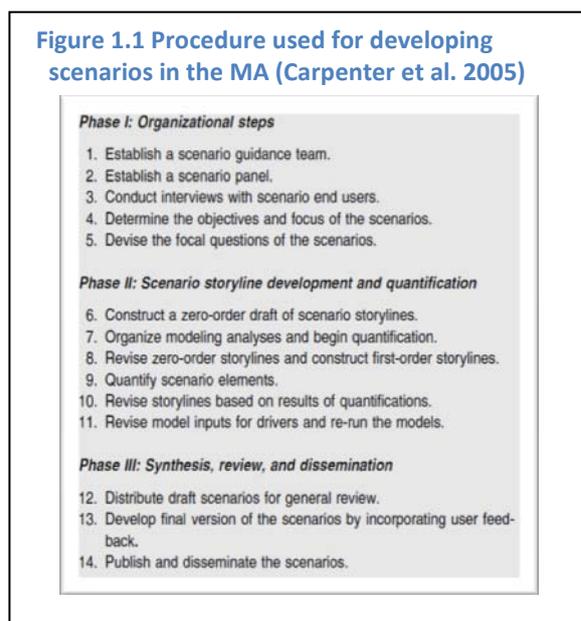
Although widely employed as an aid to policy making and as a device for stimulating debates about the need and type of social and economic change, the use of scenarios is controversial. Bradfield et al. (2005) observe that while scenarios have been used for more than three decades a number of methodological issues still remain unresolved. A reading of the large body of work that has reviewed and analysed scenario development (De Jouvenel, 2000; Alcamo, 2001; van Notten et al., 2003; Börjeson et al., 2006; Bishop et al., 2007; O'Neill et al., 2008; Wilkinson and Eidinow, 2008) seems to confirm this view. The chaotic situation arises, Bradfield et al. (2005) suggest, because of the many conflicting definitions, principles and ideas about scenarios that exist in the literature and the fact that terms such as 'planning', 'thinking', 'forecasting', 'analysis' and 'learning' are all variously used in describing what scenarios might be used for. The tension between the forecasting and learning perspectives is, it seems, particularly acute.

O'Neill et al. (2008) have recently set out some of the issues, and suggested that one theme that has emerged from recent debates is the tensions between two contrasting perspectives on the role of scenarios, namely 'scenarios as products and scenarios as processes'. Wilkinson and Eidinow (2008) make a similar point. They argue that often '... environmental scenarios are produced with enthusiasm but deployed with limited effect'. This largely comes about, they claim, because people neglect to examine the nature and scope of the knowledge and beliefs that underlie the different scenario approaches, and as a result they fail to get to grips with 'wicked' problems that characterise debates about environmental change. They propose a new typology for scenario studies to help guide future work by helping us better resolve the tension between 'problem-focused' and 'actor-centric' approaches to scenario construction, involving more hybrid approaches.

The ‘product-process’ dichotomy noted by O’Neill et al. (2008) is one that is relevant in any discussion of approaches to scenarios development within the NEA, which seeks to assemble and make available the best current scientific information to users **and** stimulate new approaches to monitoring and planning for ecosystem services based on their importance for human well-being. The ‘product’ perspective recognised by O’Neill et al. (2008) is one that views scenarios as mainly helping users to understand ‘environmental outcomes produced, how they relate to the various factors driving them, and what the results tell us about the prospects for future environmental change, for impacts, and for mitigation’ (O’Neill et al. 2008, p. 1). By contrast, the ‘process-perspective’ emphasises the importance of scenario building as a way of encouraging social learning between diverse groups, of finding synergies between different viewpoints, of consensus building, and of developing shared responsibilities for problem solving.

As a sub-global assessment conducted within the MA framework, the latter has been seen as providing a model and guide for the NEA. In the Millennium Ecosystem Assessment (MA), the method of scenario construction was presented as essentially deliberative (Fig. 1.1), involving dialogue between the research and user communities to define objectives, to determine the scope of the exercise and to identify the particular issues that the scenarios would be used to explore (Carpenter et al., 2005). While the emphasis in these descriptions is perhaps on the process of scenario building, it is clear from the work itself that efforts were as much directed towards the generation of scenario products. The scenarios were to a large extent model-based, and quantitative in character. Moreover, they were intended for general ‘dissemination’ rather than specific, on-going analysis or application (see, for example Figure 1.1, points 7, 10, 11 and 14). A belief that scenarios have ‘lives of their own, divorced from the processes that generated them...’ is one that O’Neil et al. (2008) suggest characterises the perspective of those who view scenarios essentially as ‘products’.

Figure 1.1 Procedure used for developing scenarios in the MA (Carpenter et al. 2005)



The extent to which the MA approach is essentially product or process orientated need not concern us here. The important issue is what kinds of approach are most appropriate for the UK NEA. While acknowledging the MA framework represents a starting-point it has always been recognised that the UKNEA has to take account both of the national situation and the conceptual and empirical work that has undertaken since the global exercise was completed. We look first at the conceptual and attempt to trace the implications of current debates for the design of the current work programme.

Although it is widely acknowledged that scenario building is not about trying to predict the future, but rather identify a range of possible futures that might unfold under contrasting but *plausible* assumptions about the forces that might drive change, notions of ‘predictive success’ often enter into and sometimes shape and even distort discussions. In the context of climate change studies, Hulme and Dessai (2008) have looked at the ‘predictive success’ of scenarios alongside two other potential outcome measures, namely ‘decision success’ and ‘learning success’ and emphasised just how misleading it can be in scientific terms to regard them as the prophetic devices. Problems include the fact that, by looking to predictive success we often try, inappropriately, to make a judgement about which scenario from a family of scenarios is ‘better’ or more ‘accurate’, when the actual outcomes are within the plausible or probability range of many of them.

For Hulme and Dessai (2008) 'decision success', that is whether the decisions based on a scenario building exercise were 'good ones', is also problematic. Like notions of predictive efficacy, this measure also embodies an 'instrumentalist position' that essentially regards scenarios as products. These authors argue measures based on 'decision success' only make sense if we move away from judging decisions by some kind of retrospective analysis of outcomes, to look at the robustness of the decision making processes themselves. A key test, they suggest, is whether the scenario exercise allowed the full range of uncertainties surrounding an issue to be considered by the decision makers.

Although difficult to measure, the extent to which scenario building leads to effective social learning is, according to Hulme and Dessai (2008), an appropriate test of the success of such studies. The measure is closer to the original intention of scenario studies, which was to introduce alternative and multiple views of possible futures into discussions about future strategies and plans. Learning success is, they suggest, also more lasting than 'product outcomes' which can rapidly become outdated as the relationship between the science, society and policy communities evolves.

Garb et al. (2008) argue that if we recognise that scenarios 'shape and embed their social contexts' then they can be used more effectively as decision support tools. However, the argument about the importance of processes in scenario construction is not, it seems, just about encouraging greater levels of participation in scenario building, but as Wilkinson and Eidinow (2008) suggest, ensuring that participatory processes are more effective. These authors have reviewed current scenario typologies and conclude that a modified approach to the process of developing scenarios is needed. While emphasising the importance of process, they argue it is not simply a matter of understanding *who* is involved and their respective world views, but *understanding* better the '... aims, intentions and underlying epistemological assumptions of those participating in the process' (Wilkinson and Eidinow, 2008, p.6). They propose a reflexive interventionist or multi-agent-based approach (RIMA) to scenario building that 'does not seek to construct consensus around a single understanding of current reality, but acknowledges that knowledge is multiple, temporary and dependent on context — with different points of view providing a constant challenge to any existing viewpoint or system' (Wilkinson and Eidinow, 2008, p.9). Moss et al. (2010) have also argued that more pluralistic and iterative approaches to the construction of scenarios may be appropriate in the specific context of the climate change debate, to better explore and evaluate different adaptation needs and strategies, the options available for mitigation, and the understanding of feedbacks between biophysical and social systems.

There is, of course, no best way of constructing scenarios or any simple recipe that guarantee success. Having argued the case RIMA, Wilkinson and Eidinow (2008), for example, 'draw back' from prescribing how the approach might be operationalised. However, in the basis of their review, O'Neill et al. (2008) do usefully set out a number of points that those embarking on scenario construction might consider in relation to the lessons that might be drawn from recent debates (Table 1.1). We have therefore used the points listed to reflect critically on the initial work programme agreed for the development and use of the NEA scenarios and to identify where any modifications might be necessary.

Table 1.1: Recommendations for Improving Scenario Development (after O’Neill et al., 2008)

1. Focus scenario exercises on specific questions so that results from multiple models can be more illuminating.
2. Enhance scenario transparency so as to enable extensions by users, rather than further expanding representation in global scenarios themselves.
3. Incorporate relatively simple measures (such as sub-national disaggregation of income distributions and climate change impacts) to boost the equity sensitivity of scenarios.
4. Recognise topics where social science inputs are becoming important for improving modelling and model relevance, such as providing a logic for how societies manage to transition from historical paths to the various future development paths foreseen in the scenarios, or developing measures of well-being which are independent of income levels, and include in global environmental scenario teams more representatives of social science professionals.
5. Invest greater resources in assessing scenario results, and in understanding and overcoming the barriers to carrying out such assessment.
6. Disaggregate the variety of global change decision makers targeted as audiences for scenarios.
7. Develop an additional ‘reflective interventionist’ scenarios approach that involves different epistemologies for active learning in the public interest.
8. Draw on the extensive toolkit of social science research methods to analyze the social work of scenarios.
9. Create new institutions and scenario activities that can adapt and extend global scenarios to specific, often local or regional decision contexts.
10. Create fora in which scenario practitioners, modellers, decision-makers, and social scientists of various kinds can discuss the process of scenario construction and use.

It is clear that a number of the issues identified in Table 1.1 are covered by what has already been proposed. The issue of transparency (point 2), for example, was highlighted early on as an important element of the work, as was the aim of structuring the work around a set of user-defined focal questions (point 1). The need to include reference to social processes in the scenarios (point 4), so as to help understand different future transition pathways was also acknowledged in emphasising the links that had to be made to the discussions of the response group. Finally, disaggregation of outputs (points 3 and 6) was also flagged up as an early aim of the scenario work, as evidenced by the recognition that outputs would have to be differentiated across different types of users (especially to take account of the various ‘country interests’) and across space (to help identify how potential synergies and trade-offs express themselves and to understand where particular sensitivities lie in relation to different drivers of change). The value of making scenarios spatially explicit is not one that was highlighted as important by O’Neill et al. (2008) and others. Nevertheless, it is an important feature of the NEA exercise, because it can potentially assist our learning by making assumptions better testable (cf. Hulme and Dessai, 2008).

The issue of confronting and building on the different world views represented by the various interest groups associated with the NEA (point 7) was not one addressed explicitly in the earlier document, although some elements were captured in seeking to exploit both *forward* looking

scenarios that essentially seek to extrapolate from the present using different assumption sets, and *backcasting* methods. With backcasting, users are asked to identify some target future and think through the kinds of pathway that might achieve it and the barriers that might lie in the way. However, our initial work with users and expert contributors to the NEA has certainly revealed that there are very different world views, and the tension between those who see scenarios mainly from the 'product' and 'process' perspectives is certainly evident in the group. In developing our recommendations for how the scenario work might proceed we have been particularly sensitive to this issue, and will suggest that it can only be fully resolved once the interface with the planned 'NEA Response Group' is better understood.

We have recognised from the outset that it is important that the NEA leaves a legacy (Haines-Young et al., 2008), part of which must be the social leaning that is begun or achieved by the initiative. Many of the remaining points made in Table 1.1 concern these social and institutional issues – and while they are important – they are not ones that can be resolved by the work undertaken by the scenario group. Having described and taken stock of the progress to date, we will return to these broader issues in the concluding sections of this document and highlight some of the important issues that the NEA Expert Panel and client group might like to consider.

