UK National Ecosystem Assessment
Follow-on

Synthesis of the Key Findings

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UK National Ecosystem Assessment Follow-on

Synthesis of the Key Findings

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Part 1: Overview of the UK National Ecosystem Assessment Follow-on

1.1 The Key Messages

1. The 2011 UK National Ecosystem Assessment (UK NEA) concluded that the natural world and its ecosystems are important to our well-being and economic prosperity. Yet they are consistently undervalued in conventional economic analyses and decision-making. The UK National Ecosystem Assessment Follow-on (UK NEAFO) provides new information and tools to help decision-makers across all sectors understand the wider value of our ecosystems and the services they offer us.

2. The UK NEAFO confirms that the ecosystem services derived from natural capital contribute to the economic performance of the nation by supporting economic sectors, regional and national wealth creation and employment. But the relationship between our 'natural capital' and the wider economy is complex. By mapping the relationships between ecosystem services and major sectors of the economy, such as agriculture or food manufacture, we can begin to understand the economic impacts arising from any changes in our ecosystem services. The UK NEAFO has developed a Natural Capital Asset Check (NCAC) to help this process. It can be used to consider thresholds, trade-offs and the performance and resilience of our ecosystems. It can be used to gain further insights into the properties of different ecosystem services and contribute to our understanding of how best to manage the natural world for the long-term benefit of society.

3. Building on the UK NEA, the UK NEAFO quantitatively values a number of additional ecosystem services, relating them to changes in land use, as well as marine and coastal ecosystems. The assessment concludes that spatially targeted policies deliver more economically efficient outcomes. It also shows that before decisions are made it is important to fully appraise the widest possible range of policy options that take into consideration our natural capital stocks and flows. The UK NEAFO uses an updated land use change model to quantify the benefits of different forest planting strategies. The model includes changes in agricultural outputs and farm incomes, net greenhouse gas emissions, recreational visits, water quality and biodiversity. A suite of models were identified that can be used to address the different components of the marine shelf ecosystem, and a number of options for linking land use change models to coastal waters in order to assess the consequences for coastal ecosystem services. A range of methods were used to calculate a monetary expression of both marine ecosystem stocks and the marginal economic values for changes in the ecosystem service flows over time.

4. The UK NEAFO makes particular advances in valuing cultural ecosystem services that give rise to a range of material and non-material benefits to human well-being, but are frequently overlooked in decision-making. The UK NEAFO defines cultural ecosystem services as the individual or shared benefits to human well-being that arise from the interactions between environmental spaces (e.g. gardens, parks, beaches and landscapes) and cultural practices (e.g. gardening, walking, painting and watching wildlife). Culture is not a property of ecosystems per se, but something co-created over time through interaction between people, their values and the environment. A further dimension of cultural value is the 'value to society' which is passed on through art, literature and the media. The UK NEAFO finds that values derived from group-based valuation, done through a deliberative process (where group participants are allowed to exchange evidence and reflect on matters of mutual interest), tend to be different from the conventional aggregation of individual values. These findings add to our understanding of how values are formed and influenced in a range of complex and contested situations. Also, they illustrate that combining monetary and non-monetary, deliberative and interpretive methods can deliver a more comprehensive valuation of ecosystem services.

5. The UK NEAFO confirms that the six UK NEA scenarios are plausible and useful for different stakeholders. It uses them to explore which policy measures or other interventions are likely to be most effective and resilient in the long-term. The scenarios, which now extend into the marine environment, bring different stakeholders together to increase awareness of a series of plausible future worlds. They also provide a set of products that help stakeholders to identify location-specific trade-offs and co-benefits between scenarios. By analysing the ways in which we might react to the different scenarios (our 'response options'), the UK NEAFO confirms that the sustainable delivery of ecosystem services is best addressed through a mix of spatially targeted legislation, incentives, voluntary initiatives and increases in knowledge exchange between stakeholders. The appropriate suite of responses will depend on a range of context specific factors, including political issues.

6. The UK NEAFO concludes that embedding knowledge of our ecosystems and their services into project, programme and policy appraisals, rarely considered explicitly in Government impact appraisals before 2013, is critical for decision-making. This knowledge could provide many wider benefits for

society if taken into account at an early stage of policy development. Currently, this is rarely achieved, partly due to a failure to use the full set of principles of the Convention on Biological Diversity Ecosystem Approach. Barriers to, and opportunities for, embedding an ecosystem services framework into decision-making at the practitioner, institution, and socio-political levels are identified in the UK NEAFO. Measures which may enable such embedding to happen include better integrated datasets, more accessible language and demonstration projects, stronger leadership, improved communication across actors and sectors, and mechanisms to join-up interacting policies.

7. **The UK NEAFO has developed Adaptive Management Principles to guide inclusion of ecosystem services in policy- and decision-making. They illustrate how actions to support and manage our ecosystems can be tailored to, and subsequently amended in response to new knowledge.** This is supported by a coherent set of methodologies and functional tools within the UK NEAFO's ecosystem services framework. These can be used within policy- and decision-making cycles alongside a comprehensive implementation of the Ecosystem Approach.

This provides policy-makers and practitioners with advice on which methodologies and tools are best for a given situation, how they should be used, and in which combination.

Overall this includes:

i. An updated, overarching Ecosystem Services Conceptual Framework for the management of ecosystem services which reflects our deepened understanding of the roles of governance and institutions in the decision-making process, and the importance of built, human and social capital in transforming natural capital and the flow of ecosystem services into goods and benefits for people;

ii. Adaptive Management Principles, which offer flexible responses to inform policy- and decision-making as our knowledge grows;

iii. A Decision Support System (DSS) Toolbox which offers a set of tools by which decisions regarding ecosystems and their services may be supported. The toolbox is supported by an independently developed web-portal offering a way for decision-makers to navigate and access existing tools and methods (the National Ecosystem Approach Toolkit [NEAT Tree]); and a

iv. Balance Sheet Approach for interrogating and presenting evidence from appraisals that can be adapted according to the complexity and importance of the issue under consideration.
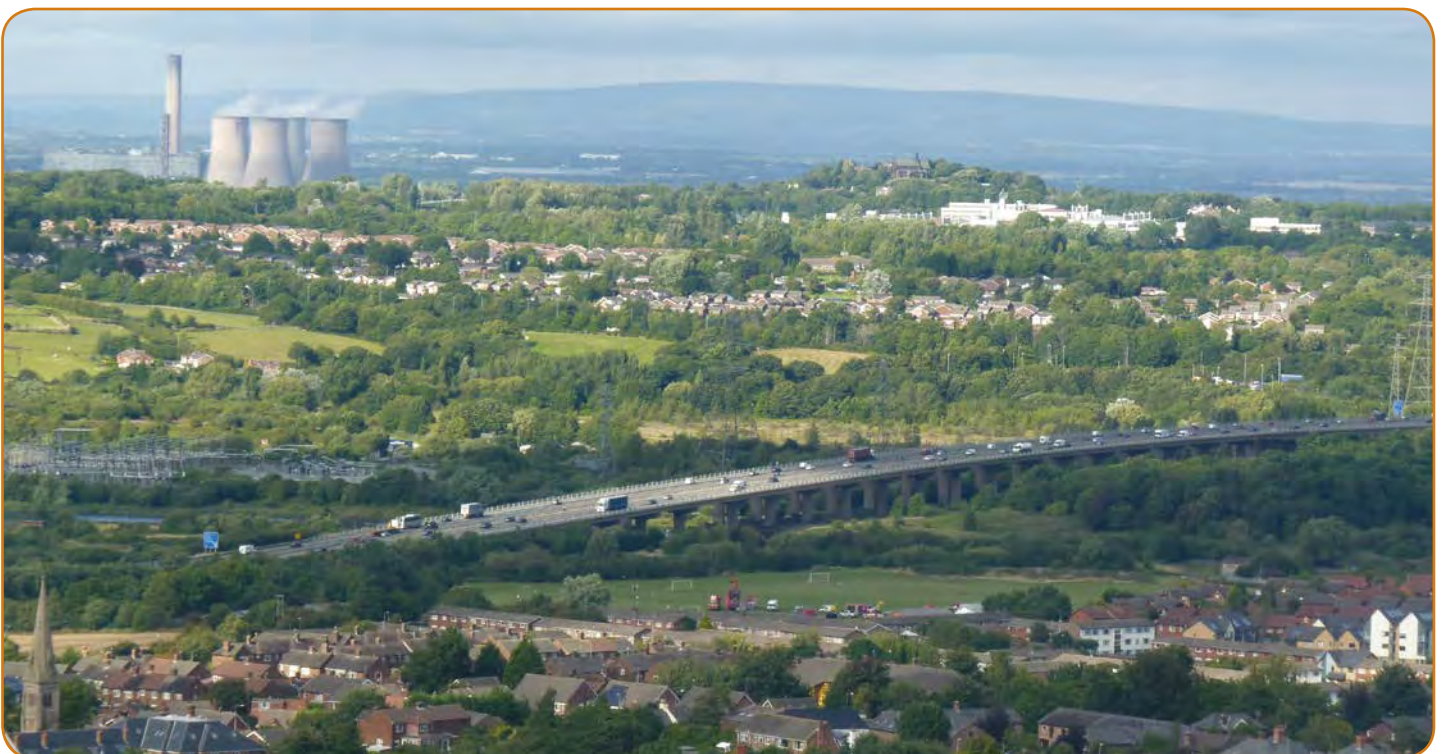
1.2 Introducing the UK NEAFO and why this matters to you

The UK National Ecosystem Assessment Follow-on (UK NEAFO) project built on the work and findings of the UK National Ecosystem Assessment (UK NEA 2011a, b) (**Box 1**).

The aim of the overall project was to deliver a world-leading, peer-reviewed, independently produced report with supporting materials which develop and communicate the work of the UK NEA and make the ecosystem service framework highly relevant to decision- and policy-making at a range of spatial scales across the UK. This is particularly relevant in the face of changing pressures and governance models. The UK NEAFO had three high-level aims:

■ Further our understanding of the economic and social value of nature.

■ Develop tools and products to operationalise the Ecosystem Approach.

■ Support the inclusion of natural capital in the UK's National Accounts.

In particular, the UK NEAFO was commissioned to address the UK Government White Paper on the Natural Environment – The Natural Choice: securing the value of nature (2011)[1]. The White Paper's aims for a follow-on to the UK NEA are to help put nature at the heart of our decision-making by: (i) investigating the actions most likely to secure the greatest benefits for people from our ecosystems and their services; and (ii) developing practical tools to help decision-makers to apply the lessons of the UK NEA. The UK

NEAFO also provides a growing evidence base for other initiatives started by the White Paper, such as the Natural Capital Committee.

A wide range of academics, policy-makers, delivery agents and other interested parties from the public, private and voluntary sectors have worked together in the UK NEAFO to further understanding in the following four areas:

■ *Economic Analysis:* Further development of the UK NEA's economic analysis to increase the range of ecosystem services valued, develop our understanding of the value of natural capital stocks and changes in flows, and an analysis of the macroeconomic implications of the findings of the UK NEA.

■ *Cultural Ecosystem Services:* Additional exploration of the monetary and non-monetary values of cultural ecosystem services. Examination of how the many values that exist at individual, community or societal levels can be better understood and considered alongside economic analyses in a range of decision-making contexts.

■ *Future Ecosystem Changes:* Further development of ways in which to analyse future ecosystem changes, apply and further develop the UK NEA scenarios for decision-making, and examine a range of societal responses to the possible changes ahead.

■ *Tools and Supporting Material:* The communication of key messages and information from the UK NEA and UK NEAFO. The development of a set of practical tools and supporting materials, in partnership with key groups from the public, private and voluntary sectors, to enable audiences and end users to make the best use of the evidence.

[1] http://www.official-documents.gov.uk/document/cm80/8082/8082.pdf

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Box 1. Key Messages of the UK NEA (UK NEA 2011a, b).

■ The natural world, its biodiversity and its constituent ecosystems are critically important to our well-being and economic prosperity, but are consistently undervalued in conventional economic analyses and decision-making.

■ Ecosystems and ecosystem services, and the ways people benefit from them, have changed markedly in the past 60 years, driven by changes in society.

■ The UK's ecosystems are currently delivering some services well, but others are still in long-term decline.

■ The UK population will continue to grow, and its demands and expectations continue to evolve. This is likely to increase pressures on ecosystem services in a future where climate change will have an accelerating impact both here and in the world at large.

■ Actions taken and decisions made now will have consequences far into the future for ecosystems, ecosystem services and human well-being. It is important that these consequences are understood, so that we can make the best possible choices, not just for society now, but also for future generations.

■ A move to sustainable development will require an appropriate mix of regulations, technology, financial investment and education, as well as changes in individual and societal behaviour and adoption of a more integrated, rather than the conventional sectoral, approach to ecosystem management.

The UK NEAFO initiative and its findings have been guided by a set of three principles: pluralism, pragmatism and precaution.

■ Pluralism was critical to the building of a support process and tools for decision-making that incorporates the ecosystem services framework because it requires collaboration across scientific disciplines. In addition, there is a need to recognise the prevailing and growing diversity in social and cultural values, ethics and norms in contemporary society. These changes make the value of nature a multidimensional concept that is context-dependent.

■ A pragmatic stance was taken in order to raise awareness of the ecosystem services concept within government (particularly finance ministries), non-governmental organisations (NGOs) and private business. The underlying aim is to manage ecosystems in a way that maintains or enhances their resilience and the valuable flow of services they provide rather than to maximise biodiversity conservation per se as a moral imperative. Therefore, the methodology used deliberately allows for the monetary and non-monetary valuation of ecosystem services.

■ Given that there is scientific uncertainty about how some ecosystems and their services may be adversely affected by human development, a precautionary approach to decision-making is needed. We cannot wait for more complete information as this may result in services being further degraded. Decisions should, therefore, take place within a risk-based framework using Adaptive Management Principles which emphasise flexibility and 'learning by doing'.

The UK NEAFO consists of a Synthesis Report and 10 work package reports. The Synthesis Report combines the key findings of the individual work package reports, drawing out conclusions that arise from analysis across the individual work areas. Cross reference to the individual UK NEAFO work package reports is designated by (WPR X.Y) which indicates the relevant Work Package (X) and section (Y) of the report.

The Synthesis Report has three parts:

■ **Part 1** (Overview) consists of a set of key messages, an introduction and expanded summary, and addresses a series of questions specific to the work packages. The expanded summary tackles the question: "What are the advances in our ability to make better decisions regarding the management of our ecosystems and their services?"

■ **Part 2** (Evidence) comprises the key findings from the individual work packages.

■ **Part 3** (Knowledge Exchange) is a series of reports that summarise the key findings from the UK NEA and UK NEAFO that are most relevant for specific audiences and end users. These audiences are: national government departments, government agencies, local authorities, the general public, businesses, environmental non-governmental organisations (NGOs), and the research community. The reports also summarise what each group can do to implement the ecosystem services framework and realise more sustainable benefits (**Table 1**) and has been written by or with individuals from each of the audience groups.

The UK NEAFO was funded by the Department for Environment, Food and Rural Affairs (Defra), the Arts and Humanities Research Council (AHRC), the Economic and Social Research Council (ESRC), the Natural Environment Research Council (NERC) and the Welsh Government. Wherever possible, the project has shared information with related initiatives, such as the Natural Capital Committee, the Biodiversity and Ecosystem Service Sustainability (BESS) programme, the Valuing Nature Network (VNN), Defra's Natural Value and Biodiversity Programmes, the Living Wales programme (now the Welsh Government's Natural Resource Management Programme), the Scottish Government's Environment and Rural Affairs Strategic Research programme, and the Mapping and Assessment of Ecosystems and their Services in Europe (MAES).

The work of the UK NEAFO was highly interdisciplinary and was conducted and peer-reviewed by more than 150 experts. The time these experts generously dedicated to the project is very much appreciated. The co-chairs and authors were supported by a management structure that consisted of: (i) a Funders Group which included representatives from the project's funders; (ii) an Expert Group which comprised leading experts from a range of disciplines who peer-reviewed and guided the outputs of the project; (iii) a Stakeholder Group which included representatives from the public, private and voluntary sectors who helped with developing tools, external communications, and provided evidence on the application and implications of the project's findings; and (iv) a Secretariat managed by the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC).

Table 1: How information from the UK NEAFO may be used by different audiences or end users.

Audience	The UK NEAFO provides information for the following stakeholder actions
National government departments	• Incorporating the benefits our ecosystems provide into policy development • Ensuring impact assessments include any implications for our ecosystems and their services • Considering the spatial consequences of policy decisions for our ecosystems and their services • Using deliberative and participatory techniques (where individuals and groups can share evidence and opinions) to take account of cultural ecosystem services in policy development
Government agencies	• Embedding and making use of the Ecosystem Approach • Collaborating across government agencies • Engaging with local communities and businesses • Promoting and developing Adaptive Management Principles
Local authorities	• Conducting impact assessments of planning decisions and policies on ecosystems and their services • Supporting staff training on the benefits, and application, of the Ecosystem Approach • Working strategically with relevant partners to manage natural assets and support business development
General public	• Engaging in local action for the environment • Participating in neighbourhood plans to manage the local environment
Businesses	• Examining the risks and opportunities arising from their dependence on ecosystems and their services • Considering the impact of business practices on ecosystems and their services • Using the UK NEAFO tools and methods for strategic planning
Environmental NGOs	• Implementing the Ecosystem Approach at a landscape scale • Communicating the value of nature • Developing and implementing natural capital asset checks • Designing and implementing Payment for Ecosystem Services (PES) schemes
Research community	• Promoting interdisciplinary processes and structures in funding agencies, research institutions and journals • Conducting natural and social science research to address key uncertainties and knowledge gaps

- **Section I:** The methodologies and tools that can be used by a range of stakeholders in their decision-making processes.

- **Section II:** Answers to four key questions:

    (i)   What have we learned from analysing the economic value of ecosystems and their services?

    (ii)   How have we increased our understanding of the cultural services and shared values provided by ecosystems?

    (iii)   How might the delivery of ecosystem services change in the future?

    (iv)   What processes and systems can be used to ensure ecosystem services are considered in decision-making?

- **Section III:** An illustrative example of how the work of the UK NEAFO can be implemented at the local level.

Section I: Methodologies and tools to aid decision-making processes

One important outcome of the UK NEAFO is the development of a coherent set of conceptual frameworks, methodologies and tools that can be used by a range of stakeholders (government, private sector, NGOs, etc.) to inform and improve decision-making. This is particularly important given that the UK NEAFO concludes that prior to 2013 government departments did not generally consider ecosystem services and their values in policy appraisal processes. The integrated approach the UK NEAFO has in mind begins with an overarching Ecosystem Services Conceptual Framework (Figure 2) in line with the Ecosystem Approach principles and then moves on to management by championing Adaptive Management Principles which stress the importance of flexibility in the face of prevailing environmental and socio-economic uncertainties. Our approach is completed by a practical Decision Support Toolbox (Figure 4).

The Convention on Biological Diversity Ecosystem Approach[2] can potentially provide added value to the design and appraisal of a project, programme or policy, as well as wider benefits to society. This approach is dependent on using supporting processes and tools to embed knowledge of our ecosystems into decision-making, and is particularly beneficial if taken into account at an early stage. The UK NEAFO found that the full potential of the Ecosystem Approach is rarely realised, partly due to a failure to fully use all of its 12 principles (**Box 2**). In fact, there is often selective use of a subset of the 12 principles at the expense of the other principles and the benefits they can provide. For example, the emphasis on maintaining ecosystem services (Principle #5), often comes at the expense of principles on decentralising to the lowest appropriate level (Principle #2), recognising thresholds and functional limits (Principle #6), taking a long-term view (Principle #7), and accepting that change will happen and recognising lag effects (Principle #9).

[2] https://www.cbd.int/ecosystem/

1.3   What are the advances in our ability to make better decisions regarding the management of our ecosystems and their services?

The 2011 UK NEA concluded that the natural world and its ecosystems are important to our well-being and economic prosperity, but are consistently undervalued in conventional economic analyses and decision-making. Government, academics and the voluntary sector all recognised that a better understanding of the value and benefits our ecosystems provide was required, and that decision-makers in all sectors needed methodologies and tools to help them account for these values. In response to these gaps, the UK NEAFO advances our understanding of how to quantify the economic, social and cultural values of ecosystem services, how ecosystem services may change in the future, and what tools can be used for informed decision- and policy-making. These advances are summarised in the following three sections:

Box 2. The 12 principles of the Convention on Biological Diversity Ecosystem Approach[3] and how they relate to the four overarching themes of the Approach: People; Management; Scale and Dynamics; and Function, Goods and Services.

PEOPLE

Objectives are a societal choice (#1)

Use all relevant available knowledge (#11)

Emphasise inclusion (#12)

MANAGEMENT

Decentralise to lowest appropriate level (#2)

Consider "downstream" effects (#3)

Understand economic context (#4)

SCALE AND DYNAMICS

Identify space and time scales (#7)

Recognise that ecosystems are dynamic (#8)

Accept that change will happen (#9)

FUNCTION, GOODS AND SERVICES

Maintain ecosystem services (#5)

Recognise functional limits (#6)

Balance demands for use and conservation (#10)

The UK NEAFO also concludes that there is no single way in which the Ecosystem Approach is mainstreamed within projects, programmes and policies. Instead, it recognises four different models of increasing integration **(Figure 1)**. A weak degree of mainstreaming can be achieved by retrofitting ecosystem thinking into existing projects, programmes and policies with a view to embedding ecosystem services into action plans and evaluations. While this results in some benefits, projects, programmes and policies are more likely to offer wider benefits for society if the Ecosystem Approach is fully integrated at an early stage (WPR 10).

The UK NEAFO assessed the institutional barriers and opportunities to embedding the Ecosystem Services Framework[4] into appraisals at the *micro* (individual), *meso* (institutional) and *macro* (socio-political) levels, recognising that there are significant interactions between different scales. It is apparent that, to aid the integration of the Ecosystem Services Framework into decisions across all three levels, we need 'enabling measures' such as better integrated datasets, more accessible language and demonstration projects,

stronger leadership, improved communication across actors and sectors, and mechanisms to join-up interacting policies (WPR 9).

The UK NEAFO helps decision-makers to make informed choices by presenting Adaptive Management Principles to guide inclusion of ecosystem services in policy- and decision-making (WPR 4). It illustrates how actions to support and manage our ecosystems can be tailored in response to new knowledge. The Principles are supported by a coherent set of functional methods and tools, which can be used within policy- and decision-making cycles alongside a more comprehensive implementation of the Ecosystem Approach. It provides policy-makers and practitioners with advice on which method or tool is best for a given situation, how and when each method or tool should be used, and which combination of methods and tools might be appropriate (WPR 10). The UK NEAFO integrated approach (see Figure 3) includes:

■ an updated, overarching Ecosystem Services Conceptual Framework;

■ Adaptive Management Principles, which offer flexible responses to inform policy- and decision-making as our knowledge grows; and

■ a Decision Support System (DSS) Toolbox; the toolbox is supported by the NEAT Tree - an independently produced web-portal to help decision-makers navigate and access existing tools and materials (WPR 10); and a Balance Sheet Approach for collating, analysing and presenting evidence from appraisals (WPR 4).
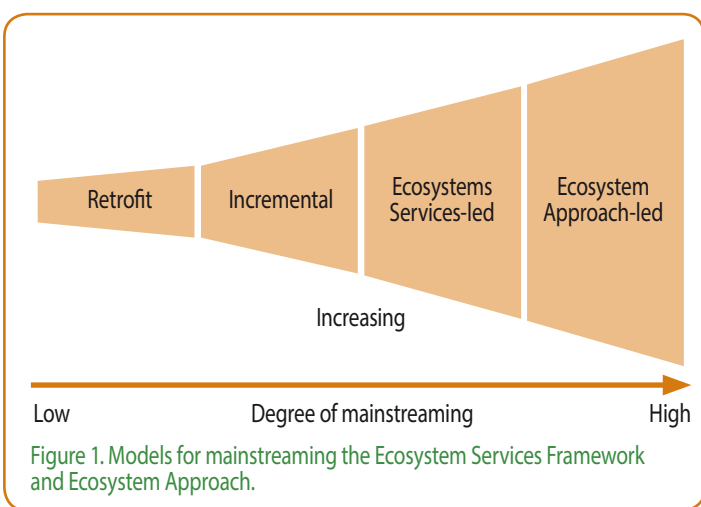
Figure 1. Models for mainstreaming the Ecosystem Services Framework and Ecosystem Approach.

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[3] https://www.cbd.int/ecosystem/

[4] HM Treasury (2003) The Green Book: Appraisal and evaluation in central government [online] http://www.hm-treasury.gov.uk/d/green_book_complete.pdf

The Ecosystem Services Conceptual Framework

An updated, overarching Ecosystem Services Conceptual Framework (**Figure 2**) for the management of ecosystem services has been developed to reflect our deepened understanding of the roles of governance and institutions in the decision-making process. It also demonstrates the importance of built, human and social capital in transforming ecosystem services into goods and benefits for people.

Adaptive Management Principles

The UK NEA and UK NEAFO both show that, despite the gaps in our knowledge about our ecosystems, more informed decisions can be made with beneficial outcomes. Adaptive management is about making policies and decisions that allow us to change our responses as our knowledge grows and we learn from our successes and failures. It is a key principle of the Ecosystem Approach. **Figure 3** illustrates the UK NEAFO integrated approach to using ecosystem services in policy- and decision-making. The

Ecosystem Approach can be implemented by using the Ecosystem Services Conceptual Framework, Adaptive Management Principles and the Decision Support System (DSS) Toolbox.

Adaptive management is a practical way of implementing the Ecosystem Approach where the specific connections between certain human activities and ecosystem services are still uncertain. The adaptive management process starts by defining both the location of the ecosystem in question, the time period over which change might occur and potential responses to that change. It is then essential to pull together as much information about this ecosystem and its services as possible. This includes looking at models of key processes that underpin and affect the relevant natural and social capital of the area. It may also be useful to explore alternative future scenarios. The knowledge base this work generates can then be used to set long-term objectives for managing the ecosystem and its services, preferably in partnership with key stakeholders. These objectives may be 'hard' (with firmly agreed indicators), or 'soft' (pursuing aspirational goals), but must be measurable. Once they are set, the next stage is to plan and implement

Figure 2. The UK NEAFO Ecosystem Services Conceptual Framework showing the roles of governance and institutions in the decision-making process, as well as the functions of built, human and social capital in transforming ecosystem services into goods and benefits for people.
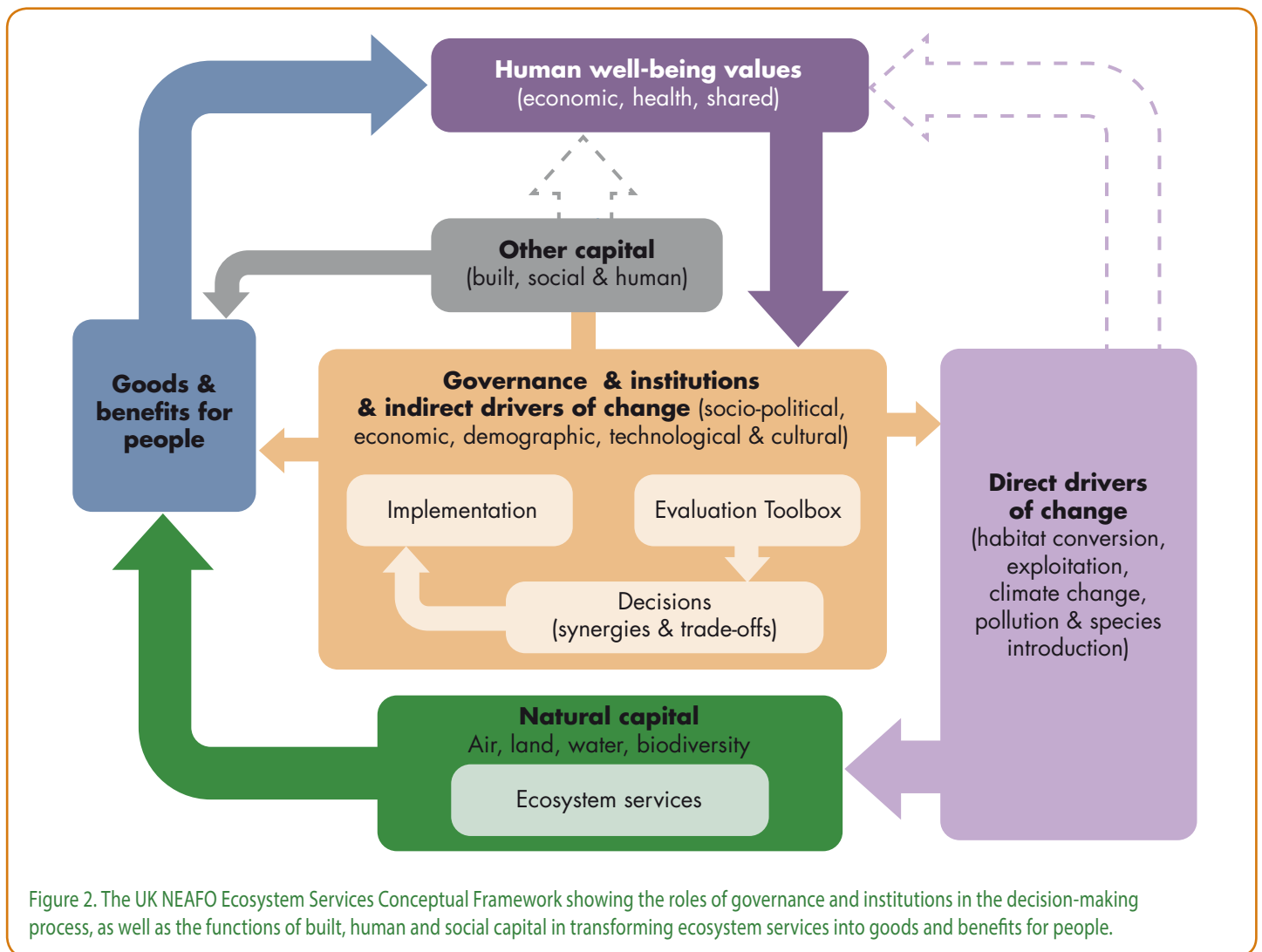
actions to meet these objectives. This can be done through a series of measures implemented across the entire ecosystem, or via a number of pilot-interventions that can be scaled up if successful. Either way, it is crucially important to monitor the outcome of any interventions and to share this information with stakeholders. As the body of knowledge grows in this way, it will be necessary to review the long-term objectives from time to time (without necessarily waiting for them to be achieved) and to develop new measures that are relevant to the updated information.

The main risks of adaptive management are: (i) setting objectives that do not prioritise the maintenance of natural capital and, therefore, result in goods and services being degraded – known as a 'slipping baseline'; (ii) not investing sufficiently in the monitoring needed to assess progress; (iii) failing to communicate both successful and unsuccessful interventions; and (iv) producing objectives that are vulnerable to manipulation if the process, goals and outcomes are not shared with stakeholders in a deliberative process.

Decision Support System (DSS) Toolbox

The DSS, represented as a process and a toolbox (**Figure 4**) comprises a set of assessment techniques that can be used in the decision-making process to:

■ establish baseline conditions and trends for ecosystems and their services;

■ identify key policy issues;

■ prepare for future changes, for example, through the use of scenarios;

■ create indicators of the state of ecosystems (stock) and changes in the supply of services (flow) over time;

■ enable a scientific, economic and socio-cultural valuation and appraisal of policy options using various tools, including models;

■ interrogate and present data and analysis using appropriate methods; and

■ establish good monitoring and review procedures.
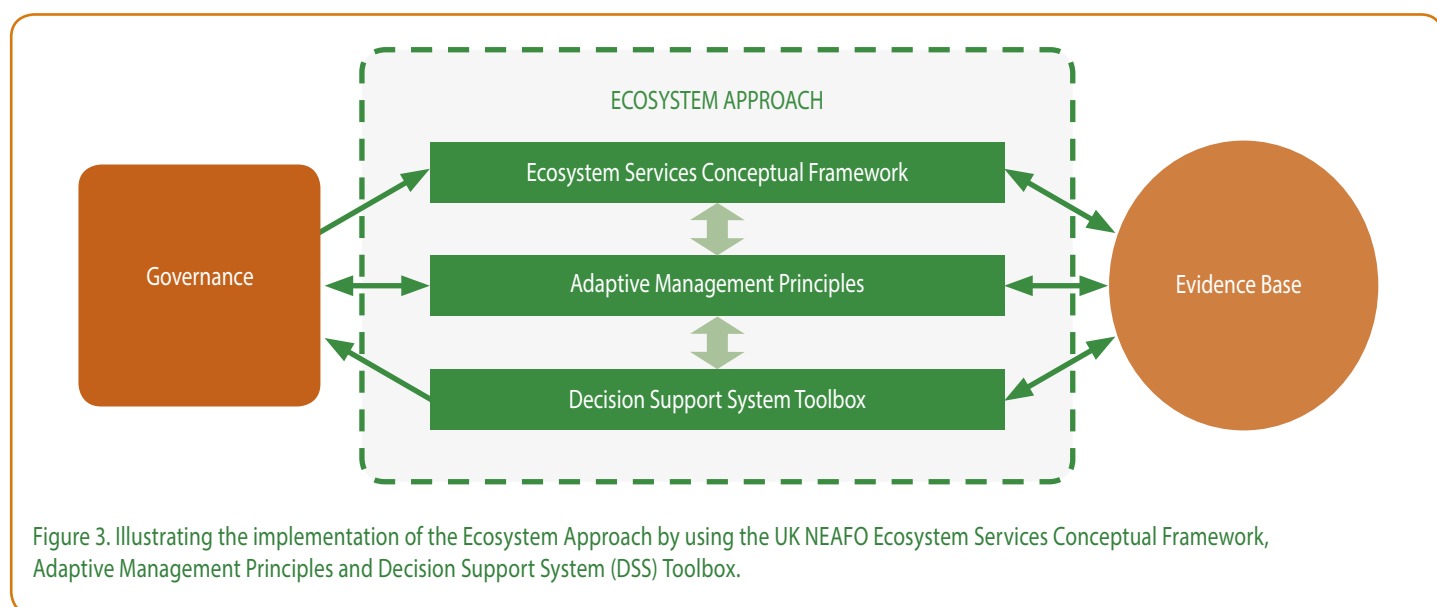
Figure 3. Illustrating the implementation of the Ecosystem Approach by using the UK NEAFO Ecosystem Services Conceptual Framework, Adaptive Management Principles and Decision Support System (DSS) Toolbox.

The toolbox puts into practice the Ecosystem Approach and consists of assessment techniques used or developed by the work packages (Part II). These techniques are:

■ *Scoping:* A Natural Capital Asset Check (Section 2.1) and a modified Drivers Pressures, State Changes, Welfare Impacts and Policy Responses audit (Section 2.4) can be used to gain insights into the state, properties and rates of change of different natural assets.

■ *Scenario building:* Scenarios (Section 2.7 and Section 2.4) can be used to explore plausible futures and assess which policy measures, or other societal responses, are likely to be effective and resilient in the long-term (Section 2.8).

■ *Modelling:* Land use models can be used to predict the impact of different future scenarios on ecosystems services at a detailed spatial scale (Section 3). A suite of models is also available to determine the impacts of various scenarios on the marine shelf ecosystem and coastal waters, and to assess the effects of land use change on coastal ecosystem services (Section 4).

■ *Indicator setting:* A set of indicators is required in order to adequately monitor changes in terrestrial and marine ecosystem services, including cultural services (Section 2.4, 2.5, 2.6 and WPR 5 A&H Annex).

■ *Valuing:* A wide range of valuation techniques can be used to assess market and non-market economic values for a range of ecosystem services (Section 2.3 and 2.4). Disaggregated macroeconomic input-output models appear to be the most useful in linking the wider economy with ecosystem services (Section 2.2). While deliberative and participatory methods can be used to consider a wider range of individual and shared values of ecosystem services (Section 2.5, 2.6 and WPR 5 A&H Annex).

■ *Formatting data, selecting approaches and methods, interrogating evidence and presenting findings:* The Balance Sheet Approach (Section 2.4) represents a different way to interrogate and present information to support decision-making (Figure 6, p. 16).

DECISION SUPPORT SYSTEM (DSS) TOOLBOX

ASSESSMENT METHODS

■ Cost-benefit analysis
■ Cost effectiveness analysis
■ Multi-criteria analysis
■ Strategic Environmental Assessment
■ Environmental Impact Assessment
■ Corporate Ecosystem Valuation

ASSESSMENT TECHNIQUES

Scoping:
■ Natural Capital Asset Check
■ Drivers, Pressures, State Changes, Welfare Impacts and Responses Framework (DPSWR)
■ Ecosystem mapping

Futures Scenarios
■ Developed UK NEA scenarios

Modelling:
■ Land use change model
■ Marine model
■ Macroeconomic model
■ Input-output model

Setting indicators:
■ Indicators related to the EU Marine Strategy Framework Directive
■ Measures related to cultural ecosystem services

Valuing:
■ Production function
■ Behaviour-based methods
■ Survey-based methods
■ Deliberative methods (focus groups, citizen juries, etc.)
■ Digital cultural mapping
■ Media analysis
■ Other interpretive methods (ethnography and participant observation)
■ Psychometrics

Data formatting and presenting findings:
■ Balance Sheet Approach

Figure 4. The DSS Toolbox comprises generic assessment methods and specific assessment techniques.

The National Ecosystem Approach Toolkit (NEAT Tree)

The UK NEAFO provides advice for a range of audiences on how to consider all 12 principles of the Ecosystem Approach within each stage of a typical decision-making cycle: Ideas-Survey-Assess-Plan-Deliver-Evaluate (**Figure 5**). The NEAT Tree links the implementation of the 12 principles within projects, programmes and policies with tools that support the decision-making process (WPR 10). As such, it has the potential to improve the quality of policy- and decision-making processes. In addition, the NEAT Tree identifies opportunities for decision-makers to develop their own indicators for addressing the 12 principles of the Ecosystem Approach at the beginning of any project, programme or policy. Central to the NEAT Tree is the need to improve stakeholder engagement by increasing clarity in our own definitions and procedures, and by recognising the terms and language that those stakeholders commonly use. The NEAT Tree identifies both generic and distinctive stakeholder-specific 'hooks' to engage those involved in business, community development, the built environment and the natural environment.

The Balance Sheet Approach

Building on the work of the UK NEA, the UK NEAFO has developed the Balance Sheet Approach as a means of collating, analysing and presenting data and evidence within the policy process (WPR 4). It is therefore both a process and a tool and forms one component of an overall decision support system. It offers a different way for analysts to build up, interrogate and present evidence (relating to a project, policy or programme) to stakeholders and decision-makers in a range of contexts (**Figure 6**). The approach is made up of three sequential and overlapping steps (which are presented as evidence sheets). Conventional national/strategic policy appraisal relies heavily on standard economic and environmental impact analysis represented by sheet 1, but our environment, economy and society are all changing at an increasingly rapid rate and in more complex ways. This may mean that a more comprehensive and spatially explicit appraisal process will be required, represented by sheets 2 and 3.

The information in the Balance Sheet Approach progressively encompasses more data and findings depending on the complexity of, and uncertainty around, the policy context under consideration. So sheet 1 will need to contain evidence drawn from conventional economic and environmental analysis but with added emphasis on equity and fairness. Information on who gains and who loses in any project/policy decision and what type of compensation, if any, could be paid to 'losers' needs to be highlighted and included. This focus then forms a key link to evidence presented in sheet 2.
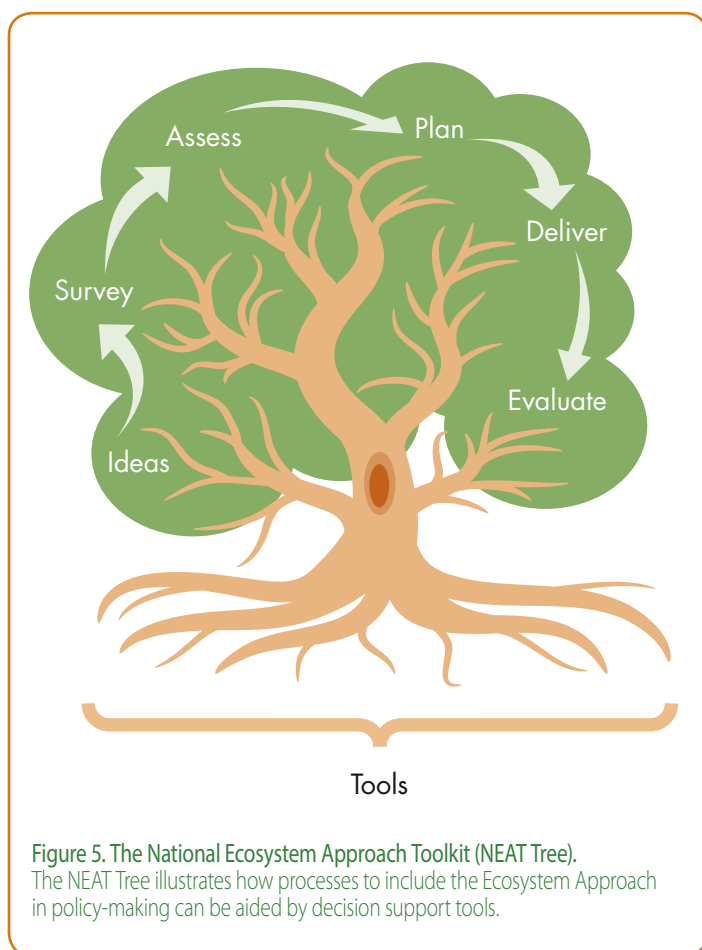
Figure 5. The National Ecosystem Approach Toolkit (NEAT Tree).
The NEAT Tree illustrates how processes to include the Ecosystem Approach in policy-making can be aided by decision support tools.

Sheet 2 should contain the results of collecting and drilling down into the information on the spatial and socio-economic characteristics of 'winners' and 'losers' down to regional and local scales and the implications for different policy contexts. A novel feature of this section of the evidence should be an up-front review of feasible compensation measures for the 'losers', rather than ad hoc responses to stakeholder reactions and political pressure after a decision has been announced. Using this sheet to interrogate regional and local project/policy impacts may reveal not just competing users for an ecosystem service(s) but 'contesting' groups with profoundly different moral/ethical positions, attitudes to risk and cultural heritages. This will make the formulation of any overarching policy or delivery plan more difficult.

Sheet 3's collected evidence should therefore specifically address these more 'contested' policy context issues. It will be drawn from the findings of multi-criteria analysis methods and group-based deliberative methods which encourage discussion and debate (arbitration) among relevant participants. This may or may not lead to a consensus about appropriate actions.

Figure 6. The Balance Sheet Approach showing the progression of information used (Strategic Analysis through to Negotiation and Trade-off Analysis) as the environmental context becomes more complex and dynamic.
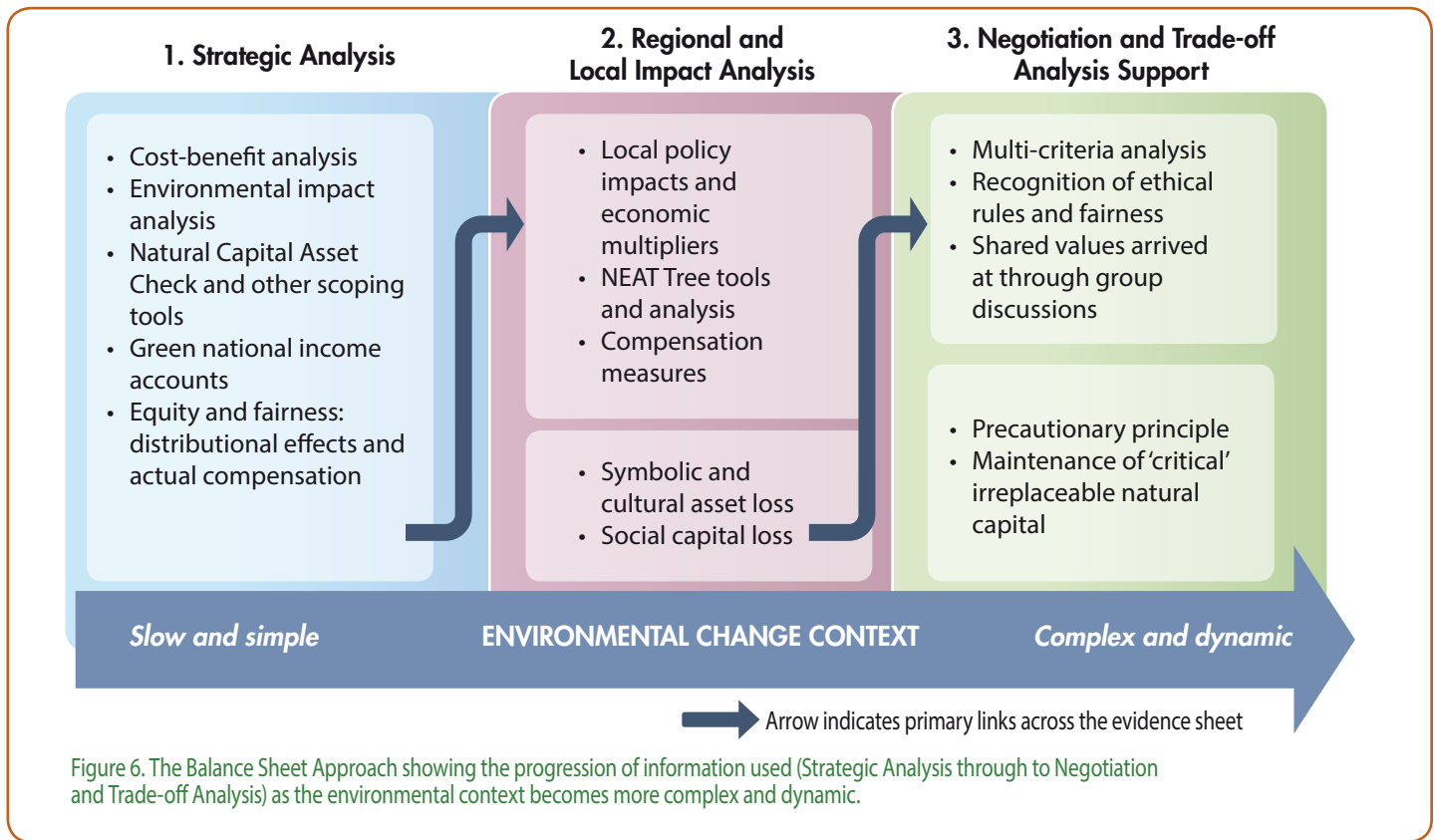
Section II: Advances in ecosystem service thinking within economic analysis, cultural and shared values, scenarios and decision-making processes.

(i) What have we learned from analysing the economic value of ecosystems and their services?

The goods and services that the natural world provides are integral to our nation's economy and contribute to society's well-being. This 'natural capital' has been formally defined by the UK NEAFO as "the configuration (in time, space, functionality and/or with other capital) of natural resources and ecological processes that contributes through its existence and/or in some combination to human welfare (WPR 1)." The UK NEAFO uses existing classifications of ecosystems to assess our natural capital. These assessments assist decision-making as they consider thresholds, trade-offs and the long-term performance and resilience of our ecosystems. This enables the sustainable management of natural capital for the long-term benefit of society. The UK NEAFO developed a Natural Capital Asset Check (NCAC) which assesses: how much of each 'asset' of our natural capital we have; the condition of those assets; what each asset produces (goods and services), and how our decisions affect the stocks, condition and flows of assets over time (WPR 1). The UK NEAFO concludes the use of an NCAC would be helpful when analysing the contribution of ecosystems to the economy. The

NCAC can also help to construct and interpret national environmental accounts. Just as we monitor our human, manufactured and social assets, there is also a need to monitor the state of the natural environment (WPR 1).

There are currently no comprehensive and quantitative assessments of the contribution of ecosystem services to the wider economy. There is also no well-established framework for evaluating the macroeconomic implications of ecosystem services (WPR 2). However, there are some partial assessments of the contribution of our ecosystem services to certain major sectors of the economy, such as agriculture and tourism. Although incomplete, the evidence suggests that ecosystem services do support economic sectors, regional and national wealth creation, and employment. To close this evidence gap, the UK NEAFO concludes that a mix of models is needed to link the macro-economy with ecosystems services and that disaggregated macroeconomic input-output models appear to be the most useful. It further identifies what work needs to be done in order to link ecosystems and their services to specific sectors, employment and the economy as a whole (WPR 2).

The UK NEAFO presents an updated and more sophisticated version of the integrated UK NEA land use change model (WPR 3). It has quantitatively valued an expanded number of ecosystem services, the results of which may be used when making decisions in relation to land use change. The land use change model now includes: new monetary value estimates for recreation and woodlands; and quantitative data for water quality and biodiversity. This is in addition to those services

previously valued in the UK NEA, such as agricultural outputs and farm incomes, and net greenhouse gas emissions. As a result, the UK NEAFO land use change model further demonstrates that natural capital-related goods and services that are not bought and sold in the market should be taken into account in decision-making. In addition, for decision-making to be robust, it should assess a comprehensive set of drivers of change, the major impacts of change and, where possible, fully appraise the widest range of options before policy responses are decided upon. The land use change model assesses the consequences of applying policies at any location and time across the UK and can identify where the application of the policy yields the highest net benefits (either in market price terms or a wider notion of value to society) from an ensemble of ecosystem services. It demonstrates that targeted spatial policies deliver a more efficient allocation of resources. For example, the model examines the planting of new forests in the UK in different areas. It concludes that using market values alone to determine the location of planting will yield poor value for money (a net loss of £65 million per year; see Figure 12). The highest net benefits (net gain of £546 million per year) are achieved when planting occurs away from vulnerable organic soils and closer to areas near major cities which yield higher recreational values. Realising such a gain for society, however, requires a substantial increase in implementation costs from £79 million per year to £231 million per year (WPR 3).

The UK NEAFO Adaptive Management Principles, supported by the Decision Support System (DSS) Toolbox, were applied to the UK marine environment (WPR 4). It involved using accounting price methods to calculate a monetary expression of ecosystem stock value, and an economic valuation of the marginal values of changes in ecosystem service flows over time. Following an in depth review, it is clear that several important UK marine habitats, and their related goods and services, have few or no valuation estimates, and that more studies are needed (WPR 4).

(ii) How have we increased our understanding of the cultural services and shared values provided by ecosystems?

In conventional economics, 'value' is usually interpreted in terms of the wants and motivations of individuals, but it can also be expressed in a collective way. Cultural goods and services often engender a shared sense of what is judged as worthwhile by a group, community or society. Therefore, to complement the UK NEAFO's economic models, a refined conceptual framework has been developed that defines cultural ecosystem services as the individual and shared cultural well-being benefits that arise from the interactions between environmental spaces and cultural practices (WPR 5). Cultural services are not a property of ecosystems per se, but something co-produced and co-created over time through interaction between people, their cultural values and the environment. For instance, people might assign such values to particular landscapes with historical significance, or to buildings with symbolic connections. The UK NEAFO reinforces the case for using mapping techniques, written text, storytelling and other methods as part of a participatory approach to assessing cultural ecosystem services at different spatial scales (WPR 5 A&H Annex). The Monitor of Engagement with the Natural Environment (MENE) survey quantitatively assessed visits to different environmental spaces in terms of cost and rationale. It also has the potential to monitor changes in cultural ecosystem services at a range of spatial scales. For example, the data it collected suggests that the time spent in natural spaces has a significant effect on well-being, with 'blue spaces' (such as beaches) being particularly beneficial (WPR 5). The UK NEAFO identifies a range of tools and assessment methods across the natural and social sciences that can help decision-makers to develop an understanding of location-specific cultural ecosystem services (WPR 5). This will help to embed cultural concerns into decision-making.

The UK NEAFO concludes that, in both monetary and non-monetary terms, shared values held across groups, communities and society (obtained through group-based valuations and deliberative processes, where participants are allowed to exchange evidence and reflect on matters of mutual interest) tend to be different from the conventional aggregation of individual values (WPR 6). These group-based valuations add to our understanding of how values are formed, influenced and can be elicited in a range of more complex and contested situations. In addition, recognising that certain overarching values are often held much more deeply allows us to see these values as morally explicit and to include them as possible constraints in decision-making (WPR 6). Given the diversity of cultural values the UK NEAFO provides a cultural values typology to distinguish and categorise the different dimensions and types of values (WPR 6).

(iii) How might the delivery of ecosystem services change in the future?

The UK NEAFO has extended the six UK NEA plausible scenarios for the future of our ecosystems and their services into the marine environment (WPR 4 and WPR 7). It also assessed how robust different policy and management interventions (our 'response options') might be within each scenario (WPR 8).

The new marine scenarios indicate that coastal and marine systems are fairly robust and resilient in the face of low to moderate stress or shock events (WPR 4 and WPR 7). A set of 'ecosystem change indicators' (consistent with the EU Marine Strategy Framework Directive) has been developed to aid future monitoring. In addition, the UK NEAFO identifies a range of models that can be used to address the different components of the marine shelf ecosystem, and provides a number of options for linking land use change models to coastal waters in order to assess the consequences for coastal ecosystem services (WPR 4).

The UK NEAFO recognises that the six UK NEA scenarios are extremely useful for bringing different stakeholders together as part of a learning process and generating a set of products that quantify relevant future worlds (WPR 7). Through engagement with stakeholders, it has been shown that people consider the future worlds the UK NEA presented to be plausible and relevant, and that scenarios have the potential to be used as deliberative tools, enabling experts and non-experts to discuss issues and learn from each other. The UK NEA scenarios can also be used to identify location-specific trade-offs and co-benefits between them. For instance, the scenarios were used with established hydrological models to identify trade-offs between the capacity to reduce flooding and prevent drought under different plausible futures (WPR 7). In this way, the scenarios can make a significant contribution to informed decision-making by government and other stakeholders.

The UK NEAFO shows that the sustainable delivery of ecosystem services requires a suite of response options that combines the strongest elements of each (WPR 8). For example, regulatory approaches are best used in combination with market-based incentives, and should be complemented by voluntary or community-based schemes, especially at the local scale. Ideally, such 'bundles' of response options should be accompanied by enhanced knowledge exchange, which can have the knock-on effect of stimulating scientific and technological innovation. Statutory approaches, including the establishment of protected areas, can define minimum standards for protecting ecosystems and their services, but may be slow to adjust to changing circumstances. Innovative schemes with the potential to improve the delivery of ecosystem services, such as offsetting and Payments for Ecosystem Services (PES), may benefit some services at the expense of others, so must be well designed. The ability of different response options to achieve multiple objectives is highly dependent on key factors such as governance, market forces (including the extent of market failures) and the scale of decision-making. Given that many decisions affecting the management of ecosystems can be challenged through legal processes (such as judicial reviews and appeals), it is important to build a process for setting response options that is based on solid evidence and is both pragmatic and robust (WPR 8).

(iv) What processes and systems can be used to ensure ecosystem services are considered in decision-making?

The UK NEAFO reviews existing processes for appraising policies and decisions that can be used to operationalise the Ecosystem Services Framework[5]. In particular, it explores barriers and opportunities to embedding the Ecosystem Services Framework into policy- and decision-making appraisals (WPR 9).

Environmental issues are addressed at three levels: (i) national policy level, which uses Impact Assessment (IA); (ii) plan and programme level, which uses Strategic Environmental Assessment (SEA); and (iii) project level, which uses Environment Impact Assessment (EIA). Even within the more localised and detailed SEAs and EIAs, many of the elements of the Ecosystem Services Framework are not explicitly embedded (WPR 9). As a result, acquiring more knowledge about ecosystems and the potential impact of policy interventions on their services does not mean that it will be used in appraisal and decision-making. The UK NEAFO identifies the key barriers and enabling measures that influence whether knowledge of ecosystem services is used at each level (WPR 9). To improve the use of ecosystem knowledge requires a better understanding of the context in which it will be used, as well as improved communication between knowledge producers, brokers and users.

[5] HM Treasury (2003) The Green Book: Appraisal and evaluation in central government [online] http://www.hm-treasury.gov.uk/d/green_book_complete.pdf

The UK NEAFO uses a number of case studies (all published between 2008–2012) to evaluate the good practice which most successfully mainstreams the ecosystem services framework in appraisal processes (WPR 10). In general, retrofitting the Framework into appraisals (as in the case study concerning policy appraisal) is a relatively weak way to mainstream it (Figure 1) (WPR 10). Often, the limited success of retrofitting is due to a perceived lack of fitness-for-purpose. In the case of EIA and SEA, assessments must conform to the legal requirements to identify significant environmental effects. There is no specific requirement to consider wider ecosystem impacts. This reduces the likelihood of fully embedding the Ecosystem Approach into these appraisals. Practice does however vary across the UK and, although the decision ultimately rests with the competent authority, there may be potential to consider wider impacts in some circumstances. However, the analysis in these types of appraisal must conform to current legal standards. This reduces the likelihood of fully embedding the ecosystem services framework into these appraisals. The case studies reveal that, although many familiar with the Ecosystem Services-led model accept that it is a holistic approach, there is a danger of overlooking some of the other key principles of the Ecosystem Approach, in favour of ecosystem services.

Section III: Putting the UK NEAFO into practice

A stated government priority for local and regional development is the supply of infrastructure to support more and better livelihoods. Yet there is also an obligation to avoid or reduce the impact on the environment of such infrastructure. Hence, an opportunity to demonstrate the added value of taking a wider Ecosystem Approach presents itself. We illustrate ways in which the work of the UK NEAFO might be incorporated into local development plans (**Figure 7**). It builds on the fact that the National Planning Policy Framework recognises both the importance of green infrastructure and the 'duty-to-cooperate' with statutory bodies (government agencies, NGOs, etc.), rather than to simply consult with them. Taking an Ecosystems Approach would not only cover formal planning requirements and neighbourhood plans, but would also connect with catchment planning, in particular, exploring how land use change might achieve multiple benefits for nature and people. For instance, while it is clear there is a continued need for prime agricultural land to produce crops, support livestock and contribute to rural livelihoods, there is a need to assess the potential to plant woodland in order to increase opportunities for amenity and recreation, contribute to flood attenuation, help diffuse pollution control, and provide a source of wood fuel, which could offer benefits both locally and further afield.

Ecosystem services, jobs and the economy (WPR 2)

To quantify the contribution of ecosystem services to local employment and economic output (£/year), ecosystem services need to be mapped to economic sectors, and an 'account' developed, for example, by using the UN System of Environmental-Ecosystem Accounting. This will generate data which can be used in econometric regional input/output modelling.

Sustaining natural capital assets (WPR 1)

Natural Capital Asset Checks can help to resolve environmental management issues that are intractable with current approaches, particularly where they cross sectors. For example:

- What are the interactions between commercial fisheries, protected areas (e.g. saltmarsh used as nursery grounds) and recreational angling?

- What role do farm woodlands play in regulating flood risk?

Spatially explicit models for land use (WPR 3)

Land use models can help consider all options for achieving the highest net benefits (both in terms of market price and value to society) from an ensemble of ecosystem services at scales down to <1 km^2. For instance:

- Where can new woodland be planted in order to generate the greatest benefits for the local community (such as providing amenity and recreational opportunities, contributing to flood attenuation, providing a source of wood fuel, etc.)?

Identifying cultural ecosystem services (WPR 5)

Characteristics of the local natural environment that are of cultural significance to people can be discovered through participatory methods, such as art and map-based techniques. These can elaborate on important, often unforeseen, aspects of cultural ecosystem services and provide compelling reasons for local authorities to use a wider evidence base for their planning choice.

Using shared values in decision-making (WPR 6)

Deliberation and social learning can add to our understanding of ecosystem services, as well as how shared values are formed, influenced and elicited in different groups within society. Thus, in more complex or contested situations, engagement in a participatory process can help to:

- build trust, manage conflicts, improve schemes; and

- increase acceptance of the final decision.

Figure 7. An illustration of how the work of the UK NEAFO can be used for planning at the local level.

Using ecosystem knowledge in appraisal (WPR 9)

Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA) are key tools for embedding ecosystem knowledge into planning processes. Using ecosystem knowledge in appraisal will:

■ help to provide a more comprehensive analysis of environmental impacts and potential problems; and

■ help identify critical factors which may facilitate or hinder the embedding of the ecosystem services framework.

An Ecosystem Approach to decision-making (WPR 10)

Using the Ecosystem Approach in decision-making helps local planners and elected members to think of the environment as an asset. It results in:

■ better engagement with stakeholders in the early stages of planning;

■ the demonstration of added value from diverse views; and

■ the identification of opportunities and ecosystem service trade-offs that may not have been considered yet.

Coastal and marine ecosystem services (WPR 4)

Combining a scoping tool with conventional coastal ecosystem classifications helps to identify key ecosystem services and policy issues. Marine and coastal models and scenarios provide information on possible changes in these ecosystems over time. Estimates of monetary values exist for some ecosystem services, while others with non-monetary values may be addressed using deliberative methods.

Scenarios: exploring future worlds (WPR 7)

Scenarios can be an effective way to engage with local stakeholders because they may find it easier to relate to changes in ecosystem services which are played out in specific locations of which they have an in-depth knowledge. For example:

■ How would the risk of flooding be affected under relevant contrasting scenarios?

■ How do local stakeholders think these effects might be addressed in different plausible futures?

Evaluating robust response options (WPR 8)

Identifying the right mix of joined-up response options using an Ecosystem Approach can help to ensure better integration of economic, social and environmental objectives by, for example:

■ combining statutory obligations (e.g. regulation) with local priorities; and

■ acknowledging future change is inevitable by planning for it and learning to adapt to it.

1.4 Specific questions addressed by the UK NEAFO

1.4.1 What characteristics of natural capital assets should we understand in order to improve environmental appraisal?

Physical, human, social and natural capital can be defined as assets which yield the goods and services that humans produce and/or use. As such, the state of the different types of capital is a key concern when trying to sustain human well-being. But, unlike other forms of capital, the state of our natural capital is not routinely assessed for its ability to provide benefits to people now and in the future. Such analysis is increasingly possible, and a better understanding of what natural capital is can improve the way we manage it. A technical definition is proposed to help shape analysis of natural capital; this is illustrated in **Figure 8.** Existing environmental classifications of ecosystems (e.g. habitat types) can be used to identify natural capital assets. The way ecosystems work (ecological functions) is recognised in our definition, along with the way natural capital assets combine with other capital in time, space and functionality to make our ecosystems productive (WPR 1.3).

Analysis of natural capital using the UK NEAFO definition requires economic valuations to take account of ecological properties and how different features of ecosystems combine to produce goods and services. For example, we can identify the role of intertidal ecosystems as natural capital by examining the different combinations of their features: they support fish stocks by combining nursery habitat with populations of different fish species; and they support recreation in combination with nearby ecosystems, such as freshwater and sub-tidal habitats. These goods and services are the natural capital provided by intertidal ecosystems (WPR 1.3.3.5).

We concluded that a cross-disciplinary approach is needed in order to take into account natural capital in economic and scientific analyses. As a result, the UK NEAFO has developed a procedure for assessing the condition of any natural capital asset – the Natural Capital Asset Check (NCAC), which is illustrated in **Figure 9.** The UK NEAFO's NCAC analyses: a) How much of a particular natural capital asset do we have? b) What does the asset produce? c) How do our decisions affect a) & b) over time? Under c), we recognise that there may be thresholds and/or trade-offs in the relationship between the state natural capital assets are in and the benefits they produce (WPR 1.4.4).
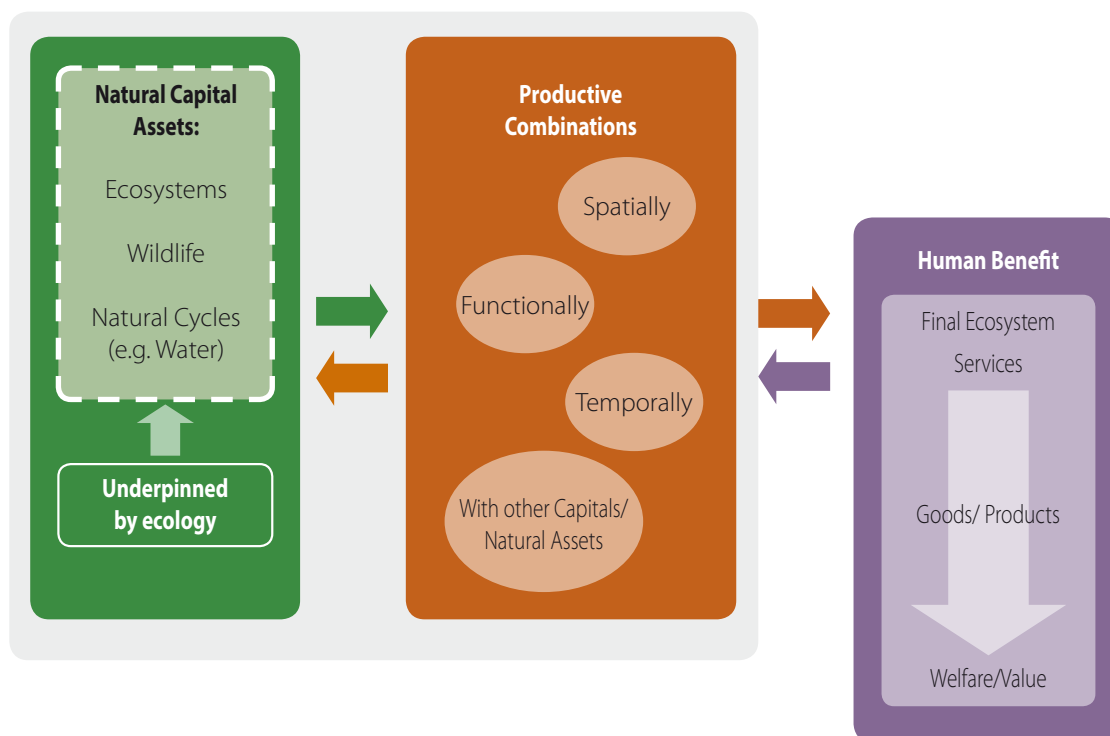
Figure 8. Representation of a technical definition of natural capital demonstrating the links between natural capital assets, productive combinations and human benefits. Understanding such linkages helps to inform an analysis of natural capital.

Figure 9. The five steps in the UK NEAFO's Natural Capital Asset Check (NCAC).
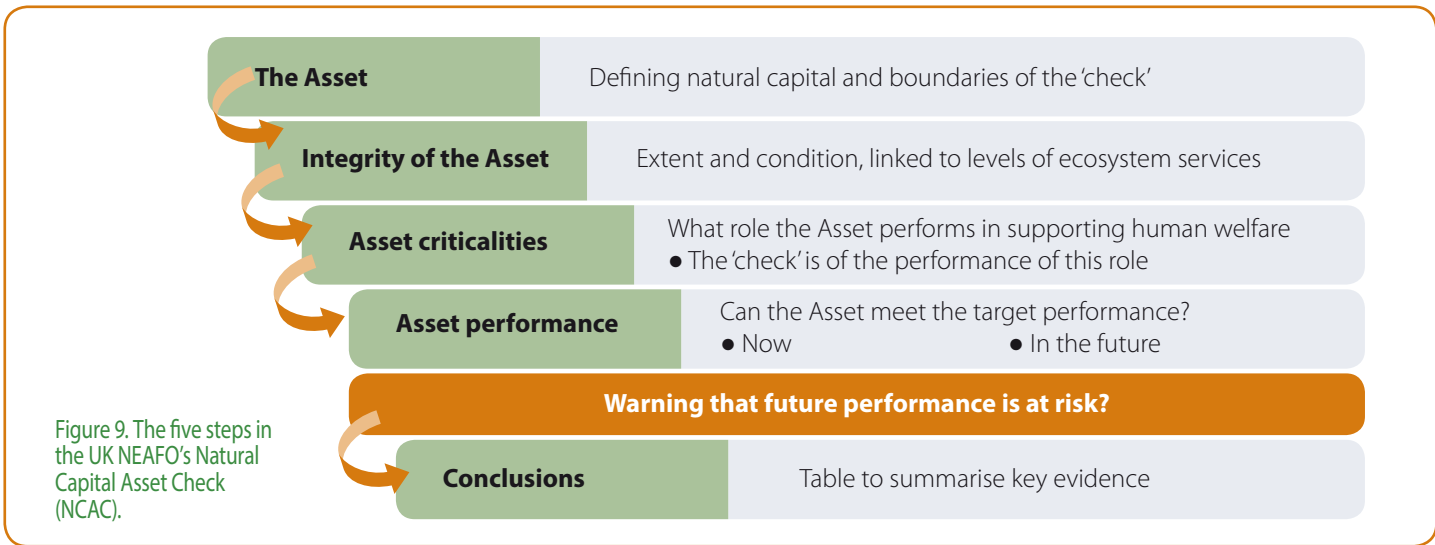
The UK NEAFO NCAC is a 'performance indicator', demonstrating the condition of a natural capital asset and how it supports human well-being now and in the future. Using the NCAC, the performance of an asset can be judged in relation to policy targets or goals, or in terms of economic activity at a regional or national scale. The NCAC procedure is data-hungry, however, and not as good at capturing the qualitative features of, and changes in, certain natural capital assets, such as cultural ecosystem services. Therefore, the NCAC should be used in situations involving significant change in only selected ecosystems and when it can be supported by modelling and scenario analysis. Despite this constraint, using the NCAC can inform decision-making at all levels, be used to scope sustainable development strategies and can provide insights into a specific ecosystem service (such as pollination) or spatially specific services, such as those supplied by an estuary (WPR 1.4.4.4).

The NCAC also incorporates precautionary 'red flags' which warn about the unsustainable use of natural capital assets and threshold risks (WPR 1.4.2). Thresholds can arise from both sudden changes to ecosystems, or from slower changes. Threshold crossing can affect ecosystems directly (for example, the collapse of fish stocks), or the ability of natural capital to recover, for example, the over-abstraction of a water table). The consequences of crossing thresholds depend on the value of goods and benefits in question, what substitutes these have and the speed of potential recovery. For instance, the existing supply of UK coastal saltmarsh, which provides nursery grounds for juvenile fish and links to spawning stock, is probably insufficient to fulfil demand for certain fish types. If the extent and/or condition of this habitat declines further, and fish stocks are not managed sustainably, the future integrity of this natural capital stock may be compromised. As a precaution, enough saltmarsh should be maintained or created to fulfil current and likely future demand for commercial fish landings (WPR 1.4.4.6).

Finally, application of the NCAC will help us to understand the characteristics of our natural capital. This will be useful for developing ways to measure changes in natural capital over time through natural capital accounts. Natural capital accounts can also be incorporated into the overall system of national accounting (WPR 1.5).

1.4.2 How can we quantify the impact of changes in ecosystem services on the national economy?

Ecosystem services support the creation of wealth and jobs at all scales. The UK NEAFO systematically reviewed more than 300 publications that focus on the links between the macroeconomy and the environment. The review reveals that some data does exist which shows the contribution that one or more ecosystem services make to the national economy, but that the coverage is patchy and not always explicitly focused on ecosystem services. In essence, we currently do not have an accurate and comprehensive picture of the contribution ecosystem services make to the UK's economy (WPR 2.4.7).

It is important to trace the impacts of changes in ecosystem services through the entire economy. By looking at Gross Value Added (GVA) and Gross Domestic Product (GDP), we can establish the values of goods and services produced by different sectors, including the environment, and how those goods and services are shared between sectors and industries; for example, the outputs of the agricultural sector in the UK are used as inputs by 40 sectors, including agriculture itself (WPR 2.2.3). In simple terms, GVA is the total of all revenues from final sales and (net) subsidies which are incomes to businesses. It measures the value of goods and services produced by each individual producer, industry, or sector in the country. It is used in the estimation of GDP, which is a key indicator of the state of the whole economy, measuring the annual value of the total amount of economic activity in a country. Essentially, GVA plus taxes on products, minus subsidies on products equals GDP (WPR 2.2.2).

At the regional and devolved administration scale, a few studies exist which try to estimate an approximate overall contribution made by the 'environmental economy' (Box 3). But the figures need to be interpreted carefully. The environmental economy is made up of a number of different types of industry, some of which will have negative impacts on the environment. Furthermore, in some contexts, such as tourism, the GVA is not solely provided by ecosystems, so ecosystem services are contributing only part of the revenue stream. The evidence base is, therefore, in a very basic state and the individual estimates in the box cannot be aggregated (WPR 2.4).

Box 3: Examples of our environmental economy[Ω] and its contribution to the UK's regional and national economic indicators.

It is important to note that individual estimates cannot be aggregated. The contribution of the environmental economy to the UK economy:

Food
■ In 2011, agriculture accounted for 0.7% of GDP (0.6% of GVA) and 1.5% of UK employment (WPR 2.4.1.1).

■ In 2011, the total agri-food chain (growing, processing, distribution and retailing) was worth £96 billion per year, (7% of GVA) and provided 14% of UK employment (WPR 2.4.1.1).

Forestry
■ In 2011, the forestry sector contributed 0.03% to national GDP (0.02% of GVA) and represented 0.06% of UK employment (WPR 2.4.1.3).

■ In 2005, all forestry related industries directly provided 167,000 jobs across the UK and generated £7.2 billion worth of GVA, or 0.7% of the UK economy (WPR 2.4.1.3).

■ In 2007, 13,200 jobs in the Scottish forestry sector were associated with the use of Scottish timber (WPR 2.4.1.3).

■ In 2004, 0.5% of GVA (direct, indirect and induced) was associated with Scottish timber, which is equivalent to around £460 million at 2007/08 prices (WPR 2.4.1.3).

Water
■ In 2011, the water supply and treatment industry contributed 0.75% of the total annual GVA and 0.16% of UK employment (WPR 2.4.1.2).

Wetlands (inland and coastal)
■ A bundle of services (water quality, flood control, recreation, tourism and amenity) was estimated in 2011 to be worth between £0.7-5.7 billion (includes non-market values) per year (WPR 2.4.1.2).

Marine environment
■ In 2011, the GVA of the sectors dependent on the marine environment and was found to be £49.4 billion (4% of GVA) (WPR 2.4.5).

Tourism
■ In 2012, tourism contributed £36.9 billion (2.4%) to UK GDP and 3.1% to total employment. If the entire supply chain is taken into account, then these numbers are 6.8% and 7.6% respectively (WPR 2.4.4).

■ In 2012, England's National Parks provided around 141,000 jobs (0.6% of total employment in England) and generated £4.1-6.3 billion of GVA (0.4-0.6% of GVA in England) (WPR 2.4.4).

Soil
■ Soil degradation is estimated to cost the UK economy between £0.9-1.4 billion per year (WPR 2.4.3.1).

Insect Pollination
■ The contribution of pollination services to UK agriculture is estimated to be £400 million per year based on the economic value of the crops produced (WPR 2.4.4.3).

The contribution of the environmental economy[Ω] to the English regional, Welsh and Scottish economies:

South East England
■ In 2000, the 'environmental economy' (agriculture, forestry, fishing, mineral extraction, tourism, recreation, leisure, environmental governance and technology initiatives) was estimated to contribute £7.8 billion of GVA (6%) to the regional economy. Similar estimates apply to South West England and the West Midlands (WPR 2.4.5).

Scotland
■ In 2003, environment-related activities contributed $17.2 billion of output, 11% of total output; and supplied 11% of jobs (WPR 2.4.5).

Wales
■ Natural environment-related activities contributed 9% of Welsh national GDP; one in six jobs and 10% of all wage and salary income (WPR 2.4.5).

[Ω] Not all the impacts valued were positive in terms of conservation and environmental protection. 'Environmental economy' comprises: (i) primary industries directly dependent on environmental resources, such as agriculture, forestry, fishing and mineral extraction; (ii) industries that are dependent upon a high quality environment, such as tourism, recreation and leisure; (iii) conservation organisations, government agencies and local authorities, which help to create quality of life and attract investment; (iv) businesses focusing on environmental technologies (waste management, water purification and sustainable energy).

Although a number of general economic approaches have been developed to link changes in the natural environment to the macroeconomy, these do not consider the impacts that changes in ecosystem services might have (WPR 2.2.1). These frameworks link the environment and economy by considering the flow of services from the existing stock of natural capital as an input into the production process. Despite the simplicity of these general approaches, there are problems with the data and understanding the outcomes. Separating natural capital from, or combining it with, other inputs and capital types is not a straightforward process. Likewise, substituting natural capital with other forms of capital (for example, using fertilisers to compensate for declines in food provision) is also not a simple issue. Therefore, a good starting point is to develop an understanding of how ecosystem services contribute to different economic sectors (WPR 2.2.3). The UK NEAFO concludes that it is vital that a comprehensive effort to map the interrelationships between ecosystem services and major sectors of the economy, such as agriculture, energy, water and tourism, should be undertaken (WPR 2.4.7). This needs to be followed by an evaluation of (quantities, qualities, monetary values) the main ecosystem goods and services that are used as inputs by particular economic sectors. This work will provide an opportunity to make a formal link to the national accounting system (WPR 2.4.7).