Part 2: Review of existing scenario studies and their value for the NEA

2.1 Introduction and Approach

In designing the work programme for the NEA scenario it was agreed that it should take account of the other relevant studies such as: FORESIGHT Land Use, UKCIP, the scenario work undertaken in the Marine Sector (e.g. FEUFAR, Pinnegar et al., 2006), and the recent initiatives by Natural England (Vision 2060) (Creedy et al., 2009, Natural England 2009a & b), the Environment Agency (Scenarios 2030) (Environment Agency, 2006). It was felt that considerable effort had already gone into these other studies, and the wider community were already familiar with many of the assumptions and outcomes. It was also felt from initial discussions that the UK NEA should attempt to build on what has gone before. Thus a 'SWOT' analysis was proposed, to examine whether earlier studies could be used to help answer the kinds of questions being asked in the NEA or whether their approach might be helpful in developing narratives or analytical approaches that were relevant for the NEA.

A detailed review of scenarios is provided in **Appendix 1**. In the main body of this Interim Report, we focus on the broad conclusions that can be drawn from this analysis and the implications of these findings for the NEA. In relation to the 'SWOT' analysis we have interpreted this as involving the identification of the particular strengths that these other studies showed in relation to the assessment of ecosystem services, or any lessons that might be gleaned from any weaknesses identified. In addition we have looked at the opportunities that exist for building on these other initiatives and any risks (threats) that might be associated with doing so in terms of the resources required.

2.2 Review of existing scenario studies: Approaches and Methods

From our initial discussions with people in the NEA network and a review of recent literature we identified 21 scenarios studies as relevant to the kinds of issue being considered in the NEA, or which were useful in helping to develop a methodology for the national assessment. The studies and the broad correspondence between them are shown in Table 2.1 and an over view of the analysis made of them is given in Table 2.2.

In Table 2.1, the scenarios are grouped according to whether they are mainly UK focused, or whether they have a global or European perspective. To make comparisons between their broad structures easier, the two widely known global studies, SRES (the IPCC's Special Report on Emissions Scenarios) and the MA (Millennium Ecosystem Assessment), are repeated across the two pages. To make comparisons between their broad structures easier, the two widely known global studies are repeated across the two pages. The approach used to construct the table is based on the one initially proposed by Pinnegar et al. (2006) who sought to map out the correspondence between the storylines used in the different studies. As these authors note a four storyline is a common feature of many of the studies, and the table seeks to cross reference the various narratives to each other. Where studies have used a different number this has been indicated by grouping or nesting the different narratives.

Table 2.1: Approximate story-line correspondence between Global, European and UK scenarios (after Pinnegar et al., 2006)

<i>SRES story-line</i> ²⁰	<i>MA</i> ²¹	Natural England ¹	EA Water Resources Strategy for England & Wales ²	Foresight Futures ³	Foresight Land use ⁴	UKCIP Socio-economic scenario ⁵	UKCIP Climate Change Scenario ⁶	PSI BESEECH ⁷	AFMEC Marine Scenario ⁸	Net Benefits ⁹
Global	Global	England	E&W	UK	UK	UK	UK	UK	UK	UK
B1	Techno-garden	Connect for Life	Sustainable behaviour	Global Commons	Leading the way	Global Commons	Low Emissions	Global Responsibility	Global Commons	Green World
B2	Adaptive-mosaic	Keep it Local	Local Resilience	Local stewardship	Valued service	Local Stewardship	Medium-Low Emissions	Local Stewardship	Local Stewardship	-
						Fortress Britain	Medium-High Emissions	National Enterprise	Fortress Britain	Fortress-Europe
A2	Order-from-Strength	Succeed through Science	Innovation	Provincial Enterprise						
A1	Global Orchestration	Go for Growth	Uncontrolled Demand	World Markets	Competition rules	World Markets	High Emissions	World Markets	World Markets	Market World

/cont...

Table 2.1 cont: Approximate story-line correspondence between Global, European and UK scenarios (after Pinnegar et al., 2006)

SRES story-line ²⁰	MA ²¹	WCS Futures of the Wild ¹⁰	Global Scenarios Group ¹¹	UNEP 3 rd GEO Four Scenarios for Europe ¹²	ELME European Lifestyles & Marine Ecosystems ¹³	EEA PRELUDE ¹⁴	ACCELERATES ¹⁵	ATEAM ¹⁶	EURuralis ¹⁷	ALARM ¹⁸	ESPON ¹⁹
Global	Global	Global	Global	Europe	Europe	Europe	Europe	Europe	Europe	Europe	Europe
B1	Techno-garden	Connecting the dots	(Great Transitions) New Sustainability	Sustainability First	Global Community	Big crisis - Europe of Cohesion	B1	B1	Global co-operation	SEDG	-
B2	Adaptive-mosaic	The New Zoogenesis	(Great Transitions) Eco-communalism	Policy First	Local Responsibility	Evolved Society, Europe of Harmony	B2	B2	Regional Communities	BAMBU	Cohesion oriented future
A2	Order-from-Strength	Bad to Better	(Barbarization) Fortress World (Barbarization) Breakdown	Security First	National Enterprise	Lettuce Surprise U, Europe of Innovation	A2	A2	Continental Markets	-	-
A1	Global Orchestration	While the World Warms	(Conventional Worlds) Market Forces	Markets First	World Markets	Great Escape - Europe of Contrasts	A1	A1	Global Economy	GRAS	Competitiveness oriented future

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Table 2.2: Key aspects of the scenarios reviewed

Scenario (see Appendix 1 for details)	Main focus	Timeline	Data	Uses five ¹ main indirect drivers?	Outlines habitat impacts	Ecosystem Services
SRES ²⁰	Climate change, economic development	2100	Ql, Qn	y	0	n
MA ²¹	Ecosystem Services		Ql, Qn	y	8	y
Foresight Futures ³	Environment	2020	Ql, Qn	2	8	y
Foresight Land Use ⁴	Land use, environment and society	2060	Ql	y	6	Y, some detailed discussion
UKCIP socio-economic ⁵	Climate change	2050	Ql, Qn	y	6	n
UKCIP Climate change ⁶	Climate change	2050	Ql, Qn	4	0	n
AFMEC Marine ⁸	Marine	2040	Ql, Qn	y	1	brief discussion
Net Benefits ⁹	Fisheries	2025	Ql, Qn	4	1	brief discussion
Natural England 2060 ¹	Environment	2060	Ql	4	7	brief discussion
EA Water Resources ²	Water	2050	Ql	y	0	brief discussion
UNEP 3 rd GEO ¹²	Environment	2040	Ql, Qn	y	6	n
WCS Futures of the Wild ¹⁰	Biodiversity	2030	Ql, Qn	4	6	n
ELME ¹³	Marine	2040	Ql, Qn	4	1	n
EEA Prelude ¹⁴	Environment	2035	Ql, Qn	y	4	n
PSI BESEECH ⁷	Urban, climate change	2050	Ql, Qn	4	1	n
Global Scenarios Group ¹¹	Environment	2050	Ql	y	4	n
ACCELERATES ¹⁵	Agriculture	2050	Ql, Qn	4	1	n
ATEAM ¹⁶	Climate change	2080	Qn	4	4	y
EURURALIS ¹⁷	Land use, environment	2030	Ql, Qn	y	5	y
ALARM ¹⁸	Biodiversity	2050	Ql, Qn	4	4	y
ESPON ¹⁹	Geopolitics & planning	2030	Ql, Qn	y	4	n

Table 2.2 shows that there is considerable diversity in the breadth of the different studies, with some quite wide in their scope (e.g., environment generally) while others are more focused around particular topics (e.g., agriculture or water use). The European and global scenarios also tend to be broader in their remit than the UK or national studies, although there are some exceptions, such as the nationally-focused work of Natural England (2060). There are also some differences in the time horizon considered, with global and European studies tending to look further into the future (2100), while those with a national or regional focus consider developments over the next fifty years or so. Despite these differences, however, there is considerable similarity in terms of the contrasting narratives that have been constructed. Thus while some interpretation was necessary in cross-referencing the story-lines of the different scenario studies in Table 2.1, the conclusion of Pinnegar et al. (2006) about a similarity of structure between studies seems to be borne out in this wider and later review of studies.

The four basic story-lines that run across the many of the scenario studies shown in Table 2.1 involve variations on: a sustainable or green vision (corresponding to the SRES B1 scenario, and the MA *Techno-garden* narrative); a future characterised in terms of local stewardship (that is variations of SRES B2, or the MA *Adaptive mosaic*); a free market future (corresponding to the SRES A1 scenario, and the MA *Global orchestration* storyline); and, a national security model (corresponding to the SRES A2 scenario, and the MA *Order from strength* narrative). Thus:

- **Green future scenarios** (top row, Table 2.1) are where environmental sustainability is key and the profligate consumption of finite resources is replaced by conservation management of resources and biodiversity. Adaptation to climate change is paramount (as is mitigation) and often the maintenance of ecosystem services is a prime societal goal. Social equity is the norm (within local and global communities) and strong relationships between countries across the world are forged or renewed.
- The **local stewardship** types of storyline (second row, Table 2.1) is one where big government is eschewed in favour of devolved power (but not all power) to regions and a greater emphasis on community 'togetherness'. Local food production blossoms but so do other aspects of society including regional planning control and an emphasis on partaking in community projects. Everything is slightly 'lo-tech' and economic growth is not strong. Whilst not as friendly to biodiversity as the green scenario, it is certainly a more sustainable than the next two potential scenarios.
- **National security** futures (third row, Table 2.1) are 'nation-first' types of scenario where individualistic and socially conservative attitudes reign and power is concentrated centrally. Biodiversity and ecosystem services receive little or no attention and decline as a result. Economic development is everything and should not be impeded at any cost; however, national industry is protected from foreign competition by trade barriers and tariffs. There is some export trade but it grows slowly as a result of the government's protectionist stance. Privatisation increases and planning controls weaken; short-termism rules.
- The **free market visions** (bottom row, Table 2.1) envisage a world of unfettered economic growth across global markets. No restrictions to trade between regions and countries exist and tariffs, quotas, and green regulations curbing industry have disappeared. Not surprisingly, the environment suffers considerably. Innovation is encouraged and many technological advances are made; however, much of society does not bother with adaptation to climate change and the poor (this is a very inequitable society) suffer accordingly. Agriculture is extremely industrial and efficient.

Although the kind of analysis presented in Tables 2.1 and 2.2 tends to represent the scenarios as products, ultimately to be used, it should be noted that many were also concerned with process issues surrounding scenario construction. Thus many of them were devised in a similar way drawing heavily on the involvement of multiple stakeholders (through interviews, workshops and

questionnaires), expert advice, peer-reviewed sources as well as the extrapolation of trend data using model-based approaches. Where differences do exist they are in the balance between qualitative to quantitative methods and output: the majority utilised both (and nearly always with a stronger emphasis on the qualitative aspect) but about one quarter used qualitative descriptions only (example). There are also differences according to whether the scenarios are explorative or normative. Explorative studies, which took a forward-looking perspective towards an 'uncertain future', were in the majority. Normative approaches, which involve backcasting from some agreed goal and using the scenario to describe how to achieve it, are less frequent. The ALARM SEDG scenario study was an example of this approach, which explored how the target of the European Sustainable Development Goal might be achieved, and what kinds of shock might prevent it.

The shocks, or more formally: 'low-probability high-impact events' (Alcamo et al., 2006b) in scenarios have been included in some studies to examine the consequences of extreme events, such as droughts, pest outbreaks, disease pandemics, or large-scale floods. Although it is argued that the inclusion of 'wildcard events' is useful for developing contingency plans to be implemented should an emergency or extreme event occur (as in the original use of scenarios by Shell, Bradfield et al. 2005), their use is not widespread amongst the studies reviewed. Only about a quarter mentioned a wildcard event and of these, only ALARM incorporated shock events explicitly in the story-lines. Although the AFMEC marine scenario did not incorporate shock events into the scenarios it did, however, assemble a comprehensive inventory of the major types of event to inform thinking (covering geological and astronomical, extreme climatic, biological/ecological, and human shock events).

2.3 Review of existing scenario studies: ecosystem services and the drivers of change

The main motivation for making this review was to determine what had been achieved by recent studies that could help us understand how ecosystem services might change in the UK for a range of plausible futures. Two aspects have been looked at most closely, namely: the extent to which ecosystem service trajectories are dealt with implicitly or explicitly by the studies; and, whether the studies could be used to help us develop plausible projections of the major drivers of change being considered by the NEA.

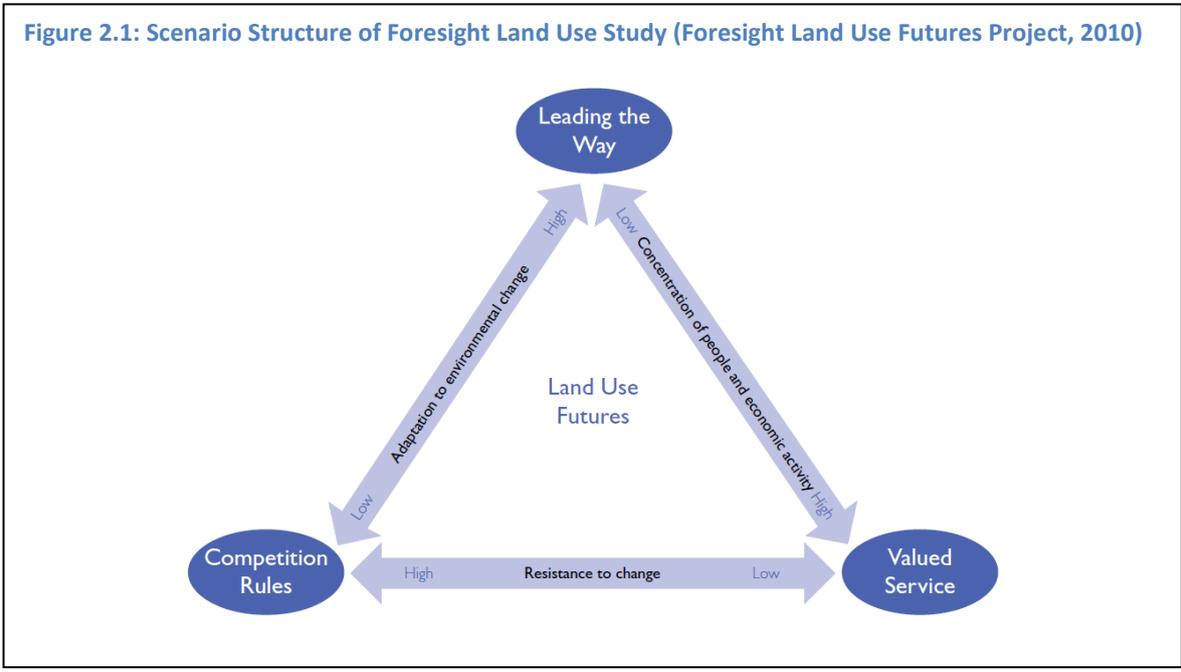
In relation to their coverage of ecosystem services, it is clear that along with biodiversity issues, the topic is covered in many of the studies even if, as in the majority of cases, this is not done so explicitly (Table 2.2). For example, crop yield models have been used to provide some quantification in agricultural land-use change scenarios by Ewert et al., (2005) and Rounsevell et al., (2005). Such work is obviously relevant in the context of understanding how provisioning services might change even though ecosystem services issues were not the main focus. Where ecosystem services are mentioned explicitly, these studies tend to use them to characterise the importance that different story lines attach to the management of natural capital, rather than in making a detailed analysis of how particular services might change. An example of this is provided by Natural England's 2060 study, which suggests that under all scenarios people become aware of the importance of ecosystem services as resource pressures change behaviour and people become more aware of the natural environment and benefits it provides, but to different degrees.

The most explicit analysis of changes in ecosystem services output using scenarios is, of course, provided by the Millennium Ecosystem Assessment (Alcamo et al., 2006a). This deserves special attention in this analysis because it provides the starting point of the NEA, and the approach it recommends for constructing scenarios has initially been used as a guide for this work. The particular strength of the MA study was the way it built the scenario exercise on an analysis of user needs, identified by asking a wider range of people and organisations questions about: the possible plausible future changes in ecosystems and in the supply of and demand for ecosystem services and how it might change well-being; costs, benefits, and risks of these futures and what sectors of

society and geographical regions might be affected; the unintended negative consequences associated the various futures; and, what response might options can lessen the vulnerability of people and communities. Finally, users were asked to consider what under what circumstances are thresholds, regime shifts, or irreversible changes likely to occur. Having developed the broad storylines with uses the MA went on to examine the impact of the various direct and indirect drivers of change for ecosystem services using a range of quantitative and quantitative modelling techniques. A particular feature of the outputs of the MA was a better understanding of who might be affected most by the changes identified.

Despite it many strengths, however, the main weakness of the MA is that the results are not sufficiently detailed to allow one to 'drill down' to the national level. Sub-global assessments were made at the time of the MA, and others have been developed since, but they have not applied the modelling framework directly to more local circumstances. There was, for example, no 'tool box' of the kind offered by EURUALIS (Westhoek et al., 2006, see also Tables 2.1 and 2.2) allowing users to customise modelled output to suit their particular interests.

At best therefore the MA provide a global context against which any UK analysis might be set and considerable methodological insights, but the direct application of the story lines would have to be looked at in the context of our particular national needs. Although the more recent Natural England study suggests that, in general terms, the contrasts between scales of action and commitment to the environment may be appropriate axes around which to construct scenario narrative, this study did not look at issues in Scotland, Wales or Northern Ireland, and so this conclusion may not apply across the board. By contrast, the Foresight Land Use study (Foresight Land Use Futures Project 2010) developed three scenario narratives, which did not map easily on to the structure used by the MA and other studies. The three Foresight Land Use scenarios were formed by pair wise combinations of the degree of adaptation to environmental change, the degree societal resistance to change, and concentration of people and economic activity within the UK (Figure 2.1).



Like the Natural England study, the sustainable management and restoration of ecosystem services was used to characterise some of the characteristics of the scenario narratives in the Foresight Land Use Project, but a detailed analysis on the implications for particular services and habitats was not made (Table 2.2). However, both studies do make a detailed analysis of the drivers of social, economic and environmental change, and so may nevertheless provide useful background for the NEA scenarios. Although the insights gained in the wider community of applying the Foresight Land Use scenarios have not been reported, the Land use Foresight Project's evidence review did produce a rich body of recent information that can help thinking through the impact of land use change on ecosystem services. Much of it is published in the peer reviewed literature, in a special issue of *Land Use Policy* (see Beddington, 2009) and covers such topics as urbanisation and the environment, carbon and soils, land use and water management, tourism and recreation.

Using the general structure and approach of the MA, Winn et al. (2010) have summarised the most important direct and indirect drivers of change that are relevant for the analysis ecosystem services in the UK. The five **indirect** drivers identified are: socio-political; economic; science and technological; cultural and religious; and, demographic. As Table 2.2 indicates most of the other scenario studies reviewed also use this breakdown. Of the five cultural and religious drivers are the least used but are still adopted by 70% of these studies. Treatment of the **direct** drivers of change suggested by Winn et al. (2010) across the scenario studies is, by contrast, more variable, and heavily influenced by the focus of the study. Amongst the set of studies reviewed the dominant direct drivers considered are climate change (in 100% of scenarios), resource consumption (95%) and land use change (80%). Surprisingly, biotic drivers like invasive species only appear in about 40% of the scenarios. Thus while ecosystem services may only be covered explicitly by a few of the studies reviewed, many provide relevant information on the kinds of future change that might be anticipated that might impact upon service delivery or and the general ecosystem types that might be impacted by them (Table 2.2).

2.4 Conclusions for the existing scenario studies

All the studies reviewed here fulfil Alcamo's (2001) criteria for the main elements of scenarios, namely: a description of stepwise changes; a list of the main driving forces; a base year; a time horizon and time steps; and, a storyline. In so doing their strengths clearly lie in the fact that they are useful sources of information for the development of a better conceptualisation and understanding of the drivers of change that are relevant for the NEA, and for identifying some common story-line styles. In the context of the NEA, their main limitation is that they do not really allow us to look at the kinds of change that might occur at the UK and thus fulfil the ambition set for the National Assessment.

Coreau et al. (2009) highlight a number of challenges for understanding how future ecosystems (and their services) may change. Firstly, there are difficulties in envisioning the future of ecosystems for ecologists because of the paucity of long-term data pertinent to important ecological functioning processes (Coreau et al., 2009). Secondly, it is often assumed that current ecological relationships and processes will stay the same over time although this is not necessarily true (Carpenter, 2002). For example, this may be particularly pertinent in the face of climate change which may affect species differently (e.g., through migration rates and even genetic or phenotypic responses); this could have serious implications for habitats based on long-standing community structures (Thuiller et al., 2008). Indeed, non-analogue biotic communities (Jackson and Williams, 2004; Williams and Jackson, 2007; Keith et al., 2009) may arise that could have significant consequences for ecosystem function and hence ecosystem services. Finally, future human drivers of change may be completely different from the current drivers and despite the explorative nature of most of the scenarios they are all based on known and current drivers of change.

Thinking through the implications of change for ecosystems and ecosystem services is therefore challenging, and it is clear that the contribution that the NEA could make in beginning this complex task could be considerable. The nationally focused studies like those associated with the two Foresight initiatives and that recently published by Natural England clearly provide a foundation. In order to take this work forward two immediate steps seem to be required, namely to:

- look at the general suitability of scenario themes developed in recent studies as a framework for the kinds of question that potential users of the NEA are asking; and,
- extract from the recent relevant studies the range of projections that they have made about the divers of change that are relevant in the context of the NEA.

These steps are described in the next two parts of this report.

Part 3: Review of focal questions for the NEA

3.1 Introduction and Approach

Building appropriate scenarios and storylines for ecosystem services assessments requires an understanding of how and why the scenarios will be used. To do this we have undertaken a review of the kinds of question potential users of the results of the NEA are asking about the changing output of ecosystem services across the UK. The review has been based on two key sources of evidence: (a) an analysis of the responses received by Defra during the scoping phase of the NEA; and, (b) an internet, questionnaire survey of the stakeholder and client groups already established as part of the overall NEA exercise. The on-line survey was supplemented by information gathered at a workshop held in London in February, 2010, which also included members of the science teams and user group. A detailed account of the review of user interests is provided in **Appendix 2**.

3.2 The role of focal questions in scenario studies

Since scenarios are fundamentally an aid to planning and decision making their design must start from an analysis of the issues and questions that interest potential users. While the overarching questions posed by the NEA brief are:

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

there is obviously considerable scope for both interpretation and refinement, and given the time span within which the NEA has to be completed, some prioritisation around particular issues is necessary. Thus our main aim has been to explore how the general concerns captured in the two overarching questions link to the specific topics that potential users have identified as being most relevant to their work. Following the terminology of the MEA and other scenario studies we have therefore asked stakeholders to pose what they consider are the most important 'focal questions'. The aim is to use these questions both to understand the kinds of issue that the scenario storylines ought to consider and the kinds of contrasts between alternative futures that it would be helpful to inspect. They also provide a template against which the usefulness of the outputs of other existing scenario studies might be judged and the gaps in our 'futures thinking' that might be addressed. It was also recognised that an open discussion of what questions potential users of the NEA thought were important would help identify some of the different world views that the various interest groups were bringing to the table.

3.3 Methods used to assess the needs of potential scenario users

The identification of focal questions that the NEA scenario exercise might address has brought together three different strands of evidence. First the material collected together by Defra following its letter to potential stakeholders for the NEA sent out in November 2008. These materials were analysed and a number of focal questions ‘derived’ from the responses. It should be noted that the identification of focal questions for the construction of scenarios was not the main purpose of the invitation that Defra sent out, rather it was to test the case for an National Ecosystem Assessment. The problem with using these materials was that since they predated the start of the NEA, they did not map easily on to the elements of the conceptual framework that was subsequently agreed such as the target ecosystems and services that form the core of the analysis. Nevertheless, the material did contain some responses that are relevant to any futures work, and so they were examined to derive an initial, draft set of questions that could form the basis for further discussion.