Combining macroeconomic and environmental methods of measuring contributions to the UK economy is likely to be the best way to model the economic impacts of changes in ecosystem services. There is a wide range of methods and tools that could be used to assess the two-way relationship between ecosystem services and the macroeconomy, as well as the implications of changes in policy and practices (WPR 2.3.1). However, because of the limitations of existing data and methods, there are currently no models that are entirely fit for this purpose (WPR 2.5). To make progress in this area, more work is required to adapt the the existing models and national accounting procedures to better reflect the contribution of natural capital to our wealth. At the sectoral level, disaggregated multi-regional econometric input-output models and Dynamic Stochastic General Equilibrium (DSGE) models seem to be the best candidates for the job (WPR 2.3.1). These models could be expanded, for example, by using the Eora MRIO time series database[6] that includes 511 sectors of the UK economy to prepare them for inclusion of ecosystem services (WPR 2.3.3.2). The differences in theoretical foundations across models will have to be taken into account when interpreting results.

At international scales these proposed new models, which take into account natural capital, will be able to track the impacts of changes in ecosystems services caused by international trade. Trade stimulates economic development, but at the same time, can cause cross-border changes in the provision of ecosystem services. For instance, around 30% of species on the IUCN Red List of Threatened Species are affected by the international trade in commodities. In fact, the international trade of 15,000 commodities produced in 187 countries has been linked to negative effects on more than 25,000 species. In this respect, the UK is actually in the top ten of 'net importers of biodiversity' (WPR 2.4.6).

[6] http://worldmrio.com/

Since the 1970s, the UK's National Accounts have been extended to better reflect environmental impacts, well-being and sustainability concerns. While GDP and other indicators from national accounting are important to assess economic activity, their limitations as measures of well-being and sustainability are well-known. Given the established position of macroeconomic accounting and modelling, it is most practical to extend these systems to include changes in the stocks and flows of ecosystem services. Building macroeconomic models that can track the impacts of changes in ecosystem services requires: accounting for non-market environmental and other welfare impacts; measuring and analysis of distributional impacts; constructing well-being indicators, including the provision of ecosystem services; and assessing the sustainability of economic development through natural capital asset checks (**Figure 10**) (WPR 2.3).

1.4.3 How can economic valuation be used to explore the trade-offs in the delivery of ecosystem services arising from alternative land uses?

The UK NEAFO extends mainstream economic valuation methods to include environmental services and benefits (WPR 3). This aids decision-making by improving the way in which ecosystem services are incorporated into policies, plans and procedures. We illustrate the way in which this research has enhanced current methods of economic valuation through a specific case study focusing on the interrelationships between natural capital and land use: the contemporary policy question of where to plant new forests (**Box 4**).

Box 4: Case study: Where to plant Britain's new forests?

The case study the UK NEAFO uses to present its new economic valuation model focuses on the current debate regarding planting new forests in Great Britain. It assesses both market and non-market impacts of the planting policy at a fine spatial resolution over the period from 2014 to 2063. The potential policy options used in the model as drivers were:

- A 'Business As Usual' (BAU) baseline. Under this policy option, no new forests are planted. This assessment provides a control against which the other policy options can be analysed. It also reveals the impact of forecast climate change on all the model's component modules during the time period looked at.

- A 'Market Value' (MV) driven planting policy. Under this policy option, new forests are planted. However, the government seeks to minimise the financial costs of meeting its afforestation targets and does not consider the wider social benefits that planting trees might generate. Since forestry is invariably less profitable than the agriculture it displaces, this policy requires subsidies to be paid from the public purse to landowners in order to encourage them to plant trees. The optimal MV policy selects planting locations that minimise the size of these subsidies.

- A 'Social Value' (SV) driven planting policy. Under this policy option, new forests are planted. Locations for these new forests are chosen by considering a wide range of social benefits. The process accounts for both market-priced goods (such as timber and the costs of displaced agriculture) and those non-market goods for which we can estimate robust economic values (such as greenhouse gas emissions and storage and recreation). Once again, subsidies must be paid to landowners to encourage tree planting, but now the policy focuses on getting the best social returns possible on that investment in natural capital.
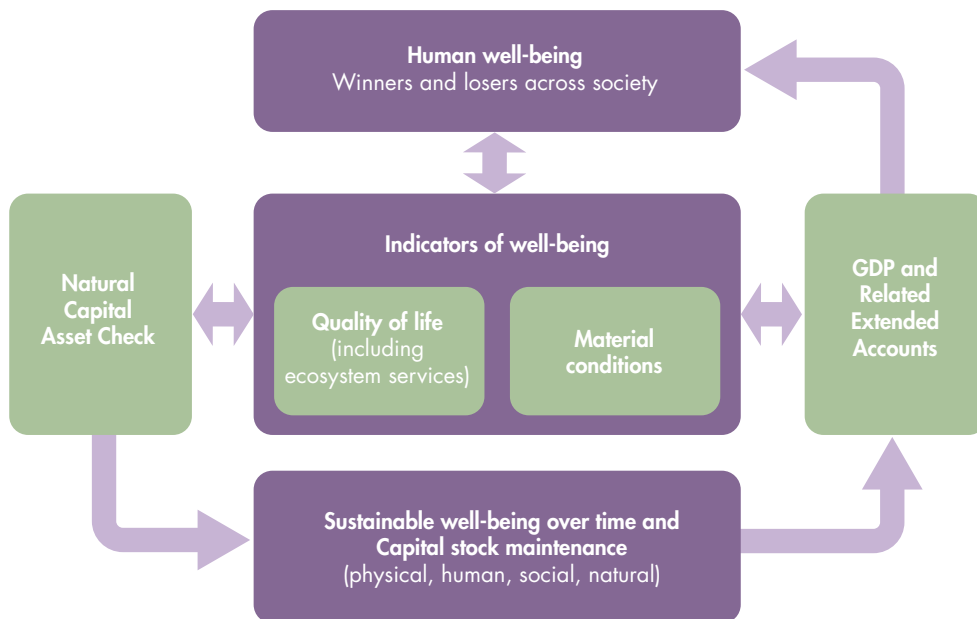
Figure 10. Links between human well-being, natural capital and national accounting.

This updated land use model links together a set of newly constructed modules detailing the drivers of land use change and the consequences of such change, which is illustrated in **Figure 11.**

The process starts with the various drivers of change including: policy (both pre-existing policies and changes occurring over the analysis period); market forces (prices, costs, etc.); and variations in the physical environment (both between locations and across time due to processes such as climate change). The model allows us to examine different policy scenarios by adjusting these drivers; for instance, by introducing different policy options, we can see how each option affects economic values and objectives over a chosen period of time (WPR 3.13.2). To perform these calculations, the model draws upon a series of component modules (all of which take into account the effects of climate change):

- Farm module: This module models farm-level decisions regarding land use and estimates the market-priced returns from the resultant agricultural production. It draws upon an econometric analysis of 45 years' worth of agricultural land use information gathered at a spatial scale of 2km squares for Great Britain. The module predicts how agricultural activities and the value of agricultural production might react to farm-level decisions taken as a result of changes in the various drivers (WPR 3.5).

- Timber module: Developed in collaboration with the Forestry Commission (FC), this module draws upon FC data to determine, for various tree species, the production decisions that optimise net revenues from timber production under different conditions (WPR 3.7).

- Farm greenhouse gas (GHG) module: This module uses the Cool Farm Tool developed by the University of Aberdeen to model net GHG emissions resulting from agricultural activities. It includes direct and indirect changes in carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) emissions arising from agricultural activities, such as the use of machinery, arable production, the use of fertilisers, keeping and managing livestock and soil carbon (WPR 3.6).

- Forestry GHG module: This module employs the FC CARBINE model to quantify the net GHG emissions resulting from forestry activities (WPR 3.8).

- Recreation module: Based on the MENE database, created by Natural England, Defra and the FC, this module explores the trade-offs which individuals make between their choice of where to visit, the characteristics of available recreation sites and their alternatives , and the costs of visits (WPR 3.11).

- Water quality module: Drawing upon Environment Agency General Quality Assessment data, this module describes the hydrological processes that link land use to nutrient concentrations in rivers (WPR 3.9 and 3.10).
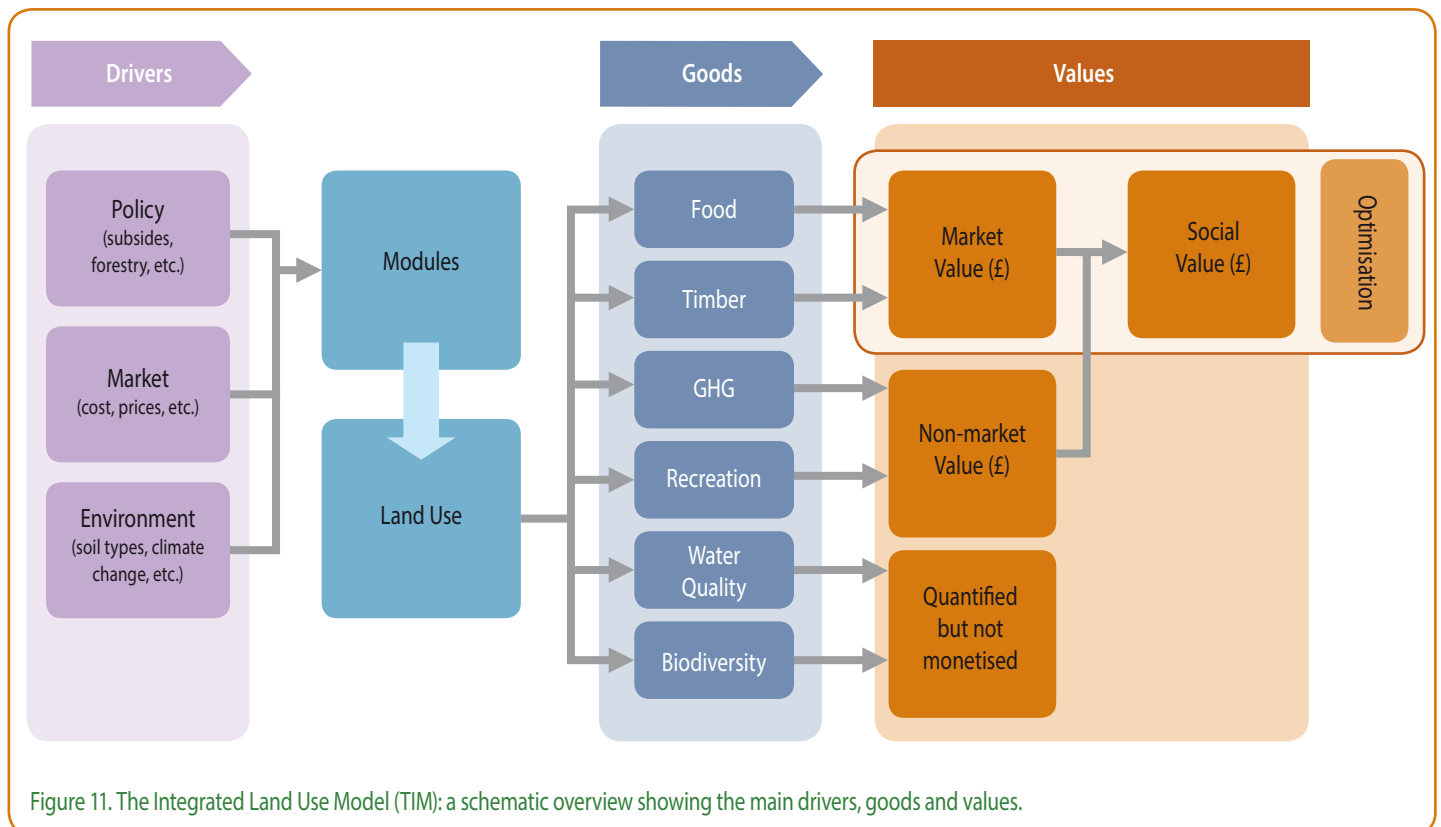
Figure 11. The Integrated Land Use Model (TIM): a schematic overview showing the main drivers, goods and values.

Where should we plant Britain's new forests?

We could…
   maximise market value…

…and now consider…
   green house gases and recreation

Net cost/benefit:	-£65 million p.a.	+£546 million p.a.
Implementation cost:	+£79 million p.a.	+£231 million p.a.

Figure 12. A comparison of the costs and benefits of different forest planting schemes showing the effects on where woodland would be planted, and the relative benefits and implementation costs incurred, when considering only the market values of timber versus a wider set of ecosystem services.

■ Biodiversity module: Developed in conjunction with partners at the British Trust for Ornithology (BTO), and using their British Bird Survey (BBS) data, this module examines the impacts of land use change on the diversity of bird species in, and around, the location of such change (WPR 3.12).

When used together to consider a particular scenario, the modules predict how changes in the various drivers will affect land use now and in the future. They also allow for a comparison with relevant baselines (WPR 3.13.2). Of course, such land use changes will affect the type, quantity, distribution and quality of ecosystem goods and services. Some of these goods and services, such as food and timber, are traded in markets and, therefore, have prices. Others, such as greenhouse gasses and recreation, lack market prices, but may still be valued in monetary terms. Where consistent values can be obtained, TIM uses mathematical programming routines to identify land use mixes that satisfy some particular optimisation objective. For instance, market values alone can be maximised, or

analysis can incorporate the wider range of market and non-market values available – this gives a more complete measure of society's net benefit from land use. It should be noted that, within the present research, values for changes in water quality and biodiversity could not be estimated robustly, so were not entered into the optimisation routine. Instead, the quantified impacts of land use changes are assessed for each of these effects and considered further in the main WP 3 Report (WPR 3.13.2 and 3.13.3).

Figure 12 maps the results from these three assessments. On the left hand side, the Market Value (MV) analysis is displayed. In order to minimise financial costs, forests tend to be planted on remote upland sites where the expense of compensating landowners for displaced agriculture is at its lowest. However, these locations include many areas with peat soils which yield high levels of greenhouse gas emissions when disturbed and drained for tree planting. They also provide fewer benefits for recreation. When all costs and benefits are considered, this policy option results in an

annual net loss to society's welfare (WPR 3.13.5.2).

On the right hand side of Figure 12, we can see the radical change that occurs when we consider greenhouse gas emissions and recreational values in planting decisions. Forests move from the hills and peats, instead, displacing areas of high farm (livestock) emissions. They are also planted around the fringes of Britain's major cities. The outcome of these changes is that planting now delivers a significant annual net gain to society's welfare. The figures under each map take into account the benefits and costs of each policy option and report the sum of both market and non-market values over the full planting period for each of the two analyses. They clearly demonstrate that incorporating non-market values into decisions about where to plant forests provides significant gains for society as a whole (WPR 3.13.5.2).

In addition to the results from TIM, the UK NEAFO's Balance Sheet Approach (p. 15-16) highlights a number of key messages in this case study. Conventional cost-benefit analysis (sheet 1 type analysis) shows that, under the MV policy option, an implementation cost of £79 million per year (in terms of planting and landowner compensation) results in a net loss to society of £65 million per year. When the planting strategy takes into account greenhouse gas emissions and recreational values, the implementation costs increase to £231 million per year. But under this Social Value (SV) policy option, society actually enjoys a net gain of £546 million per year (WPR 3).

But compensation costs to landowners differ significantly across the two scenarios, so the cost of implementing the different planting schemes varies. In addition, the costs of planting in urban fringes are substantial, and, in practice, will still lead to some loss of productive agricultural land. Yet, in essence, it is clear that we need to invest in order to save. Despite this conclusion, the actual winners and losers at the local level, and the 'fairness' of these decisions and their impacts including any cultural ecosystem services changes, also need to be factored into the political decision-making process (sheets 2 and 3 type analysis in the Balance Sheet Approach).

1.4.4 How can we better measure and value changes in ecosystem services in coastal and marine environments?

The UK NEAFO describes a set of strategic level principles and practical tools to inform the sustainable management of coastal and marine ecosystem services (WPR 4). Coastal and marine habitats are in constant flux and under the influence of a range of human pressures. As such, the interactions between coastal and marine habitats and land use and river basins are dynamic and complex. At the present time, our understanding of the functioning of coastal and marine ecosystems, their reactions to pressures and their contributions to well-being is limited. Yet, regardless of this

knowledge gap, it is clear that sustainable management of these ecosystems requires an ecosystem services approach that works on a landscape-scale.

The UK NEAFO suggests that Adaptive Management Principles are adopted by policy- and decision-makers to ensure the sustainable management of our coastal and marine ecosystem services (WPR 4.2.2). The inbuilt flexibility of adaptive management allows us to adjust to new knowledge and new drivers and pressures, as well as long-term issues, such as climate change. Given the rapid change typical of coastal and marine habitats, and the decline already seen in some areas, the UK NEAFO advocates a precautionary approach within adaptive management strategies (i.e. erring on the side of caution when objective-setting if data is unavailable to demonstrate a potential decline or loss) to ensure that both the stock and flow of coastal and marine ecosystem services are sustainably managed (WPR 4.2.4). This may include compensation for habitat or resource losses, and financial recompense for certain users (WPR 4.7). **Figure 13** presents a classification of all the significant ecosystem services supplied by coastal and marine ecosystems (WPR 4.2.3 and 3.4.2).

The UK NEAFO has adapted the Drivers-Pressures-State-Impact-Response (DPSIR) scoping tool to better reflect changes in ecosystem services and their impacts on human well-being (WPR 4.2.6). The tool has been used to identify the main policy issues resulting from trends in drivers for and pressures on coastal and marine ecosystems. These drivers and pressures include increased human population size and activities in coastal areas, increased shipping and exploitation of rivers and coastal and marine areas, and climate change resulting from greenhouse gas emissions. The original DPSIR tool has been modified to include state changes and impacts specifically tailored to ecosystem services and their human welfare effects. Next, we linked the adapted DPSI(W)R tool to a scenario analysis using the Delphi-technique (WPR 4.3.1 and 4.3.2). Four marine based scenarios (see WPR 4.3.2 for details) which deviated from a baseline condition were explored and exposed to changes in ecological and political drivers. The results of this assessment show that UK marine and coastal ecosystems are resilient in the face of low to moderate pressures and shocks, and habitats can be expected to recover relatively quickly. Despite this, it is important to note that society's reaction to these shocks, often in the form of policy changes, could lead to more permanent changes in ecosystem service delivery (WPR 4.3.3 and 4.3.4). Another key message from this assessment is that, if current national and international policies were to be fully implemented, we could potentially maintain and increase the benefits to human well-being derived from coastal and marine ecosystem services.

Based on the classification of ecosystem services in Figure 13, and the DPSI(W)R tool, a set of SMART (Specific, Measureable, Attainable, Relevant, Time-bound) ecosystem services change indicators have been developed which are consistent with the implementation of the EU's Marine Strategy Framework Directive (WPR 4.4.2). These indicators can be to be measured and monitored by the relevant agencies in order to evaluate changes in coastal and marine
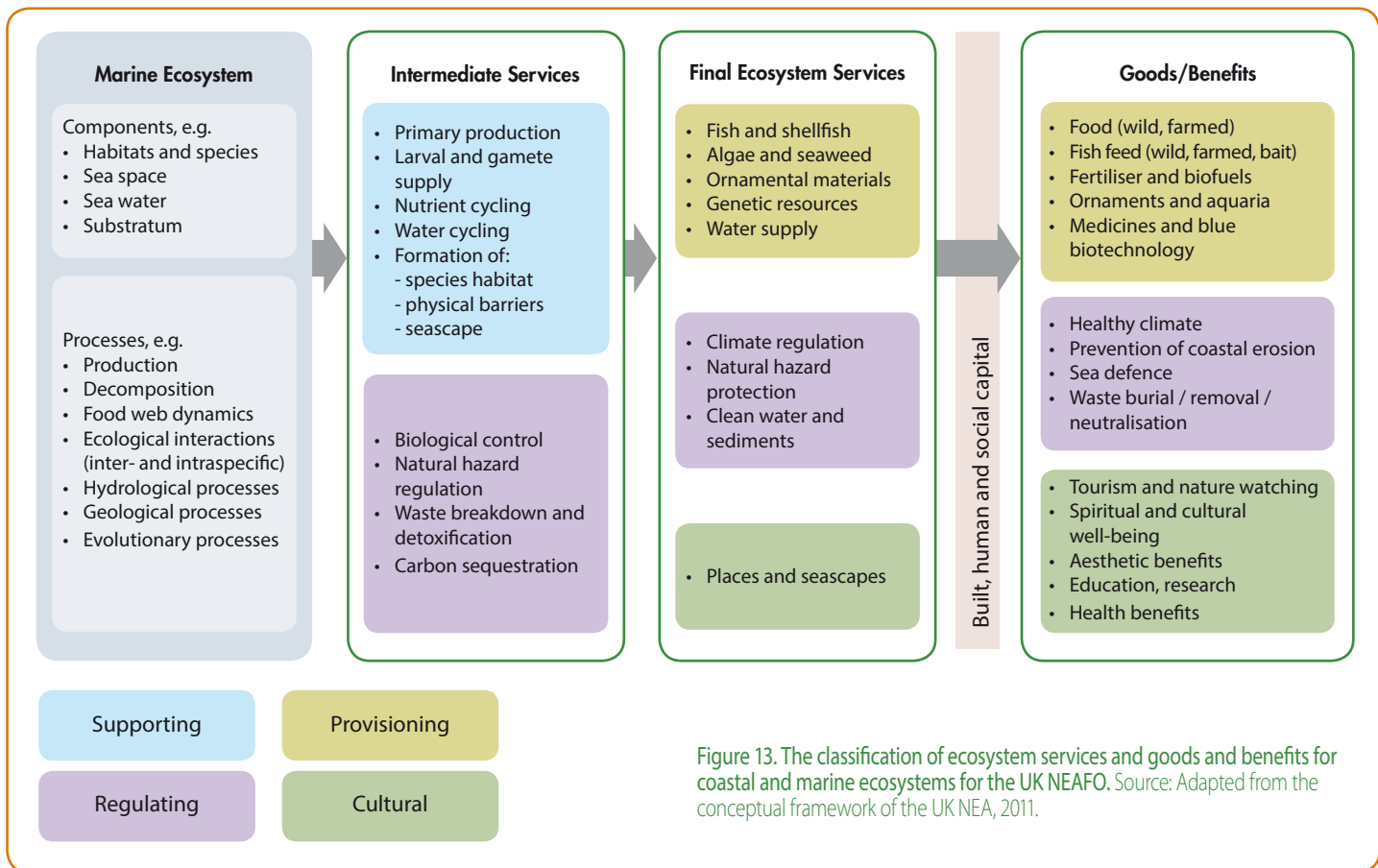
Figure 13. The classification of ecosystem services and goods and benefits for coastal and marine ecosystems for the UK NEAFO. Source: Adapted from the conceptual framework of the UK NEA, 2011.

ecosystem services. They encompass the link from processes, to intermediate and final ecosystem services, thereby covering both stock and flow. The data requirements for these indicators include existing national level observations and models as well as published and 'grey' literature for specific cases. In order to monitor the indicators over time, continued data collection is needed (WPR 4.4.4).

The UK NEAFO has also assessed formal models to quantify changes in ecosystem service stocks and flows, and the practicality of linking land use, estuarine, and coastal and marine models (WPR 4.5). It is apparent that both the heterogeneity of the UK's estuaries, and the lack of site-specific data for many river basin and estuary habitats, do not allow for an integrated, spatially sensitive model. Instead, spatial 'box' models could be further developed to analyse the extent to which nutrients present in river catchments as a result of land use are recycled by estuaries, and how this mediates the impact of land use on marine ecosystems. This is the most pragmatic approach for linking the UK NEA (TIM) land use model to marine models given our current knowledge (WPR 4.5.4).

The UK NEAFO evaluated the evidence base required for the monetary valuation of goods and benefits arising from coastal and marine ecosystems (WPR 4.6). The evaluation shows that several important or unique UK habitats, and their related services, have few or no marginal economic value estimates. These include estuarine and machair habitats; sea defence, erosion prevention and provisioning services; and climate benefits. Only 25 suitable UK-based valuation studies were found, which is insufficient to map and transfer the benefits of different coastal and marine habitats across the UK (WPR 4.6.4). Figure 14 highlights the data gaps, in particular, the lack of evidence for a number of services judged to be important by marine science experts. Even across international literature (over 200 studies published since 2000), the evidence base was considered either too small or too different from the UK's culture and ecosystems to close this knowledge gap (WPR 4.6.4). Therefore, new assessments of site-specific monetary and non-monetary values for coastal and marine ecosystem services are needed to improve our trade-off analyses and decision-making (WPR 4.6.6).

The UK NEAFO's Balance Sheet Approach helps to inform policy-makers when sustainable approaches to coastal management may have unequal impacts on different stakeholders. For example, managed realignment provides a flexible way of dealing with coastal defence and climate change, but may be chosen as a response purely for the sake of efficiency and cost. In contrast, the Balance Sheet Approach allows for the inclusion of long-term ecological changes and impacts, stakeholder engagement and the inclusion of equity criteria in policy-making. In addition, the question of appropriate compensation for losers in any trade-off decision, which has been a particularly contentious issue in recent coastal management contexts, is highlighted in the Balance Sheet Approach (WPR 4.7).

Habitat	Products	Sea defence	Erosion prevention	Healthy climate	Tourism and nature watching	Education research	Aesthetic: property§	Spiritual/ aesthetic: wild species, seascapes
Dunes	0	2	0	1	1	0	0	1
Beaches	0	1	1	0	4	0	0	0
Sea cliffs	0	0	0	0	1	0	0	0
Machair	0	0	0	0	0	0	0	0
Lagoons	0	0	0	0	0	0	0	0
Salt marshes	1	4	0	4	1	0	0	1
Mudflats	0	2	0	2	1	0	0	0
Inter. wetland	0	0	0	0	0	0	0	1
Seagrass beds	0	0	0	0	0	0	0	0
Kelp forest	0	0	0	0	0	0	0	0
Estuaries	0	0	0	0	0	0	0	0
Cold water coral reefs	0	0	0	0	0	0	0	0
Rocky bottom	0	0	0	0	0	0	0	0
Coastal shelf	3	0	0	1	5	0	0	5
Open ocean	0	0	0	0	0	0	0	0

§ The importance of property related aesthetic values of some coastal ecosystems (grey cells) was not assessed in the UK NEA.

Services of high importance with no relevant valuation studies

Important services with one valuation study, or services of medium importance with no valuation studies

Important services with two or more valuation study or services of medium importance with one valuation studies

Services of low importance or services of medium importance with two or more valuation studies

Figure 14. The importance of ecosystem services for each coastal and marine habitat and the availability of UK-based valuation studies. The numbers reflect the number of available studies published in the peer-reviewed literature since 2000. The colours indicate the importance of the ecosystem service as reviewed by experts (the darker the colour, the more important).

1.4.5 How can we strengthen our understanding of the link between ecosystem attributes and the delivery of cultural services and goods to improve decision-making?

Understanding how the features of our ecosystems enable people to experience cultural benefits has proved a difficult area for ecosystem assessments. There has been considerable debate in academic and policy documents over how to define and measure cultural ecosystem services. The UK NEAFO moves this debate forward by providing a newly refined approach for understanding cultural ecosystem services and demonstrating how they can be analysed using a wide range of methods and approaches developed in the social sciences, arts and humanities (WPR 5 A&H Annex). Such a multi-disciplinary approach is vital to assist decision-makers when faced with the problem of how to analyse cultural ecosystem services. The approach is shown in **Figure 15;** it illustrates that the assessment of cultural ecosystem services to support decision-making must be based on an understanding of environmental spaces, cultural values, cultural practices and benefits. These are the four key components of cultural ecosystem services (WPR 5.2).

A number of key decision-making organisations already use a range of quantitative and qualitative approaches to understand the cultural benefits linked to our ecosystems. For example, the National Trust uses quantitative measures of visitor numbers, alongside qualitative 'Statements of Significance' and 'Spirit of Place' reports (WPR 5 Annex 2; WPR 5 A&H Annex). These statements are devised by experts and conservation staff to communicate to society a shared understanding of the qualities that make the Trust's properties and land special. The UK NEAFO also adopts a wide range of methods to analyse cultural ecosystem services, including quantitative and qualitative measures. Using existing data covering England, Wales and Scotland, our assessment includes: quantitative measures of the well-being benefits of visits to outdoor spaces; questionnaire surveys; participatory mapping; qualitative analysis of group discussions regarding cultural ecosystem services; and arts-based approaches (WPR 5.4 and 5.5). The UK NEAFO demonstrates how a combination of these different methods and approaches can produce an in-depth understanding of cultural ecosystem services. Specifically, the UK NEAFO presents a range of case studies which use the various methods outlined to assess cultural ecosystem services in urban Nottingham (WPR 5.3.6), the peri-urban settlements of the Inner Forth (WPR 5.5.3), and rural North Devon (WPR 5.5.2). These case studies highlight the need for decision-makers to select methods of assessment that are appropriate for local situations and policy challenges.

The UK NEAFO has developed a set of measures to analyse cultural ecosystem services. These measures are based on the available data related to the stock of, and access to, environmental spaces; they are:

- The physical supply of environmental spaces (categorised into 14 types including urban green space) expressed as percentage land cover down to Local Authority District level in Great Britain (WPR 5.3.3).

- The accessibility of environmental spaces (ancient woodlands, nature reserves, natural terrestrial habitats) based on size and distance to population centres (WPR 5.3.4).

- The demand for environmental spaces is estimated with data which indicates when a given individual would most likely visit an environmental space to participate in an activity there, such as go for a walk or watch wildlife (WPR 5.3.5).

- The quality of an environmental space, including whether play areas were available, rates of local crime were high and noise levels were excessive (WPR 5.3.6).

Cultural Values

Norms and expectations **influencing and influenced by** services, benefits and their biophysical context

Biophysical domain

Provides material components of…   Provides opportunities for…

Cultural ecosystem services

Environmental Spaces

Geographical contexts of interaction between people and nature e.g.

Gardens and parks
Farmland and woodland
Beaches and seascapes
Rivers and streams

…Shape

Enable…

Shape…

Shape…

Cultural practices

Activities that relate people to each other and the natural world e.g.

Playing and exercising
Creating and expressing
Producing and caring
Gathering and consuming

Cultural goods

Service-benefit products e.g. organised opportunities for recreation and tourism, food and drink of local provenance, local festivals etc

Enable…

Enable…

Shape…

Shape…

Cultural ecosystem benefits

Dimensions of well-being associated with cultural spaces and practices

Identities (e.g.)
• Belonging
• Sense of place
• Rootedness
• Spirituality

Experiences (e.g.)
• Tranquility
• Inspiration
• Escape
• Discovery

Capabilities (e.g.)
• Knowledge
• Health
• Dexterity
• Judgement

Figure 15. A conceptual framework for the linkages between cultural ecosystem services, values and benefits, emphasising the importance of the interaction between environmental places and cultural practices.

The overall picture that emerges from our assessment of cultural spaces shows: a relative abundance of open access land in northern England; good access to woodland in Wales and South East England, but relatively little woodland in the Midlands and parts of North East England; a concentration of accessible country parks in London, North West and South West England; good access to nature reserves in Wales, Scotland and southern England, but poor access to nature reserves in the English Midlands; and a scarcity of designated sites in the English Midlands (WPR 5.3). To build on this work, we need to expand data on the quality of environmental spaces and improve mapping of public access to local environmental spaces.

Figure 16. An example of school children connecting with environmental spaces through the arts. A Google map was used as a base and overlain with artefacts collected from the environment, as well as photographs, sound recordings and personal reactions to the settings.
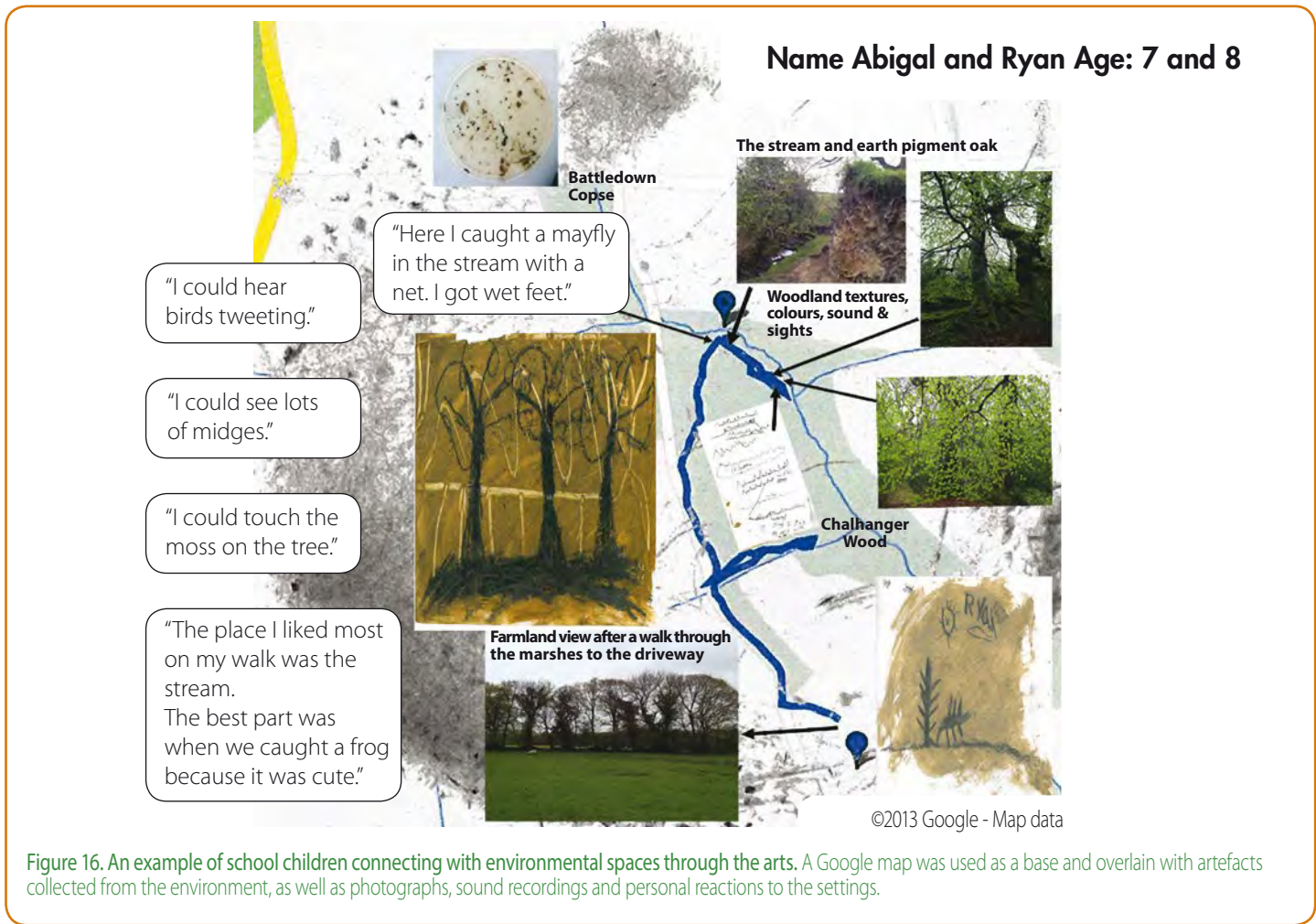
While extremely useful, the measures we outline for assessing environmental spaces do not get at the fine detail of the public's relationship with nature and the benefits it provides. This detail can only be understood through in-depth surveys, participatory mapping, workshops and studies of the geography of specific locations (WPR 5.5). From an evaluation of these methods, the UK NEAFO reveals that participatory mapping is fundamentally about meaning and the environment; it is both metaphorical and material. It can be used in a variety of locations ranging in scale from national parks to small farms. It can provide new understanding of the cultural significance of ecosystems and help articulate latent cultural values that remain hidden from other methods (WPR 5.5.1 – 5.5.5). For instance, we used maps within a survey instrument to reveal that rural environments are often valued for their 'unspoilt' character, so new housing, traffic and renewable energy developments are seen as key threats to such untouched areas (WPR 5.5.2). The participatory mapping technique the UK NEAFO presents is quite flexible and has been successfully adapted for art education in schools (**Figure 16**) (WPR 5.5.4).

The UK NEAFO has also conducted a quantitative analysis of the Monitor of Engagement with the Natural Environment (MENE) survey data in terms of environmental spaces (WPR 5.4). We found evidence of a significant effect on well-being associated with an increase in time spent in natural spaces, such as woodland and forests. In particular, we found 'blue spaces' (beaches and coasts) to be very beneficial. Urban parks are the most visited spaces (around 25% of all visits), but visits are short in duration, reducing the intensity of well-being benefits. Regardless, time spent outdoors, in either a domestic garden or public outdoor space, has a positive effect on well-being through increased enjoyment and/or increased relaxation (WPR 5.3.4.6).

Looking to the future of cultural ecosystem service analysis, the MENE survey could be further enhanced to provide even more insight into services and benefits. Data on the use and characteristics of domestic gardens would need to be collected more regularly. Questions on the particular features and quality of public cultural spaces (for example, congestion levels, heritage features, etc.) would also need to be included in the survey. More formal well-being numerical scales are required, while well-being measurements could be done on a monthly basis. In addition, respondents could be asked to rank the key types of natural spaces in well-being enhancement terms and provide more information on how nature is valued without physically visiting sites (WPR 5.6.2).
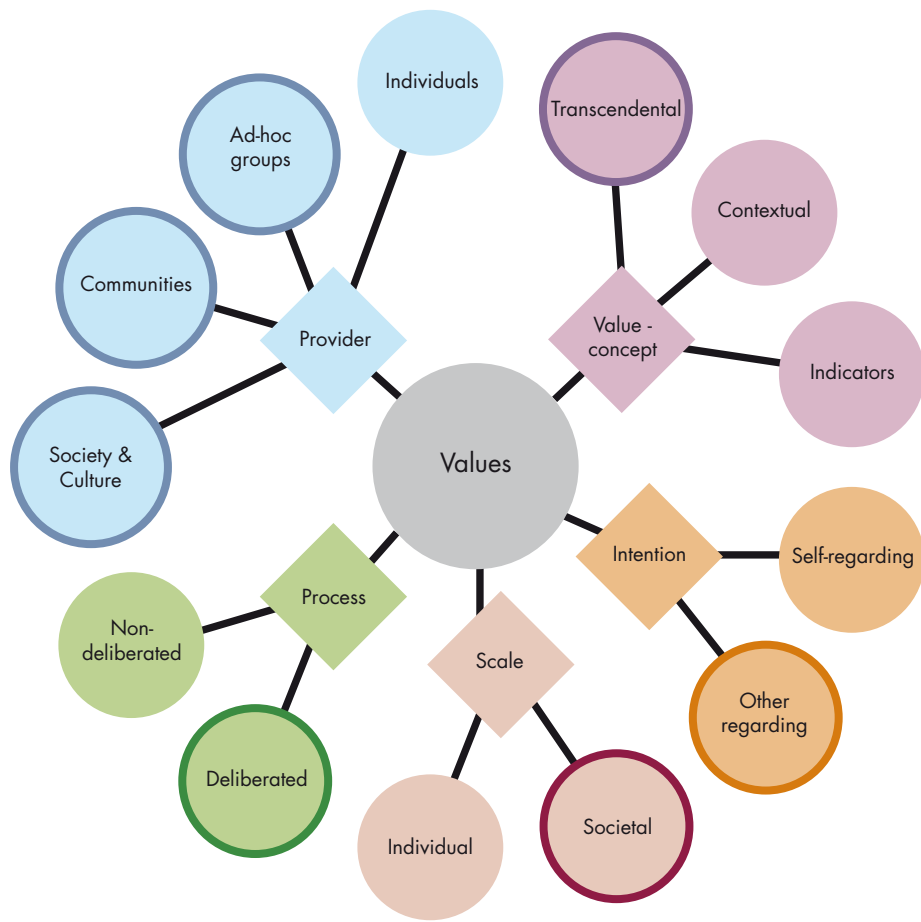
Figure 17. The UK NEAFO's definition of 'shared values' which illustrates the five dimensions of values (depicted as different coloured diamonds). Dimensions are depicted as diamonds. Emerging from the dimensions, we can differentiate between types of values that might be termed 'shared', 'social', or 'shared social' values (outlined circles), and other types of values (non-outlined circles).