Table 3.1: Example questions derived from Defra consultation materials on scope of NEA, November 2008

<i>Cross cutting</i>	<i>Ecosystem or service specific</i>	<i>Policy focus</i>
<ul style="list-style-type: none"> • What is the role of biological diversity in the provision of ecosystem services, the resilience of ecosystems and in mitigating against anthropogenic impacts e.g. climate change? • How should we respond to respond to both the causes and effects of climate change? • How do we achieve multiple benefits from different areas of land and environmental assets? • What is the spatial coincidence of service needs and service delivery and where are the areas of service poverty? • What is the significance of development impacts on ES? 	<ul style="list-style-type: none"> • What is the role of geological diversity and earth system processes in the provision of ecosystem services? • How does geodiversity contribute to ecosystem services and what changes may occur (soil landscapes and geology)? • What climate regulation service is provided by coastal and marine habitats? • What potential exists to reduce flood risk away from the coast by changes to land management? • How does land management influence the carbon storage and sequestration service (is carbon in soils stable or decreasing)? • How are the services provided by upland freshwater systems being affected by acid rain and what are the effects of catchment afforestation? • How do we reinvigorate our landscapes and enhance sense of place? • How will climate change affect the features of high natural value in Natural Character Areas? 	<ul style="list-style-type: none"> • What are the different futures derived from slow simplification and increasing ubiquity of our landscape as a result of single policy approaches to land use and management (agricultural and forestry policy) versus ecosystem service delivery and multi-purpose land use which provides a way of bringing diversity back into the landscape? • How does Environmental Stewardship in England contribute to ES delivery? • What ES are provided by Lowland Grassland BAP habitats in the UK and Wales? • What are the contributions of the coastal and marine SSSI network and Marine Conservation Zones to the provision of key ecosystem services? • What is the impact of rising sea levels on the key ecosystem services provided by England's coastal natural environment e.g. flood and erosion risk management, carbon sequestration, fish nurseries, recreational opportunities? • What is suite of ecosystem services provided by both healthy upland moorland and lowland riparian ecosystems? What financial mechanisms could equitably and effectively pay for delivery of such services?

Example focal questions derived from the analysis of the Defra’s materials are listed in Table 3.1. These were tabled at a workshop with invited stakeholders held in February 2010, and the event used to test a simple template that might be used as the basis of a subsequent questionnaire survey. At the workshop a general discussion of futures issues was followed by breakout sessions designed

to allow people to propose new focal questions. The sessions used a simple template or grid that asked users to consider both cross-cutting issues that required an integrated analysis across the major types of services or across all ecosystems, or more particular question that related either to specific ecosystems and their outputs. The workshop sessions, which included 19 people from a range of organisations concerned with science and policy issues identified more than 50 questions.

Having established that the template was satisfactory, it was used to undertake an internet-based survey designed to elicit further user input on the topics that they felt the NEA scenario exercise should address. The survey materials were set up on the UNEP-WCMC website and participation was invited from members of the wider NEA user and client groups by e-mail. In total, 72 people were invited to respond to the on-line survey from the user group, client group, expert panel and the chapter leading authors. The website was open between 11th April and 31st May, 2010. Thirty one individuals responded that is about 43% of those invited; altogether they posed 152 questions. [Note: Further added comments on online questionnaire on website, as well as results from conference calls with topic related scenario experts will be incorporated into the analysis for the final report.]

Table 3.2: Results of internet-based questionnaire survey

	Provisioning	Regulating	Cultural
Cross-cutting issues across all services (Provisioning, Regulating and Cultural)	12		
Issues cross-cutting habitats	13	13	13
Mountains, moors, heaths	8	8	8
Semi-natural grasslands	12	12	12
Enclosed farmland	11	11	11
Woodland	7	7	7
Rivers, lakes, and lowland wetlands	7	7	7
Urban	6	6	6
Marine, coastal, estuarine	5	5	5

Table 3.3: Results of content analysis of internet-questionnaire

	Keywords	Number of references
Drivers / responses	Climate change, GHG, Ozone	31
	Policy (ies), CAP	8
	Management	9
	Market, pay, payment, cost, trade	6
	Technology	2
	Population (human), people	9
Services	Energy	11
	Food	14
	Water	13
	Carbon sequestration, storage, etc	9
	Biodiversity, species richness	6
	Recreation, leisure	5

3.4 Results of user needs study

Results from the questionnaire survey asking about general, cross cutting issues revealed that provisioning and regulating services were of more interest than cultural services. In terms of habitats or ecosystems, semi-natural grasslands and enclosed farmland were received more attention than the other habitats (Table 3.2); marine and coastal issues seem under-represented.

Table 3.4

Topic	Provisioning	Regulating	Cultural
<p>Cross-cutting issues across all services (Provisioning, Regulating and Cultural)</p>	<p>What will be the impact of increased renewable energy production on ecosystem services, eg impact of increased areas of bioenergy crops and increased deployment of marine environments for wind/wave/tidal power and algae farming?</p> <p>What are the possible roles of market-based instruments, such as habitat banking, in biodiversity protection and in the management of species adaptation to climate change?</p> <p>How will our view of the "countryside" from towns change in a changing climate? Landscape, Cultural</p> <p>How will different environmental drivers affect service delivery? General</p> <p>What are the synergies and trade-offs between different services? General</p> <p>What are the likely impacts on urban biodiversity that could occur as a result of climate change, and could the effects of multiple drivers for change result in cumulative impacts?</p> <p>What will be the impact of non native invasive species, including new pests and diseases? (There are the obvious problem species like Japanese knotweed but there are others that may be lying dormant or still in their population lag phase that may be able to benefit from climate change. Phytophthora is of particular concern and could have widespread impacts as it spreads geographically and taxonomically).</p> <p>How will the management of habitat composition within an area, to maximise service production, be achieved? i.e. balancing extent of habitat according to service provision</p> <p>Impact of changes in habitat extent - how will the proposed expansion of woodland/forest cover in the UK impact of the provision of key ecosystem services ?</p> <p>How do synergies and trade-offs between services vary according to scale/management unit?</p> <p>Climate change scenario - what would be the impact of a specific set of UK climate change predictions (many options to consider) by a specific year (2050?) on the continued delivery of provisioning and regulating services across a range of UK broad ecosystems? Sustainability</p> <p>Will people be more dependent on ecosystem services and will they be aware of this.</p> <p>What percentage of GBP will be made up by Ecosystem Services Economic</p> <p>Will the coastal defence ability of Coastal Margin habitats be an increasing or a decreasing component of coastal flood defence (for Urban, SNG, Farmland etc.) under predicted rates of sea-level rise?</p> <hr/> <p>What are the services we should be getting from elsewhere?</p> <p>Do we make policy that relies on and uses ecosystems or relies on technology and protects the 'best bits' of ecosystems?</p> <p>What happens if you implement all the sustainable management option chapters in the NEA?</p> <p>Will reversal of habitat fragmentation (e.g. through networks) affect services?</p> <p>What will be the consequences of focusing on enhancing only those ecosystem services that we can value economically?</p> <p>How will land use conflict impact on ecosystem services?</p>		

Topic	Provisioning	Regulating	Cultural
Issues cross-cutting habitats	<p>How can we change consumer behaviour to recognise the new 'reality' of agriculture in a changing climate and global food shortage situation?</p> <p>How best can we integrate the issues of climate change (adaptation and mitigation), energy security and price and global economic drivers to deliver a viable UK agriculture industry fit for the future?</p> <p>How will food production impact on other services?</p> <p>Will issues of food security and reducing carbon footprint of food prioritise food production above other services?</p> <p>Will impacts be limited to restricted geographical areas and other services prioritised elsewhere? or will a balance between services be attempted generically?</p> <p>Given the predicted challenges of climate change and an increasing population creating possible food shortages, the UK appears to be well positioned to play a key role in meeting, not just UK food needs, but also global food demands. What can be done to use land to meet these demands - to produce more but at the same time to have less of an impact on the environment?</p> <p>How do we manage the need for resilient habitats for climate change - should we have thresholds beyond which the objective of conservation of existing ecosystems change to an objective of redefining future ecosystem provision from an area?</p> <p>How do we trade off the impacts on ecosystems overseas against domestic impacts when</p>	<p>How can we integrate climate adaptation strategies, energy needs and waste management together with maintenance of quality habitats to ensure continuity of ecosystem regulation?</p> <p>How can we create multi-functional landscapes to promote regulating services alongside provisioning and cultural?</p> <p>Are regulating services considered to be as important as provisioning and cultural to a general audience? If not how can their importance best be communicated?</p> <p>Green Belt provides a wide range of regulating, provisioning and cultural services that contribute to the quality of life in urban areas. Can ecosystem assessment help to inform decisions on future Green Belt use and designations?</p> <p>How would relaxation of green belt regulation and increased urbanisation in these areas affect the ecosystem service provision (of all types) in farmland and grassland - what are the tradeoffs?</p> <p>How will biomass demands in semi-natural</p>	<p>How best can we encourage people to value natural ecosystems and landscape when their priorities are on short term crises?</p> <p>What is the role and significance of different habitats (and combination of habitats) in contributing to cultural services?</p> <p>Is there a conflict between public perception of culturally valuable habitats and landscapes and those habitats required for other services such as biodiversity and carbon storage?</p>

Topic	Provisioning	Regulating	Cultural
	<p>trying to secure national food, fibre (timber) and bioenergy supplies?</p> <p>Does food security prevent change of land use from agriculture?</p> <p>Does global trade in commodities (e.g. food and timber) remain the same, increase or decrease?</p> <p>How will we prioritise energy versus food security from land?</p> <p>What would 70% food security mean for UKs ecosystems?</p> <p>How will global food prices impact on ecosystem services?</p> <p>How should we be producing food without destroying ecosystems?</p> <p>What impact will new crops have on UK's ecosystems?</p> <p>What will be the impact of low carbon agriculture?</p> <p>What is the impact of another foot and mouth outbreak?</p> <p>What would a shift to naturalistic grazing/ re-wilding deliver?</p> <p>What impact will loss of single farm payments have on ecosystem services?</p> <p>How will new energy technology affect society (e.g. wind, solar, wave)?</p> <p>How will future UK energy policy impact on ecosystems?</p> <p>How would large scale release of CBRN materials impact on ecosystems?</p> <p>What will the impact of continuing atmospheric N pollution (including methane) be on ecosystem services?</p>	<p>habitats, including inshore waters, impact on biodiversity and other ecosystem services?</p> <p>What will be the consequences of recasting biodiversity targets in terms of ecosystem services? General</p> <p>How may new policies such as habitat banking enhance ecosystem services?</p> <p>What would a shift towards managing BAP habitats and SSSIs for complexity and heterogeneity deliver in terms of ecosystem services?</p> <p>Do future climates emerge in line with expectations (projections)?</p> <p>What habitat has most potential to sequester carbon?</p> <p>How will future scenarios impact on the integrity of the ozone layer / protection it brings?</p> <p>How do ecosystems modify atmospheric concentrations of air pollution in the future?</p> <p>What would 'fixing' diffuse pollution deliver for ecosystem services?</p> <p>ESWNI - How do different amounts of habitat per nation affect what is important? (e.g. Wales has little arable)</p>	<p>What is the impact of public attitude change to environmental issues?</p> <p>Does leisure time increase or decrease? Is it spent inside or outside?</p> <p>How do people react to a changing landscape? How does its value change?</p> <p>What are the ecosystem service implications of a continuing growth in leisure use of the countryside?</p> <p>How does one 'account' for cultural services in future scenarios (e.g. is forest increase at the expense of grassland good)?</p>

Topic	Provisioning	Regulating	Cultural
Mountains, moors, heaths	<p>How do we manage the need for resilient habitats for climate change - should we have thresholds beyond which the objective of conservation of existing ecosystems change to an objective of redefining future ecosystem provision from an area?</p> <p>WALES –How do CAP and Glastir agri-environmental scheme affect upland ecology and services?</p>	<p>Are carbon stock in soil in these habitats increasing, decreasing or remaining stable? Are there land-use trends that are likely to change the current situation with regard to soil carbon stock? What are the net GHG fluxes for these habitats and how can they be optimised?</p>	<p>WALES –For cultural services and recreation what are the renewable energy and ‘landscape’ Tradeoffs?</p>
Semi-natural grasslands	<p>Are semi-natural grasslands becoming more or less productive in terms of meat and milk production per unit of GHG emissions (CO2 equivalence)? What are the reasons for any increase or decrease in production efficiency where production per unit of GHG emissions is used as the measure of efficiency? trends</p> <p>How can other services e.g. wild species diversity, carbon storage be enhanced whilst maintaining appropriate levels of production? Does enhancement require loss of production? Trade-offs</p> <p>How can providing provisioning services help maintain/ improve quality/quantity of semi-natural grassland? Trade-offs</p>	<p>What trends in management practices for semi-natural grasslands are evident if any and what are the primary drivers for these trends? What are the implications of any trends observed for emissions of GHG from grassland and the efficiency of milk and meat production?</p> <p>How do changes in stocking levels impact on regulating services?</p> <p>What are the optimum grazing levels for sheep and cattle for maintaining habitats, yet minimising GHG emissions?</p> <p>How do you overcome the tacit view that ‘improved grassland’ improves all services?</p> <p>How will continuing loss of species from grasslands (and other habitats) affect other services? Driver</p>	
Enclosed farmland	<p>Is enclosed farm land more or less productive in terms of energy produced in edible output per unit of GHG emission? What are the primary causes of any trends in efficiency of production observed and how are these likely to change over the coming decades?</p> <p>Can long term sustainability be incorporated into</p>	<p>How is efficient natural nutrient cycling in the soil likely to be affected by temperature increase (1-2 degrees) from climate change?</p> <p>Are GHG emissions from enclosed farmland increasing or decreasing per unit of edible output (in joules) and what is the</p>	<p>What is the impact of increased tree planting on regulating and cultural services?</p>

Topic	Provisioning	Regulating	Cultural
	<p>valuation of yield? i.e. accounting for regulating and supporting services as well as short term provisioning.</p> <p>What are the implications of climate change, increasing water stress and a growing population on the productivity of farmland?</p> <p>How can we balance domestic food supply versus imports? Should we seek to limit domestic production to protect UK ecosystems and rely increasingly on imported food as population grows (and with it food demand) or should we maximise domestic production to protect overseas ecosystems?</p> <p>How will most food be grown after climate change?</p> <p>Does technological change continue to increase farming yields and therefore competition for land?</p> <p>How could CAP reform help delivery of services other than 'provisioning' from farmland?</p>	<p>basis for any trends observed. What will the consequences for GHG emissions be if significantly more land than is currently the case is used for food production as compared to increasing production efficiency?</p> <p>Some options within the agri-environment stewardship schemes are targeted at benefiting ecosystem services, for example in terms of soil quality, water quality, boosting pollinators and natural enemies. Under what (economic or otherwise) conditions is the policy of paying farmers for agri-environment schemes likely to change, or alternatively can it be predicted under what conditions farmers would stop taking the schemes up? And if they were no longer paid for or taken up, will this have a real and calculable effect on regulatory service provision?</p> <p>Payment for water yields and flood regulation in land management?</p>	
Woodland		<p>Taking account of carbon fixation and nitrous oxide emissions, is the overall contribution of UK woodland to GHG emissions in terms of CO2 equivalents positive, negative or neutral - and over what time scales? If positive, what is the annual amount of above and below ground carbon sequestered in UK woodland?</p> <p>In converting semi-natural grassland to woodland, what are the net GHG emissions, and to what extent will they</p>	<p>What kind of woodland do people prefer and value culturally? i.e. dense or well-spaced, coniferous or broadleaved, species-rich or species-poor?</p> <p>Seeing the trees for the wood? What is the impact of increased tree planting on regulating and cultural services?</p>

Topic	Provisioning	Regulating	Cultural
		<p>be affected by climate change?</p> <p>In converting semi-natural grassland to woodland, what are the net GHG emissions, and to what extent will they be affected by climate change?</p> <p>Does a market for carbon (or biofuels) develop to shape many land related decisions?</p> <p>How do forests and woodland affect water regulation in catchments?</p> <p>ENGLAND – Does forest cover expand as per policy aspirations?</p> <p>SCOTLAND – Does forest cover expand as per policy aspirations?</p>	
<p>Rivers, lakes, and lowland wetlands</p>	<p>What are the implications of climate change and a growing population on the availability of water for agriculture?</p> <p>Given the pressure for more food and more trees, how will future trends in farming practice and land management impact on water resources and flood control? Trade-offs</p> <p>WALES –How should English users pay for the ecosystem service of water production from Wales?</p> <p>Is water abstraction from lowland rivers and wetlands likely to increase and what will be the impact on other services? Trade-offs</p>	<p>When will water quality or quantity become a limiting factor on development in the South East of England?</p> <p>Will the water framework directive help the regulating services in wetland systems?</p>	<p>Helping the public value what lies below water level.</p>

Topic	Provisioning	Regulating	Cultural
Urban	<p>Urban provisioning services appeared to peak in the 1940s. What are the viable options for increasing urban productivity? Where are the synergies with other ecosystem services and the trade-offs? Could investment in crop production through increased efforts in domestic gardens, allotments, containers on hard surfaces, green roofs etc make a significant difference to all ecosystem service delivery?</p> <p>Ecological connectivity – green or grey infrastructure opportunities?</p>	<p>Are housing densities likely to continue to increase across cities, and what will be the impact on regulating services?</p> <p>Tree planting is cited as a viable option for reducing temperatures and improving air quality. How viable is this option given the cost of planting and maintaining trees. How much would the added benefits to soil regulation, biodiversity and cultural services offset management costs?</p> <p>The extent of impermeable surfaces in urban areas is increasing severely compromising regulating services. How viable are the options for increasing areas of exposed soil and the use of permeable materials in urban centres and what additional benefits</p> <p>How can impermeable surfaces be reduced to improve services and benefits?</p> <p>How will loss of green infrastructure due to increasing housing density in urban centres impact on regulating and cultural services?</p> <p>Arrest and reverse extent of impermeable surfaces – effects on hazard regulation and water quality</p>	<p>How will our view of the "countryside" from towns change in a changing climate?</p> <p>Given the increasing cultural multiplicity of our towns and cities, how relevant will be the traditional native ecologies of the UK in the future?</p> <p>If future growth is restricted to existing urban areas, is development on green spaces with low recreational value likely to increase, and what will be the impacts on other cultural services, and regulating services?</p> <p>Which would people living in urban areas value more; local environmental services e.g. habitats for recreation which may be of poor quality or services which they have to travel to but may be more numerous and varied?</p> <p>Valuing urban green spaces and trees?</p>
Marine, coastal, estuarine	<p>How will changes in terrestrial ecosystems impact on marine/coastal ecosystems delivery e.g. shell fisheries</p> <p>Marine renewables and impacts</p>	<p>What effect will the establishment of a marine conservation zone have?</p>	<p>How will sea-level rise alter the current coastal defence function provided by coastal margin habitats?</p>

While this pattern of responses mainly reflects the interests of the people who were willing to contribute to the survey, the sample was considered large enough to begin to gauge the types of question that users were asking of the NEA. A content analysis of the responses (Table 3.3) suggested that in terms of the drivers of change, the most frequently cited issue in the questions related to the implications of climate change on ecosystems and services (31 questions), followed by the impacts of demographic factors (9), management interventions (9) and policy (8). In terms of the services, the most frequently asked questions concerned issues related to food (14), water (13) and energy (11).

The questions posed through the internet-questionnaire were consolidated with those identified in the earlier workshop session and from the review of the Defra consultation materials for further analysis (Table 3.4). An inspection of this material suggests both a wide range of interests in terms of topics, and most importantly, quite different types of perspective in relation to the kinds of outputs that scenarios might be expected to deliver.

The questions listed in Table 3.4 have been reviewed and coded according to subject and theme, although further analysis and categorisation is required, it is clear that some general patterns are emerging. While users were prompted to pose questions in the context of constructing scenarios, it is apparent that while they were thinking about ‘the future’, some of the issues they posed are not easily or best answered via ‘scenarios’. Thus:

- A number of questions focused on trying to understand **mechanisms** or the way various drivers of change **impacted** on some outcome. Archetypal questions in this category included: “In converting semi-natural grassland to woodland, what are the net GHG emissions...?” or “How do forests and woodland affect water regulation in catchments?” or “How will sea-level rise alter the current coastal defence function provided by coastal margin habitats?”. While such questions are important, they are of a kind that is perhaps best explored in the individual service, habitat or driver assessment chapters. Plausible scenarios would have to be based on an understanding of the relationships implied by these types of question, but the emphasis in scenario studies has to be more on the **contexts** in which such, say, land conversions occur, or the implications of sea defences holding or not.
- Other questions focused on the nature of the **relationships** between various combinations of biophysical and social variables. Typical questions of this type were: “What are the synergies and trade-offs between different services?”, or “What kind of woodland do people prefer and value culturally?”, or “Is there a conflict between public perception of culturally valuable habitats and landscapes, and those habitats required for other services such as biodiversity and carbon storage?”. Again while such questions may be important in a decision making context, they are perhaps best addresses in detail through the evidence-based review elements of the NEA and the analysis of the past impacts of drivers. The issues of trade-offs and synergies are clearly ones that ought to be highlighted in any comparisons of alternative plausible futures which have to be based on some understanding of underlying relationships. However, understandings are perhaps best developed through the analysis of past or current evidence, rather than through a scenario exercise that would only track the implications of the insights and assumptions we currently hold.
- Some questions expressed an interest in making some kind of **prediction** about future conditions, rather than simply a desire to explore what is possible under a range of **projections**. For example, one respondent asked: “Will the water framework directive [WFD] help the regulating services in wetland systems?” and another, “Does leisure time increase or decrease? Is it spent inside or outside?”. Such things are of course unknown, and scenario

studies are not going to provide an answer. What scenario studies can do, however, is consider the circumstances under which such things as the WFD might be more or less successful, and suggest what the consequences of these alternative outcomes might be. Similarly, in relation to leisure patterns, scenario studies might help us to think through the implications of increasing or decreasing recreational opportunity.

Although the questions noted above can be read in a number of ways, their formulation does suggest that there are a number of different expectations and conceptualisations within the potential user community about what any 'futures exercise' might offer. In contrast to these 'problematic' questions, however, the survey did provide a number of other responses that could nevertheless be used to refine the broad aims of the current work. Thus a number of the questions proposed focused on the need to:

- Explore **strategies**, as in the desire to know: "What happens if you implement all the sustainable management option chapters in the NEA?", or "What will be the consequences of recasting biodiversity targets in terms of ecosystem services?", or "What effect will the establishment of a marine conservation zone have?". These kinds of question clearly imply some kind of comparison between scenario story lines of the kind identified in Part 2, in which a future in which ecosystem service management has a high priority is looked at in relation to a more business as usual situation or, say one in which biodiversity outcomes are emphasised.
- Examine the impacts of specific **policy options**, as in "What would a shift towards managing BAP habitats and SSSIs for complexity and heterogeneity deliver in terms of ecosystem services?", or "How could CAP reform help delivery of services other than 'provisioning' from farmland?". To address these kinds of question the suite of scenarios would have to allow the impact of 'policy on' and 'policy off' worlds to be thought through based on our assumptions about the different kinds of relationship between services outputs and factors that influence them.
- Identify consequences of changing **circumstances**, as in: "What would 70% food security mean for UK's ecosystems?", or "What are the implications of climate change, increasing water stress and a growing population on the productivity of farmland?". These questions are clearly of a kind that can be explored in scenario studies, providing that the framework adopted includes reference to the appropriate drivers of change which allows impacts to be compared in different situations.