1.4.6 How can we characterise and assess the shared values provided by ecosystems?

The UK NEAFO recognises that there are a number of dimensions to the idea of natural capital and that some important ecosystem services cannot be sufficiently valued through conventional economics. In general, economic analyses consider values as mostly individualistic, self-interested and related to the usefulness of things. However, some values are not for, or about, the self, but relate to others and the communities, societies and places in which we live. These broader, less selfish values include important ethics and norms in relation to nature. Indeed, both our individual and communal identities are linked to the landscapes and places we live in and visit, and many people experience emotional and spiritual connections to these locations.

Traditional consultation and valuation often fails to reach out to these values. This is because they often assume that the opinions we express as individuals tap into all forms of value. They also assume that adding up these individual values represents the sum total of values held by a constituency of people. However, it can be argued that not all of the different types of values can be boiled down to a single figure, be that economic, or expressed in other ways. The different value systems are not directly comparable (and can well be incommensurable). Many of the ways we appreciate the world are subconscious – far from preformed in our minds – and emerge only when we share them with others. The UK NEAFO considers what these shared and cultural values are, how they are different from individual values and how to incorporate them into decision-making (WPR 6).

The term 'shared values' has not yet been distilled by the research community and is used to indicate a wide variety of different things. In order to provide users with a sound and united definition, the UK NEAFO presents a theoretical approach that discriminates values along five dimensions (**Figure 17**) (WPR 6.1.1 and 6.3):

(i)   the concept of the value, i.e. whether it is an overarching life principle or fits a particular situation ('Value-concept');

(ii) the value provider, i.e. whether it comes from an individual, group or whole society ('Provider');

(iii) the intention of the value, i.e. whether it is self-regarding or not ('Intention');

(iv) the scale of the value, i.e. whether it relates to the individual or the societal level ('Scale'); and

(v)   and the process used to elicit the value, i.e. whether it has come from a deliberative process (group-based discussion), or gleaned from another source ('Process').

Emerging from these five dimensions, 'shared values' refers to several types that are not necessarily mutually exclusive: group values (the outcomes of group-based valuation), deliberated values, value to society, other-regarding values, transcendental values (overarching principles and life-goals that transcend specific situations, such as honesty, justice, wealth or enjoying life) and communal, societal and cultural values (the values held in common by communities, societies and cultures) (WPR 6.1.1 and 6.3). Ultimately, the collection of these different types of shared values represents the overarching opinions that we come to hold and express through our interactions with others. It is these shared values that inform and shape narratives of our 'common good'. Systematic literature searches on shared and cultural values indicate that this plurality was seen to be very important by social science and the humanities (WPR 6.2); all the 117 non-economic papers reviewed emphasised the importance of recognising and including multiple dimensions of shared values (WPR 6.2.2.4).

A wide variety of methods and tools exist to assess our shared values (**Table 2**) (WPR 6.3.4). Deliberative methods allow participants to ponder, exchange evidence, reflect on matters of mutual interest and attempt to change each other's minds. The outcomes of deliberative methods are often qualitative and might include priority lists, recommendations and verdicts. Analytical-deliberative methods such as Deliberative Monetary Valuation (DMV) and Multi-Criteria Analysis (MCA) integrate deliberative-based techniques with more formal decision-making tools. Outcomes from these methods are expressed in monetary terms, or as a quantitative ranking or rating. Deliberation can be used to both elicit shared values and provide possible solutions amidst conflicting held values, interests and evidence (WPR 6.3.4 and 6.5.3).

While the use of deliberative methods is increasingly being advocated, a clear explanation of how group deliberation and social learning shape shared values is lacking. To address this issue, the UK NEAFO has developed the Deliberative Value Formation (DVF) Model to demonstrate the process of value formation in deliberative methods (WPR 6.3.5). A carefully designed deliberative process can explicitly aim to bring out individual and shared overarching principles and life goals, making these values more explicit. This allows participants to apply them in practical contexts, such as discussing responsibilities or the consequences of actions, and helps to form contextual values. These contextual values can then be assessed using indicators, including verdicts, rankings and monetary estimates (WPR 6.3.5).

Various non-monetary and deliberative methods also have the potential to draw out and analyse particular types of shared values. Interpretive and qualitative methods can reveal community wide values and overarching values and beliefs, the latter of which can also be assessed using psychological survey-based methods and interviews. On a wider scale, societal and cultural values can be assessed through ethnographic methods, media analysis and other textual methods. Participatory mapping is particularly useful for eliciting shared contextual values (WPR 6.4, 6.3.4 and WPR 5.5).

To test the DVF, further develop non-monetary, non-deliberative methods and investigate differences between individual values and shared values expressed by groups, the UK NEAFO explores four empirical case studies:

(i)   *The design and implementation of a landscape-scale conservation project in the Inner Forth, Central Scotland.* With community councils, we undertook a regional assessment of a range of ecosystem services in the area using group-based monetary valuation, conceptual systems modelling and participatory mapping. We also used before-after psychological testing of overarching opinions, beliefs and norms to better understand the impacts of the chosen deliberative methods (WPR 6.4.2).

(ii) *The cultural ecosystem services provided by inshore fisheries in Hastings, East Sussex.* Working with the Hastings Fisheries Local Action Group, and a wide range of local stakeholders, we ran three workshops to assess the value of the marine environment alongside other social priorities using a range of deliberative methods (WPR 6.4.3).

(iii) *The cultural ecosystem services provided by marine locations identified as potential Marine Protected Areas (MPAs).* Working with divers and sea anglers, we used well-being indicators for the non-monetary valuation of marine cultural ecosystem services. We also ran a series of 16 workshops that undertook valuation and multi-criteria assessment methods. We used before-after psychological testing of overarching opinions, beliefs and norms to better understand the impacts of the chosen deliberative methods (WPR 6.4.4).

(iv) *The presentation of shared values for coastal and marine locations in the media.* We analysed both content and discourse in a wide range of media publications to determine if this approach might help us to better understand broader cultural, societal and communal values (WPR 6.4.5).

Table 2. An overview of the techniques that can be used to assess shared cultural values.

Technique		Description
Deliberative	In-depth discussion groups	Group discussions (usually 4-8 people; often repeated), during which participants shape the terms of discussion, and develop themes relevant to their own needs and priorities.
	Citizen's juries	A small cross section of the general public work together to come to a considered judgement about a stated policy issue or problem through detailed exposure to, and scrutiny of, the relevant evidence base. The group responds by providing a recommendation or 'verdict'.
	Deliberative opinion polls	A large citizen test group learns about a topic and the evolution of their views is observed. Typically, the group votes on the issues before and after an extended debate.
Analytical-deliberative	Participatory modelling	Stakeholders are involved in the design and content of analytical models that consider ecosystem services and their benefits under different spatial and temporal conditions.
	Deliberative monetary valuation	Formal methods of group deliberation are used to reach decisions about monetary values for ecosystem services. May be allied to survey-based techniques (e.g. contingent valuation or choice experiments), or use a non-econometric approach to establish monetary values (e.g. by incorporating citizen's juries).
	Deliberative multi-criteria analysis	Groups of stakeholders design formal criteria against which to judge the non-monetary and monetary costs and benefits of different management options as the basis for making a decision.
Interpretive, potentially deliberative	Participatory mapping/GIS	A group of stakeholders consider, or create, a physical or digital map to indicate landscape features that are valuable and/or problematic. Participants may also rate or rank the importance of these features. Map layers can incorporate a range of media, including photos, video, artwork and literature.
	Storytelling	Participants tell stories about their experiences of, or in relation to, certain locations. Groups of participants may reflect on these experiences together in order to discuss shared values.
	Interviews	Participants are interviewed about their beliefs and preferences. Group interviews allow for deliberation and are similar to in-depth discussion groups. In group interviews, however, terms are set by the interviewer rather than the group.
Interpretive	Media analysis	A range of textual analysis tools (particularly content, frame and discourse analysis tools) are used on (mass) media outputs and social media content over a selected period of time.
	Desk-based cultural history study	This approach can be used to quickly scan existing literature over a specified period of time to identify values connected with the decision-making being considered. The study can cover academic and grey literature, as well as creative writing (prose and poetry). Historical analysis can deliver understanding of past value and belief conflicts that can help to better manage present issues and mitigate risks.
	Other interpretive methods	A wide range of qualitative techniques are used to study shared values, such as ethnography and participant observation, genealogy, life history methods, dramaturgical analysis, and textual analysis of various sorts including discourse, content and frame analysis.
Psychometric deliberative	Values compass	Participants consider which of their individual transcendental values are most important by ranking or rating them. They then discuss the degree to which these transcendental values are important for their community, culture or society. Transcendental values may also be ranked or rated on a group basis.
Psychometric	Subjective well-being indicators	Subjective well-being indicators are used to assess how places contribute to human well-being, and the degree to which they contribute. These indicators are highly suitable for providing quantitative non-monetary values for cultural ecosystem services.
	Other psychometric	Psychometric testing measures psychological phenomena and processes, such as knowledge, experience, attitudes, values, beliefs and norms. Psychometric models can be used to better understand the impact of deliberative processes on shared values.

An extended table, with spatial scales, time scales and resources required, can be found in WPR 6 Table 18 and the associated manual on shared values for decision-makers.

In both the Inner Forth and MPAs workshops, individuals were asked what they would be willing to pay ('willingness-to-pay' [WTP]) for a range of ecosystem services. In addition, participants were also asked to decide as a group what might be a 'fair price' to pay for improvements in ecosystem services from their perspectives as community members (Inner Forth), or divers and sea anglers (MPAs). The evidence from both the Inner Forth and MPAs workshops shows clear differences between individual and group values. Overall, WTP decreased substantially when the group decided (by 45% to 73% for the Forth depending on the ecosystem service, and on average by 51% for the MPAs case study), and priorities for the allocation of resources to improve ecosystem services became more targeted, with a stronger focus on protecting biodiversity (WPR 6.4.2 and 6.4.3).

It was also found that group-based monetary values arising from the Inner Forth and MPAs workshops better reflected non-monetary measures of human well-being. Having to decide on what others should pay brought about substantial debate as to whether a tax rise (Inner Forth) or suggested donation (MPAs) was 'just' or might be detrimental to the well-being of some or all of society (WPR 6.4.2 and 6.4.3). Discussions about justice focused on:

■ what the benefits really meant, and which benefits were ultimately most important, including in the long-term;

■ who would benefit from improving ecosystem services, for example, the whole society or just a section of the people paying;

■ competing priorities, in particular, which environmental concerns the money should be spent on, or whether non-environmental social concerns like education and health were more important;

■ duties to other species and future generations; and

■ responsibilities, i.e. whether local people were responsible for local sites, or everyone had to 'do their bit' towards societal goals, such as protecting biodiversity.

The Hastings case study provided a different model of how shared values could be assessed. Here, a group of stakeholders spent three afternoons together doing a beach walk, storytelling, discussing communal values, performing systems modelling, visioning and multi-criteria analysis, and developing policy packages and budgets for Hastings in 2030. Through a process of democratic deliberation, and through an enhanced understanding of the motivations for various values attributed to the marine environment, participants came to a consensus regarding their shared values. Instead of focusing on conflicts, participants actively sought synergies across dimensions and solutions that did justice to both shared values and different interests. For example, investing in a harbour arm would help fisheries to adapt to sea level rise, while also supporting cultural identity by protecting the fishing fleet (WPR 6.4.3).

Finally, through the analysis of content and discourses in media outlets, we were able to recognise both overarching societal and cultural values relating to the coast and the marine environment. The coast in the media case study shows a distinct relationship between the material loss of coastline from erosion and shared values regarding national culture, heritage, tradition and identity. Media stories concerning the loss of coastline framed it as a 'collective loss' that compromised shared values on the natural environment. Despite such examples, other media stories also clearly revealed different sets of self- and other-regarding values between different interest groups, and the (potential) conflicts between them. This may help predict where conflict could occur as a result of a new policy, and how potential tensions might be prevented or managed better by decision-makers. As such, this approach is a promising avenue for characterising societal and cultural values at a large scale (WPR 6.4).

These studies illustrate that combining monetary and non-monetary, deliberative and interpretive methods can deliver a more comprehensive valuation of ecosystem services that provides a rich understanding of the meanings and significance of individual and shared values (WPR 6.4.6). By inquiring into our emotional, spiritual and cultural connections to the environment, individual and shared values can be incorporated into decisions, and trade-offs can be sensibly discussed. The shared and cultural values relating to ecosystems and cultural ecosystem services have, so far, not played a prominent part in many project and policy appraisals. Better consideration of these values can help safeguard the contributions of cultural ecosystems services to well-being and encourage more public engagement with environmental issues. It may also help to ameliorate conflicts between environmental and other interest groups, which flare-up in a range of policy contexts. Within the policy cycle, and guided by the goal of sustainable development, there are opportunities to extend the 'ethical envelope' and formally recognise that values are plural and not one dimensional. These UK NEAFO case studies offer signposts towards a better understanding of the significance of emotional, spiritual and cultural connections to the environment and their role in trade-off decisions (WPR 6.4.6 and 6.5).

1.4.7 How can plausible future scenarios help us to understand, manage and communicate the consequences of changes in ecosystem services across all scales?

To answer this question, the UK NEAFO recognises two fundamental strands in the way future scenarios can be used. Firstly, scenarios must be capable of facilitating deliberative processes between stakeholders. And, secondly, scenarios must be capable of supporting the development of analytical products. Both strands must be pursued if the six contrasting scenarios presented in the UK NEA (**Box 5**) are to be used effectively to support decision-making. Although it is useful to distinguish between the 'process' and 'product' strands, they are, in fact, mutually supporting and deserve equal attention (WPR 7.1.2). The six UK NEA scenarios have been found to be sufficiently rich and comprehensive enough to support debate with stakeholders across a wide range of topics relevant to current policy concerns (WPR 7.2). Also, the scenarios can aid understanding of plausible future changes by providing a way in which a range of mechanistic models can be applied to generate analytical products (WPR 7.3). This has helped the UK NEAFO to test the plausibility of the scenarios themselves, allowing us to extend the insights derived from them (WPR 7).

[7] Haines-Young et al 2011, The UK NEA Scenarios: Development of Storylines and Analysis of Outcomes, Chapter 25 pp. 1196 – 1272, in the UK NEA Technical Report. UNEP-WCMC, Cambridge: http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

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Box 5: Descriptions of the six future scenarios developed by the UK NEA, 2011[7]. All six scenarios share the common characteristics of a decline in global resource availability and an ageing UK population. They also include some level of anticipated technical innovation, although this depends on the sectors involved. Source: Modified from the UK NEA 2011.

A preservationist attitude arises because the UK can afford to look after its own backyard without diminishing the ever-increasing standards of living.

Green and Pleasant Land

Go with the Flow

Nature @ Work

This scenario is essentially a projection based on current trends and results in a future UK that is roughly based on today's ideals and targets.

The belief that the promotion of ecosystem services through the creation of multifunctional landscapes is essential for maintaining the quality of life in the UK is widely accepted.

UK NEA scenarios

Local Stewardship

World Markets

National Security

This is a future where society is more concerned with the immediate surroundings and strives to maintain a sustainable focus on life within that area.

High economic growth with a greater focus on removing barriers to trade is the fundamental characteristic of this scenario.

Under this scenario climate change results in increases in global energy prices forcing many countries to attempt greater self-sufficiency (and efficiency) in many of their core industries.

The different plausible future worlds are based upon contrasting societal priorities, which change the balance of both direct drivers (climate change, habitat conversion, pollution, etc.) and indirect drivers (cultural, demographic, economic, socio-political, technological, etc.). In turn, these influence the way we use our land, freshwater, coasts and seas. For example, *World Markets* is "a vision of unfettered economic growth" with a focus on removing trade barriers. As a consequence, imports increase, environmental perspectives are largely ignored, and non-market-based response options have little relevance, possibly even having negative effects on some ecosystem services, such as cultural services. In contrast, *Nature@Work* has a very "strong emphasis on maintaining ecosystem services through all sectors". This scenario is inherently about resolving trade-offs between ecosystem services, in order to sustain multi-functional ecosystems. Subsequently, it emerges as more receptive to a wide set of response options, usually resulting in a more positive outcome for all ecosystem services.

The UK NEAFO showed that scenarios can be a powerful deliberative process aiding understanding for both stakeholders and researchers alike. Through engagement with different groups of stakeholders, it became clear that the original UK NEA scenarios are considered to be both plausible and relevant to a wide range of stakeholder concerns. Also, the scenarios appear to have significant potential as tools for developing dialogues between people with differing interests and perspectives (WPR 7.2.3 – 7.2.4). Importantly, the deliberative methods provided two-way feedback, with the contributions of stakeholders enriching the scenarios themselves, allowing us to see new perspectives and gain further insights from them (WPR 7.2.5). In fact, it became clear from discussions that the UK NEA scenarios are already being used independently by Scottish Government, Defra Noise Futures and a number of research institutes, including Forest Research. In addition, a workshop in Northern Ireland showed that the scenarios can be successfully adapted to a single region and specific locations within it (WPR 7.4).

Although the UK NEA scenarios 'worked' for environmental policy-makers and researchers when they were exposed to them, it is apparent that more needs to be done to embed them into the thinking of the broader stakeholder community if their full potential is to be realised. To achieve a wider uptake of the scenarios, there is a need to find ways to both communicate the relevance of them to different stakeholders, and to present the ecosystem services framework as a useful tool in decision-making. This will help stakeholders to use the scenarios actively in debates. It is crucial that relevant and accessible scenario analyses and products are provided to inform and stimulate debate. It is also necessary for facilitators to have the flexibility and time to allow the narratives of the scenarios to develop and to explore the way people might live in these future worlds. Yet, the time required to work with scenarios might be too long for many of those engaged in policy development, so more indirect ways of developing the scenarios with policy-makers may be required. For instance, it may be fruitful to work with 'champions' – people who advise managers and can act as knowledge-brokers explaining the ecosystem services framework and Ecosystem Approach. This was found to be very useful in the application of the scenarios in the marine environment. Another approach might be to complement the 2060 time horizon with shorter-term (e.g. five year) versions that would be more compelling and relevant to the shorter timescales of a lot of policy-making (WPR 7.2.4 and 7.2.5).

Four topic areas were used to examine how current modelling approaches could support the development of analytical 'products' to enrich the debate surrounding changes in the delivery of ecosystem services within and between the UK NEA scenarios. These topic areas were:

(i)   Futures for farmland birds – modelled the different trade-offs between, and co-benefits with, other ecosystem services under the different scenarios (WPR 7.3.3).

(ii)   Risks of flooding and drought – used established hydrological models to illustrate the trade-offs in the risk of flooding and drought under the different scenarios (WPR 7.3.2).

(iii)   Impacts on the marine environment – modelled the likely impacts of the different scenarios on the delivery of ecosystem services in the marine environment at a regional level. Also, the effects of shock events, such as shading by volcanic dust, or pollution from an overtopping of the Thames Barrier were explored (WPR 7.3.4).

(iv)   Impacts on cultural ecosystem services – used national-scale survey data from the Monitor of Engagement with the Natural Environment (MENE) data to model cultural ecosystem services under the different scenarios (WPR 7.3.5).

The richness of the analytical opportunities that the UK NEA scenarios provide was demonstrated by the analysis of trade-offs and co-benefits between the abundance of farmland birds and other ecosystem services. The UK NEAFO modelled the annual
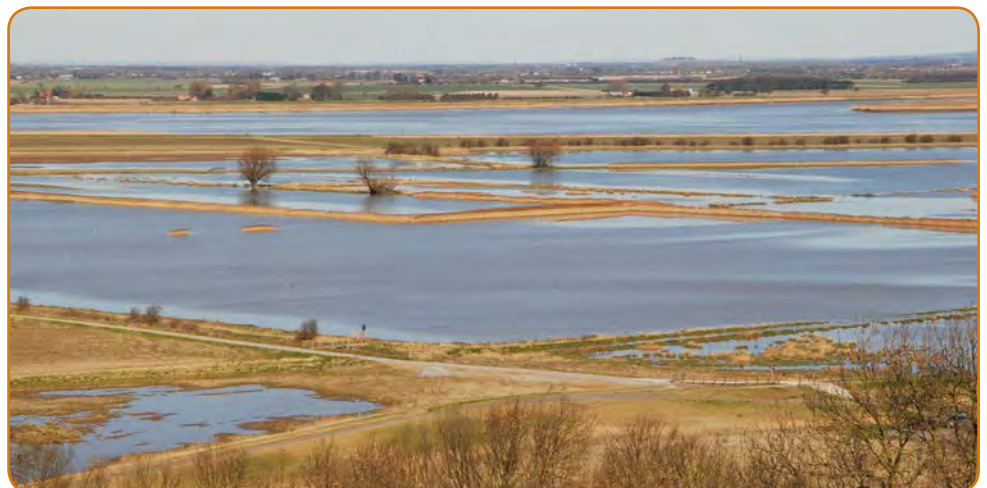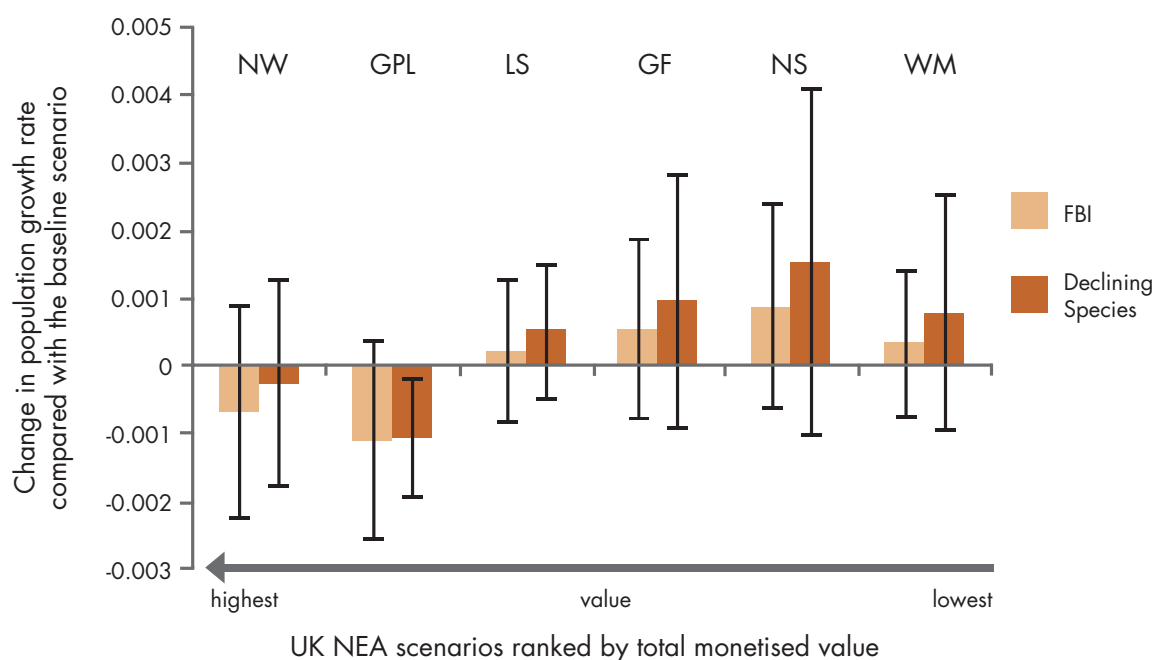
Figure 18. Projected changes in population growth of all 19 farmland bird species in the Farmland Bird Index (FBI; light orange bars), and the 11 species already declining (dark orange bars), under each of the UK NEA scenarios. Ranked by total monetary value from highest (left-hand side) to lowest (right-hand side). The vertical lines show the ±95% confidence interval.. Key to scenarios: NW = Nature@Work; GPL = Green and Pleasant Land; LS = Local Stewardship; GF = Go-with-the-Flow; NS = National Security; WM = World Markets.

population growth rate of each of the 19 species used to calculate the Farmland Bird Index, taking into account changes in land use under each of the six scenarios. The only statistically significant result was a further reduction in population size for a subset of 11 species already declining under the *Green and Pleasant Land* scenario (**Figure 18**); under the other scenarios, changing land use appears to have relatively little impact on bird populations. However, a negative correlation between bird population growth and increasing monetary values for other ecosystem services (as measured by the UK NEA) was evident across the six scenarios. This seems to be because the area of arable crops declines most sharply under the *Nature@Work* and *Green and Pleasant Land* scenarios. This decline in the area of crops is partly due to a reduction in oil seed rape, cereal and sugar beet, and partly the conversion of arable land to other habitats, such as woodland, that are important for other ecosystem services, rather than food production. Thus, farmland bird populations decline under these scenarios. In contrast, in the *World Markets* and *National Security* scenarios, cereal production is maintained at the expense of other types of crops and alternative land uses. As a result, seed eating bird populations are less impacted under scenarios with more intensive farming. Taken together, these results imply a trade-off between the monetary values of certain ecosystem services and the conservation of farmland birds, particularly seed-eating species (WPR 7.3.3.2 – 7.3.3.3). This highlights

the need to consider the specific impacts of land use change on biodiversity alongside other ecosystem services. This apparent trade-off reinforces the conclusions of the enhanced UK NEAFO Land Use Integrated Model (TIM; p. 26-29) and the systematic evaluation of response options (p. 42-45), both of which recognise that spatially targeted policies may be the best way to increase the efficiency of the delivery of a wide range of ecosystem services.

The UK NEAFO development of analytical products demonstrates the potential of the UK NEA scenarios as new tools to help people in their thinking about the future. One such tool which the UK NEAFO has developed already is a Bayesian Belief Network – this provides rapid, interactive access to the MENE database. A web-based version of this Bayesian Belief Network is now available and can be used to explore the UK NEAFO's evolving conceptual framework for Cultural Ecosystem Services (p. 32-35)[8]. Within this tool, there is the capacity to link to the geography of the 2011 census. For the first time, this offers users the potential to explore the effects of changes in socio-demographic make-up within the scenarios on the use of environmental spaces and the frequency of different cultural practices, including exercising and playing (WPR 7.3.5).

[8] http://nea-scenarios.hugin.com/

Final Ecosystem Service	Region	Baseline (1)			Baseline (2)			National Security			World Markets			Global Community			Local Stewardship		
		SEE	N&W &W	SC	SEE	N&W &W	SC	SEE	N&W &W	SC	SEE	N&W &W	SC	SEE	N&W &W	SC	SEE	N&W &W	SC
Wild fish/shelfish/seaweed		-1	1	5	-5	1	6	1	1	1	-18	-18	-13	20	20	20	12	13	13
Cultured fish/shelfish/seaweed		7	9	16	2	5	13	-2	2	5	1	16	18	3	10	10	10	9	14
Genetic resources		1	4	4	-1	0	2	-6	10	-8	-14	-14	-14	0	0	0	6	8	8
Climate regulation		1	4	3	1	2	4	-5	2	-8	-16	-18	-18	18	10	10	-3	-3	-2
Natural hazard protection		5	6	3	2	3	4	-9	-6	-4	-10	2	-2	18	10	10	5	7	7
Waste breakdown/detoxification		2	4	4	3	4	4	-9	-7	-5	-12	-4	-4	1	10	10	5	8	5
Meaningful places - Socially valued seascapes		3	8	7	2	6	9	8	5	7	-18	-5	-9	1	10	10	8	8	8

Figure 19. Expert opinions about the relative change in delivery of marine ecosystem services under five different scenarios in three British sub-regions: South East England (SEE); North and West England and Wales (NWW); and Scotland (S). Green is positive (good, max. score +20); white is relatively little change; and orange is negative (bad, max score -20). The *Go with the Flow* scenario was assessed by the group before (Baseline 1) and after (Baseline 2) the deliberations. Since marine systems are open and heavily influenced by global and regional policies, a *Global Community* scenario was devised and tested (emphasising wider international factors and increased globalisation of governance in the maritime environment), rather than the *Nature@Work* and *Green and Pleasant Land* scenarios designed for terrestrial environments. All other scenarios are those from the UK NEA.

Finally, the UK NEAFO explored the effects of the scenarios on the marine environment in much more depth. Some modelling was used to produce likely outcomes for fish stocks and carbon sequestration, but a deliberative process garnered 'expert opinion' in order to explore a wider range of ecosystem services. The 'experts' came to the view that the *World Markets* and, to a lesser extent, the *National Security* scenarios would likely lead to the degradation of most marine and coastal ecosystem services. In contrast, the *Local Stewardship* and other 'greener' scenarios would lead to improvements in ecosystem services, in general (**Figure 19**). This contrast is because the dominance of the market in *World Markets* leads to overexploitation of wild fish stocks, little regard for environmental pollution and less interest in coastal defences (with exceptions like London and the major ports). In comparison, priority is given to environmental sustainability in the greener scenarios, and the reactive and partial nature of governance in *National Security* results in a more neutral outcome for fisheries but deterioration in the delivery of regulating services. Regional differences in the delivery of ecosystem services are expected under all scenarios; typically, resulting in a gradient of change in

ecosystem services from South East England (where population and pressures are highest) to Scotland (where pressures are lower and the environment is suitable for aquaculture) (WPR 7.3.4).

1.4.8 What response options might be used to improve policy and practice for the sustainable delivery of ecosystem services?

The UK NEAFO has evaluated a range of ways in which decision-makers might respond to, or intervene in, different societal issues in terms of their ability to sustain the delivery of ecosystem services. Information from the natural, economic and social sciences has an important role in the design of such 'response options', but the challenges of a rapidly changing world mean that new approaches are required to enhance resilience and adaptability of ecosystems. Nearly 50 response options were 'stress-tested' to see how robust they are under both present conditions and the plausible UK NEA future scenarios, which include the potential compound effects of

climate change. This allowed an evaluation of the strengths and weaknesses of individual response options, as well as the identification of which response options may be more robust when used together. The response options considered included conventional interventions, such as statutory regulation, planning and protected areas, as well as more novel initiatives, such as voluntary or market-based schemes and the role of partnerships and networks. Specific emphasis was placed on cross-sectoral issues (including existing barriers to sectors working together) to enable a more strategic application of the Ecosystem Approach at multiple scales. To facilitate this cross-cutting role the UK NEAFO reviewed a series of long-term topical policy issues, including the transition to the low carbon economy and the EU Water Framework Directive that could potentially benefit from further integration (WPR 8.1 and 8.2).

Not surprisingly, the sustainable delivery of ecosystem services cannot be guaranteed by individual response options in isolation, but is best addressed by combining appropriate response options. Most response options have been designed around very specific requirements that constrain their scope and limit their flexibility for managing changes in time, or differences across locations. For instance, market-based schemes can create new investment in ecosystem services and improve efficiency in delivery of such services, but are exposed to market volatility (i.e. if markets prices fall, ecosystem services may suffer from a decrease in investment). Therefore, they are best accompanied by regulation, or other safeguards (e.g.: insurance bonds), to ensure minimum standards of investment are continued regardless of changes in the market. However, regulation and other statutory top-down approaches can be slow to adapt to changing circumstances (such as climate change), and so need to incorporate appropriate safety margins (e.g.: through 'headroom' concepts) in order to anticipate rather than react to changes in supply and demand for ecosystem services. To counter the risks from pure market-based schemes, innovative hybrid programmes with the potential to improve the delivery of ecosystem services before the onset of degradation,

such as offsetting and incentive payments, may allow greater flexibility and adaptability. These schemes need to be carefully designed, however, to ensure that certain ecosystem services are not targeted for investment at the expense of others. Ecosystem services that may be vulnerable to such targeting include those that provide less tangible market benefits, those that have a more localised value, and those that deliver more long-term than short-term benefits. In general, targeting response options to specific areas may be the best way to cope with the spatial differences in ecosystem services, thereby maximising both the efficiency and long-term effectiveness of such interventions. This conclusion is reinforced by the fact that the evaluation of which response options are appropriate for which situations can be constrained by a lack of knowledge of cultural and supporting ecosystem services across different areas. Both these types of services differ considerably depending on location, and are a key factor in landscape change. As a consequence, interventions that support community-based initiatives can have an important role to play because these initiatives are often built on local awareness of multiple benefits arising from local ecosystems, particularly cultural ecosystem services (WPR 8.4).

More can be learned about the future robustness of different response options by testing them against the UK NEA scenarios. The cross-sectoral overview (**Figure 20**) showed that statutory and regulatory responses may deliver successful outcomes in some scenarios (such as *Nature@Work* and *National Security*), but may be less effective where market forces dominate (*World Markets*), or local agendas take over (*Local Stewardship*). By contrast, economic incentives and market-based schemes that have greater support and potential to deliver ecosystem services under the *World Markets* scenario may be less successful within the *National Security* or *Local Stewardship* scenarios, unless they complement national and local priorities, respectively. However, for some of the economic incentive schemes highlighted in Figure 2, we currently have rather limited evidence, so further testing may be required (WPR 8.3.1).

A selection of possible response options to illustrate the range of likely outcomes	Relevance				Positive net effect on ecosystem services			
	N@W	WM	NS	LS	P	R	C	S
Statutory protected/designated areas:								
Protected areas	High/Med	Low	High/Med	High/Med	0	3	2	3
Marine no-take zones (nursery areas)	High/Med	Low	Low	High/Med	4	2	0	4
Statutory/regulation and quality standards:								
UK Forestry Standard	High/Med	Low	High/Med	Low	2	1	1	1
Water Framework Directive	High/Med	Low	High/Med	Low	1	2	2	2
Compulsory set-aside	High/Med	Low	Low	High/Med	0	2	0	2
EU energy legislation	High/Med	Low	Low	Low	1	1	1	1
Conservation measures in fisheries	High/Med	High/Med	Low	High/Med	4	2	0	4
Direct economic incentives/market-based schemes:								
Payments for Ecosystem Services (outcome-based)	High/Med	High/Med	Low	Low	2	4	2	2
Grant aid for spatial woodland targeting	High/Med	Low	High/Med	Low	3	1	1	1
Biodiversity offsetting (national level)	High/Med	High/Med	High/Med	Low	2	2	0	1
Agri-environment schemes	High/Med	High/Med	High/Med	High/Med	2	3	2	3
Water demand-side measures	High/Med	High/Med	High/Med	High/Med	1	3	2	2
Spatial and integrated planning:								
Land sparing	High/Med	Low	Low	Low	3	1	0	0
Sustainable Urban Drainage Systems (SUDS)	High/Med	Low	High/Med	High/Med	0	3	2	2
Ecological networks	High/Med	Low	High/Med	High/Med	0	3	3	3
Multi-functional green infrastructure	High/Med	Low	High/Med	High/Med	3	3	3	3
Integrated catchment management	High/Med	High/Med	Low	High/Med	2	2	2	2
Marine plans	High/Med	High/Med	High/Med	High/Med	2	2	2	2
Management practices:								
Mitigation of diffuse pollution	High/Med	Low	Low	High/Med	0	2	2	2
Natural flood management	High/Med	Low	High/Med	High/Med	2	2	2	2
Voluntary standards and quality assurance:								
Woodland carbon code	High/Med	High/Med	Low	Low	2	2	0	0
Fisheries certification	High/Med	High/Med	Low	High/Med	3	2	2	0
Social and cultural networks, partnerships and community schemes:								
Urban food production	High/Med	High/Med	High/Med	High/Med	4	3	2	2
Agricultural networks, associations and initiatives	High/Med	Low	High/Med	High/Med	3	3	3	3
Community woodland groups	High/Med	Low	Low	High/Med	2	2	2	2
Nature-based partnerships	High/Med	Low	High/Med	High/Med	0	3	3	3
River Trusts	High/Med	Low	Low	High/Med	2	2	2	2

Figure 20. Cross-sectoral assessment of all response options, the relevance of response options in each scenario and their aggregated performance in delivering types of ecosystem services. Key to selected scenarios: N@W = Nature@Work; WM = World Markets; NS = National Security; LS = Local Stewardship. Key to ecosystem services: P = Provisioning; R = Regulating; C = Cultural; S = Supporting. The net effect on ecosystem services is calculated as the number of scenarios which have a positive score, after a deliberative process to reconcile any individual differences in scores (range: 0-4). Schemes with greater uncertainty or dependence on context have light orange shading.

In comparison, local and community partnership schemes appear more effective in delivering ecosystem services under both *Nature@Work* and *National Security* scenarios, as well as a *Local Stewardship* future but have little support in the *World Markets* scenario. This suggests that a combination of each of these three types of response options (statutory and regulatory, economic incentives and market-based schemes, and partnerships and networks) may collectively produce a more robust design for policy development. This is especially true if the design could be adapted across scales, for example, involving local partnerships in shaping local objectives. Combining response options could also address some of the issues relating to the uncertainty of long-term outcomes for market-based schemes by using regulation to identify minimum standards of ecosystem service delivery, but encouraging innovation that goes beyond these minimum standards.

The UK NEAFO highlights the use of the existing 4 'I's framework (Institutions, Information, Incentives, Identity) for assessing complementary response options (WPR 8.1.4). This approach shows that there are currently basic institutional barriers that impede the adoption of the Ecosystem Approach and therefore constrain a more coordinated and robust response to change (WPR 8.3.8). Furthermore, it suggests that knowledge exchange and the targeting of incentives could be better achieved through a clearer recognition of the importance of local place-based identities which strongly influence cultural ecosystem services (WPR 8.3.9 and 8.7.4). Consequently, some flexibility will be required when implementing schemes locally in order to achieve genuine inclusive and synergistic outcomes.

The stress-testing the UK NEAFO performed showed that the robustness of response options across the four UK NEA scenarios varied in each sector. For example:

■ Agriculture: The most effective response options in agriculture are those that develop and disseminate knowledge, technology and practice because these appear to support the delivery of ecosystem services under all scenarios, to a greater or lesser extent. Such response options include appropriate agri-environment schemes or Payments for Ecosystem Services (PES) schemes (WPR 8.3.2).

■ Forestry: This sector already incorporates features of adaptive management because of the long-term planning horizons it requires. Therefore, response options that further develop adaptive knowledge-based initiatives, such as collaborative management groups, advisory services and visits, and community woodland groups, may be most effective in delivering ecosystem services (WPR 8.3.3).

■ Biodiversity: A key requirement for this sector is to integrate its objectives with other sectors. In a changing world the response options that are most likely to achieve this include greenspace and ecological networks, agri-environment schemes, and local partnerships. It should be noted that the differences in both species and habitats across locations will require the targeting of response options, although protected areas should continue to be an important intervention in key locations across the UK (WPR 8.3.4).

■ Water: The response options that are the most robust for the water sector are integrated planning (e.g. 'blue' networks, River Trusts and Sustainable urban Drainage Systems; (SuDS). These provide a range of ecosystem services and are flexible enough to adapt to a variety of different future conditions (WPR 8.3.5).

■ Urban (including energy and transport): The most robust response options for this sector are those related to spatial and integrated planning, and scientific research and development. The latter develops and communicates knowledge on the multiple benefits of urban ecosystems, including greenspace and blue and green networks (WPR 8.3.6).

■ Marine and coastal: In the marine environment, the response options that are the most robust include no-take zones and fisheries conservation. If these are effectively targeted (e.g. nursery areas) then they can enhance market potential (due to the mobility of fish stocks) as well as ecosystem integrity. However, a key limitation for the sector is the general availability of analytical information and the lack of consideration of cross-boundary issues when deciding on interventions or responding to change (WPR 8.3.7).

A common requirement across these different sectors is a more systematic framework to monitor and communicate different aspects of present and future change (including both direct and indirect effects), and, in particular, to better understand adaptation to climate change.

The UK NEAFO concludes that the effective implementation of a range of response options to achieve the best ecosystem service outcomes in different situations entails institutional flexibility and close collaboration. Today, many organisations are bound by narrow interpretations of their institutional responsibilities and have constraints on their implementation of response options, whether through legislation, the application of common law, or the provision of stakeholder advice. These institutional constraints may inhibit the realisation of joined-up outcomes across ecosystem services, as well as opportunities for coordinating the management of change. As a consequence, the UK NEAFO concludes that collaborative stress-testing in workshops can enable better evaluation of response options, to provide a wider spectrum of knowledge, to enhance the learning process, and to ensure that actions are coordinated for multiple benefits as guided by the principles of the Ecosystem Approach (WPR 8.4).

1.4.9 What constrains and enables the use of knowledge about our ecosystem services in decision-making?

The UK NEAFO reveals that there are three levels of institutional behaviour and culture which influence whether knowledge about ecosystem services is, or is not, used in systems of appraisal. These levels are: practitioner behaviour (*micro-level*); institutional culture (*meso-level*), and societal and political context (*macro-level*) (**Table 3**) (WPR 9.3). The research evaluates three types of appraisal commonly used in the UK and other countries of the Organisation for Economic Cooperation and Development (OECD): (i) Impact Assessment (IA), which is used at national policy level; (ii) Strategic Environmental Assessment (SEA), which is used at plan and programme level; and (iii) Environmental Impact Assessment (EIA), which is used at project level (WPR 9.2). Given the traction of these longstanding appraisal systems within policy- and decision-making, they are critical areas for embedding ecosystem service knowledge. Even within the more localised and detailed SEAs and EIAs, many of the elements of the Ecosystem Services Framework[9] are not explicitly embedded. As a result, acquiring more knowledge about ecosystems and the impacts of policy interventions on their services does not mean that it will be used in appraisal and decision-making. Our evaluation used three sources of information to reach its conclusions. Firstly, through a comprehensive review of the extensive literature published on appraisal, including academic books and journal articles, consultancy reports and government reviews (WPR 9.4). Secondly, through the analysis of a large sample of appraisal documents published between 2008 and 2012 to examine how far the Ecosystem Services Framework has been considered in recent policies (IA: N=75), programmes/plans (SEA: N=49) and projects (EIA: N=50) (WPR 9.5). Thirdly, through a total of 32 interviews with practitioners who undertake, oversee and are affected by appraisals (WPR 9.6). This helped us to investigate the patterns we observed in our literature and appraisal reviews, and better understand the validity of the lessons we drew from our analysis (WPR 9.7).

Overall, the UK NEAFO shows that appraisal practice falls short of political ambitions to embed the Ecosystem Services Framework into decision-making more widely. Where elements of the Framework were present, it was only implicitly covered in a broader environmental framing, rather than explicitly embedded. This may

[9] HM Treasury (2003) The Green Book: Appraisal and evaluation in central government [online] http://www.hm-treasury.gov.uk/d/green_book_complete.pdf

Table 3. Examples of key barriers to, and enabling measures for, embedding the Ecosystem Services Framework (ESF) into three types of appraisal (IA, SEA and EIA) across different institutional levels. The evidence is drawn from a review of academic literature, analysis of published appraisals (between 2008-2012) and interviews with those involved in appraisals.

Level	Examples of key barriers	Examples of enabling measures
Practitioner behaviour (*micro-level*)	• Resources and capacity, including data, time, money, skills, training and guidance • Limited awareness of the ESF concept • Difficulty understanding the ESF concept	• Better integrated datasets relevant to the ESF • Awareness raising of the ESF, highlighting its value for government and society • Tailoring language to different audiences • Demonstration projects to show how the ESF contributes to, and works in, practice
Institutional culture (*meso-level*)	• Fragmented working across departments and levels of governance • Different legal requirements across appraisal levels and types • Narrow focus of appraisals	• Stronger high level leadership with statutory control measures • Integrating the ESF into existing institutional mechanisms and processes • Better integration of institutional mechanisms and cooperation between institutions to join-up policy • Creating vehicles to encourage communication and learning across actors and sectors
Social and political context (*macro-level*)	• Underlying societal values and, therefore, political priorities are not aligned with ecosystem protection (e.g. pressures to reduce environmental regulation)	• Using the ESF as platform for debate and enhanced dialogue among stakeholders • Using political 'windows of opportunity' such as floods and media interest • Encouraging partnership between government, non-government and international bodies to use and promote the ESF

be because the Ecosystem Services Framework is a relatively new concept, so requires more time to gain standing among practitioners. At the same time, it must be recognised that the Ecosystem Services Framework may not always be 'fit-for-purpose', particularly in non-environmental contexts where it may not add value to the policy agenda. In such circumstances, resources could be wasted trying to promote the Framework where it has little immediate relevance or likelihood of being used. However, this does not mean that the other 11 principles of the broader Ecosystem Approach (see Box 2 p, xx) should not be considered in order to ensure that different policy agendas are systematically reviewed with regards to their impacts on the environment (WPR 9.5).

The evidence from the literature review, appraisal documents and interviews shows that, across all three types of appraisal, there are recurring barriers to embedding the Ecosystem Services Framework into policies, plans, programmes and projects (WPR 9.6). Yet, from the interviews, a number of measures to improve the use of the Ecosystems Services Framework were suggested (Table 4).

At the practitioner behaviour level, a lack of resources, particularly time and data, and a limited awareness and understanding of ecosystem services are key barriers. Relevant enabling measures include better integrated datasets, accessible language and demonstration projects. At the level of institutional culture, barriers include fragmented working across sectors and governance levels, the narrow focus of appraisals and confusing differences in legal requirements. Enabling measures for this level include strong leadership, mechanisms to join-up interacting policies, advocacy of the Ecosystem Services Framework, and improved communication across actors and sectors. Crucially, a key barrier in the social and political context is the limited appreciation of the dependency of human well-being on ecosystem services. In part, this is because there is a need for better communication of the case for the Ecosystem Services Framework in terms that make sense to specific audiences. Currently, certain audiences do not see the added value of the approach, even if they do understand the basic concept. Other enabling measures, at this level, include a more inclusive stakeholder debate, and the recognition of the need for government and non-government institutions to work together, supported by leaders of international organisations. Across all three levels, it is clear that better communication between knowledge producers, brokers and users is crucial to our understanding of how knowledge can be tailored to the context in which it is intended to be used (WPR 9.7).

When considering the different types of barriers and enabling measures it is also important to be aware of the interaction between levels. This is particularly true of the practitioner behaviour and institutional culture levels, but the societal and political context is often more autonomous. For example, the quality of political leadership (institutional culture level) can influence the amount of resources available to practitioners. Likewise, the way in which the Ecosystem Services Framework is communicated (practitioner behaviour level) may affect the ability to integrate it into existing procedures (institutional culture level). Ultimately, finding the right

suite of enabling measures to overcome the key barriers within a given institutional or policy-making setting is what matters. Success requires a combination of political leadership and opportunism, as well as, a commitment to engage in joint learning exercises, coupled with the institutional capacity to develop, synthesize and use knowledge on ecosystems services to inform decisions (WPR 9.4 and 9.8).

Finally, each of the three types of appraisal (IA, SEA and EIA) has advantages and disadvantages in terms of their potential for improving the embedding of the Ecosystem Services Framework into policies, plans, programmes and projects. The fact that SEAs and EIAs are legally mandated can act both as a barrier and as an enabling measure at the institutional culture level. Both appraisal types require an assessment of environmental impacts to the standards laid down in the relevant EU Directives. However, while environmental analysis is guaranteed, and EIAs, in particular, provide greater opportunities for stakeholder engagement at the local level, the legal standards mean that appraisers may be unwilling to embed the Ecosystem Service Framework for fear of not conforming to guidance and the risk of judicial review. To counteract this barrier, the Ecosystem Services Framework could have been better incorporated into EIAs through a revision of the EIA Directive but a recent review of the EIA Directive makes this unlikely. Another, less hierarchical approach, would be to provide demonstration projects showing how the Ecosystem Services Framework can enhance appraisal, while still meeting legal requirements. When conducting a policy level IA (and, to a lesser extent, an SEA), there is scope for more strategic decision-making regarding the environment as national policy sets the scene for the development of programmes and plans. Despite this opportunity, the broader perspective of IAs, and their concern with the reduction of regulatory burdens, means that they are much more likely to be geared to the strategic needs of the sector in which they are being applied. As a result, cross-cutting initiatives like the Ecosystem Services Framework are in danger of being squeezed out. This may account for the very low incidence of the embedding of ecosystem services in IAs (compared to SEAs and EIAs) revealed in our review of appraisal documents (WPR 9.5 and 9.7).

1.4.10 How can we embed the Ecosystem Approach and an Ecosystem Services Framework into effective advice and tools for improved policy- and decision-making?

To address this question, the UK NEAFO brought together research, policy and practice from different disciplines, sectors and professions to develop a set of tools and methods to support decision-making. These tools and methods have been integrated into an independently produced web-portal (the National Ecosystem Assessment Toolkit; NEAT Tree[10]) which displays co-produced advice on embedding ecosystem thinking into existing tools and techniques used in policy- and decision-making processes. Developing this advice involved identifying existing tools (WPR 10.6), reviewing and prioritising user-led assessments, and producing a 'tool typology' with recommendations on which tool to use at which stage of a policy- or decision-making cycle (WPR 10.7). This was trialled and adapted through the application of the Ecosystem Approach to a suite of case studies within the environment, business, local community and planning sectors (WPR 10.7.6). All of the case studies championed partnerships working to facilitate learning and bringing together the expertise and experience of academics, professionals in practice and community members, as well as policy-makers (WPR 10.8).

The NEAT Tree focuses on when and how to use selected tools within the policy cycle in order to embed the ecosystem services framework into decision-making. The conventional policy cycle, used by Defra, consists of Rationale-Objectives-Appraisal-Monitoring-Evaluation-Feedback (the ROAMEF model) (WPR 10.4.1.1). We adapted this to produce the NEAT Tree Ideas-Survey-Assess-Plan-Deliver-Evaluate model (WPR 10.5.4). This makes the key stages in a decision- or policy-making process more explicit. The model can start at any stage in the decision-making cycle as evaluation and adaptation can be incorporated at all stages. The case studies identified that the Ideas, Delivery and Evaluate stages of the policy cycle were all too often forgotten. Furthermore, the experience and lessons learned across the case studies have helped us to translate the 12 principles of the Ecosystem Approach into a realistic toolkit, incorporating prompts and actions at all stages of the decision-making cycle, and signposting suitable tools for embedding ecosystem thinking into decisions. The focus on the decision-making cycle provides a common reference point that the majority of stakeholders are familiar with, or use, in their own operations. For each stage of the cycle, the NEAT Tree answers a series of questions relating to user actions: Why? What? Who? When? Where? (WPR 10.7.4). The answers to which lead to specific tools being recommended for particular contexts (**Table 4**).

The NEAT Tree presents a 'tool typology' to highlight, classify, and help people navigate the existing tools available within the public domain to consider human-environment interactions. The tool typology is based on the original function and scope. In addition to ecosystem service tools that have been explicitly developed for ecosystem

assessment, the typology recognises the following categories: regulatory tools (e.g. Strategic Environmental Assessment [SEA]), incentives (e.g. Payments for Ecosystem Services [PES]), valuation tools (e.g. Cost-Benefit Analysis [CBA]), futures tools (e.g. scenarios), and participatory tools (e.g. Delphi Technique). The categories are not necessarily mutually exclusive (WPR 10.6).

The tool typology was used to undertake a review of more than 30 tools commonly used in current policy- and decision-making processes. This was a bespoke process which recognised that guides on some decision-making tools already exist (e.g. CBA in the HM Treasury 'Green' Book[11]). The review was user-led and looked at the perceived or potential value of using a particular decision-making tool within the ecosystem services framework and the impact on policy this might have. It was apparent that many tools are best used in combination with each other in order to suit different stages and aspects of the policy and decision-making process. From these reviews, a final suite of nine tools were selected as appropriate for adaptation within the Ecosystem Services Framework (Table 4) (WPR 10.7.5).

The nine tools the NEAT Tree presents cover all stages of the policy- and decision-making cycle and we provide advice to facilitate their use. The objective was to show the benefits of incorporating the 12 principles of the Ecosystem Approach into decision-making, rather than highlighting which principles are not currently addressed. Many tools are best used as bundles to suit different stages and aspects of the policy/decision-making process. Decision support tools developed by the UK NEAFO (Figure 4, p. 14) could be used to augment those listed in Table 4.

[10] the NEAT Tree will initially be made available on an independently produced and hosted website, www.eatme-tree.org.uk

[11] HM Treasury (2003) The Green Book: Appraisal and evaluation in central government [online] http://www.hm-treasury.gov.uk/d/green_book_complete.pdf

Table 4. The suite of nine tools the National Ecosystem Assessment Toolkit (NEAT Tree) selected as most appropriate for embedding the Ecosystem Approach and advice on when to use them in decision-making.

Tool	Why should the tool be used? (Ask the following questions)	When should the tool be used in the policy/decision-making cycle?
Strategic Environmental Assessment (SEA) (WPR 10.7.5.5)	• Does my project/programme/plan/policy have any significant impacts on the environment? • Do I have to undertake a SEA as a statutory requirement under the EU Directive? • How can I have a better understanding of the way my plan or policy can be adapted to maximise environmental benefits and minimise environmental l damage?	Ideas and Survey stages. Focus on scoping at the outset of the process, within the ecosystem assessment itself, and afterwards.
Environmental Impact Assessment (EIA) (WPR 10.7.5.6)	• Does my project or proposal have any significant impacts on the environment? • Does my project or proposal require an EIA as a statutory requirement under the EIA Directive? • How can my project be adapted to maximise environmental benefits and minimise environmental damage?	Ideas and Survey stages. Focus on scoping at the outset of the process, within the ecosystem assessment itself, and afterwards.
Payments for Ecosystem Services (PES) (WPR 10.7.5.7)	• What are the key interdependencies affecting ecosystem services in my area of interest? • Who are the providers of ecosystem services (locally in the area and upstream)? • Who are the recipients (beneficiaries) of ecosystem services? • Who is benefitting and who is losing from the current spatial extent and quality of ecosystem service(s)?	Survey stage onwards
Cost-Benefit Analysis (CBA) (WPR 10.7.5.9)	• Does my project or plan have conflicting views as to its need or value? • What are the benefits versus the costs of the proposed programme, plan, policy or project?	Survey stage onwards. Links into SEA, EIA and EA processes.
Corporate Ecosystem Valuation (CEV) (WPR 10.7.5.8)	• What are the major risks to my business from a changing environment? • What are the major business opportunities making use of ecosystem services? • How can my business embed ecosystem services into its strategic operational planning and performance systems?	Ideas stage onwards
Ecosystem Assessment (EA) (WPR 10.7.5.1)	• What is the state, condition and value of ecosystem services produced and/or consumed in my geographical area? • To what extent are ecosystem services imported or exported? • How does the provision of ecosystem services change in the future?	Ideas stage onwards
Ecosystem Mapping (WPR 10.7.5.2 and 10.7.5.3)	• What ecosystem services are key in my area and what is the condition of the underpinning natural capital asset? • Where do the services originate and where do they 'flow' to? • Where are opportunities for achieving multiple benefits from these ecosystem services? • Where are the users benefitting from these services (local and/or elsewhere)?	Survey stage, but may need updating or reviewing as part of Evaluation stage. Links with Ecosystem Assessment.
Futures/Scenarios (WPR 10.7.5.10)	• What kind of area/development/future do we want? • How might our programmes, plans, policies or projects impact on the environment in the future? • What are the implications of current trends on the future of ecosystem services?	Ideas stage onwards
Natural Capital Asset Check (WPR 10.7.5.4)	• What ecosystem services do we get from natural capital assets now? • What ecosystem services might we get in the future?	Survey stage onwards

The NEAT Tree is currently hosted externally[12] and offers easily accessible and updatable resources. This enables users to engage with, and use, the key findings from the work on embedding the Ecosystem Approach in decision-making, as well as access the research material on which the NEAT Tree was built. In addition, the web platform hosts an array of information on the case studies the Ecosystem Approach was applied to, including video interviews focusing on good practice. The NEAT Tree enables users to explore the tools which the review highlighted as most relevant in embedding the ecosystem services framework into policy- and decision-making.

The detailed analysis of the case studies identifies four distinct models for the way in which ecosystem thinking is embedded into projects, plans, programmes and policies: (i) Retrofit; (ii) Incremental Ecosystem Services; (iii) Ecosystem Services-led; and (iv) Ecosystem Approach-led. These models reflect an increase in the mainstreaming of the ecosystem service framework and Ecosystem Approach into policy- and decision-making, in ever more holistic and inclusive ways. They do not, however, judge which the best approach is in any specific circumstance.

(i)   Retrofit model. This enables the ecosystem services framework to be retrospectively applied to existing plans; for instance, incorporating the concept through a review procedure. Not surprisingly, this model tends to cherry-pick ecosystem services which are easily reviewed (WPR 10.8.1.1).

(ii   Incremental model. This bolts the ecosystem services framework onto existing processes. It is inevitable that some degree of cherry-picking of ecosystem services occurs with often minor, but incremental, adaptive management over time (WPR 10.8.1.2).

(iii)   Ecosystem Services-led model. This embeds ecosystem services thinking into the Ideas and Survey stages of the NEAT Tree decision-making cycle, normally within an ecosystem assessment process. It goes beyond cherry-picking of ecosystem services (WPR 10.8.1.3).

(iv)   Ecosystem Approach-led model. This systematically considers all 12 principles of the Ecosystem Approach, exploring aspects of engaging people, management, scale and dynamics, and functions, good and services, throughout all stages of the project planning and policy processes. It is rarely followed, however, unless the user is starting from a 'blank sheet'. The NEAT Tree advice focuses on engaging with the policy cycle, rather than the 12 principles per se, and shows that using this model does not need to be resource intensive (WPR 10.8.1.4).

The case studies reveal useful insights into good practice (WPR 10.7.5 and 10.7.6). For instance, it is important to engage all key decision-makers and stakeholders in the process of embedding the ecosystem service framework from the outset to help secure ownership, particularly when implementing novel policies and practices. Such inclusiveness inevitably requires time, but investing in building partnerships and relationships is crucial if the ultimate decisions are to be sound and equitable. Identifying Ecosystem Approach 'champions' among different stakeholders or audience groups can be an effective way to communicate and demonstrate the benefits of using the Ecosystem Approach. Powerful visual tools, such as GIS and their mapped outputs, as well as the monetary valuation of ecosystem services, can be very influential in supporting communication. They can also facilitate dialogue about land use and other resource management options, increasing the understanding of the complex science behind it. All of these practices may be helpful in engaging more sceptical audiences (WPR 10.7.5 and 10.7.6).

Collectively, the case studies provide evidence of the added value that using the Ecosystem Approach provides to decision-making. These include:

■ Bringing together stakeholders within new interdisciplinary partnerships and encouraging participatory governance which cuts across traditional silos.

■ Helping stakeholders and decision-makers buy into sustainable visions and management options through a unifying language of risks, benefits, choices and assets.

■ Improving the evidence base for decision-making highlighting trade-offs and unforeseen risks.

■ Providing a framework that takes into account diverse forms of knowledge and values.

[12] the NEAT Tree will initially be made available on an independently produced and hosted website, www.eatme-tree.org.uk

Part II: Key findings from the UK National Ecosystem Assessment Follow-on work package reports

2.1 Key findings: Natural Capital Asset Check (WPR 1)

A clear, shared definition of 'natural capital' is necessary to enhance our understanding of how natural capital is integral to our economy. Better understanding and agreement on what natural capital is can improve the way society manages it. The Natural Capital Committee (2013) defines natural capital as "…those elements of nature which either directly provide benefits or underpin human well-being". This highlights that natural capital generates value for people. A more technical definition is proposed by the UK NEAFO, which includes how natural capital generates value: a configuration of natural resources and ecological processes which contributes, through its existence and/or in some combination, to human welfare.

The definition proposed is based on 'configurations' – the way natural capital assets work together (in time, space, function and/ or with other capital) to be productive. This distinguishes natural capital from other analytical approaches. Natural capital assets can be identified through existing environmental classifications of ecosystems (e.g. habitat types) and other natural resources (e.g. living/non-living, renewable/non-renewable). This link to existing classifications facilitates the use of existing data.

The focus on productive combinations has practical implications for analysing ecosystem services. It requires economics to use a holistic approach which takes into account ecological properties. Rather than looking at ecosystem services from habitats, it examines how parts of ecosystems combine to produce services. For example, in analysing the role of saltmarshes in commercial fisheries, there are a number of different natural capital assets involved, including fish species (e.g. bass) and the habitat (intertidal saltmarsh). To be productive, they need to work in certain combinations of space, time and function, and with other capital in the commercial fishing fleet. These combinations define this capital asset as they support the growth of juvenile fish (measured as biomass gain in fish stocks over time – an ecosystem service), which results in increased fish landings (goods) and has value to people as reflected in price of food.

An approach to extend current economic and scientific analysis to take account of these features of natural capital is proposed: the UK NEAFO Natural Capital Asset Check (NCAC). This offers a way of analysing available evidence to provide insights into the productive relationships that define natural capital through the following questions: (a) How much of a natural capital asset do we have? (b) What does it produce? (c) How do our decisions affect (a) and (b) over time? Examples of the key effects of our decisions identified in (c) include thresholds and/or trade-offs in the relationships between natural capital assets and the goods and services they produce. Analysis of such thresholds and trade-offs helps us to understand risks to society: our management of a natural capital asset to increase the productivity of certain goods or services may affect our ability to produce those, or other, goods and services now and in the future.

Thresholds can arise from tipping points, or chronic changes. They may become evident when productivity decreases with the decline in integrity of the natural capital concerned, or when the capacity of the natural capital to recover decreases. This highlights the importance of resilience as part of the value that ecosystems provide within natural capital assets. Data on exactly where thresholds are is rarely available to inform decision-making. A NCAC helps us to use the best data available; for example, observations of different examples of natural capital management can provide data on systems that are above and below thresholds (such as healthy versus collapsed fish stocks). The consequences of crossing thresholds depend on environmental factors, such as the speed with which productivity will recover, and economic factors, including the value of goods and services produced and the substitutes available.

Examples of applying the NCAC provide evidence on how it can help us to understand thresholds, trade-offs and other aspects of natural capital management. While extensive data on ecosystems and their services has been compiled, our understanding of the productive relationships that define natural capital is still limited. However, NCAC case studies provide examples of how declines in the integrity of natural capital can be linked to that capital's productivity; for instance, a decline in fish stocks and saltmarsh nursery habitat, results in a decrease in fish landings. This evidence supports strategic management of natural capital, and the consideration of whether it is being used sustainably or not.

Different types of natural capital are easier to analyse using a NCAC than others. The NCAC is best used when natural capital can be specifically defined by a clear spatial boundary and/or the productive configurations that provide goods and services. It is best implemented by multi-disciplinary teams (involving natural scientists and economists, for example) with existing knowledge of the best available data.

The analysis in a NCAC provides important contextual information to help construct and interpret national environmental accounts. Firstly, a NCAC helps identify the various parameters (such as the properties of the asset and the services that it produces) that can guide thinking about whether particular natural capital assets are being used unsustainably. In helping decision-makers work towards a definition of 'unsustainable use', a NCAC can provide guidance (e.g. on metrics) that can be translated into useful information for extended national accounting. Secondly, a NCAC differs from the marginal valuation of ecosystem services by emphasising the ecological properties and characteristics of natural capital assets that give rise to these services in the first place. This provides a practical mechanism that can aid ongoing efforts to construct environmental accounts linked to national accounting concepts of income and productivity, as well as balance sheets.

2.2 Key findings: Ecosystem services and the macroeconomy (WPR 2)

There is an increasing appreciation of the importance of the interactions between ecosystem services and the macroeconomy, and of the consequences of changes in ecosystem services for indicators of macroeconomic performance, such as Gross Domestic Product (GDP), trade balance and employment. Although a number of conceptual frameworks have been developed to represent interactions between the environment and the macroeconomy, they have not yet been transposed into sufficiently robust and comprehensive methods to measure those interactions in practice, or to support policy appraisal and decision-making. This is mainly due to the complexity and uncertainty of these interactions, and the limited availability of necessary data.

Mapping the interrelationships between ecosystem services and major sectors of the economy, such as agriculture or the manufacturing of food, is an important first step towards understanding the macroeconomic impacts of changes in ecosystem services at sectoral, regional and whole economy levels. For some sectors, such as agriculture, the interactions between ecosystem services and the sector are relatively well known, but links have not been made explicit for macroeconomic assessment purposes, and the range of ecosystem services covered is limited. Mapping will help to identify potentially economically important interactions and focus efforts on developing appropriate measurement and accounting methods, and practical decision support tools.

There is a range of macroeconomic modelling methods, which vary in purpose, theoretical background and analytical procedures, but no one existing approach is adequate to deal with the complex interactions between ecosystems and the macroeconomy. Most macroeconomic models are designed to assess the implications of policy change, and mainly operate within established and accepted macroeconomic frameworks. The most practical, immediate approach to bridging the gap is likely to involve 'extending' existing macroeconomic accounting procedures and modelling approaches to accommodate the interactions between ecosystem services and the macroeconomy. It may be appropriate to combine a number of macroeconomic modelling methods to suit the treatment of ecosystems services, thus avoiding any bias that might arise from the use of any one method.

Although some studies have assessed the macroeconomic performance of certain environment-related sectors (particularly agriculture, forestry and fisheries), they have generally not explicitly considered the impact of changes in ecosystem services on macroeconomic indicators, such as GDP, employment and trade. The UK NEAFO literature review did not identify any studies that comprehensively cover the contribution of ecosystem services to the macroeconomy. Yet, there are studies that focus on selected interactions between certain ecosystem services and the economy – often at a local, context-specific scale – which may help to inform wider sectoral and whole-economy appraisals.

The priority for research should be to develop and test suitable frameworks and methods for ecosystem-macroeconomy assessments, starting with selected key ecosystem services and economic sectors. This will quantify selected key interactions and adapt suitable macroeconomic modelling methods to accommodate ecosystem–macroeconomy interactions. We can then apply these methods to selected key sectors in order to demonstrate the feasibility and value of modelling ecosystem-macroeconomy interactions to support policy analysis and decision-making. Most benefit will probably be gained from developing methods of ecosystem services accounting that can fit within, and eventually extend, existing sectoral and national accounting conventions and models used for macroeconomic policy analysis.

2.3 Key findings: Economic value of ecosystem services (WPR 3)

For decisions to be both robust and efficient, they should avoid appraising pre-determined options, instead, allowing the characteristics and corresponding values of the real-world to determine the best use of scarce resources. Many decision analyses assess a small number of pre-determined options. In the case of land use, such appraisals might typically consider around half a dozen options, each described in terms of a different end point. A major weakness of such approaches is that they are not 'robust', i.e. the decision-maker has no way of knowing whether the best option is included in the analysis. Consequently, the chosen option may not be 'efficient' because it may not offer the best value for money. More practically, such analyses give no indication regarding which policies might be required to attain a desired end point (or even if that end point is feasible). To avoid these problems, the UK NEAFO presents The Integrated Model (TIM): a programmed system that links a series of modules together to assess both the drivers and consequences of land use change (for instance, the agricultural production module links changes in drivers, such as government policy, prices, costs, soils, climate, etc., to changes in farm outputs).

Decisions need to take into account all of the major drivers of, and impacts from, the changes they are considering. Changes in natural capital-related goods can be driven by many factors at the same time. For example, shifts in policy and ongoing climate change may simultaneously affect land use. In turn, such changes in land use may have a variety of impacts, all of which need to be analysed in order to assess the true consequences of alternative policies. Appraisals can incorporate many of the drivers of land use change, in particular, paying close attention to the impacts of changes in both climate and policy. They provide extensive assessments of the impacts of such changes, including agricultural outputs and incomes for all farm types, water quality, greenhouse gases, recreational visits, forest outputs, and biodiversity (represented in the UK NEAFO by the indicator of bird species richness).

Many of the services provided by the natural environment can be robustly assessed using economic values, which are then readily incorporated within decision-making systems. Assessing environmental public goods in terms of their economic value permits the even-handed comparison of gains and losses in both market and non-market goods. The UK NEAFO builds on previous work to significantly extend the robustness of economic values for non-market environmental goods. The valuations the UK NEAFO presents should be applicable to a wide variety of decision-making challenges, as well as being compatible with the rigorous requirements of TIM, which requires appraising a broad array of possible policy changes (i.e. options that may cause minor or major increases in the supply of ecosystem services). The UK NEAFO recognises cases where current valuation and modelling techniques do not provide robust values for certain aspects of natural capital (e.g. the non-use existence values associated with biodiversity), so presents approaches which focus on incorporating such natural capital within conventional decision-making via the estimation of the costs of ensuring specified levels of provision (e.g. ensuring no net loss in biodiversity).

Leaving the uptake of subsidies to market forces alone is likely to result in poor value for money for the taxpayer. When subsidies are made available, but not tied to the value of public goods produced ('untargeted'), their effectiveness may be poor. In such cases, the uptake of subsidies will be determined by the private profits they support rather than the social value they generate. With regards to land use, this effect can be seen in the historic failure of EU Common Agricultural Policy (CAP) set-aside payments – put in place to reduce the overproduction of agricultural output, in reality, they mainly removed only the poorest quality land from use.

Targeted policies deliver greatly improved value for money from available resources. Working with, rather than in ignorance of, the natural environment allows the decision-maker to see how the alternative implementation of a policy can significantly enhance value for money. The UK NEAFO offers a methodology that can spatially 'target' resources (e.g. CAP payments) to almost any scale, from very small areas, up to the whole of Great Britain. Our use of this methodology shows that such targeting greatly improves the generation of environmental (and other) public goods and, therefore, benefits society. Such resource-efficient approaches are of particular importance during periods of financial austerity.

A UK NEAFO case study, relevant to current policy questions, examines the potential for establishing new forests in England, Scotland and Wales. This analysis, which was prompted by government announcements of the intention to expand forestry in all three countries, assesses land use at a maximum 2 km resolution for the entirety of Great Britain during the period 2014 to 2063. It considers the impact of any land use change on all of the various systems: agriculture, timber, water quality, greenhouse gases, recreation and biodiversity. Key outputs of this analysis include three scenarios developed by the project:

■ Investigation of a 'Business As Usual' (BAU) baseline in which no new afforestation policies are implemented. This assessment provides a counterfactual for the other policy change analyses. Furthermore, it reveals the impact of forecast climate change on all the aforementioned systems during the appraisal period.

■ Investigation of a 'Market Value' (MV) driven planting policy in which TIM is employed to consider all feasible locations for afforestation, selecting those which maximise the net value of market-priced agricultural and forestry outputs alone, while ignoring potential societal benefits. This simulates the consequences of announcing a general, untargeted planting policy and results in forestry being confined to remote upland areas of marginal agricultural value. Such locations are far from human populations, which limits the recreational values new forests might generate. Planting under this scheme also occurs on organic soils, which become degraded and emit large volumes of greenhouse gases. This approach to decision-making ends with negative overall value to society. Hence, it is not only poor value for money for the taxpayer, but actually results in net losses for society.

■ Investigation of a targeted 'Social Value' (SV) driven planting policy in which TIM selects planting locations that take into account the full sweep of benefits and impacts generated by afforestation. The targeting process accounts for both market-priced goods (including timber and the costs of displaced agriculture) and those non-market goods for which we can estimate robust economic values (e.g. greenhouse gas emissions and storage, and recreation). This results in woodlands being located away from vulnerable organic soils and close to areas that yield higher recreational values. Analysis of the impacts on non-market goods which could not be given robust economic values (e.g. biodiversity and water quality) shows that water quality and woodland bird species richness are also enhanced when the value of all goods and services are considered in choosing planting locations.

2.4 Key findings: Coastal and marine ecosystem services (WPR 4)

Understanding and adaptively managing the impacts of the diverse and dynamic environmental change experienced in coastal zones requires better interdisciplinary knowledge, methods and tools. Adaptive coastal management requires a flexible decision support system in order to enable actual changes in policy and management practice, and follow-up through 'learning by doing'.

The UK NEA Ecosystem Services Framework has been adapted by the UK NEAFO for the UK coastal and marine environment in order to identify its specific components and processes, intermediate and final ecosystem services, and goods and benefits. This Framework and its related tools provide a pluralistic foundation for the use of Adaptive Management Principles in UK coastal policy practice.

An expert-based scenario analysis by the UK NEAFO suggests that UK marine ecosystems would prove resilient to temporary shocks, and that there will be some improvement in ecosystem services as a consequence of present trends in environmental policy. Experts were asked to assess how marine ecosystem services would alter by 2060 under five scenarios, and how these services would respond to shocks, such as shading by volcanic dust for half a year, pollution as a result of the Thames Barrier overtopping, or financial crisis similar to that of 2008.

The UK NEAFO has developed specific indicators, informed by a drivers, pressures, state changes, welfare impacts and policy responses pressures (DPSWR) scoping framework, for six ecosystem services: fisheries and aquaculture, sea defence, prevention of erosion, carbon sequestration/storage, tourism and nature watching, and education. These multiple indicators are necessary to capture the complexity of the marine system associated with even single ecosystem services. It also detects changes over time in marine ecosystem service provision in relation to management measures. The set of practicable ecosystem indicators was developed to reflect 'state changes' and 'welfare impacts' relating to ecosystem services supply. These indicators meet operational requirements and are grounded within the NEAFO ecosystem service and management frameworks.

The UKNEAFO concludes that one pragmatic way to link terrestrial models for nutrient flows from land use in catchments to models for estuaries and coastal waters to assess ecosystem services provision, is through the use of estuarine box models. A box model is a model without spatial representation, which captures the main dynamics as a function of time and driving pressures. There are different types of models available to assist in the effective management of the range of final ecosystem services and their goods and benefits.

The UK NEAFO argues that the future goal for economic assessments of sustainable coastal management should be to measure and value service flows and changes in stocks (i.e. ecosystem health). A separate and complementary ecosystem services account or index may also be a worthwhile objective.

There are considerable gaps in the current valuations of UK coastal and marine ecosystem services, including those benefits deemed important by experts. More primary valuation studies are needed for reliable social welfare assessment. A review by the UK NEAFO found 208 international studies, of which, 25 provide UK-based value estimates. The main gaps relate to the biodiversity and seascape values (non-use existence values) of the majority of global coastal and marine habitats, and some of the typical UK habitats, such as machair. Both temporal and cultural bias constraints remain formidable challenges for any benefits transfer exercise.

The UK NEAFO has promoted the Balance Sheet approach as a pragmatic format for collating, interrogating and presenting evidence. It is both a process and a tool which addresses the complexity of real world decision-making and trade-offs. It captures economic, ecological and social/deliberative perspectives in trade-off assessments. This not only incorporates efficiency, but also considers the distribution of gains and losses, resilience and carrying capacity aspects of sustainable management.

2.5 Key findings: Cultural ecosystem services and indicators (WPR 5)

Cultural ecosystem services encompass the environmental spaces and cultural practices that give rise to a range of material and non-material benefits to human well-being. These spaces and practices interact with contemporary cultural values to shape people's identities, provide experiences that contribute benefits in terms of well-being, mental and physical health, and equip people with a range of skills and capabilities. The UK NEAFO characterises the four key components of cultural ecosystem services as: environmental spaces; cultural values; cultural practices; and benefits. Our assessment of cultural ecosystem services to support decision-making is based on this understanding.

A range of quantitative and interpretative research techniques are required to gather evidence for cultural ecosystem services

and the benefits they provide to human well-being. Although the assessment of cultural ecosystem services is generally recognised to be a conceptually and methodologically challenging area, the UK NEAFO shows that: (i) quantitative indicators and analysis of cultural ecosystem services can be developed, which draw on publically available datasets; and (ii) participatory and interpretive research techniques developed in the social sciences, and arts and humanities, can be used to assess and understand cultural ecosystem services in location- and community-based contexts. The approaches of these different disciplines vary considerably. Social science techniques often attempt to generalise and systematise knowledge about human relationships with place, locality, nature and landscape. Arts and humanities perspectives are grounded in the ambiguity, variety, irreducible difference, contingency, unpredictability and incertitude of human experience. Paying attention to these qualities improves, rather than impedes, understanding of the values and benefits attached to ecosystems and environmental spaces. Innovation towards accounting for cultural ecosystem services in decision-making relies on engaging with this diversity of approaches.

The UK NEAFO developed and evaluated indicators of cultural ecosystem services to explore supply and demand in a range of environmental spaces. Our assessment reveals considerable regional variability across the UK in terms of the provision of environmental spaces and peoples' access to them. Additionally, it shows that domestic gardens represent a particularly important environmental space – up to a third of land cover in some areas. Our work on these indicators also demonstrates their potential role in decision-making: they enable benchmarking and the comparison of local areas in terms of the provision of different types of environmental spaces. The interpretation of indicators in local areas, however, will generally need to be accompanied by locally specific data.