One type of question that is particularly difficult to handle in the context of scenarios are those which involve some normative or judgemental aspect, as in: "What are the services we should be getting from elsewhere?" or "Should we maximise domestic production to protect overseas ecosystems?", or "How best can we encourage people to value natural ecosystems and landscape when their priorities are on short term crises?", or even "How should English users pay for the ecosystem service of water production from Wales?". To the extent that such questions can be recast as a comparison of alternative strategies, whose outcomes we might compare, they can be accommodated in a scenario exercise. However, it must be understood that scenarios are **not** designed to identify the best or optimal strategy but rather examine at how different strategies might look under different circumstances.

3.5 Conclusions for the user needs study

In Part 2 a comparison was drawn between a number of scenario studies, and it was apparent that there was a good deal of commonality in this work. Many studies focussed on a 2 x 2 comparison involving futures that emphasised the contrasts between reactive and proactive policy responses in alternatively, regionalised or globalised worlds. Although further work is required on the way our survey of focal questions map on to different types of narrative and whether four or more storylines are required to address their range, some preliminary conclusions can be drawn for the design of scenarios for the NEA.

A review of the questions collected together in Table 3.4 suggests that it was not easy to see how the 'global-regional' and 'proactive-reactive' axes in other scenario studies did not map on the range of user interests suggested by these materials. Clearly some questions did consider the impacts of changes in world markets, on potential policy responses in the UK, as in: "How will global food prices impact on ecosystem services?", but mostly these types of issue were only implicit in the views expressed. The focal questions were largely UK-centric, and if 'scale issues' were considered at all it was when respondents asked questions with reference to one of the four countries, or about cross-country relationships. Thus in the context of forestry respondents asked if forest cover would expand in line with policy aspirations in England and Scotland respectively. Another asked in relation to the four countries: "How do different amounts of habitat per nation affect what is important?".

The NEA work programme recognises that it is important to recognise the different conditions and concerns that may exist between England, Scotland, Wales and Northern Ireland, and the final report will include separate country chapters. In terms of the NEA scenarios, while generally the impacts of changing world conditions on the UK must be considered, it is evident that some attempt to explore the impacts of different futures across the four countries would be important. The present set of focal questions is not, however, sufficient to identify what kinds of issues need to be examined at the country level, and we suggest that further work to establish needs at individual country level is required. **We recommend that the disaggregation of scenarios to the country level is an important element of the future work programme, and that an analysis of issues at a UK and country level would be a valuable output from the study.**

Like the 'global-regional' contrast, the 'proactive-reactive' perspective is also not one that is apparent in the focal questions identified in the survey. While some of the questions noted above that relate to specific types of policy intervention could be interpreted in this way, as in helping us to understand the value of acting now or not, a more evident concern in the way many questions were framed was in terms of security and risks. Thus one respondent asked: "How will we prioritise energy verses food security from land?" while others posed questions such as "How will global food prices impact on ecosystem services?". Issues of security are increasingly topical, and in these questions clearly bound up with notions of self-sufficiency. **Given the interest in these issues evident in the responses it would seem important to include this kind of contrast in any overall scenario structure, with perhaps the proactive-reactive theme carried over in relation to exploring how present policies might be helpful in given different future needs.**

Some of the policy questions or issues suggested in the survey responses have already been noted above. Another theme evident in some of the questions was the desire to understand whether a shift to policies that emphasised ecosystems services was different, or had different outcomes, to one that focused explicitly on biodiversity. This kind of issue sits outside the 'proactive-reactive' debate and really concerns the consequences the shifts in policy emphasis, between ecosystem services and biodiversity on the one hand, and between these green options and a 'business as usual' strategy. Although such contrasts in policy emphasis are more subtle than the ones considered in other futures projects, given the results of the user survey we suggest it is a comparison that should be built in to the analytical framework for the NEA. **We suggest that**

contrasts between 'ecosystem service' and 'biodiversity' futures should be explored further as part of this work.

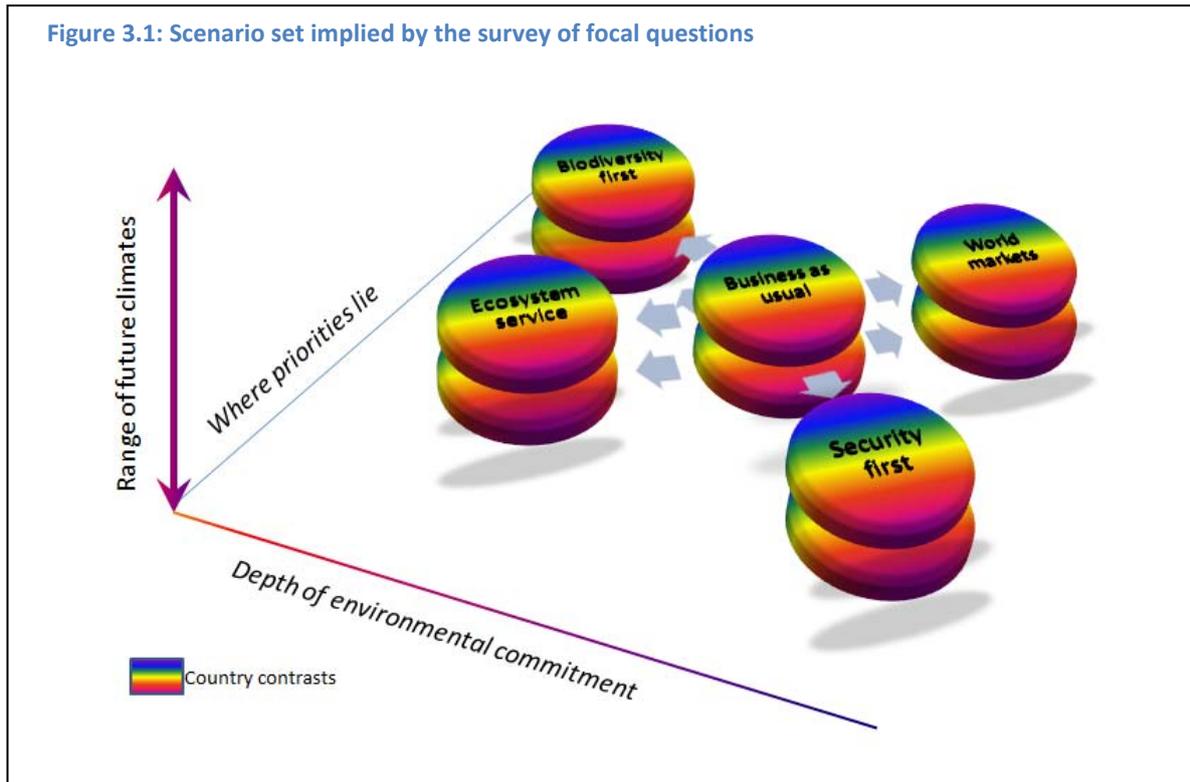
In terms of risk-related questions suggestion included: "What will be the impact of non-native invasive species, including new pests and diseases?" and "How would large scale release of CBRN materials impact on ecosystems?". Risks like these are often included in scenario studies as a 'wild card' that could be looked at in relation to all story lines to see if we are more vulnerable in some situations than others. The present materials are probably not adequate to identify the full range of questions that need to be considered in terms of risks and vulnerability of ecosystems. **However, we suggest that some use of scenarios to explore general questions of resilience would seem to be needed if the work were to address some of the significant user needs identified here.**

In relation to **climate change**, while some respondents were specifically interested in comparisons across different climate futures, as implied by: "What would be the impact of a specific set of UK climate change predictions... on the continued delivery of provisioning and regulating services across a range of UK broad ecosystems?", many questions accepted some level of climate change as a given. Thus more people were more concerned about climate change for other issues, or more frequently, how other drivers might impact on emissions or what implications different emissions reduction strategies might have in different social or economic contexts. Thus in terms of linkages between climate and other issues, one person asked: "How can we integrate climate adaptation strategies, energy needs and waste management together with maintenance of quality habitats to ensure continuity of ecosystem regulation?". Another enquired: "What are the implications of climate change and a growing population on the availability of water for agriculture?". In the context of understanding how future emissions might be impacted, a typical question was "Are semi-natural grasslands becoming more or less productive in terms of meat and milk production per unit of GHG emissions...?" and "What are the implications of any trends observed for emissions of GHG from grassland and the efficiency of milk and meat production?".

The conclusion to be drawn from the way these questions about climate change were framed is that in any set of scenarios, 'moderate' and 'extreme' climate change versions of the narratives constructed around other drivers would address a number of user concerns. Rather than focus on the impacts of climate per se, the scenarios could explore how different mitigation or adaptation strategies might play themselves out in different circumstances, or how different policies or trends on other areas might support or undermine them.

The conclusions and recommendations presented here are preliminary ones, intended to stimulate further discussion. However, even at this early stage, the results suggest if the NEA scenario exercise is to address the alternative perspectives and contrasting world views that the different interest groups bring to the table, then a more subtle and multi-dimensional approach is required compared to most other recent studies (Figure 3.1). In this figure, an investigation of potential contrasts within countries is set in the context of a broader set of comparisons of futures in which other kinds of concern or issue dominate. These are expressed in terms of the depth of commitment to environment (thus world markets or security first vs the two 'greener' futures), and where priorities lie (self sufficiency or engagement in a globalised world). As the diagram suggests, all potential narratives have to be looked at against a backdrop of the range of potential climate futures that might confront us.

Figure 3.1: Scenario set implied by the survey of focal questions



The structure suggested by Figure 3.1 is not, however, the last word. There are many interpretations of the themes and issues contained in the set of survey responses, and this representation is an attempt to crystallise the important elements as the basis for further discussion. There may also be important theme missing – such as a closer scrutiny of who might be affected by change and where. However, reflecting upon the discussion of methodological issues in Part 2 of this report, it does seem clear that, given the varied nature of focal questions suggested by users, a scenario exercise that draws upon a range of different quantitative and qualitative models is probably needed, as is the attempt to disaggregate narratives to the scales at which they work. It is also apparent from the questions that many potential users simply wanted to *learn* more about mechanisms or relationships rather than to think about particular alternative futures. The design of the outputs from the scenario exercise and the work programme that delivers it must therefore be sensitive to this need. Our finding seems to confirm that indeed, scenario building is as much about the process of construction as it is about the products (models, projections etc.) that it might deliver.

Part 4: Methodologies for constructing and implementing scenarios

4.1 Introduction

In this final part of the Interim Report we discuss the methods used to refine the construction of scenarios for the NEA. An outline of the analytical framework was described in an initial scoping paper for the work, which was agreed in early in 2010 (see Haines-Young and Potschin, 2010). We also reported on the progress that has been made. Two aspects are considered:

- First, the use of ‘morphological analysis’ to construct a suite of candidate scenarios based on the set of direct and indirect drivers of change being considered by the NEA; and,
- Second, the use of Bayesian Belief Networks (BBNs) to capture in a transparent way, the major assumptions made about the mechanisms linking these drivers and the output of ecosystem services.

While the work in both these areas is not yet complete, it is useful now to review what has been achieved in order to use the time that remains most effectively.

4.2 Identifying drivers and defining scenarios

As the review in Part 2 of this Report has shown, many studies use dichotomous axes to construct scenarios. Despite this unanimity it is by no means clear that this kind of structure is appropriate for the NEA. Our preliminary analysis of focal questions posed by potential users of the NEA (Part 3) suggests that the contrast and comparison that interest them may be more subtle and less diametrically opposed compared to the ‘traditional model’. To explore these issues further we have applied the morphological approach to scenario construction described by Pillkhan (2008). This technique has the advantage of keeping open decisions about the exact number and nature of the scenario story-lines, while bringing together all the relevant information about the potential impact of the different drives for more systematic analysis. The general approach was pioneered by Fritz Zwicky in the 1940s to investigate relationships between multiple non-quantifiable factors and has been used for scenario development by Godet (2000) and Ritchey (2006).