With some further development, the Monitor of Engagement with the Natural Environment (MENE) survey has the potential to be used as a major evidence base for monitoring cultural ecosystem services in England in terms of well-being benefits and cultural practices associated with public and private environmental spaces. Analysis of MENE survey data (boosted by extra questions on domestic gardens developed for the UK NEAFO) highlights that beaches are considered by MENE respondents as the most well-being enhancing environments (35%), with woodlands or forests (21%), and private gardens (19%) also considered significant. In addition, time spent outdoors, in either a domestic garden or a public cultural space, has a positive effect on well-being. People who live in Greater London gain the most in terms of well-being from domestic gardens, and, interestingly, women gain a higher level of enjoyment from gardens than men. Therefore, domestic gardens should be recognised as an important environmental space where people experience interactions with nature that enhance their well-being.

The findings of the UK NEAFO reinforce the case for using mapping techniques to develop a participatory approach to assessing cultural ecosystem services. Simple annotations of maps as part of an extensive social science questionnaire survey, or group-based exercise, provide a useful way of revealing concentrations of cultural benefits and identifying associated management issues. Participatory mapping produces new understandings of the cultural significance of ecosystems and helps bring latent cultural values to light, which may remain hidden when using other methods. The use of art-based mapping techniques can further animate and expand the understanding of cultural ecosystem services among communities. Creative approaches influenced by research in the arts and humanities not only provide new forms of evidence for decision-makers, but can help engage communities and engender stewardship of local natural resources; such approaches may be particularly effective when incorporated into a learning curriculum, for instance. Linking these techniques to wider tools and approaches developed in the landscape and heritage sector represents an opportunity for future innovations in the practical application of cultural ecosystem services concepts.

2.6   Key findings: Shared, plural and cultural values of ecosystems (WPR 6)

Shared values resulting from deliberative, group-based valuation are different from individual values. Case study evidence suggests that they are more informed, considered, confident and reflective of participants' deeper-held, transcendental values. Deliberated, group-based monetary values may be a better reflection of real welfare impacts than non-deliberated individual values, if derived through a carefully designed and managed process. Although more research is needed to expand the currently small evidence base on deliberative monetary methods, group deliberation has the potential to significantly enhance elicitation of values.

The ethical, moral and justice dimensions of many environmental issues necessitate approaches that allow for the elicitation of shared and plural values. Key ethical concerns include: 1) providing a space and opportunity for people to identify values that they may find difficult to articulate (e.g. spiritual, identity); 2) recognising that some values cannot be traded without discussion and negotiation (e.g. the legal or felt rights of local people, intrinsic values of other species); and 3) understanding that it is often difficult to isolate valuation from decision-making processes because people feel there are strong ethical or moral issues at stake that need to be debated (e.g. the justice of the process, fairness

in the distribution of benefits or disbenefits, responsibility, and issues of sustainability and future generations).

Catalyst and/or conflict points can play a key role in the emergence and articulation of values at a societal or community level that have not previously been outwardly or explicitly articulated. Catalyst and conflict points can be symbolic and are often linked to wider contested issues and meanings about who is involved in decision-making, whose voice counts and who receives the benefits or disbenefits of environmental change. These catalyst points can potentially be connected to feelings of powerlessness that give rise to concern and protest. By recognising transcendental societal and communal values (the deeper-held and overarching values held by society and communities), it becomes possible to make these values explicit and incorporate them in decision-making to better anticipate and manage conflicts.

There is a diversity of ways in which shared, plural, cultural and social values are used, but they are rarely conceptualised. The UK NEAFO provides a clear theoretical framework that distinguishes and categorises different dimensions and types of shared values. The proposed range of value types was both identifiable and distinguishable within case study results. This suggests that the framework provides a useful basis for operationalizing shared values for decision-making.

Shared and social values in the sense of value to society is conceptualised very differently by conventional economics and other disciplines. Neoclassical economists have generally undertaken valuation by equating social value with the aggregate of individual values. They consider values as fundamentally commensurable. In contrast, literature from other disciplines consistently considers values as plural, not just in the sense that multiple things have value, but also that there are multiple dimensions to value that cannot necessarily be captured in a single metric. Within mainstream economics, the difficulties associated with commensurability and aggregating values have long been recognised, but have also been neglected. An interesting area for future debate between economic and non-economic views on values may be the normative nature of value-aggregation.

A mixed method approach is required to elicit the multiple dimensions of shared values and to translate deeper-held, transcendental values into contextual values and preferences. Monetary valuation is limited to quantifying values. Other methods are needed to understand their meaning or content, and the communal, societal and transcendental values that underpin them. Psychometric, non-analytical and interpretive methods (e.g. storytelling) can reveal those shared values. They can be combined with deliberative-analytical methods (e.g. deliberative monetary valuation and multi-criteria analysis) to provide a comprehensive valuation that can quantify values, understand their individual and shared meanings and significance, and better include ethical dimensions.

Deliberative and social learning processes help people to understand the values held by others; they can lead to increased sharing of values and/or to greater acceptance of the decisions emerging from such processes. Deliberation clearly affects what values participants express compared to non-deliberated processes. There is also a growing body of theoretical and empirical research suggesting that deliberation has the potential to affect how people understand and shape the values of others. Although rarely considered in the economic literature, the concept of social learning helps to explain some of the processes involved in deliberation. The extent to which deliberation or social learning helps participants express and shape values will depend upon the frequency and depth of interactions and the timescale over which interactions occur. Only a shift in cultural values (e.g. less emphasis on material wealth), reflected in other societal institutions (e.g. changes in the indicators used to measure national progress) is likely to achieve sustainable outcomes in the long-term.

Media analysis is a promising avenue for characterising different types of shared values at a large scale, as well as assessing the conflicts between the communal values of different sectors of society. There has been a marked increase in public interest in environmental issues over the last decade, which is reflected in their increased media coverage. Media content and discourse analysis is able to distinguish and characterise the plurality of cultural, societal and transcendental values and their interrelationships, and can offer a picture of the self- and other-regarding values that underpin environmental issues and conflicts. Social media can provide a further forum for understanding societal and communal values surrounding environmental issues.

Aesthetic and spiritual values of ecosystems have a strong non-instrumental component. While they benefit human well-being, they should not simply be classified as just 'services' or 'benefits'. Many spiritual discourses about nature resist talk of consequentialist benefits and economic analysis. These discourses counter assertions of the disenchantment of the world, which is associated with an instrumental environmental ethic and the commodification of nature. Allowing the possibility of enchantment can be a richer way of understanding our experience of nature and alerts us to the limitations of using economic models for valuation and informing decisions about these profound cultural ecosystem 'services'. Faith communities have experience of using these non-utilitarian values in their own decision-making and provide models that could be adapted for use in environmental decision-making.

Subjective well-being measures provide a useful means of assessing 'intangible' cultural ecosystem services and their benefits. Different user groups associate common elements of subjective well-being with environmental settings, providing opportunities for development of standardised measures. In the UK NEAFO, key facets of well-being associated with places in nature across different user groups included: engagement with nature (incorporating elements of connectedness, getting to know nature and the beauty of nature, and taking care of a place); therapeutic benefits (including physical and mental aspects of health); place

identity (including a sense of place and belonging); spiritual value (in the sense of feeling connected or responsible to something larger than oneself); social bonding with others; and transformative and memorable experiences. Further empirical work with different user groups and environmental settings would allow for the continued development of a standardised tool for large-scale non-monetary assessment of cultural ecosystem services.

2.7 Key findings: Operationalising scenarios (WPR 7)

In work which sought to operationalise the UK NEA scenarios, the UK NEAFO shows that there is a complementarity between the roles of scenarios as 'processes' and as 'products'. The 'process' approach uses scenarios as deliberative tools that enable experts and non-experts to discuss issues and learn from each other. In contrast, the 'product' approach aims to produce a series of outputs describing and, if possible, quantifying the implications of a series of plausible futures.

Stakeholder engagement exercises show that the UK NEA scenarios are both plausible and relevant. They also have significant potential as tools for developing dialogues between stakeholders holding differing interests and perspectives. This is a two-way process: the contributions of stakeholders enrich the scenarios and allow experts to see new perspectives and insights within them.

The UK NEAFO shows that the original UK NEA scenarios have developed a life of their own. They are already being used by Forest Research, the Defra Noise Futures Project and the Scottish Government. Although they 'work' when people are exposed to them, more needs to be done to bring them to the attention of the broader stakeholder community if their full potential is to be realised.

UK NEAFO hydrological modelling work presents evidence of differences between scenarios in our capacity to reduce flooding or drought. Our study looked at 34 UK catchments. The results suggest that whether a scenario is 'preferable' or not varies by location; the majority of catchments are little affected by changes in land cover under the scenarios, but flooding or drought does get worse in some areas. The results indicate that, when managing land cover change, a balance needs to be struck between alleviating the likelihood of increased drought and the likelihood of increased flooding, depending on the possible effects of these phenomena in the catchment.

The UK NEAFO presents evidence of both trade-offs and co-benefits between the abundance of farmland birds and other ecosystem services, based on an examination of expected differences between each of the scenarios. These derive from functional space models of the relationship between land use and the annual rate of population growth rate of 19 farmland bird species included in the Farmland Bird Index, as well as mechanistic models of the relationship between land use, food availability and abundance for two of these species, which represent distinct types of seedeaters - the linnet and yellowhammer. By focusing on food availability and the abundance of farmland birds, rather than species number, the study shows that biodiversity outcomes are more adversely affected by the scenarios with the highest monetised value than previously thought. Therefore, our results challenge some of the findings of the impact of land cover change on conservation values put forward in the original UK NEA. This suggests that there is a greater need to consider the specific impacts of land use change on biodiversity, alongside other ecosystem services.

Work on marine ecosystem services shows that, of four scenarios considered, only the free market-driven *World Markets* scenario appears to result in a marked decline in fish stocks by 2060. This is offset to some degree by the higher levels of investment in aquaculture we would expect under this scenario. However, this study also highlights the gaps in data and knowledge about drivers which is needed to examine the effects of possible future change on marine environments; so these conclusions are tentative.

In its analysis of cultural ecosystem services, the UK NEAFO finds that people tend to prefer environmental settings with higher woodland cover than the average for the surroundings when they travel intermediate distances from their home; but this tendency declines when people travel longer distances. The UK NEAFO work is based on the Monitor of Engagement with the Natural Environment (MENE) survey for England. An analysis of the spatial changes in woodland cover under the different scenarios suggests that woodland expansion targeted to enhance conservation value also benefits the delivery of cultural ecosystem services in the areas close to where people currently live. We found that tools based on Bayesian Belief Networks maybe an effective way of operationalising the conceptual framework for cultural ecosystem services developed by the UK NEAFO WP 5, and of rapidly visualising key relationships in the MENE data.

The development of targeted analytical studies within the qualitative framework of the UK NEA scenarios is required in order to understand, manage and communicate the consequences of changes in ecosystem services across different scales and in different contexts. Such studies can enrich our understanding of today's issues and how we might respond to future change.

2.8 Key findings: Robust response options - What response options might be used to improve policy and practice for the sustainable delivery of ecosystem services? (WPR 8)

Each of the response options has key requirements and decision-makers have alternative types of options for responding to environmental and societal change. Each option type has key requirements and interdependencies that translate into specific strengths, weaknesses and suitability for managing ecosystem services. This typically means that the sustainable delivery of ecosystem services cannot be guaranteed by individual response options in isolation, and is best addressed by combinations of options. Market-based schemes can leverage new investment in services and improve efficiency, but are exposed to market volatility; therefore, they are best accompanied by regulation, or other mechanisms to ensure minimum standards. Bottom-up initiatives can be valuable to engage and catalyse local action to manage change, but can result in missed synergies with related initiatives if wider planning to maximise coordination is not undertaken. Knowledge exchange systems can improve the uptake of scientific and technological innovation, including linking with good management practices. Investment in science and technology may provide possible 'low-regret' options which enhance other responses, regardless of the exact pathway of change.

Response options have strengths and weaknesses in terms of their flexibility to handle temporal change (including future uncertainty) and to match with different geographic contexts. Statutory top-down approaches, including protected areas, can define uniform minimum standards, but may be slow to adjust to changing circumstances. Innovative schemes with the potential to improve the delivery of ecosystem services, such as offsetting and incentive payments, may benefit some ecosystem services at the expense of others that provide less tangible benefits in market terms, or have a more localised value. Spatial targeting of response options may provide the best means to cope with the heterogeneity of ecosystem services. Further attention needs to be given to how future risk is factored into incentive schemes.

The evaluation of response options is currently constrained by a relative lack of knowledge about cultural ecosystem services and supporting ecosystem services. This constraint challenges approaches to identify a sustainable balance of ecosystem services. Cultural ecosystem services are particularly important in understanding the role of local identity as a key factor in managing terrestrial landscape or marine environment change. Supporting ecosystem services are crucial for enhancing ecosystem resilience and for buffering against abrupt change, including the loss of final ecosystem services. The inherent uncertainty of the future suggests that measures to enhance community cohesion and ecosystem resilience are a good strategy because they can provide a foundation for accommodating change management. The role of local identity in adapting to change has been understated in previous work on response options.

The robustness of response options when 'stress-tested' by the UK NEAFO under a range of UK NEA scenarios varies according to the differing influence of key factors, such as governance, market forces and the scale of decision-making. Thus, market-based options are most unconstrained within scenarios that emphasise free markets, such as the *World Markets* scenario. Similarly, national-scale interventions may be overridden by local priorities under the *Local Stewardship* scenario, while local initiatives may be subordinated by top-down priorities under *National Security*. Two UK NEA scenarios, *Nature@Work* and *Local Stewardship*, emerged as more receptive to the suite of response options, resulting in the most positive outcomes for all categories of ecosystem services (provisioning, regulating, cultural and supporting). In the *World Markets* and *National Security* scenarios, some responses are of low relevance, or may have negative effects on certain services, as they become overly focused on specific demands (often provisioning ecosystem services); cultural ecosystem services are identified to be particularly vulnerable when demand is focussed on individual services in isolation.

The UK NEAFO shows that the most effective response options in agriculture are those that develop and disseminate knowledge, technology and practice, because they support the delivery of ecosystem services under all scenarios, to a greater or lesser extent. The broadest range of response options is relevant to *Nature@Work*, with far fewer response options available for influencing outcomes under the *World Markets* and *National Security* scenarios. Very few response options give rise to negative impacts on ecosystem services, compared to the scenarios playing out without any interventions. This does not imply that ecosystem services on farmland will be maintained across all scenarios, rather that many individual interventions have a limited effect in modifying outcomes associated with the scenarios. The present situation in agriculture has elements of all scenarios. Designing robust response options that can work across the scenarios should build on cost-effective ecosystem service delivery as prioritised under the *National Security* and *World Markets* scenarios, while emphasising innovation and knowledge exchange using multiple platforms that embrace communities, policy and industry.

The forestry sector already incorporates features of adaptive management because of its long planning horizons. Therefore, response options that further develop adaptive knowledge-based initiatives, such as collaborative management groups, advisory services and visits, and community woodland groups, scored most highly in our assessment, particularly under the *Nature@Work* and *Local Stewardship* scenarios. These support structures operate

through either national objectives (e.g. UK Forest Standard and grant aid), or local decision-making (e.g. community groups). Grant aid with specific spatial targeting is considered to be a relevant and robust response option across most scenarios, having a positive impact on the different groups of ecosystem services. However, it may become more unbalanced towards provisioning ecosystem services in *World Markets* and *National Security* if these scenarios become overly focused on material demands.

A key requirement for the biodiversity sector is to integrate its objectives with other sectors. In a changing world, the response options the UK NEAFO identifies as most viable in achieving this are greenspace and ecological networks, agri-environment schemes, and partnerships. However, the heterogeneity of biodiversity and ecosystems requires the recognition of spatial differentiation in responses, with protected areas continuing to be important in key locations. Most response options can actively contribute to the sustainable delivery of regulating, cultural and supporting ecosystem services, but with potential trade-offs against provisioning ecosystem services. Current protected areas could be made more robust to climate change through integration with ecological networks. The effectiveness of biodiversity offsetting and nature-based partnerships is notably reliant on other factors, especially the need for balanced regulation (offsetting) and support structures (partnerships). Voluntary quality-assurance and compulsory set-aside schemes are potentially weakened in futures dominated by free markets and increasing food production, but quality assurance and local provenance may become an asset in risk-averse conditions. There is currently limited evidence available to assess schemes like land-sparing and offsetting, which may be able to deliver provisioning services alongside other ecosystem services, but also involve balanced trade-offs that may not continue to hold in the future.

The response options that the UK NEAFO identifies as the most robust for the water sector are blue networks, River Trusts and Sustainable Urban Drainage Systems (SUDS). These can provide a range of ecosystem services and are sufficiently flexible to adapt to a variety of future conditions. The response options tested range from those which are short-term, local and relatively inexpensive, such as community-based urban stream restoration projects, to long-term, national-scale and hugely expensive infrastructure projects, including new reservoirs and desalinisation plants. The EU Water Framework Directive offers great potential to embed ecosystems thinking across the water sector with regards to sustainable ecosystem protection and enhancement, but this is dependent on strong governance, which may not occur under all scenarios. SUDS are designed to emulate natural processes contributing to regulating, supporting and cultural ecosystem services, and offer many positive benefits to the built environment; they are the most robust of all the response options we considered. With regard to industry-based responses, a mix of measures for both supply and demand provides the greatest resilience to future economic and climate shocks.

The response options that are the most robust across all scenarios in urban areas are those relating to spatial and integrated planning, and science research and development that advance and communicate knowledge on the multiple benefits of urban ecosystems, including greenspace and blue and green networks. Of the eight response options the UK NEAFO tested, three were mainly positive for the delivery of all categories of ecosystem services: multi-functional green infrastructure, technology for water-saving and urban ecosystem assessments. These approaches have the capacity to deliver multiple ecosystem services and are adaptable enough to meet different challenges and drivers predominating in each of the scenarios. Some of the other response options tested were less likely to be robust for ecosystem services in all futures. For instance, energy-related EU legislation and national planning policy frameworks have less traction in scenarios where the role of legislation or international agreements declines (notably *World Markets*).

The most robust marine and coastal response options include 'no-take' zones and fisheries conservation measures because they can enhance market potential, as well as wider ecosystem integrity. A major challenge for the marine sector is the mobility and variability of stocks, especially with climate change, so the role of legally binding agreements is crucial to ensuring sustainability. Marine planning, certification of fisheries and environmental non-governmental organisations (NGOs) contribute significantly under the *Nature@Work* and *Local Stewardship* scenarios, but are less likely to have a major influence under *World Markets* and *National Security*, which have a stronger focus on economic objectives. The role of environmental NGOs, however, is particularly important in communicating the existence (non-use) value of marine ecosystems. Opportunities to strengthen the robustness of response options include a clearer articulation and application of the Ecosystem Approach within marine planning, defining legally binding management measures within no-take zones (especially nursery areas), and clear and enforceable fisheries conservation measures.

Stress-testing of response options collaboratively, or in workshops, enables greater discussion of the reasoning behind evaluation scores, is informed by a wider spectrum of knowledge, and enhances the institutional learning process. The impacts on ecosystem services of various response options were considered by the UK NEAFO in terms of the main categories (provisioning, regulating, cultural and supporting), all of which cover a wide diversity of individual ecosystem services which may not be affected in the same way. Further deliberation may refine our initial analysis, may result in different variants of a generic response option, and can help to distinguish the relative importance of different drivers of change, including the interaction of socio-economic factors and climate change. The definition of reference baseline conditions is an important precursor to assess change, particularly with regard to notions of sustainability; otherwise, there is a risk that progress is not effectively measured.

Effective implementation of a range of response options appropriate to achieving the best outcomes for ecosystem services in different situations entails institutional flexibility and close collaboration. Today, many institutions are bound by narrow

interpretations of their responsibilities and have constraints on their response options, such as a subset of legislation, application of common law, or advice. These institutional constraints may inhibit realisation of joined-up outcomes across ecosystem services and opportunities for coordinated change management. The use of general behavioural frameworks to guide complementary responses, such as the 4 Es (Enable, Encourage, Exemplify, Engage) or 4 Is (Information, Institutions, Incentives, Identity) can provide a structure for more joined-up responses.

2.9 Key findings: Embedding the Ecosystem Services Framework into appraisal (WPR 9)

Policy appraisal is widely practiced in government from the EU level right down to the lowest level of decision-making within individual Member States. In theory, it seeks to align individual policies with long-term objectives, is widely advocated by international bodies, and has a long history of engaging with environmental concerns. Therefore, in principle, policy appraisal is a critical avenue for embedding ecosystem knowledge into policy processes.

Appraisal practice in the UK consistently falls short of high-level political ambitions to explicitly embed an Ecosystem Services Framework in decision-making. While few appraisals are explicitly framed in terms of an Ecosystem Services Framework, many of its constituent elements are often implicitly covered.

The Ecosystem Services Framework places a great deal of emphasis on securing a better knowledge of ecosystem functions and processes. But possessing 'more knowledge' does not necessarily mean that it will be embedded in appraisal and, subsequently, inform decision-making. Institutional cultures and behaviours determine how such knowledge is used. Crucially, these cultures and behaviours vary within, and between, different levels of appraisal.

The key barriers and enablers to embedding the Ecosystem Services Framework have been identified.

At the *micro level* of practitioner behaviour, barriers to embedding the Ecosystem Services Framework include:

(i)   limited resources available to officials undertaking appraisal (e.g. data, time, money, skills, training and guidance);

(ii)   limited awareness of the concept of the Framework; and

(iii)   difficulty in understanding the concepts underlying the Framework.

Greater embedding of the Framework may result from actions such as:

(i)   more integrated datasets formatted around the core concepts of the Framework in order to encourage a mixed-methods approach;

(ii)   awareness-raising about the concepts of the Framework, highlighting its value in government and beyond;

(iii)   simplifying and tailoring the language of the Framework to suit different audiences; and

(iv)   having more demonstration projects to show what the Framework can contribute to appraisal.

At the *meso scale* of institutional culture and practice, barriers to embedding the Ecosystem Services Framework include:

(i)   fragmented working across departments and levels of governance;

(ii)   different legal requirements across appraisal levels and types; and

(iii)   narrow focus of appraisals.

Greater embedding of the Framework may result from actions such as:

(i)   stronger and sustained high-level leadership, backed up by statutory quality control measures and peer-review by professional bodies and stakeholders;

(ii)   integrating the Framework into existing institutional mechanisms and processes (e.g. through guidance for appraisal of the planning process);

(iii)   better integration of mechanisms and institutions to help join-up policy (e.g. inter-sector working groups, and cross-sector training); and

(iv)   creating neutral spaces such as workshops and knowledge networks to encourage communication and learning between actors and sectors.

At the *macro scale* of the wider social and political context, barriers to embedding the Ecosystem Services Framework include:

(i)   underlying societal values – and, hence, political priorities – not being aligned with ecosystem protection.

Greater embedding of the Framework may result from actions such as:

(i)   engaging with the many potential uses of the Framework, including using it as a platform to stimulate debate and enhance communication between different stakeholders;

(ii)   using political 'windows of opportunity', such as floods, periodic media interest, or changes in government; and

(iii)   encouraging partnership between government, non-government and international bodies to promote and employ the Framework.

There is significant interaction between types of barriers and enablers at different scales. Finding the right mix of approaches is what really matters, not focusing on one or two headline-grabbing changes at one level. This requires a combination of political leadership and opportunism, a commitment to engage in joint learning exercises (such as the UK NEAFO), and the institutional capacity to put the Ecosystem Services Framework into practice.

The whole issue of how the Ecosystem Services Framework is and/ or could be embedded into decision-making is under-researched. Work Package 9 has begun to fill this gap, but we present a number of additional areas that researchers and practitioners could jointly address in order to more deeply embed the Framework in decision-making.

2.10 Key findings: Tools, application, benefits and linkages for ecosystem science (WPR 10)

The UK NEAFO Work Package 10 translates the 12 principles of the Ecosystem Approach into pragmatic advice to enable policy- and decision-makers to embed the value of nature within policies and decisions and produce better outcomes for ecosystems and their services. The Ecosystem Approach is currently used in policy- and decision-making in a piecemeal fashion, hindering the way nature is embedded into complex resource management issues. Using a policy cycle/decision-making model, a bespoke toolkit has been developed which uses the 12 principles of the Ecosystem Approach in conjunction with real-life lessons learned from exemplar case studies. The decision support tools and methods developed by the UKNEAFO have been integrated into an independently produced web-portal (the National Ecosystem Assessment Toolkit; NEAT Tree) to help decision-makers to engage with the Ecosystem Approach.

Making sense of the diversity and complexity of tools available to help assess risks to, and benefits of, ecosystem services poses a significant challenge for many. The NEAT Tree helps policy- makers

and practitioners identify which tool is best suited to a given situation, how it should be used, when it should be used, and in what combination with which other tools. Our functional 'tool typology' helps identify an accessible and integrated suite of tools judged to have high impact and suitability for using the UK NEAFO Ecosystem Services Conceptual Framework; they are structured into categories of regulatory, incentive, valuation, futures, ecosystem services and participation tools.

Many stakeholders are often unfamiliar with, and confused by, ecosystem terminology, which can hinder engagement with the Ecosystem Approach. Thus, we need to focus ecosystems language towards more recognisable 'hooks'. In the research and policy literature, the UK NEAFO found uncritical use of terms such as the Ecosystem Approach, Ecosystems Assessment, Ecosystem Services Framework and Ecosystem Services Approach. These terms are currently ill-defined and, so, can be bewildering for many potential user groups, including the 'experts'. In response, a recognisable and generic policy/decision-making cycle is presented by the UK NEAFO: Ideas-Survey-Assess-Plan-Deliver-Evaluate. This offers stakeholders a way to embed the Ecosystem Approach into their policies, plans and projects.

Rethinking the role of nature as producing multiple benefits to society makes ecosystem thinking attractive to different user groups. The UK NEAFO Ecosystem Services Conceptual Framework provides a positive structure within which more holistic considerations of nature can be used in both decision support and incentive schemes, ideally as joined-up bundles. For instance, the use of incentives within new market instruments, such as Payments for Ecosystem Services, can help flood management in upland catchments. Equally, regulation can provide important societal and environmental protection where market failure occurs.

Different sectors have particular hooks to enable initial engagement with the Ecosystem Approach and UK NEAFO Ecosystem Services Conceptual Framework.

■ For business interests, the hooks revolve around the concept of risk and the delivery of multiple benefits; environmental management systems and corporate social responsibility feature prominently.

■ For the built environment, EU Directives (Impact Assessments and the EU Water Framework Directive), together with the National Planning Policy Framework, provide key hooks.

■ In local authorities, the Duty to Co-operate (Localism Act 2011) provides a hook for wider engagement in local plan-making where ecosystem services in one administrative area frequently supply consumers, or provide benefits, in another area.

■ For local communities, the Localism Act 2011 and Public Services (Social Value) Act 2012 provide hooks, set within asset transfer, community ownership and management goals.

- In the natural environment sector, EU Directives (NATURA 2000) and national policies (e.g. Biodiversity 2020 and Natural Environment White Paper) provide hooks for initial engagement.

Efforts to mainstream ecosystem thinking are enhanced when the ecosystem services framework is used at the outset of policy- and decision-making processes. In particular, the Ideas and Survey stages of the NEAT Tree provide a baseline from which evidence can be assessed and used in subsequent stages, hence allowing different trade-offs to be identified and considered. It is important to invest in the Ideas stage in order to identify alternative approaches which can be carried through to the Assess stage and, ultimately, result in a preferred option. Currently, this is rarely done, except where it is mandatory, for example, in Strategic Environmental Assessment.

Our case studies and tool examples reveal the added value that using an Ecosystem Approach can bring:

(i) The environment represents an 'opportunity space' for providing multiple benefits that support growth, development and quality of life.

(ii) Many ecosystems services flow across administrative boundaries; therefore, identifying service flows in terms of providers and beneficiaries can facilitate genuine landscape-scale collaborations and new markets (e.g. flood mitigation by investment in upstream land management).

(iii) Creating markets for undervalued ecosystem services can help to support conservation projects through strong partnerships based on supplier and vendor relationships within new flows of private investment (e.g. Payments for Ecosystem Services [PES]).

(iv) New partnerships can emerge when the Ecosystem Approach highlights the need for innovation to manage trade-offs (such as the trade-off between food production through intensive agriculture with water quality and biodiversity).

(v) The Ecosystem Approach provides evidence-enhancing communication about the importance of the natural world to sectors, services and functions which are not usually involved in environmental issues.

Part III: Knowledge Exchange - What does the UK National Ecosystem Assessment Follow-on mean for different users?

3.1   General Public

Who is this description for?

This description of the recent work of the UK National Ecosystem Assessment is for members of the wider public who may be less familiar with the benefits that the natural world provides us with and how you can help to enhance our ecosystems. This account may also be helpful to other users before reading descriptions focussed on more technical information relevant to specific audiences.

Why is nature important to us all?

The natural world is critically important to every one of us. It contains an amazing diversity of living things and is shaped by climate, geology and human activity. We refer to the contrasting landscapes and waterscapes, with their different plants and animals that result from these interacting processes as 'ecosystems'. Examples include woodlands, rivers, grasslands and moorlands. People have shaped these ecosystems over thousands of years.

Ecosystems are vital to us all, supporting a wide range of our needs. They provide for our physical survival by supplying fresh air, water, food and a favourable climate. We also get building materials and energy from them, gain employment from them, learn from them, and enjoy activities in them and delight in their natural beauty, improving our mental and physical health.

Often, we take these benefits for granted. Some resources are being overused, limiting their availability to future generations. We also regularly overlook the damaging consequences of many of our activities. If we don't value and look after our ecosystems, we will create problems in the future in terms of our health, our economy and our quality of life.

We use the term **ecosystem services** to describe the benefits that people get from ecosystems. Ecosystem services include:

- The **things we get from nature,** such as crops, livestock, fish, water, minerals and energy.

- The **ways in which nature regulates** the climate, flooding and air quality.

- The **way nature enriches our culture,** for example, by providing treasured landscapes and recreational opportunities.

- The **way nature supports processes within ecosystems,** such as nutrient cycling, which are essential for ensuring the delivery of other ecosystem services.

All of these ecosystem services are interdependent. Understanding the full range of services and how they interact can help us to recognise:

- the unintended consequences of how we use ecosystems, such as the risk of flooding and loss of wildlife due to past intensification of farming; but also,

- the opportunities to change how we use ecosystems, and to improve the benefits both for the natural world and ourselves.

Looking at our rivers as an example, rainwater runs through the soil into rivers, which then flow into seas. If soils are polluted, these pollutants are also washed into rivers and seas, affecting the plants and animals that live in these ecosystems. This also affects us as we depend on these ecosystems for food, drinking water, recreation and many other needs.

To better understand the many benefits ecosystems provide us with, the UK undertook the **National Ecosystem Assessment** (UK NEA) in 2011. This gave us information about what we need to do to protect our ecosystems. The UK NEA was the world's first country-wide assessment of ecosystems and their services.

Ecosystems have changed significantly over time. The UK NEA recorded significant change in our ecosystems over the past 60 years, reflecting changes in society. Some aspects of the natural world are being lost or degraded. For example, flat areas of land surrounding rivers and streams, known as floodplains, are

increasingly being built on, or have been drained for farming. Loss of floodplains and other types of wetlands can:

- reduce the quality of fresh water in rivers, lakes and underground reserves;

- increase the risk of flooding in low-lying areas;

- reduce soil fertility and the recycling of nutrients;

- affect animals and plants that depend on these habitats; and

- degrade the beauty of the landscape and affect its uses.

All of these impacts affect the way people use and value the natural world and have associated costs, including:

- **economic** costs from building more flood defences and cleaning contaminated water;

- **social** costs from impacts on health and well-being; and

- **environmental** costs from changes in wildlife and the health and resilience of our ecosystems.

Quantifying the costs of environmental degradation and demonstrating the benefits to our well-being of **protecting essential ecosystem services** was a major outcome of the UK NEA. In 2014, the UK NEA Follow-on project (UK NEAFO) addressed some of the gaps in our knowledge about both the monetary and non-monetary values of a wide range of services provided by ecosystems. As a result, it provides extra information to help decision-makers make the best choices for the natural world and our well-being.

UK NEAFO research included looking at how people use and enjoy the natural environment. Some of the understanding of the way people connect to the environment was based on the Monitor of Engagement with the Natural Environment (MENE) surveys in England, which describe how people use natural spaces. These uses include visiting the countryside, watching wildlife, exercising and volunteer work.
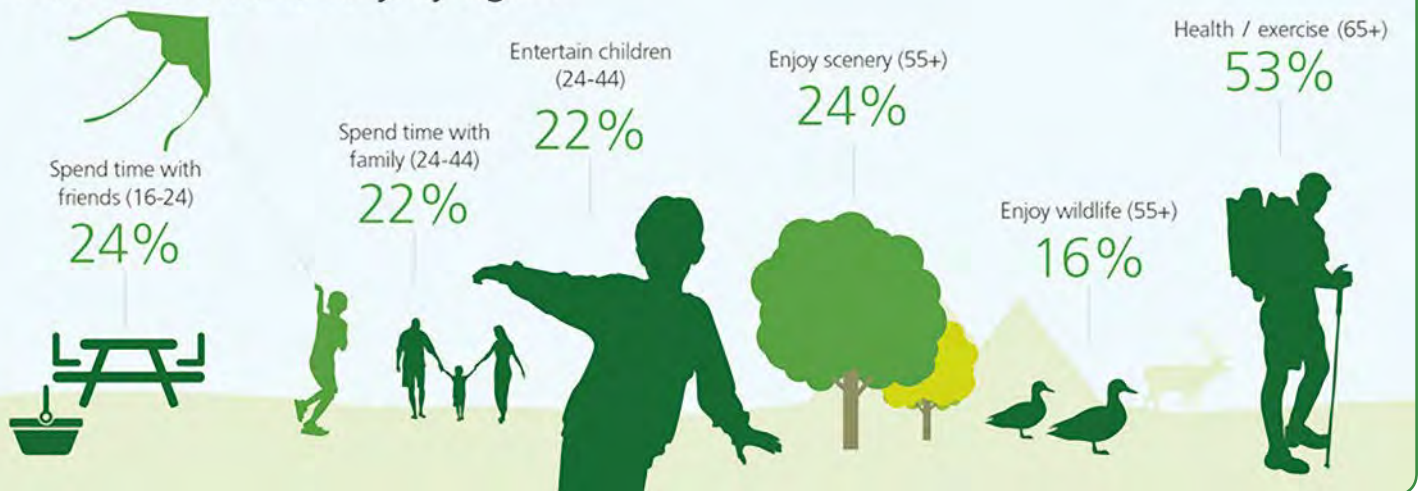
The MENE surveys found that natural spaces – ranging from gardens to National Parks, and from beaches to woodlands – are really important for people's well-being and happiness. For example, a large proportion of English adults visit the natural environment regularly. Our reasons for visiting nature depend on who we are. Some of us walk the dog, others spend time with friends and family, or go out to learn, relax or simply enjoy the wildlife and scenery. Understanding how people use and value the outdoors, and who does and doesn't use it, helps us make better decisions (WPR 5.4).

The UK NEAFO also explored different potential futures for our ecosystems. For example, it found that expanding our woodlands around towns and cities not only helps nature conservation, but also benefits people by improving access to nature close to where people live (WPR 3).

Much of the UK NEAFO work explored a number of case studies to help illustrate the use of ecosystem thinking to inform decision-making. Two examples are described on page 65.

Visit motivations vary by age…

Spend time with friends (16-24)
24%

Spend time with family (24-44)
22%

Entertain children (24-44)
22%

Enjoy scenery (55+)
24%

Enjoy wildlife (55+)
16%

Health / exercise (65+)
53%

Case study 1:
Birmingham's Green Infrastructure Strategy

Nature is important in urban areas. Trees break down air pollution and help reduce noise; and parks and other green spaces help prevent flooding, provide homes for wildlife and are enjoyed by people. Urban ecosystems, often called 'green infrastructure', have previously been overlooked, but are now being recognised for providing many valuable ecosystem services.

In 2013, the Local Authority in Birmingham introduced a Green Living Spaces Plan. It worked with a range of people and other organisations to develop maps of where ecosystem services came from and where there was a demand for them. Key ecosystem services included places for recreation and for wildlife. The maps helped people explore existing green infrastructure in different neighbourhoods, and to identify places where an increase in green infrastructure could improve people's quality of life and health. This initiative recognises and makes use of natural processes in the city in order to enhance the quality of life of the people of Birmingham by, for example, reducing the risks of flooding and pollution (WPR 10.7.6.1).

Case study 2:
North Devon Nature Improvement Area (NIA)

The Nature Improvement Area (NIA) programme is a government-backed scheme in England. It is establishing a network of local initiatives to help wildlife by improving the connections between different landscapes and with the people that live in them. The North Devon NIA is helping to develop a better understanding of the ecosystem services that nature provides for local communities in the Torridge area. These services include clean water, flood prevention, fuel, wildlife, high quality food, tourism, health and well-loved local places. All of these services influence our well-being.

The NIA partnership, led by the Devon Wildlife Trust, aims to create a wildlife-rich landscape that is "bigger, better and more joined-up". The partnership works with local people across the area, encouraging all sectors of the community to get involved. This has included more than 1,000 visits to landowners to give advice on their activities, and publicising the project to more than 100,000 local residents. This work recognises and makes use of nature and the benefits it provides in this rural area in order to enhance the quality of life of local people (WPR 5.4.2 and WPR 5.5.4).

The UK NEAFO programme explores a range of processes and tools to help us make better decisions about the natural world.

Tools that help us work together include:

- Ways to **explore shared values,** which may differ from the ways we express individual preferences. For example, one UK NEAFO case study brought together local people from the community to consider the value of the coastal fishery in Hastings, East Sussex. Having a wide range of people involved helped them to share different opinions, discuss new insights and discover common views. This developed a richer vision of how the

fishery should be conserved, not just for fishery purposes, but also to address social issues like youth unemployment (WPR 6.4.3).

■ **Mapping** which can make complex information easier to understand. The creation of maps can also bring together different perspectives and types of knowledge in a process called 'participatory mapping', or 'community-based mapping'. This was used in the UK NEAFO North Devon NIA case study. Local knowledge – about which landscape features are of particular value, where rubbish gets dumped, which drains get blocked, and so on – is all useful in helping us to make better decisions (WPR 5.5.2).

■ Ways to explore **alternative possible futures** (called 'scenario tools') can help us to understand how things may turn out in the future if particular decisions are taken, or if key events occur. Scenarios can help us to make better decisions about our ecosystems, such as where best to build homes for a growing population without putting communities at greater risk of flooding (WPR 7.3.2).

In summary **ecosystems really matter for all of us.** The natural world supports many of our needs. If we let it continue to degrade, we will harm our chances of living healthy, profitable and fulfilled lives. **To build a better future we all need to work together.** We all benefit from, and influence, the natural world. Ecosystems are both our inheritance and our legacy, so everyone's views matter. **We will all benefit from getting involved.** While we are all dependent on it, our views and uses of the natural world vary from person to person. It is important that we take into account the many ways in which people value and use the natural world.

What could I do now to help?

There are things we can all do to look after the natural world. For example, you could:

■ Think about the ways you use and recycle resources.

■ Get involved with local action for the environment, through:
- your local OPAL project (www.opalexplorenature.org)
- Wildlife Trusts (www.wildlifetrusts.org) and Rivers Trusts (www.theriverstrust.org)
- Buglife (www.buglife.org.uk)
- Butterfly Conservation (www.butterfly-conservation.org)
- The National Trust (www.nationaltrust.org.uk) and the National Trust for Scotland (www.nts.org.uk)
- local Nature Improvement Area (NIA) projects
- Plantlife (www.plantlife.org.uk)
- The RSPB (www.rspb.org.uk), including Futurescapes initiatives (www.rspb.org.uk/futurescapes/)
- The Woodland Trust (www.woodlandtrust.org.uk)
- The Marine Conservation Society (www.mcsuk.org/)

■ Participate in Neighbourhood Plans and other initiatives to manage community assets.

■ Look after wildlife in your own garden, or in the local community.

To learn more about both the UK NEA and the UK NEAFO and the key lessons it holds for all of us about building a sustainable future, go to http://uknea.unep-wcmc.org or www.lwec.org.uk/.

3.2 Environmental Non-Governmental Organisations (NGOs)

Who is this description for?

This description of the recent work of the UK National Ecosystem Assessment is targeted at the trustees, executive and operational staff of environmental NGOs, but may also be of interest to their members, too. While this account specifically seeks to raise awareness about the Ecosystem Approach, it may be helpful to first read a non-technical description of ecosystem service concepts outlined for the 'General Public' audience (see p. 63-69).

The natural world supports many aspects of our lives, from economic activities to health and general quality of life. Society has often overlooked this in the past, harming both ecosystems and our own interests. But we are now learning more about the inter-dependencies between natural and socio-economic systems, providing us with exciting opportunities to generate greater support for nature conservation.

The Ecosystem Approach addresses human-environment interactions, and *"is a strategy for the integrated management of land, water and living resources to promote conservation and sustainable use in an equitable way"* (Convention on Biological Diversity). The twelve principles[1] articulating the Ecosystem Approach promote participation in decision-making of affected people, the management of natural resources at appropriate scales of space and time, and assessment of the breadth of outcomes using an 'Ecosystem Service[2]' Framework, to describe the many benefits nature delivers to society.

Recognising the wider benefits that nature delivers helps prioritise actions to safeguard it. Historically, arguments in favour of nature conservation may have been perceived as 'special pleading', because of some intrinsic/inherent value, constraining legitimate development. However, recognising the many services nature provides elevates the case for conservation, reinforcing its importance when scarce funding is being allocated.

The philosophies of many environmental NGOs are becoming increasingly consistent with the ethos of the Ecosystem Approach.

Several environmental NGOs are already breaking down barriers and building bridges between sectors of society with narrower interests, including land managers, utilities and business more generally. Nature conservation for human benefit is becoming a key objective of environmental NGOs as they increasingly recognise that nature cannot be preserved in isolated, special places alone. Protection of individual sites, including nature reserves and local 'green' and 'blue' (freshwater and marine) spaces, remains vital, particularly in light of a changing climate. But addressing nature conservation at a landscape-scale, and forming coherent ecological networks, is essential for the resilience of our ecosystems and their capacity to provide a wide range of benefits for people and wildlife. Advocacy of the Ecosystem Approach has become a key priority for many environmental NGOs, as they build upon more than a century of promoting such concepts as 'natural capital[3] and the protection of areas considered ". . .worthy of preservation".

As major land managers, environmental NGOs are well placed to champion the Natural Capital Asset Check (NCAC) recommended by the UK National Ecosystem Assessment Follow-on project (UK NEAFO; p. 22-23, WPR 1.4.4). Currently, environmental NGOs play a major role in documenting change in species and habitats; potentially, they could extend this monitoring to include wider natural capital 'assets[4]'. Since natural capital underpins well-being, for each natural capital asset, it is crucially important to assess:

- How much of the asset do we have?

- What is the asset's condition?

- What ecosystem services does the asset produce?

- How do our decisions affect stocks, condition and flows of ecosystem services over time?

The nationwide collection of such data would help quantify the poorly understood relationship between the location and condition of a natural capital asset and the services it produces. This would help us to identify the risks of thresholds and trade-offs between ecosystem services that might threaten long-term sustainability (WPR 1.4.4).

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[1] www.cbd.int/ecosystem/principles.shtml

[2] **Ecosystem services** are the benefits people obtain from ecosystems. These include provisioning services, such as food and water; regulating services, such as flood and disease control; cultural services, which encompass the environmental spaces and cultural practices that provide a range of material and non-material benefits; and supporting services, such as nutrient cycling, that maintain conditions for life on Earth.

[3] **Natural capital** is the stock of natural ecosystems that yields a flow of valuable ecosystem goods or services into the future. In the UK NEAFO Natural Capital has been formally defined as "the configuration (in time, space, functionality and/or with other capital) of natural resources and ecological processes that contributes through its existence and/or in some combination to human welfare (WPR 1,3)." In this sense, Natural Capital can be placed alongside other types of capital including financial, physical (manufactured), human and social, as integral to our nation's economy and contributes to society's well-being.

[4] The Scottish Wildlife Trust has recently launched the Scottish Forum for Natural Capital bringing together public, private and voluntary organisations to protect and rebuild Scotland's natural capital.

Environmental NGO activities and the protection of ecosystem services

The **Futurescapes** initiative from the Royal Society for the Protection of Birds (RSPB), the **Living Landscape** approach of The Wildlife Trusts and The Rivers Trust movement are all examples of NGO-led initiatives practising conservation at a landscape-scale to deliver a wide range of ecosystem services that benefit both people and wildlife. These initiatives recognise the **importance of working within an economic context to protect nature's services** and the need for champions, knowledge brokers and knowledge providers to help embed the Ecosystem Services Framework into innovative schemes

For example, the **Westcountry Rivers Trust** (WRT) works closely with local farms, helping them to save money on farming practices, while also benefitting river health. The Trust also works in partnership with South West Water (SWW), the regional water company, to find and implement cost-effective and innovative ways to protect water resources, including reducing contamination from farmed land under SWW's 'Upstream Thinking' programme. Upstream Thinking also produces other benefits, such as enhancing fisheries, increasing biodiversity, providing ecotourism opportunities, improving landscape quality and helping the rural economy (WPR 10.7.5.7).

The Pumlumon Project, led by the **Montgomeryshire Wildlife Trust,** is a landscape-scale project seeking to revive the ecology and economy of the Welsh uplands. Spanning 105 square miles of the Cambrian Mountains, including the source of major rivers like the Severn, this 'Living Landscape' works with local farmers, foresters and tourism businesses to bring the landscape back to life and realise benefits far beyond it, for example, in terms of water supply, carbon storage, tourism, wildlife and sustainable grazing.

Both the West Country Rivers Trust and Pumlumon Project are based on 'Payment for Ecosystem Services' (PES) schemes[5]. In both these cases, natural processes reducing river contamination are paid for by a buyer (often the water company benefitting from reduced treatment costs) as a grant, subsidy or payment to sellers (such as farm businesses) for improving their practices. Such PES schemes are one way we may respond to, and reduce the impacts of, changes to our ecosystems. It is one of a range of response options which the UK NEAFO 'stress-tested' to explore the extent to which the delivery of multiple ecosystem services could be sustained under a range of plausible 'future worlds' (p. 42-45; WPR 8.4.2).

Comparison of alternative land uses, and where they occur, have consequences for the delivery of multiple ecosystem services, including provisioning of crops, regulating water quality, recreation and supporting biodiversity. These services, and their associated monetary and wider social benefits, should be of interest to environmental NGOs. The UK NEAFO uses an updated land use model to appraise a case study of the location of tree planting under policies to substantially expand forestry in Great Britain (p. 26-29). The case study demonstrates that maximising the net value of market-priced agricultural and forestry outputs confines tree planting to remote upland areas of little value for agriculture. However, analysis of the wider social values arising from woodlands (including market-priced goods and non-market products, such as recreation, and greenhouse gas emissions and storage) suggests a very different ideal location for new woodland: close to people's homes. Indeed, recreational and amenity values generated by new woodland are substantial and significant, dominating the switch from upland areas to around urban population centres (WPR 3.13).

How can environmental NGOs enhance delivery of ecosystem services?

Environmental NGOs largely comprise members united by the values they hold and share concerning the natural world. However, the UK NEAFO shows that in relation to particular issues, such as around decisions and trade-offs, values are not necessarily pre-formed in people's minds, and may only become evident when people share thoughts and deliberate about the value of natural resources, including the competing demands upon them. Although the inclusion of these non-monetary values in decision-making is important, they have often been overlooked (WPR 3 and WPR 6).

5 "Payments for Ecosystem Services (PES) often involves a series of payments to land or other natural resource managers in return for a guaranteed flow of ecosystem services (or, more commonly, for management actions likely to enhance their provision) over-and-above what would otherwise be provided in the absence of payment. Payments are made by the beneficiaries of the services in question, for example, individuals, communities, businesses or government acting on behalf of various parties". Payment for Ecosystem Services: A Best Practice Guide, Defra (2013)

40 million visits annually, the South Downs National Park is the most visited National Park in Britain, and is, therefore, a valuable amenity for around 2 million people living in or near it. However, 1.2 million people depend on water filtered through, and stored in, downland chalk, and some groundwater catchments are close to failing water quality standards. Both the *'Chalking up the Benefits'* project which works with the community to explore what the town of Lewes gets from its local environment, and the *'Town to Down'* project which works in collaboration with the Brighton, Hove and Lewes Downs Biosphere proposal, aim to demonstrate the benefits of ecosystem services to urban populations (WPR 10.7.6.7).

Learning about the effect of deliberation on the values people hold highlighted that policy-makers, decision-makers, academics and environmental NGOs need to work together to accommodate a more holistic range of values in processes that support decision-making. The UK NEAFO presents a new way of understanding both cultural ecosystem services and shared values, and how to incorporate them into decision-making (WPR 5 and WPR 6). This is informed by a number of case studies, including how recreational divers and sea anglers value proposed and existing Marine Protected Areas (MPAs) in England, Scotland and Wales (p. 35-38, WPR 6.4).

Conventional economic valuation is usually based on the wants and motivations of individuals, yet people can also be selfless and have 'other-regarding' values, including those relating to the meaning and significance of ecosystems (i.e. cultural values like sense of place, peace, tranquillity and places for engaging with nature and recreation). The UK NEAFO identifies how techniques like deliberative valuation (where groups discuss opinions and share knowledge) can reveal these deeper-held values, which are often not immediately evident, helping us factor what is important to people into decision-making processes (WPR 6.3.4 and 6.3.4).

The UK NEAFO has produced a set of tools and methods that have been integrated into the independently produced National Ecosystem Assessment Toolkit (NEAT Tree) web-portal to promote the uptake of the Ecosystem Approach in decision-making (p. 48-50). Among the case studies assessed in the analysis were Nature Improvement Areas (NIAs), pilot schemes set up in England, which seek to secure improvements in the delivery of multiple ecosystem services (WPR 10.7.6).

The South Downs Way Ahead NIA, a partnership project, led by Sussex Wildlife Trust, and involving the National Park, local government authorities, and a wide range of local business and other stakeholders, is piloting techniques to engage with the public, increase understanding of the value of ecosystem services and improve the benefits flowing from chalk grassland. With nearly

Establishing the South Downs NIA has encouraged communities and businesses alike to recognise the often overlooked benefits they receive from nature. Sympathetic management of chalk grassland to deliver drinking water improvements and recreational benefits is also likely to benefit wildlife, such as the endangered Duke of Burgundy butterfly, corn bunting and stone curlew (WPR 10.7.6.7).

Taking the Ecosystem Approach forwards

Environmental NGOs have an important role to play in promoting the Ecosystem Approach. For many, this represents an evolution, rather than a revolution, as many environmental NGOs have already been shifting their emphasis towards nature's broader societal benefits, in addition to its inherent value. This progressive shift to an Ecosystem Approach needs to shape the ways in which environmental NGOs communicate, act and use their networks and prominent spokespeople to influence the perceptions, policies and practices of others.

Environmental NGOs can present arguments about the value of nature in different ways to different audiences, promoting the multiple benefits that nature provides for all in society. For example, stories and case studies may be framed in terms of the Ecosystem Approach (not necessarily using technical terminology, but adapting language to suit different audiences) in order to demonstrate to different groups of people the range of benefits that flow from nature. Environmental NGOs are already particularly successful in developing landscape-scale initiatives and communicating the benefits of nature to a variety of audiences; this represents a specific contribution to promoting the Ecosystem Approach.

What could environmental NGOs do now to help?

Environmental NGOs could be communicating, in broad terms, the value of nature to society, in addition to its inherent importance. Actions could include:

- **Thinking about the implications for all ecosystem services when managing ecosystems and influencing policy.** This includes taking account of how an Ecosystem Approach can provide broader societal benefits, as well as providing positive examples for policy-makers.

- **Influencing and educating members about the wider societal benefits of nature** to spread awareness and promote an increased uptake of this way of thinking and acting.

- **Illustrating what the Ecosystem Approach means** through case studies and stories which are meaningful to different groups of people, particularly ones based on practical schemes at local and landscape scales.

- **Implementing Natural Capital Asset Checks locally** and articulating the ability of natural capital to deliver flows of ecosystem services both now and into the future.

- **Engaging in projects that illustrate and harness the benefits of activities in outdoor spaces** in terms of the cultural ecosystem services and well-being benefits they provide.

- **Acting as partners or intermediaries** in the establishment (design and implementation) of new PES schemes.

Find out more about the Ecosystem Approach from:

- CBD Guidelines – The Ecosystem Approach (www.cbd.int/doc/publications/ea-text-en.pdf)

- The Ecosystems Knowledge Network (www.ecosystemsknowledge.net)

Government initiatives promoting an Ecosystem Approach include:

- Nature Improvement Area projects (NIA): (www.naturalengland.org.uk/ourwork/conservation/biodiversity/funding/nia/default.aspx)

- Local Nature Partnerships (www.gov.uk/government/policies/protecting-biodiversity-and-ecosystems-at-home-and-abroad/supporting-pages/local-nature-partnerships) and

- Catchment-Based Approach projects (www.gov.uk/government/publications/catchment-based-approach-improving-the-quality-of-our-water-environment)

3.3 Government Agencies

Who is this description for?

This description is for the staff of government agencies that have responsibility for regulating and managing the environment in order to help them take forward the **Ecosystem Approach**[1] at an operational level through Adaptive Management. While this account specifically seeks to raise awareness about the use of the Ecosystem Approach, it may be helpful to first read a non-technical description of ecosystem service concepts outlined for the 'General Public' audience (see p. 63-66).

How can the Ecosystem Approach help government agencies?

At the strategic level, the UK National Ecosystem Assessment Follow-on project (UK NEAFO) seeks to assist decision-makers in making informed choices and exercising them through an **Adaptive Management Strategy** – a flexible, 'learning-by-doing' process. Adaptive Management takes place within the **Ecosystem Services Conceptual Framework**[2] and wider **Ecosystem Approach,** and can be implemented through a **Decision Support System (DSS) Toolbox** (p. 14). This Toolbox is presented as both a process and a collection of tools, and comprises a set of assessment methods and techniques that can be used in an iterative way. The techniques include scoping baseline natural capital assets and trends in ecosystem services (flows); identifying key policy issues; bringing together monetary and non-monetary valuations, as well as other evidence; exploring possible future scenarios and response options; and developing appropriate indicators and systems for monitoring change.

At the tactical level, the UK NEAFO helps to translate the Ecosystem Approach into realistic action. This incorporates prompts and actions – Why? What? Who? When? Where? – at all stages of the decision-making cycle, which lead to **specific tools** being recommended at particular points. The National Ecosystem Approach Toolkit (NEAT Tree), which builds on the work of the UK NEAFO, helps decision-makers to make informed choices which will deliver more sustainable outcomes.

Given many ecosystems, and the services they deliver, are in long-term decline there is an urgent need to illustrate the threat of further environmental deterioration to well-being. The UK and devolved governments identify well-being as an important measure of societal progress but the co-dependence of social wellbeing, the economy and the environment, is not always clearly articulated. By having a clearer and more widely shared understanding of the state of our natural capital, decision-makers in government agencies can demonstrate the importance of protecting the environment when considering policy and management options.

How can you put the Ecosystem Approach into practice?

Realising nature's value is about finding environmental management solutions that consider economic, social and environmental benefits collectively. In some cases, this will mean trade-offs between competing demands on natural resources. Different stakeholders need to come together at the earliest opportunity to find ways of developing joint solutions to the demands we place on the environment.

The **assessment techniques,** recommended as part of the DSS Toolbox, start with a need to understand and establish a baseline for the extent and condition of natural capital 'assets'. The UK NEAFO recognises the need for a Natural Capital Asset Check tool, which takes into account the fact that natural capital assets are specific components (living/non-living, renewable/non-renewable) of ecosystems that can come together and interact in productive combinations with other 'capitals' e.g. financial, human, social, to deliver ecosystem services (WPR 1.3). For example, in analysing the role of saltmarshes in commercial fisheries, a number of different natural capital assets are involved, including fish species (such as bass) and the habitat (intertidal saltmarsh). However, to be productive, they need to work in certain combinations – not just in space, time and functions, but also with other capital (for instance, financial and human capital like the commercial fishing fleet). This example of a natural capital asset also illustrates the flow of ecosystem services, since it supports the recruitment of the fish stocks over time, the 'goods' measured in fish landings, which in-turn has 'value' to people, reflected in the price of food (WPR 1.3.3.5 and 1.4.4). Clearly, quantifying the baseline in this example requires economists, as well as natural scientists, to understand the interactions between natural and other capital assets.

In order to facilitate more flexible outcomes, **institutional barriers** to embedding ecosystem services in government policies and decision-making need to be recognised. The UK NEAFO explores these issues in project, programme and policy appraisals (p. 46-47; WPR 9), and finds that, at the practitioner level, resources like time

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[1] **The Ecosystem Approach** addresses human-environment interactions, and "is a strategy for the integrated management of land, water and living resources to promote conservation and sustainable use in an equitable way" (Convention on Biological Diversity). The twelve principles articulating the Ecosystem Approach promote participation in decision-making of affected people, the management of natural resources at appropriate scales of space and time, and assessment of the breadth of outcomes using an 'Ecosystem Service' Framework, to describe the many benefits nature delivers to society.

[2] **Ecosystem services** are the benefits people obtain from ecosystems. These include provisioning services, such as food and water; regulating services, such as flood and disease control; cultural services, which encompass the environmental spaces and cultural practices that provide a range of material and non-material benefits; and supporting services, such as nutrient cycling, that maintain conditions for life on Earth.

and data are often lacking and sometimes there is limited understanding of ecosystem services concepts, though awareness of these is increasing (WPR 9.7). As a result, ecosystem services are undervalued in decision-making. Organisational barriers are also important, and include fragmented working within, and between, sector and governance levels. In some cases appraisals have a narrow focus, and there may also be confusion over differences in legal requirements. Government agencies could help with leadership and improved evidence-base regulatory mechanisms (such as incentives and voluntary measures) to overcome these issues, and facilitate better connected policies. We also need better communication across actors and sectors, and **more inclusive stakeholder debate,** with government, its agencies and non-government bodies working together more closely (WPR 9.4 and 9.7).

The UK NEAFO demonstrates that **the decision-making process is strengthened when it is more inclusive.** In particular, participatory methods (including group-based deliberation, mapping and valuation) can elicit shared values held across groups, communities and societies in both monetary and non-monetary terms. These are different from the conventional aggregation of individual values, and may influence the perceived impact a decision will have on people and their environment. This wider stakeholder engagement in decision-making is most useful when **applied at a scale relevant to the issue.** Developing more local solutions may often provide better outcomes for the different interest groups involved (WPR 8.3.9 and 8.7.4; WPR 10.8).

The UK NEAFO also shows that the exploration of **different plausible future worlds (scenarios)** as a useful deliberative tool for bringing together experts and non-experts. Not only do scenarios facilitate dialogue between stakeholders holding different perspectives about a given issue, but the stakeholders' contributions also enrich the scenarios themselves, allowing the experts to gain new insights about possible futures. Scenarios can be used to produce a series of outputs describing and, in some cases, quantifying the implications of a contrasting series of plausible futures. The UK NEAFO uses the six contrasting scenarios presented in the UK NEA (p. 39-42; WPR 7.2.1) to explore a range of issues, including: the qualitative analysis (expert judgement) of changes in ecosystem services associated with our regional seas (WPR 7.3.4); the quantitative modelling of the effects of land use change on farmland birds (WPR 7.3.3); and modelling of the changes in the flows of rivers in catchments across the UK and incidence of droughts and floods (**Box GA1**). Furthermore, scenarios are helpful when 'stress-testing' response options to assess the effects of policies on the long-term delivery of ecosystem services (WPR 8.3.1).

Box GA1: Using scenarios to explore possible consequences on river flows

The UK NEAFO explores how quantitative modelling and analysis tools can be used to gain practical insights into the six UK NEA scenarios (p. 39-40; WPR 7.2.1). One such case study examines how river flows in 34 catchments are affected by changes in land cover expected under two different scenarios. Under the *Nature@Work* scenario, ecosystem services are promoted through the creation of multi-functional landscapes and response options include schemes like upstream water retention, which is essential for mitigating flooding. This scenario was projected to lead to significantly lower river flows in 11 (32%) catchments (Figure GA1, left panel), reducing the likelihood of flooding, but increasing summer droughts. In contrast, under the *World Markets* scenario (in which, the removal of trade barriers is a priority to stimulate high economic growth), land use change would be driven by more intensive agriculture and urban expansion. The resulting ground sealing would lead to significantly greater run-off and higher river flows in 9 (26%) catchments (Figure GA1, right panel), with an increased risk of flooding.

Furthermore, the size of these effects differed between catchments, highlighting the need to look at regional and local contexts, particularly when considering the synergies and trade-offs between natural resources. Interestingly, five catchments which were projected to have significantly reduced river flows under *Nature@Work* had significantly higher river flows under *World Markets*. More information can be found in WPR 7.3.2.

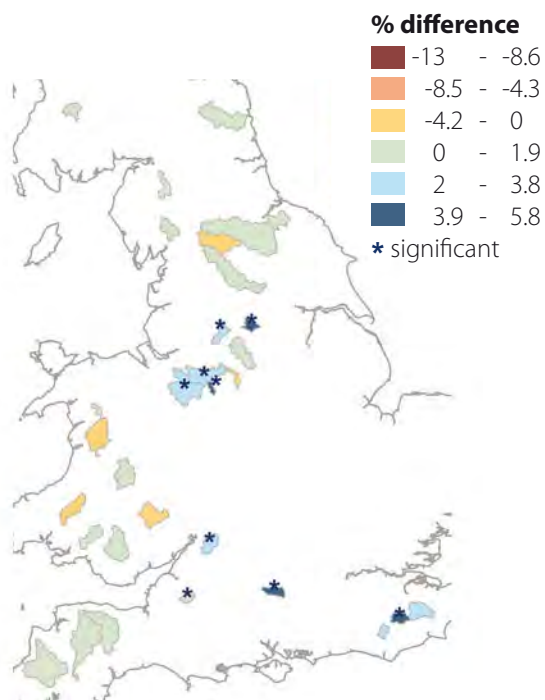## What indicators of natural capital and ecosystem services are needed?

We need to develop **practical and cost-effective indicators** of:

(i) The state and trend of both natural capital assets and the delivery of ecosystem services (especially in response to direct drivers of change, such as climate change, habitat transformation and pollution, and indirect drivers of change, such as cultural, economic, socio-political philosophies and technological innovation).

(ii) Resilience of our ecosystems and their services, especially in terms of detecting threshold limits in respect of pressures on ecosystem functioning. These indicators should be simple enough to measure and communicate change, but also sufficient enough to characterise complex ecosystem components and their interactions.

Indicators of cultural ecosystem services can be difficult to develop because of the number of variables involved, the expense of data collection from representative samples and the complexity of the relationship between a measurable parameter and the level of service. Yet, they are of great importance for human well-being, so it

World Markets (High)

% difference
- -13   -   -8.6
- -8.5   -   -4.3
- -4.2   -   0
- 0   -   1.9
- 2   -   3.8
- 3.9   -   5.8
- ∗ significant

Nature@Work (Low)

% difference
- -13   -   -8.6
- -8.5   -   -4.3
- -4.2   -   0
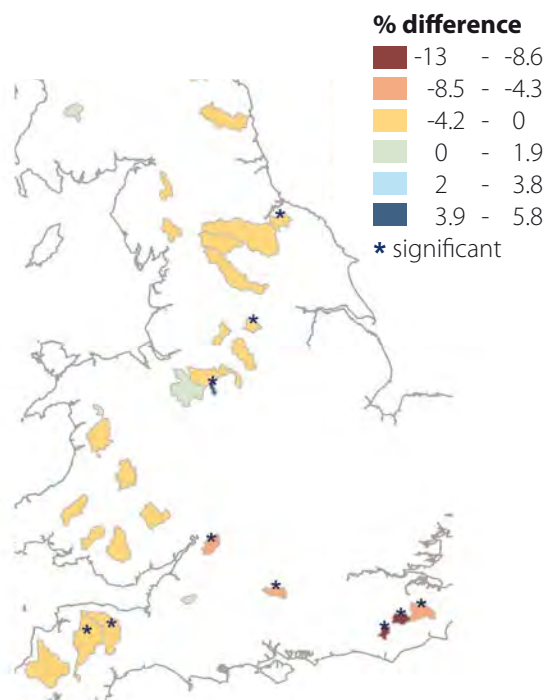- 0   -   1.9
- 2   -   3.8
- 3.9   -   5.8
- ∗ significant

Figure GA1. The effect of land cover change on average annual river discharge (expressed as percentage differences compared to the baseline) **under** *Nature@Work* and *World Markets* **scenarios.** Blue/green colours show increases in flows, and yellow/orange/red colours show reductions in flows. Significant changes from the baseline are shown by an asterisk (∗).

is important that we gather these measures. The UK NEAFO identifies a range of cultural ecosystem service indicators for potential use by government agencies (WPR 5.3). In Scotland, the Scottish Environment Protection Agency (SEPA) has already begun to use cultural ecosystem service indicators, alongside indicators of provisioning, regulating and supporting services, to characterise river basin issues[3].

What tools are available to help practitioners?

To guide practitioners through the key stages of the Ecosystem Approach the National Ecosystem Approach Toolkit (NEAT Tree) has been developed independently and incorporates the tools and methods from the UK NEAFO (p. 48-50). It takes the user through a decision-making cycle – from forming ideas and planning a response, to delivery and evaluation – using 11 case studies. These provide examples of good practice for practitioners and institutions to consider when looking to adopt and embed the Ecosystem Approach in their work. Helpful additional information is given on valuation, regulation, incentives and engagement. Several case studies are accompanied by short video recordings to illustrate the processes. A diagram of the information available is shown in **Figure GA2**, where a range of tools to help deliver multiple societal and economic benefits are linked to a number of current drivers (or 'hooks').

What monitoring is required to protect and enhance natural capital?

We need more evidence to demonstrate how the effective management of natural capital can provide both environmental and socio-economic benefits. This will help decision-makers in their assessment of potential ecosystem service trade-offs for specific locations. We need easily accessible and robust information on the state of our natural capital assets, ecosystem functioning, and the trends in ecosystem services in relation to changing pressures. Such information would be hugely helpful in developing common goals among government agencies, and encouraging collaboration.

Several of the UK NEAFO case studies show that incorporating ecosystem services into decision-making is much more sustainable when the **appropriate levels of data and knowledge** are available to stakeholders, and information is presented simply and clearly.

[3] www.sepa.org.uk/water/river_basin_planning/significant_issues.aspx
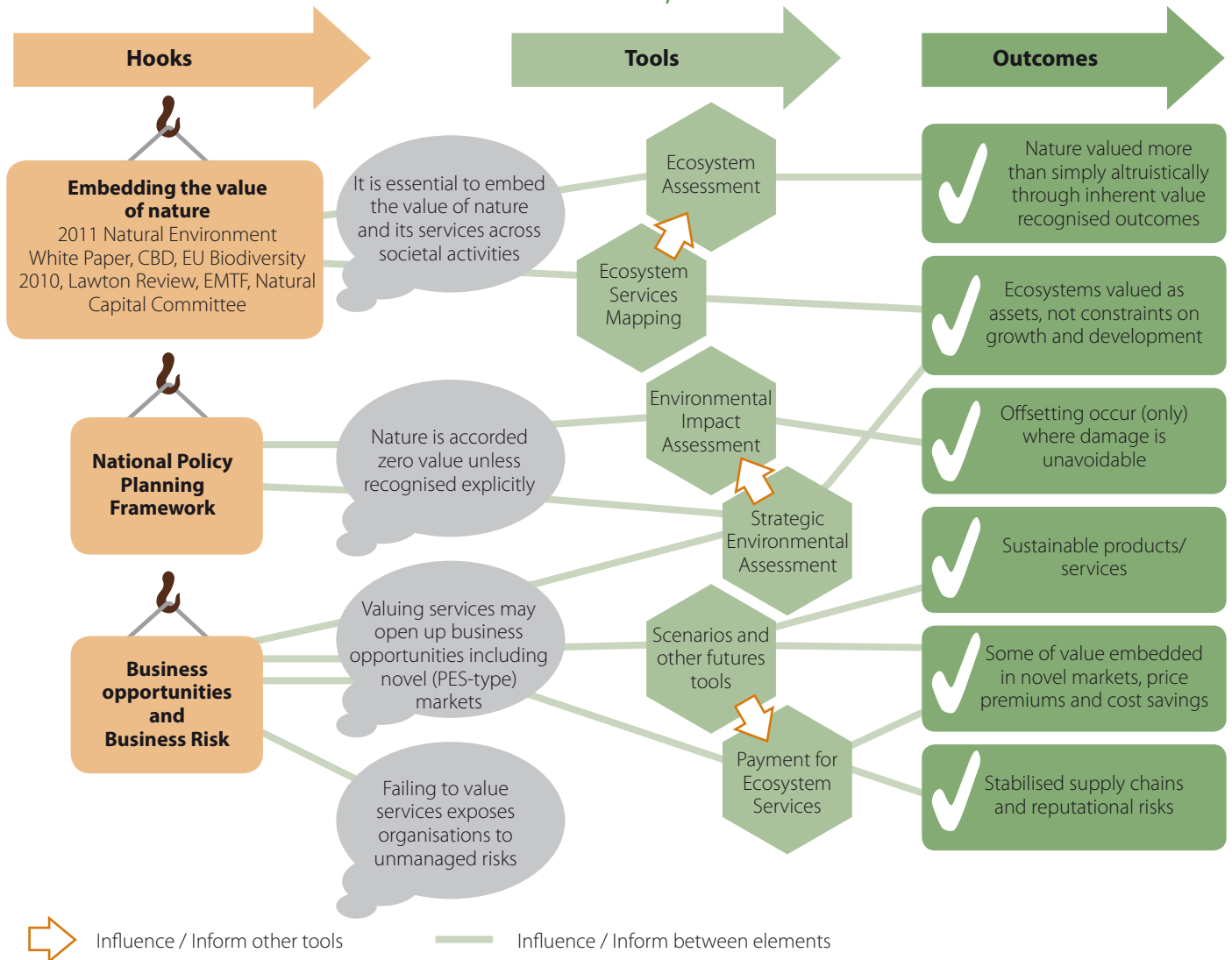
Figure GA2. An example of the advice and tools developed as part of the UK NEAFO, which are available at the NEAT Tree web-portal (www.eatme-tree.org).

What could government agencies do now to help?

■ **Become familiar** with the available background and tools needed to mainstream nature's value, and apply the Ecosystem Services Framework at an operational level.

■ **Share learning** in order to improve and incorporate new measures (such as cultural benefits and well-being) into decision-making and to develop useful indicators to assess and communicate changes.

■ **Collaborate** more widely across Government Agencies to avoid the potential trade-offs from conflicting interventions and deliver the multiple benefits from more integrated programmes of work.

■ **Engage** with communities and businesses, working together to make decisions using the principles of the Ecosystem Approach. This will make a real difference to how we manage natural capital assets.

■ **Promote and develop** Adaptive Management Principles to contribute to the wider implementation of the Ecosystem Approach.

3.4 Government

Who is this description for?

This description is for cross-departmental government audiences throughout the UK, including both the UK government and the devolved administrations in Scotland, Wales and Northern Ireland. While this account specifically seeks to raise awareness about our wider dependency on the natural environment, it may be helpful to also read a non-technical description of ecosystem service concepts outlined for the 'General Public' audience (see p. 63-66).

Why is nature important for our economy and well-being?

■ **The natural environment is critically important to our well-being.** Nature provides us with a large range of services, known as 'ecosystem services', which underpin our very existence. For example, we depend on nature to produce our crops, fish and livestock, regulate flooding, water supplies and climate, and break down waste products. Also, contact with nature gives pleasure, provides recreational opportunities and has a positive impact on long-term health and happiness. Wise use of our natural environment delivers many benefits for society and can help support a variety of policy aims.

■ **The natural environment contributes significantly to our economic prosperity.** In Scotland and Wales, the estimated contribution of natural environment-related activities to Gross Domestic Product (GDP) was 11% and 9%, respectively. These activities also accounted for 11% of jobs in Scotland and, in Wales, 16% of jobs and 10% of all wage and salary income (p. 23-26; WPR 2.4.5).

■ **All too often we have taken these benefits for granted, so some elements of our natural environment have been overexploited and are in long-term decline, and others are in a reduced or degraded state.** Furthermore, our environment is likely to be under increasing pressure in the future and sustaining the delivery of ecosystem services will be even more challenging. While there is a need to fill some gaps in our knowledge regarding ecosystems and their services, particularly in the marine environment, current evidence demonstrates that we do have sufficient knowledge to act now and make a difference.

What does this mean for government departments in England, Scotland, Wales and Northern Ireland?

■ **We can do more to take better account of the benefits provided by nature as part of sustainable development.** Recognising the benefits from nature more fully will enable us to better understand the consequences of our actions and decisions, and to make the best possible choices for society now, and in the future. Otherwise, we risk losing the important ecosystem services that nature provides to society. The need for such recognition is supported by government[1] – both in Westminster and the devolved administrations – and internationally, including by the EU[2]. Despite this, current evidence demonstrates that there is still some way to go to improve recognition of the value of nature, and integrate this more widely in government policy-making.

■ **Sustainable development is an issue across government, not just an issue for environment departments.** Working with nature can affect the delivery of many benefits to society and, therefore, help to achieve a wide range of policy objectives, not just environmental ones. For example, ecosystem services influence many aspects of well-being, including public health (mental and physical) objectives[3], economic growth and flood and climate regulation.

How can government immediately take the value of nature into account in policy-making?

■ **A promising way forward is to build consideration of ecosystem services into existing policy mechanisms and processes, adopting the Ecosystem Approach[4].** An ecosystem approach is not a separate process to be carried out in addition to regular policy development. It is a holistic, integrated way of looking at interacting economic, social and environmental consequences throughout the policy-making process, for example, as required in the UK wide Marine Planning Statement. Thus, it helps you to take the value of nature into account in your decisions in a proportionate way and as part of sustainable development.

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[1] For example, the Natural Environment White Paper, 2011 (England); and 'Towards the Sustainable Management of Wales's Natural Resources', 2013 (Wales). The government has also undertaken to include natural capital in our system of national accounts, alongside GDP (through a series of improvements to the UK Environmental Accounts up to 2020).

[2] For example, the United Nations Convention on Biological Diversity Strategic Plan 2011-2020; the EU Biodiversity Strategy, 2011, and EU Marine Strategy Framework Directive

[3] For example, the contribution of green spaces to health is recognised in the Public Health White Paper, 2010, https://www.gov.uk/government/publications/the-public-health-white-paper-2010

[4] The Ecosystem Approach addresses human-environment interactions, and "is a strategy for the integrated management of land, water and living resources to promote conservation and sustainable use in an equitable way" (Convention on Biological Diversity). The twelve principles articulating the Ecosystem Approach promote participation in decision-making of affected people, the management of natural resources at appropriate scales of space and time, and assessment of the breadth of outcomes using an 'Ecosystem Service' Framework, to describe the many benefits nature delivers to society.

- The key UK national policy appraisal process is Impact Assessment (IA), which looks at all the pros and cons of policy options. But this should not be left to the end of the process. To maximise the benefits to society, it is best to think about nature's capacity to deliver ecosystem services throughout the policy development process, rather than considering the impacts of policies in a final appraisal, once the options have already been determined. This will help to shape the best options for managing ecosystem services for the benefit of both people and wildlife. Although this issue has been recognised by government, more can be done to ensure that IAs are carried at an early stage more widely. The UK National Ecosystem Assessment Follow-on project (UK NEAFO) reviews the barriers to successful implementation of IA and suggests specific enabling measures (Table G1) (WPR 9.4.1).

- Guidance on how to take into account the value of nature is provided in HM Treasury's Green Book Supplementary Guidance on Accounting for Environmental Impacts in Policy Appraisal[5]. This promotes the use of the Ecosystem Services Framework to understand the full range of impacts (the guidance applies across the whole of the UK).

- Economic valuation is possible for changes to a number of ecosystem services. Taking this into account helps us to maximise positive outcomes and value for money for public sector expenditure. It is not practical to capture the effects of all decisions on the delivery of all ecosystems services, but major impacts can be identified and assessed. Certain ecosystem services cannot be assessed through conventional economic valuation. However, non-monetary and deliberative methods provide a complementary assessment that can capture a range of other values. In this respect, the evidence base is constantly improving (WPR 3; WPR 4; WPR 5). The government's professional economist network plays a key role in IA, so working with your economist is a good starting point.

- Effective stakeholder engagement is central to the successful implementation of the Ecosystem Approach. An inclusive procedure helps participants to understand the range of ecosystem services which are relevant to particular decisions, to provide informed and rounded solutions, and to engage across both different 'experts' (economists, ecologists, planners) and the public. In particular, stakeholder engagement is helpful where there is a strong local dimension to policy-making, for instance, in relation to cultural ecosystem services (WPR 8.3.9 and 8.7.4; WPR 10.8).