Morphological analysis works by constructing a matrix that links key factors or issues to alternative projected future states (Table 4.1). Thus columns set out the key or critical elements that need to be considered in the potential scenario exercise, and the rows the potential trends. In the example shown, the columns are the five direct drivers of change suggested as being relevant for the NEA and the rows the potential states suggested in the 21 different scenario studies that we have reviewed. To draw up the table some interpretation of the various scenario studies was necessary, not least in to make the trend statement have resonance for the UK. However there is, at this stage no assumption that the entire range of possible states for each driver is represented – additions can be made as users the scenarios construction process develops.

The merit of using the morphological approach is that different scenarios can quickly be constructed or represented by horizontally linking particular combinations cells in the matrix. Each combination forms a distinct, but equally plausible scenario. The linked sets of driver states represent our joint understandings of how drivers are associated or causally connected. Even though the matrix shown in Table 4.1 is relatively simple, with only five drivers and at most five potential states there are 1200 combinations are theoretically possible. The next step is therefore to select from within this set a small number that are distinct and useful to examine the main contrasts that concern potential users. A further advantage of the morphological approach is the way it potentially supports discussion and even co-learning amongst users.

Table 4.1: A morphological matrix based on the five indirect drivers of change suggested for the NEA

Demographic	Socio-political	Economic	Science and technological	Cultural and religious
Population grows steadily through ageing and immigration. The average family size is larger than today.	Strong, centralised national government. Devolved power has been taken away. Markets have very little regulation; there are few environmental policies. The welfare state is reduced considerably.	Moderate economic growth with global free trade. Growth continues seemingly without any downturn.	Rapid development of technology through greater government investment.	A strong sense of stewardship and responsibility towards nature. The intrinsic value of biodiversity is heavily supported. The Judeo-Christian old-world view is disappearing.
Population grows steadily through ageing and immigration.	Local government gains considerable powers from Westminster and almost creates a mini-United States of GB & NI. A higher % of tax raised locally is spent locally.	Strong initial economic growth but characterised by occasional global market crises and periods of stagnation.	The private sector undercuts technology advancement and it flourishes but benefits a smaller proportion of society.	A strong utilitarian view dominates but also a greater understanding that nature supplies finite goods and services.
Population grows but slowly; immigration is very tightly controlled and only rich & skilled workers may enter the UK. Small families are encouraged. There is an expanding elderly cohort.	A globally-minded government. Decision-making is strongly influenced by EU and other countries ideas. Global issues are dealt with in a global manner. Public services are a priority.	Fairly static but reasonably healthy - most needs are catered for although excess supplies of goods are hard to come by.	Science and technology advancement slows in some areas (e.g., biotech) but in others increases (social network enhancements; green tech.)	Society values landscapes and much of the beauty nature provides - particularly those which embody national identity. In 'uglier' areas though nature is given less respect.
	The government interferes with the free market to protect UK interests and institutes trade barriers and other protectionist measures.	Modest growth but sustained and steady without any major perturbations.	Strong tech industry guided by improving sustainable resource use.	Utilitarian without greater understanding of nature's benefit to mankind. A return to the traditional Christian stewardship values.
	Government continues to move between bouts of EU-friendly policies and stronger nationalist identity. A slow removal of public services.		Moderate development but greater focus on self-sufficiency in food and construction goods.	

Although the linkage and identification of the scenario strands can be driven by experts, both the construction of the matrix **and** the extraction of particular story lines must draw heavily on the views

of stakeholders. In relation to the present study we can, for example, use the framework to look at how selected storylines might be used to address the focal questions posed by users, but we also recognised that wider consultation is necessary. At this stage in the work the morphological matrix allows us to construct only the skeleton of a more detailed set of scenario that can begin to serve as a framework for discussions about impacts and potential response options.

There are several structural features of the morphological matrix that are useful in helping the processes of scenario identification and construction, namely:

- The projections assigned to each of the drivers in the rows of the matrix can be both qualitative and quantitative. In the example shown in Table 4.1, only qualitative projections have been included for simplicity. The information given in many of the cells could be expanded to include quantitative projections derived from the other scenario studies or other sources.
- The number of projected states for each of the columns represents the degree of uncertainty we have about the future for each particular factor. Thus the columns express something of the 'belief ranges' associated with each driver (cf. Rounsevell and Metzger, in press; Busch, 2006). If we are highly certain about the future then only one projection would be used. As our uncertainty increases additional rows are needed. Hence the uneven number of states associated with the five drivers in the table.
- Finally, in drawing up the morphological table it should be noted that there is no implication that there is a direct read-across between cells that are in the same row. While the matrix can be organised to suggest, say, increasing strength of change as one moves down the columns, such organisation is not necessary and has not been attempted here.

In relation to building scenarios for the NEA the morphological approach need not only be confined to the analysis of the indirect drivers of change shown in Table 4.1. In Table 4.2 we present a similar matrix for some of the direct drivers as identified by Winn et al. (2010). Clearly both could be joined, and more of the 'internal logic' or the mechanisms that trigger change within each scenario storyline exposed.

In our preliminary work we have attempted to map the five scenario themes identified from the analysis of the user focal questions on to the matrices shown in Table 4.1 and 4.2. We have chosen not to present them here because we intend to use these tables for consultation with potential users of the NEA. Our aim is to determine:

- whether for the indirect and direct drivers shown, the full 'belief range' is represented in the set of projections proposed;
- the particular combinations of driver projections that people think it is useful to examine given the kinds of question they want to ask about alternative, plausible futures; and,
- the level of agreement amongst the different people or groups about which combinations of driver projection might best capture the five scenario themes that emerged from our preliminary analysis of focal questions.

A particular issue that we would like to consider is whether the projections and combinations might differ across the four countries of the UK.

Table 4.2: A morphological matrix based on some of the main direct drivers of change identified as relevant for the NEA

(Adaptation & mitigation to) Climate change	Land-use change	Pollution and external inputs	Resource consumption	Invasive pest species	Energy
Adaptation and mitigation are given short shrift. Periodic floods and droughts affect those worse off.	Agric production declines and arable land is abandoned or converted to semi-natural grassland or woodland. Much of this helps to protect existing reserves or connect them.	Polluters of any kind are heavily fined but pro-active legislation ensures it is a rare occurrence.	Resource consumption is driven by efficient use and recycling where possible and continuity of supply is good. Education schemes instill the 'waste not, want not' theme.	A global bio-security agreement toughens border control and also implements invasive spp control system to eradicate major pests.	Dependence on fossil fuels and an ageing nuclear industry continues. Little investment is given towards renewable energy sources.
Adaptation is implemented (not mitigation) in priority areas (London, high-value coastland) and follows technological solutions rather than EbA. Critical national assets also protected.	Agric area declines slightly but productivity increases through better agronomy and sustainable land management. Some areas are devoted to flood protection and grade 3 land is afforested.	Legislation exists to control most polluters but its use is very regional and varies immensely. Some areas still have problems with air and river quality.	Most resources are widely available but are used efficiently and sustainably. However, occasional disruptions in supply cause chaos to some areas.		A massive government investment in nuclear power as well as innovative bioenergy and hydrogen schemes is undertaken. Society is slowly weened off fossil fuels.
Adaptation (and mitigation) is a priority and is implemented through government funded schemes across sectors. Use of ecosystems to help adapt is encouraged.	Agric area for food production declines (but productivity increases) and is replaced with a greater % of perennial biomass energy crops. Most woods are dedicated to timber or fuel prodn.	Most industries are encouraged to follow 'good practice' measures to reduce their impact. Take-up is mixed.	Control on home-grown resources are very tight and self-sufficiency becomes a dominant theme.	Bio-security measures across most borders are relaxed as they are deemed contrary to free-trade practice.	Large-scale renewable energy generation sits alongside what is left of North Sea gas and nuclear power (e.g., hydro-scheme in Severn estuary).
	Arable/veg area increases and replaces grassland in peri-urban areas and traditional livestock areas; food production.	Pollution is seen as unfortunate but necessary cost to ensuring economic growth stays healthy.	Many natural resources are becoming constrained and expensive. Some sections of society cannot afford many of the things we take for granted.		Fossil fuels are heavily taxed and billions are invested in small-scale local renewable energy sources. Energy efficiency is heavily promoted and enforced.
	Arable area increases in previously hilly grassland areas. Some sem-natural habitats in also lost to arable.				

4.3 Understanding mechanisms and making assumptions transparent

Many scenario studies are criticised because they are not fully transparent in terms of the assumptions made and their internal logics. Outputs are also difficult to evaluate because the uncertainties associated with the assumptions are also unclear. To overcome some of these difficulties, we proposed that Bayesian Belief Networks (BBNs) might be used to represent key elements of the scenarios.

BBNs have been used widely in a range of environmental management applications and have recently been used in constructing sustainability scenarios in the EU FP6-funded FORESCENE Project. Fundamentally they are tools that allow us to represent the logical relationships between variables in a graphical way, and express the strength of these relationships to be expressed using conditional probabilities. Most importantly they allow us to operationalise our assumptions in such a way that we can see what happens if we change or modify them. Such networks can be used to compare, for example, forecasting and backcasting perspectives.

In our earlier methodological paper (Haines-Young and Potschin, 2010) we proposed that the morphological approach would help identify potential scenario themes, and that BBNs could be used to help describe and understand the causal logic that links the direct and indirect drivers through to their impacts on ecosystem services. It was recognised that time and resources would prevent any overarching Bayesian model to be to represent the entire suite of scenarios and their assumptions, it was argued that service and habitat specific networks could be constructed a means of assembling the underpinning evidence base and exploring that it can tell us. In our preliminary work we have looked most closely at the work of the NEA economics team and what they might need from the scenarios to make an analysis of the marginal changes in value of the different goods and benefits some set of alternative futures.

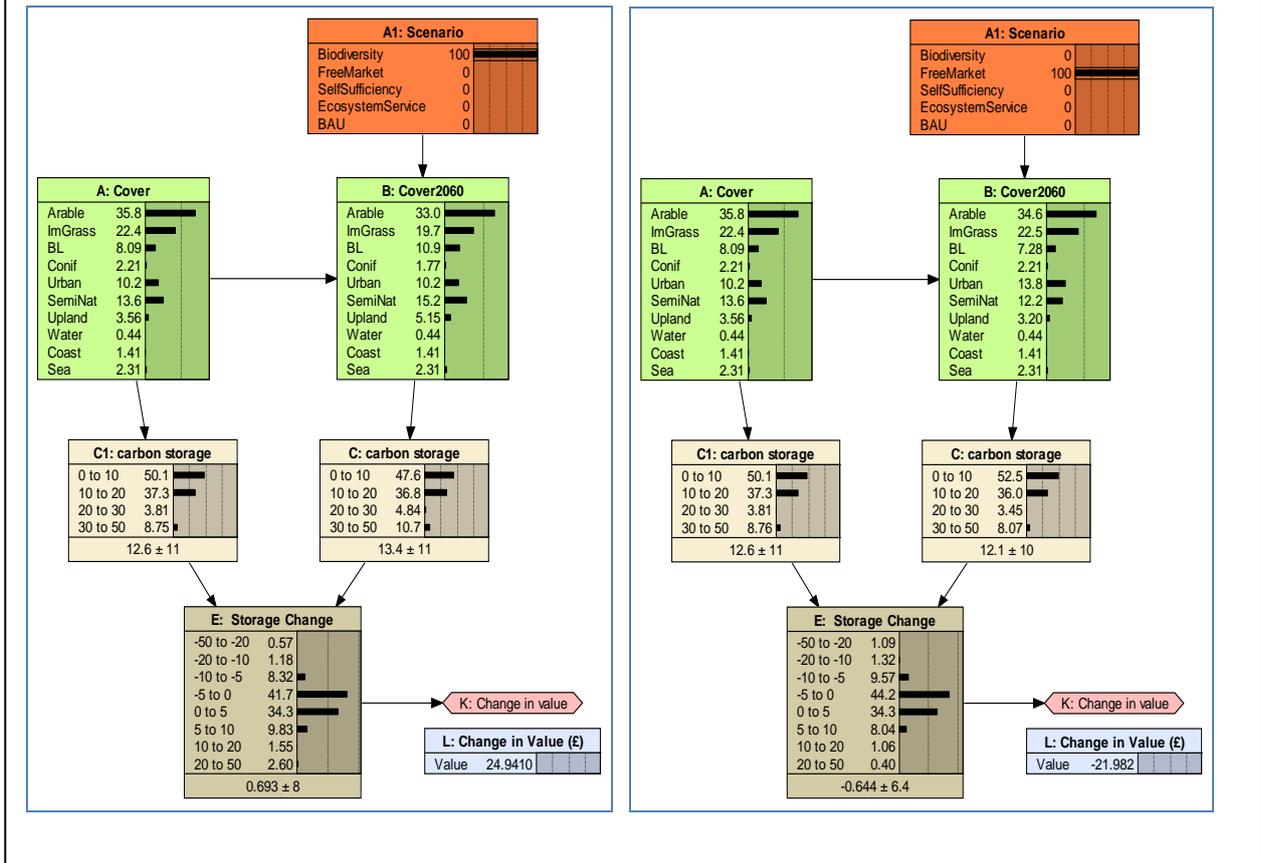
From our discussions with the economics team it was agreed that in order to achieve success, the scenario work needed to achieve three major objectives:

- the identification of a set of plausible futures with stakeholders, that addressed the questions they have about future service output and the response options that might be considered;
- the identification of a set of ‘output functions’ that help us understand how the drivers that define the scenarios impact on services, goods and benefits; and,
- the identification of a set of ‘marginal benefit functions’ that would enable estimates of changing marginal value to be made for the different scenario outcomes.

Since work on the first objective is on-going, it was agreed that a flexible approach had to be found for identifying what impacts these scenarios might have and what this might mean in terms of marginal value change. It was recognised that ideas about what kinds of future it would be interesting to explore would evolve, as users started to consider the early NEA outputs and potential responses. Thus some automation of the analysis of the consequences of changed assumptions was needed to facilitate this iterative process of stakeholder engagement; it was agreed this might be achieved through a ‘functional approach’.

The outline of the functional approach is illustrated in Figure 4.1. The figure illustrates how scenario storylines might be linked to their implications for change in a service via their impacts on land use and habitat change. The casual chain is represented using a BBN in which nodes A and B show the projected change in land cover between the present and 2060; the nodes represent the proportions of the different cover types and are based on the present day estimates for the UK derived from Land Cover map 2000.

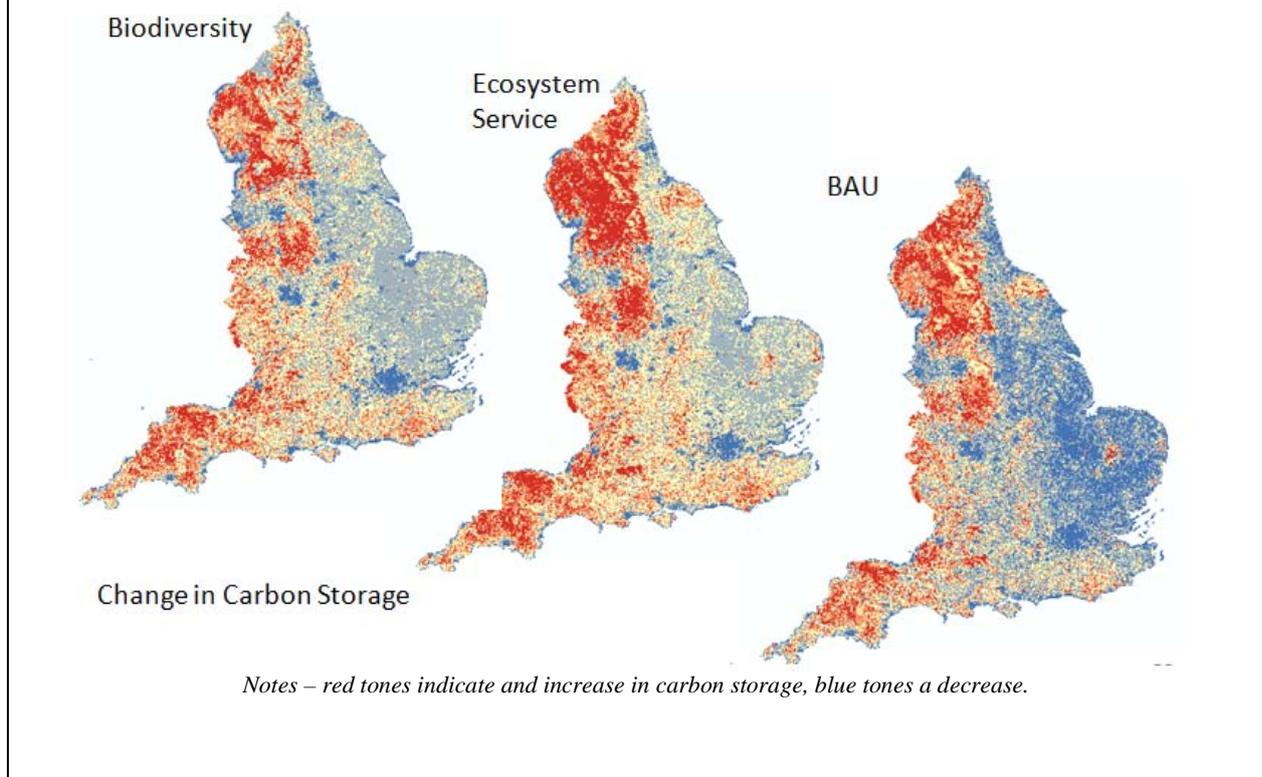
Figure 4.1: Scenario Storylines linked to their implications for change in a service: 'Biodiversity first' (left) and 'Free Market World' (right)



The transition probabilities that define this transformation are determined by which scenario is selected. The example in Figure 4.1 illustrates the difference that might be expected between a future that emphasises the importance of biodiversity (left) and one that reflects a free market world (right). Thus under free market conditions we might expect, say the expansion of woodland to be less than under the biodiversity scenario, and the loss of arable land to be reduced because of the expansion of industrial and energy crops. Urban also expands under the free market scenario. All of these expectations would be consequences of the beliefs and assumptions we (stakeholders, researchers) make about the supposed relationship between the scenario drivers and their impacts on land use.

The consequences of these changes for the service 'carbon storage' might then be estimated using the network, based on estimates of the carbon densities associated with each land cover type. In this model we have used the densities reported in Countryside Survey 2007. Thus nodes C1 and C give the estimates for the two time periods, and node E the likely marginal change. By assigning a monetary value to the change then the marginal change in value per unit area can be estimated.

Figure 4.2: Spatial patterns for change in carbon density under three scenarios using a BBN model of land cover change



The proportions of land cover shown for the nodes in Figure 4.1 are for the whole of the UK. While such networks can be used to give an aggregate picture there is no reason why they cannot also be used to generate more spatially explicit output. Mapping of service change might be useful both to better test the plausibility of the assumptions embedded in the scenarios and to help the process of valuation in situations where location is an important influence. Thus while carbon values are roughly the same everywhere, the value of a recreational trip is likely to vary according to proximity to urban areas.

Figure 4.2 shows some of the initial results of using BBNs to construct spatially explicit output. The figure shows the spatial pattern implied by the three alternative scenarios whose character is expressed solely by the supposed nature of the land cover transitions between the present and 2060. Using data from Land Cover Map 2000 at 1km x 1km resolution, the information for each grid cell was read into the model and the resulting transition predicted for each cell. The change in carbon density for each cell was then estimated and these values mapped, as shown in Figure 4.2. Only the data for England are shown – but potentially the mapping could be extended using and cove map for the whole of the UK.

Clearly there is a danger in using the BBN approach that the scenarios may seem ‘over-engineered’. It is not, however, the intention to represent the scenario outcomes solely in terms of these networks, rather to use them as part of a repertoire of story-telling devices. At this stage in the work their advantages mainly lie in helping to express the kinds of assumptions we think apply in imagining these various futures and more particularly how we can explore the insights about mechanisms and relationships being generated by the science teams through the scenarios work. At a pragmatic level these networks also allow some degree of automation in the valuation process. The network representation allows us to rapidly recalculate scenario outputs, if as a result of discussion, we change our views on the nature of the transitions in land cover implied by a particular scenario, or even propose completely new storylines for analysis.

Our initial work with BBNs has identified a number of issues that we are taking forwards in the next phase of work. The key steps that we have identified are:

- to refine the BBN approach so that the output of service could, where appropriate be modelled in terms of both changes in the quantity of each habitat and its quality (condition);
- to take up the discussion of the influences of changes in quantity and quality with the individual science teams as part of the work on constructing the set of 'service output functions';
- to circulate a questionnaire to the economics team to identify the factors that should be included in each of the 'marginal benefits functions'; and
- to review with UNEP-WCMC the data resources available and the opportunities it offers for building spatially explicit output at a minimum of 1km x 1km resolution. The acquisition of land Cover Map 2007 data would for example be advantageous in taking this work forward.

4.4 Conclusions for methodologies and next steps

To take the current work forward a priority is to work closely with the NEA science and economics teams to ensure that the scenario outputs can integrate with these two streams of analysis. In parallel we also need to engage more widely with the potential user community to refine the scenario storylines and the focal questions that can be used to explore the insights that can be gained from them.

In terms of the timetable, we propose the following immediate steps:

1. Preparing an interim report for circulation to the wider scenario group for discussion;
2. Presenting the revised interim report for review by the NEA Expert Panel at its meeting on 24th-25th June, 2010, including recommendations on the candidate set of scenarios to be used for the NEA;
3. Undertaking and finalising the scenario analysis for use by response groups in September 2010 (following NEA expert panel, 17 September 2010); and,
4. Revision of scenarios given outputs from the 'response group' and other feedback, and preparation of scenarios chapter for review by NEA expert panel, January 2011.

A provisional outline of the final 'scenario chapter' in the final NEA report has been presented to the client group (Appendix 4).

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Appendix 1: Detailed Review of the existing scenarios (to be added for final report)

Appendix 2: Detailed account of the review of users' interests (to be added for final report)

Appendix 3: List of services to be valued (to be added for final report)

Appendix 4: Proposed Structure of the NEA Scenario Chapter (see next page)

Appendix 5: Agenda and participants list of workshops referred to in this Report (to be added for final report)



UK National Ecosystem Assessment

Understanding nature's value to society

Appendix 4: Proposed Structure of the NEA Scenarios Chapter

Circulated for the NEA client conference call May 13th, 2010, and approved by Client Group
Assuming word length around 20,000 words:

1. Introduction: The role of scenarios within the NEA (500 words, but see 5a?)
2. Review of existing scenario studies and their value for the NEA (2000 words)
3. Review of focal questions posed addressed by the NEA scenarios and its links to the work of the response group (2000 words)
4. Methodologies used to construct the scenarios (5000 words):
 - a. Identifying drivers (results of the morphological analysis)
 - b. Linking drives to changes in service output (results of work with science teams)
 - c. Assessing changes in the output of goods and services (including via economic valuation and multi-criteria valuation alternatives?)
 - d. Making assumptions transparent – the role of Bayesian Belief networks
5. The NEA Scenarios and their consequences for the output of ecosystem services (10,000 words)
 - a. Overview of results (Move to section 1?)
 - b. For each scenario:
 - i. Assumptions
 - ii. Consequences on terms of outputs
 - iii. Changing values and patterns (including reference to multi-functionality and trade-offs)
6. Using the results from the scenario analysis (2000 words)
 - a. The science challenges
 - b. The policy challenges

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'NEA Scenario Team' (CEM/Nottingham), May 10th, 2010