- Future scenarios can help us to both understand the consequences of policies for ecosystem service delivery, and be a useful tool for stakeholder engagement, leading to more informed strategies. The UK NEAFO explores the outcomes of contrasting future worlds on the likelihood of floods and droughts, farmland bird populations, and the resilience of a range of coastal ecosystem services (p. 39-42; WPR 7.3). In addition, it looks at the robustness of a range of current policies to understand which policy responses achieve the most positive and sustainable outcomes, with the widest range of benefits to society under future scenarios (p. 42-45; WPR 8.3.1).

[5] www.gov.uk/government/publications/green-book-supplementary-guidance-environment

Table G1. Key barriers and enabling measures that can influence the success of embedding the Ecosystem Service Concept Framework into policy Impact Assessment (IA) in government.

| Level of institutional behaviour and culture	Examples of key barriers	Examples of enabling measures
Practitioner behaviour	• Resources and capacity, including data, time, money, skills, training and guidance	• Better training • Better guidance • More resources and improved datasets
Institutional culture	• Established policy-making norms and routines • Political policy preferences • Weak quality control mechanisms	• Political leadership • Oversight and quality control • More resources and improved datasets
Social and political context	• Competing EU and UN commitments which may narrow the scope of policy-making • Societal views about policy priorities (e.g. deregulation, austerity)	• Political windows of opportunity, for instance, media interest in floods • More advanced appraisal tools

- Continual high-level political leadership, with the support of institutional champions, can increase awareness and understanding of the Ecosystem Approach. It can also be useful to encourage influential bodies, such as businesses, international organisations and key societal actors, in relevant sectors to promote the consideration of ecosystem services in partnership with public bodies. To increase the accessibility of the Ecosystem Approach, we need to use appropriate language to suit the context and audience. The UK NEAFO also emphasises that improving knowledge of the Ecosystem Approach does not necessarily mean it will inform decision-making. Institutional cultures and behaviours need to be understood to ensure that knowledge is used. The UK NEAFO sets out a number of 'learning points' to help ensure the effective use of knowledge and generate more integrated policy and practice across different sectors and governance levels (p. 48-50; WPR 10).

What new innovative developments can help incorporate the value of nature in policy-making?

- The UK NEAFO provides a Balance Sheet approach, which helps to identify the data, methods and forms of analysis that are most appropriate in different policy contexts (p. 15-16; WPR 4.7). For example, in particularly complex or dynamic environmental contexts, it may be worth additional investment in techniques that improve stakeholder involvement (participatory and deliberative methods) in decision-making and consider ethical, moral and social 'justice' aspects.

- The UK NEAFO presents a spatially and temporally explicit integrated land use model, which shows the benefit of designing policies that are flexible and can be adapted to regional and local contexts. The model provides a 'spatially targeted' process which allocates scarce resources to those locations which maximise some pre-set objective. For example, comparing outcomes for where to plant new woodland in terms of maximising market values versus wider social benefits (p. 26-29; WPR 3.13).

- The UK NEAFO redefines cultural ecosystem services as both the environmental spaces (e.g. parks and beaches) within which people interact with the natural world and the cultural practices (e.g. exercising and playing) that define these interactions and spaces. These environmental spaces and cultural practices give rise to a range of material and non-material benefits to human well-being (p. 32-35; WPR 5.2). They interact with contemporary cultural values to shape people's identities, provide experiences that contribute to mental and physical health, and equip people with a range of skills and capabilities. Including an evaluation of cultural ecosystem services within decision-making acknowledges the prevailing diversity in social and cultural values, ethics and norms in contemporary society, and makes it a more pluralistic process.

- A new set of quantitative and qualitative indicators and techniques provides new insights for organisations on how to understand, assess, monitor and manage cultural ecosystem services (WPR 5.3). The UK NEAFO identifies a range of approaches from the social sciences, arts and humanities that can be used in different circumstances to understand cultural ecosystem services and reflect both individual and shared values more generally in policy and practice (p. 32-35; WPR 5.4 and 5.5).

- The UK NEAFO offers a powerful mix of methods to incorporate non-monetary values into decision-making alongside monetary values. These are illustrated through a range of different coastal and marine case studies at local and national scales. The case studies show that techniques which allow time for consideration and discussion of complex issues and potential trade-offs may result in significant changes in both the monetary and non-monetary values placed on different ecosystem services. It is also apparent that these methods can draw in people from outside the environmental sector (p. 35-38 ; WPR 6.4).

- The UK NEAFO provides advice on the tools available for implementing the Ecosystem Approach in policy- and decision-making at various levels. This is supported by the National Ecosystem Assessment Toolkit (NEAT Tree)[6] an independently produced web-portal that promotes understanding of the issues and takes them into account throughout the policy cycle (p. 48-50; WPR 10.7). Among other topics, this includes:

  - Advice on using Cost-Benefit Analysis and Multi-Criteria Decision Analysis.

  - The Natural Capital Asset Check, a method of thinking about maintaining the stocks and flows of ecosystem services now and in the future.

  - Information on shared, plural and cultural values of ecosystems.

  - Foresight, Backcasting and Visioning tools.

  - Stakeholder engagement tools.

[6] the NEAT Tree will initially be made available on an independently produced and hosted website, www.eatme-tree.org.uk
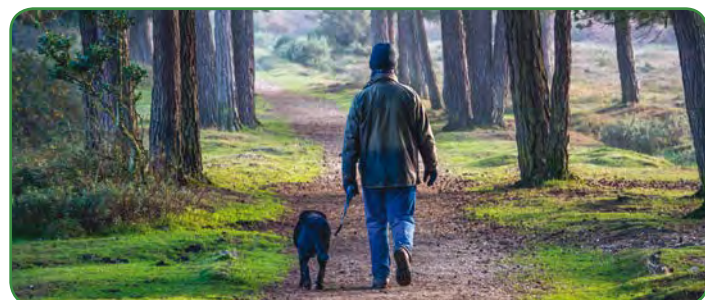
What could UK Government and the devolved administrations do now to help?

Taking better account of the value of nature in decision-making is important for sustainable development; otherwise, we risk losing the important benefits that nature provides to society.

In essence, this entails:

■ **Thinking about implications for ecosystem services throughout the policy development process (not just at the end).** This is important in order to fully understand the consequences of actions and decisions being taken, and to make the best possible choices for society now and in the future.

■ **Looking for opportunities to work with nature to deliver your policy objectives.** Ecosystem services may be able to contribute to your aims.

■ **Doing a thorough Impact Assessment** that considers the positive and negative impacts of the policy options on the ecosystem services we get from nature.

This is relevant across a broad spectrum, not just for policies directly concerned with the looking after the environment.

Doing this well is likely to involve the following:

■ Using the Ecosystems Services Conceptual Framework to identify environmental impacts, carrying out an assessment of changes to the ecosystem services involved, and undertaking a valuation of those services (as set out in the Treasury Green Book supplementary guidance).

■ Effective stakeholder engagement: Involving both the producers and beneficiaries of relevant ecosystem services in your policy development, such as those who own/manage the land producing the benefits and the sectors or communities that benefit.

■ Thinking outside traditional policy boundaries and making use of economists and other experts, such as social scientists and public health officials.

■ Using the Balance Sheet approach to identify which data and methods are appropriate in different policy contexts, especially as issues become increasingly complex.

■ Considering the use of participatory and deliberative techniques, as well as approaches from the arts and humanities, to help take account of social and cultural dimensions.

■ Thinking about the spatial scale at which policies apply.

■ Thinking long-term.

The independently produced NEAT Tree builds on the work of the UK NEAFO and provides an online resource for a wide range of stakeholders to access tools relevant to the Ecosystem Approach. Combined with the other new outputs from the UK NEAFO, it provides a powerful toolbox for facilitating the consideration of ecosystem services in the decisions made at all levels of governance.

3.5 Local authorities

Who is this description for?

This description is for local authorities, including their elected members, senior leaders, policy-makers, and delivery teams, and their community representatives. It has a wide application across local government functions, supporting progress towards sustainable development and helping to secure a better and more prosperous future for our communities. While this account specifically seeks to raise awareness about the **Ecosystem Approach**[1], as a means to enhance sustainable development, it may be helpful to first read a non-technical description of ecosystem service concepts outlined for the 'General Public' audience (see p. 63-66).

Why is nature important to local authorities?

The natural environment is an important asset to all of us, providing a range of services. Nature's services – known as 'ecosystem services' – include crop and livestock production, green energy, the regulation of water supplies and climate, and places for recreation and education. Collectively, ecosystem services provide multiple benefits for society, environment and the economy. Recognising the benefits we get from ecosystem services, the National Planning Policy Framework (NPPF) introduced in 2012, recommends the development of 'green infrastructure' and 'ecological corridors': *"a network of multifunctional green space, urban and rural, which is capable of delivering a wide range of environmental and quality of life benefits for local communities"*.

Embedding green and blue (water bodies and seascapes) infrastructure into developments can help us to adapt to climate change, reducing both flood risk and the negative effects of the heat our cities produce. Tree-lined avenues and community woodlands lock up carbon and absorb particulates from the atmosphere, both improving air quality and benefitting people's health by reducing respiratory diseases. Furthermore, there is good evidence that engaging with nature through access to gardens and parks improves people's mental and physical well-being. As a result of these demonstrable benefits, the Marmot Review of Health Inequalities (2010)[2] provided the policy steer for effective spatial planning in the NPPF to: *"Fully integrate the planning, transport, housing, environmental and health systems to address the social determinants of health in every locality. Prioritise policies and interventions that both reduce health inequalities and mitigate climate change."*

Local development plans, which all local authorities are obliged to create, include the core plans required to make decisions about land use in an area over the coming 25 years. Although produced within local authority planning departments, these plans draws together all the key areas of local authority policy under one umbrella. In many ways the local plan is the ultimate expression of partnership working, but with statutory weight and importance. Therefore, the policies and plans it outlines are crucial for shaping the future landscape. The UK National Ecosystem Assessment Follow-on (UK NEAFO) project demonstrates the importance of securing effective public involvement and use of all relevant knowledge, important elements of the Ecosystem Approach, within the planning process. It is also important to ensure that the evidence base identifies the state of ecosystems and the potential limits on their capacity to deliver ecosystem services and the consequences for well-being.

In the past, ecosystem services have been taken for granted or under-valued, and therefore often ignored in our policy- and decision-making. As a result, the condition of many natural capital assets[3] have degraded, depressing the delivery of ecosystem services, with reduced benefits with potentially major cost implications. On a positive note, several local authorities (Birmingham (**Box LA1**) and Staffordshire, for instance) are attempting to value natural capital assets and the flow of ecosystem services, in both monetary and non-monetary terms, so they can be taken into account in future decision-making (WPR 10.7.1 and 10.7.6.8). For example, in Staffordshire recent estimates by the local authority valued food, energy and timber services at £62 million per year; flood regulation services at £14.5 million per year; and the combination of all the services they have assessed so far at £112 million per year (although the real figure is likely to be higher) (WPR 10.7.6.8). Despite this good start, there are still wide gaps in our knowledge of the value of ecosystem services to local authorities, largely because the locally specific data is lacking to undertake the necessary valuation.

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[1] The **Ecosystem Approach** addresses human-environment interactions, and *"is a strategy for the integrated management of land, water and living resources to promote conservation and sustainable use in an equitable way"* (Convention on Biological Diversity). The twelve principles articulating the Ecosystem Approach promote participation in decision-making of affected people, the management of natural resources at appropriate scales of space and time, and assessment of the breadth of outcomes using an 'Ecosystem Service' Framework, to describe the many benefits nature delivers to society.

[2] www.instituteofhealthequity.org/projects/fair-society-healthy-lives-the-marmot-review

[3] **Natural capital** is the stock of natural ecosystems that yields a flow of valuable ecosystem goods or services into the future. In the UK NEAFO Natural Capital has been formally defined as "the configuration (in time, space, functionality and/or with other capital) of natural resources and ecological processes that contributes through its existence and/or in some combination to human welfare (WPR 1.3)." In this sense, Natural Capital can be placed alongside other types of capital including financial, physical (manufactured), human and social, as integral to our nation's economy and contributes to society's well-being.

The UK NEAFO produced a number of case studies which are available via the independently produced National Ecosystem Approach Toolkit[4] (NEAT Tree). These case studies identify four distinct ways in which the Ecosystem Approach and ecosystem services are embedded into local authority initiatives (WPR 10.7.6):

(i) **Retrofit:** A lack of familiarity with ecosystem service thinking, and political resistance to major change, results in ecosystem services being bolted onto the planning process retrospectively.

(ii) **Incremental:** Ecosystem services are built into existing plans and structures, but as a separate layer without full integration. The structure of overall plans does not change, often as a result of political resistance.

(iii) **Ecosystem Services-led:** This is where the ecosystem services are embedded into the plan processes from the outset. This enables the survey, assessment, delivery and evaluation stages of the NEAT Tree policy cycle to be ecosystem service proofed. Significant changes in the structure of plans result.

(iv) **'Ecosystem Approach'-led:** All 12 principles of the Ecosystem Approach are embedded into the planning process from the outset, enabling cross-sector and partnership working. It emphasises the potential benefits of understanding and taking into account the views of the public, resulting in the wider acceptance of innovative policies and schemes.

Benefits to health and well-being

Local authorities have a significant role to play in attempting to reduce health inequalities. These inequalities may arise from a complex interaction of housing, income, education, social isolation and disability, all of which are strongly affected by economic and social status. Nonetheless, it is clear that the provision of green infrastructure, and improved access to local greenspaces, can contribute to improved health and, therefore, potentially reduce the cost of treating some forms of mental and physical disease. Reactive care is expensive; for example:

■ One day spent in a mental health acute hospital bed costs £312.

■ One week in a residential care home for an older person costs around £585.

Indeed, the Department of Health suggests that increased access to greenspace could reduce national healthcare costs by more than £2 billion per year (UK NEA 2011, p. 1104).

How does the natural environment help?

Our ecosystems support lifelong health in a number of ways, through both direct and indirect impacts. For instance:

■ Experiencing nature has a significant positive impact on heart rate and blood pressure. Studies indicate that individuals with easy access to nature are three times as likely to participate in physical activity and, therefore, 40% less likely to become overweight or obese. If just 1% of the sedentary population were to move to a healthy pathway, it is estimated that more than 1,000 lives and £1.44 billion would be saved each year.

■ Green exercise results in significant improvements in self-esteem and mood. Just seeing nature can be beneficial. For example, commuters recover quicker from stress, and are less likely to suffer future stress, if travelling through nature-dominated, rather than urban-dominated, areas.

■ In East London, a study found that increasing tree and grassland cover averted 2 deaths and 2 hospital admissions (caused by particulate pollution) each year in a $10km^2$ area.

These are just some of the ways that greenspace can benefit our mental and physical health and well-being. The UK NEAFO findings suggest that domestic gardens should also be recognised as important environmental spaces where people experience interactions with nature that enhance their well-being (WPR 5.3.4.6 and 5.6.2). In particular, we found that people who live in Greater London gain the most in terms of improved well-being from domestic gardens (WPR 5.6) suggesting gardens should be a priority in urban planning.

[4] the NEAT Tree will initially be made available on an independently produced and hosted website, www.eatme-tree.org.uk

Benefits to economic growth

Healthy ecosystems directly support the rural economy through rural industries, including farming, forestry, tourism and energy production. Better green infrastructure can also encourage inward investment in urban environments. Businesses want to be located in places where they can be profitable and offer a good living environment in order to attract the best employees. The added benefit of such locations is that the improved quality of life makes for happier, more effective staff, and a reduced number of absences due to sickness.

Driving investment and increasing prosperity are major priorities for local authorities; working with the private sector, often via Local Enterprise Partnerships (LEPs), can help to achieve these goals. For example, the Greater Birmingham and Solihull LEP aims to create and support a globally competitive economy, ensuring the area is recognised as the natural home for Europe's entrepreneurs and wealth creators. Its strategy for growth identifies six key enablers, including the need to optimise physical, cultural and environmental assets. The ecosystem services of the area have been embedded into a spatial planning process, with policies and objectives to help support the delivery of the growth agenda using sound spatial planning principles that dovetail with the Ecosystem Approach (WPR 10.7.6.6). These principles are expanded and illustrated in the 'Business' audience section (see Figure B1; p. 81).

Benefits for delivery

The Ecosystem Approach provides many benefits and new ways of working for local authority delivery teams and their partners. Nature has no boundaries; working with it to solve long-term problems, soon results in innovative solutions that require different parts of the local authority coming together with unexpected stakeholders in exciting new partnerships. The duty to cooperate under the Localism Act 2011 is a key opportunity to work across scales and sectors in order to deal with strategic planning issues.

The Ecosystem Approach takes a holistic view, prioritising engagement with people, management issues and the importance of scale and dynamics, as well as ecosystem function, good and services; it can be incorporated into every stage of the decision-making cycle: Ideas-Survey-Assess-Plan-Deliver-Evaluate (WPR 10.5.4). There is a wide range of tools to help with every stage of this cycle, which are outlined in the UK NEAFO Tool Typology under the following headings: Regulation, Incentives, Valuation, Participatory and Ecosystem Services. The UK NEAFO tools and methods have been integrated into an independently produced web-portal, the NEAT Tree, which provides a single point of reference that demonstrates how all sectors can use the Ecosystem Approach (WPR 10.6). The advice in the NEAT Tree can be applied at any stage in the decision-making cycle, and may relate to any individual plan, project, programme or policy.

Benefits to communities

The Ecosystem Approach can help address the localism agenda by encouraging a better understanding within communities, or across neighbourhoods, about the multiple benefits that the local environment can provide. This new way of seeing things also identifies where potential gains are not being delivered to, or received, by communities.

The Ecosystems Approach can be applied equally, whether you are in a rural, urban, or urban fringe location. Nationally, more powers are being passed to local communities through such instruments as Neighbourhood Plans, Parish Plans, Community Asset Transfer, local place budgets, and extended opportunities for local involvement in plans, policies and local projects.

By assessing local ecosystems and their services, local authorities can highlight new ways of managing land to enhance and sustain the delivery of multiple services, while understanding the trade-offs for some ecosystem services. With such information to hand, communities can be encouraged to manage natural assets

themselves, or to apply for resources to help protect and expand the delivery of local ecosystem services and improve well-being. These ideas work at different scales and can be developed into a range of social enterprises, or leading to local solutions being delivered through Community Economic Development.

Examples of how local communities can follow the Ecosystem Approach include:

- Launch community initiatives to promote sustainable drainage including encouraging homeowners to retain permeable surfaces in gardens.

- Establish community-managed greenspace to support community cohesion and provide health benefits.

- Initiate community 'Payment for Ecosystem Services' (PES) schemes; for instance, collecting unwanted fruit from neighbourhood gardens and processing the juice to sell back to the community, both raising funds and promoting health benefits.

What could all involved in local authorities do now to help?

Things elected members, senior leaders, policy-makers, and delivery teams, and their community representatives involved in local authorities can do to embed the Ecosystem Approach into policy-making and planning:

- Look for opportunities to work through an Ecosystem Approach to deliver policy objectives, looking for win-win options that deliver multiple benefits and reduce costs.

- Carry out thorough impact assessments across existing and new policies to consider the positive and negative impacts of the policy options on ecosystems and the services they provide.

- Formally adopt the Ecosystem Approach and its 12 principles at a strategic level in order to embed it across the authority.

- Support training and development of staff to understand the benefits of the Ecosystem Approach and how it can be applied.

Things local authorities can do through partnerships to embed the Ecosystem Approach into policy-making and planning:

- Influence LEPs and local nature partnerships to embrace the Ecosystem Approach and explore tools to support businesses to develop sustainable working, both to the benefit of ecosystem services and to their income.

- Work strategically with relevant partners to manage natural assets, such as water, timber, etc.

- Promote the Ecosystem Approach to communities in order to support the localism agenda and help change attitudes and behaviour towards the environment.

- Using the Balance Sheet Approach to identify which data and methods are appropriate in different policy contexts, especially as issues become increasingly complex.

- Considering the use of participatory and deliberative techniques, as well as approaches from the arts and humanities, to help take account of social and cultural dimensions.

- Thinking about the spatial scale at which policies apply.

- Thinking long-term.

The independently produced NEAT Tree builds on the work of the UK NEAFO and provides an online resource for a wide range of stakeholders to access tools relevant to the Ecosystem Approach. Combined with the other new outputs from the UK NEAFO, it provides a powerful toolbox for facilitating the consideration of ecosystem services in the decisions made at all levels of governance.

3.6 Businesses

Who is this description for?

This description is for the business sector, broadly defined as primary production (farming, minerals and fibre) through to manufacturing, processing and service provision. This is a very wide audience, so different aspects of this report will have differing resonances for individual sectors. While this account specifically seeks to raise awareness about the Ecosystem Approach, as a means to enhance sustainable development, it may be helpful to first read a non-technical description of ecosystem service concepts outlined for the 'General Public' audience (see p. 63-66).

Introducing the Ecosystem Approach

The natural environment is critically important to both our economy and our well-being. Nature provides us with a large range of services, known as 'ecosystem services', which underpin our economic performance (see **Box B1**). For example, we depend on nature to produce our crops, regulate flooding, water supplies and climate, and break down waste products. In addition, contact with nature provides recreational opportunities and has a positive impact on long-term health and happiness. Despite this, we have taken these benefits for granted all too often, and some elements of our natural environment have been overexploited and are in long-term decline as a result. The Ecosystem Approach[1] addresses human-environment interactions through the sustainable and integrated management of land, water and living resources.

The UK National Ecosystem Assessment (UK NEA, 2011)[3] made a compelling case for the importance of embedding the concepts of ecosystem services and the Ecosystem Approach within business, particularly in terms of ensuring the long-term protection and availability of natural resources on which all businesses, directly, or indirectly, depend. Yet, the relevance of the Ecosystem Approach to business is just becoming apparent to many in the sector. Few businesses are beyond the 'innovator' or 'early adopter' stages of interest and many businesses are simply waiting to see how others in their sector respond. Accepting this, some of the findings of the UK National Ecosystem Assessment Follow-on project (UK NEAFO) are relatively 'near-market' while others may, at first sight, seem less relevant. Longer-term strategic horizon scanning should revisit the less immediately relevant findings from time to time, as they are likely to become more important.

Since the UK NEA in 2011, the Ecosystems Market Task Force[4] has identified a number of specific business opportunities arising from the management of ecosystem services. More broadly, the case for businesses to engage with the concepts of natural capital, ecosystem services and the Ecosystem Approach is increasingly associated with benefits like enhanced business resilience, competitive advantage, improved risk management, greater and new business opportunities, better stakeholder relationships and 'first mover advantage'. This is as relevant to a small farming business as it is to a large international conglomerate; it is especially relevant to any business that has a relationship with, and reliance on, any aspect of the natural environment.

> **Box B1. Sustainable Development and the Ecosystem Approach**
>
> The concept of sustainable development is at the core of the Ecosystem Approach, which recognises the crucial importance of the benefits that we receive from the natural environment. These ecosystem services might be provisioning services like crops for food, trees for timber, and other raw materials. Or they may be less obvious like the natural processes that regulate and support our environment, such as pollination, the carbon and water cycles, and soil formation. Our natural environment also provides cultural ecosystem services which may be less tangible, but include the places people visit, and how we enjoy them through exercise, learning and play, and relaxation. All these ecosystem services influence our economy, health and well-being. Alongside existing market approaches, new ways to value these services, in both monetary and non-monetary terms, are being tested and developed to better reflect the less tangible benefits from ecosystems. Such approaches to the valuation of our natural capital[2] stock and the flow of ecosystems services provide a hugely relevant resource for businesses. The Ecosystem Approach provides a systematic and measured way to develop the concept of sustainability in a commercial or organisational setting. In turn this allows business to show the long-term value that is being created through sustainable development for shareholders and other stakeholders.

[1] The 12 principles defining the Ecosystem Approach encourage participation in decision-making, promote the management of natural resources at appropriate scales of space and time, emphasise the maintenance of ecosystem functions to sustain the delivery of ecosystem services, and support the assessment of management outcomes.

[2] **Natural capital** is the stock of natural ecosystems that yields a flow of valuable ecosystem goods or services into the future. In the UKNEAFO Natural Capital has been formally defined as "the configuration (in time, space, functionality and/or with other capital) of natural resources and ecological processes that contributes through its existence and/or in some combination to human welfare (WPR 3.1)." In this sense, Natural Capital can be placed alongside other types of capital including financial, physical (manufactured), human and social, as integral to our nation's economy and contributes to society's well-being.

[3] UK National Ecosystem Assessment (2011). The UK National Ecosystem Assessment: Synthesis of the Key Findings. UNEP-WCMC, Cambridge.

[4] Realising nature's value: The Final Report of the Ecosystem Markets Task Force, March 2013 (http://www.defra.gov.uk/ecosystem-markets/files/Ecosystem-Markets-Task-Force-Final-Report-.pdf)

How does the UK NEAFO help businesses?

Key findings and outputs for business which have emerged from the UK NEAFO include the following:

i) Tools to help businesses engage with

the Ecosystem Approach

To support the work of the UK NEAFO, an independently produced web-portal has been developed to provide access for many different sectors when striving to embed the Ecosystem Approach into their activities. The National Ecosystem Approach Toolkit (NEAT Tree)[5] provides users with a visually attractive and accessible entry point into understanding and using the Ecosystem Approach (p. 48-50). Primarily, it provides a set of tools, methods and case studies to enable policy- and decision-makers to engage directly with the Ecosystem Approach.

Nevertheless, much of the material is relevant to a business development setting, particularly where businesses must engage with policy processes through Environmental Impact Assessment, planning applications and other significant development proposals (**Figure B1**) .

In addition, it brings together many examples of cases in which business risks and opportunities associated with the changing environment have been managed effectively, thus supporting business managers in making the case for engaging with the Ecosystem Approach in their own work[6] (WPR 10.7.6). These case studies also illustrate the importance of concepts like 'corporate ecosystem valuation'[7] to both business risks and business opportunities, leading to outcomes as diverse as price premiums or costs savings, better business sustainability, improved stakeholder relationships, more focused business development opportunities, improved risk assessment and management, and better compliance with external reporting requirements.

[5] the NEAT Tree will initially be made available on an independently produced and hosted website, www.eatme-tree.org.uk

Figure B1. An outline of the tools available to support the use of the Ecosystem Approach in the development of business opportunities.
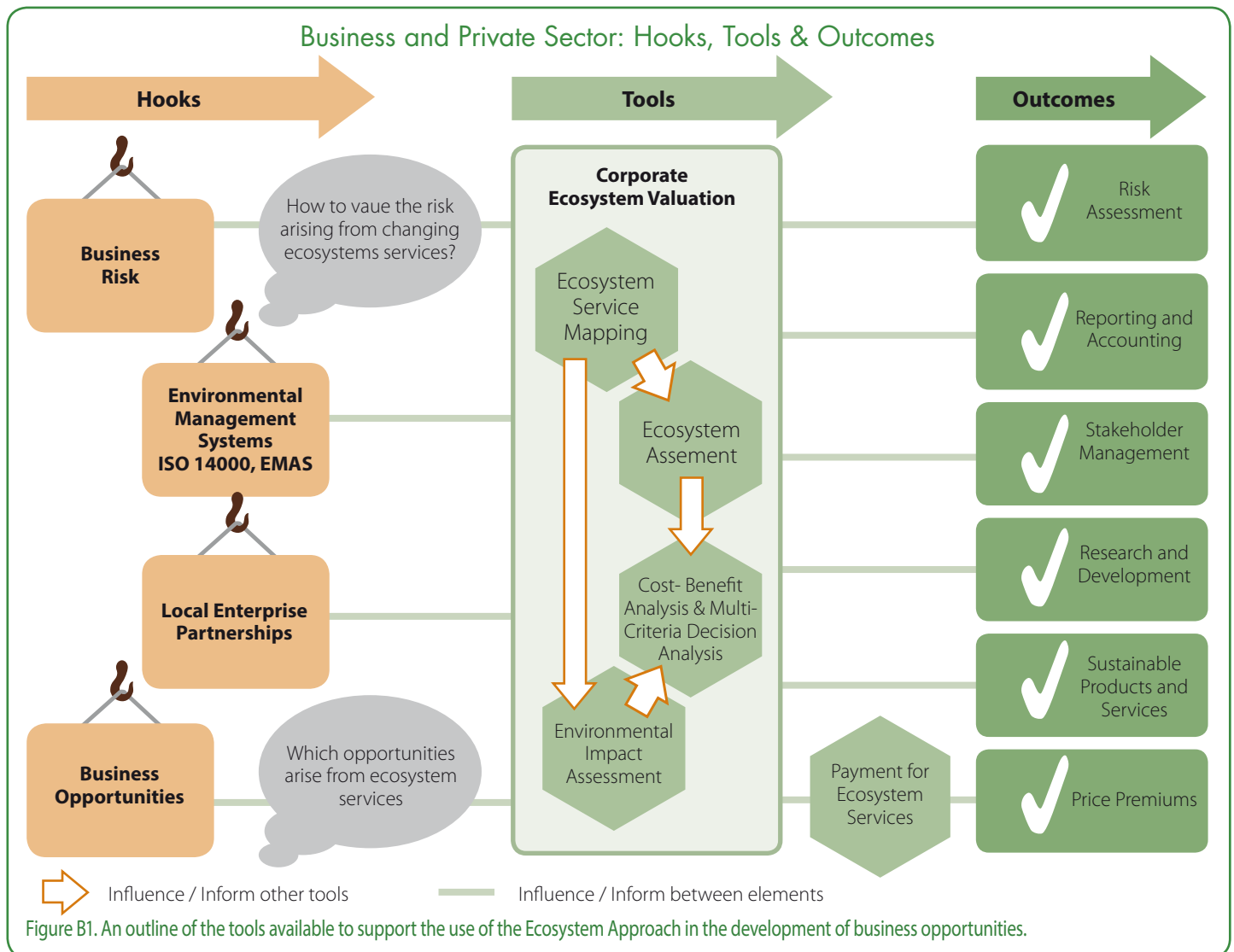
It is essential to see the Ecosystem Approach as a 'process', within which the various 'tools and techniques' which the NEAT Tree describes fit. The NEAT Tree itself can help with this; it describes the decision-making cycle as Ideas-Survey-Assess-Plan-Deliver-Evaluate (p. 48-50; WPR 10.5.4). Nevertheless, it is not necessary to start with a 'blank sheet'; some of the case studies which support the NEAT Tree illustrate that the Ecosystem Approach can be retro-fitted to existing projects (WPR 10.8.1.1). However, to achieve this, a 'champion' or leader working with business executives, acting as a knowledge brokers and facilitator with stakeholders, is vital.

ii) Insights into strategic planning and evaluation

The challenge for businesses when making decisions concerning ecosystems and their services is the trade-off between the short-term prioritisation of problems and issues relating to everyday business concerns and the long-term goals and ambitions for the sustainability of both our business and our natural world. For instance, opportunities arising from deregulation and quick economic gains can lead us to management actions that may favour short-term outcomes, not long-term goals. This theme is echoed in the UK NEAFO's findings that, despite the availability of a range of robust response options to current and future change, favoured options are often narrow and short-term. To combat this, more 'bottom-up' schemes are needed – grounded in the realities of commercial life and led by commercial interests – that have benefits for both business and the natural world, now and in the future (WPR 8.3.1). For example, innovation in Payment for Ecosystem Service (PES)[8] schemes and biodiversity offsetting may allow businesses to identify these opportunities as a source of competitive advantage and longer-term sustainability (WPR 8.4.2).

Scenarios depicting future worlds offer a way for businesses to identify the opportunities that changes in our ecosystems may bring, act innovatively in response to those changes and manage the associated risks. The six contrasting future worlds ('scenarios') developed by the UK NEA and UK NEAFO provide a useful starting point for the creation of more informed, systematic and imaginative business planning strategies (p. 39-42; WPR 7.2.1). Scenarios can be a powerful deliberative process, facilitating dialogue between people with different interests and perspectives, and enhancing understanding for all involved. Scenarios can also support the development of analytic products which permit the visioning of the consequences of different plausible worlds on business viability. At the same time one can explore the likely outcomes of potential response options in mitigating unwanted environmental interactions (WPR 7).

iii) More comprehensive approaches to economic valuation of natural capital and ecosystem services

The UK NEAFO shows that economic valuation and land use models can support land use planning, but the consideration of non-market values will help businesses to make better decisions regarding ecosystem services. There is some scope for economic valuation and land use models to support land use planning, incorporating both market and non-market values (p. 26-29). Better estimation of the latter can support better decisions. The UK NEAFO shows that integrated ecosystem modelling is possible, and can be overlaid with economic data where it is available (WPR 3). As more accessible data sources are developed, this area may become of more practical benefit to business, particularly in understanding how to deliver better value for money from more spatially targeted delivery of ecosystem services. While the economic analysis has extended our understanding, there remains a need for caution over some of the remaining uncertainties which the economic models have been unable to incorporate (e.g. land tenure considerations and future food prices in looking at land use change implications).

[6] the NEAT Tree will initially be made available on an independently produced and hosted website, www.eatme-tree.org.uk

[7] The World Business Council for Sustainable Development – Guide to Corporate Ecosystem Valuation (CEV) is the first-of-its-kind framework enabling businesses to consider the actual benefits and value of the ecosystem services they depend upon. www.wbcsd.org/work-program/ecosystems/cev.aspx Advice on the use of CEV is also available at www.eatme-tree.org.uk/CEV-tool.html

[8] "Payments for Ecosystem Services (PES) often involves a series of payments to land or other natural resource managers in return for a guaranteed flow of ecosystem services (or, more commonly, for management actions likely to enhance their provision) over-and-above what would otherwise be provided in the absence of payment. Payments are made by the beneficiaries of the services in question, for example, individuals, communities, businesses or government acting on behalf of various parties". Payment for Ecosystem Services: A Best Practice Guide, Defra (2013).

The UK NEAFO demonstrates that ecosystem services can support wealth and job creation, but, as yet, precise quantification has not been possible (WPR 2). The UK NEAFO highlights the need for further work in this area. For example, mapping the interrelationships between ecosystem services and major sectors of the economy, such as agriculture or the manufacturing of food, is an important first step towards understanding the macroeconomic impacts of changes in services provided by ecosystems. In addition, this links closely to developing 'ecosystem accounting' that fits within broader national and business sector accounting frameworks.

Of practical relevance to business is the UK NEAFO's Natural Capital Asset Check (NCAC). This is a procedure for assessing the stock and condition of any 'natural capital asset' in terms of their capacity to deliver ecosystem services and analyses: a) How much of a particular natural capital asset do we have? b) What does the asset produce? And, c) How do our decisions affect a) and b) over time? As such, the NCAC is a 'performance indicator', demonstrating the productivity of a natural capital asset and how it supports human well-being now and in the future (p. 22-23; WPR 1.4.4). Using the NCAC, the performance of an asset can be judged in relation to policy targets or goals, or in terms of economic value, at a regional or national scale. The NCAC highlights ecosystem service risks and opportunities for business, and helps decision-makers to think about the maintenance of ecosystem services now and in the future.

iv) Non-monetary valuation

Monetary values alone will not take into account all the benefits we receive from the natural world – from provisioning services to cultural ecosystem services – a number of non-monetary approaches are needed to cover other values, including those that are interpretative and deliberative (p. 35-38; WPR 6). Group-based valuation, done through a deliberative process (where group participants are allowed to exchange evidence and reflect on matters of mutual interest), is proving valuable for the identification of ethical and spiritual values (WPR 6.3.4 and 6.5.3). These methods have direct benefits for business and development decision-making, especially with regards to anticipating and managing conflict. They are also useful as part of a development process, or when managing change. Yet, due to time, and resource constraints, many commercial decisions must continue to be made without the benefit of non-market and non-monetary valuation of all the ecosystem services that may be affected.

v) Working with wider society is important for improving engagement with external stakeholders and for enhancing internal relationships.

The importance of green and blue (ponds, lakes, rivers and seas) spaces to our physical and mental health and general well-being is clear. As a result, insights from the arts and humanities are becoming more and more useful in implementing the Ecosystem Approach. For instance, 'participatory mapping' (where people are asked to annotate maps with art, media, opinions and other evidence for why a place is special to them) can provide helpful information on the way people feel about, and use, certain open spaces (WPR 5.5). They can be used to develop cultural indicators that can be monitored under change, and can lead to better ways to assess, monitor and manage cultural ecosystem services (WPR 5.3). While it is necessary for the public to communicate the value they put on open spaces and amenity, businesses need to engage with these values in order to prosper, especially in terms of the management of external stakeholder relationships and internal relationships with staff. This is important for businesses that have a close dependence on the natural environment (such as farming and minerals), but others will also benefit from working positively with wider society and in their dealings with individual customers, stakeholders and their employees.

What could businesses do now to help?

■ Use the UK NEAFO findings to re-examine the risks and opportunities facing your organisation. The findings are valuable to entrepreneurs, consultants, decision-makers, advisers, intermediaries, stakeholders and investors.

■ Use the NEAT Tree, and its associated tools and case studies, as a starting point for evaluations of risks and opportunities. Businesses can then draw upon more specialised areas of valuation, the Natural Capital Asset Check (NCAC), stakeholder relationship management and the Balance Sheet Approach as appropriate.

■ Assign clear responsibilities within the organisation to further explore the Ecosystem Approach and its potential benefits. Use 'champions' to promote its potential benefits at all levels of strategic, tactical and day-to-day management.

■ Analyse key dependencies within the business on the natural environment and apply scenario-planning and other techniques to analyse the impacts of change on these dependencies. This will help your sustainability and resilience through more confident compliance, greater understanding of key dependencies, longer-term assurance of revenue streams and resource supplies, and the creation of new business revenue or cost-saving opportunities.

3.7 Researchers, research funders and research users

Who is this section for?

This description is about furthering research on human-environment interactions. It is for researchers, the main funders of strategic research (research councils and government departments) and the end users of such research who are interested in addressing the challenge of sustainable development. While this account specifically seeks to raise awareness about the Ecosystem Approach, draw attention to knowledge gaps, it may be helpful to first read a non-technical description of ecosystem service concepts outlined for the 'General Public' audience (see p. 63-66).

How will further research on human-environment interactions help decision-makers?

By taking early account of ecosystem services[1] that are considered difficult to grasp or perceived as impediments to development, we can make better decisions. The current tendency for limited systems thinking means that environmental issues are often dealt with in a piecemeal and reactive, rather than proactive, manner. Adopting an Ecosystem Approach[2] at the outset of an initiative will lead to more positive outcomes for individual well-being, the economy and society in general. The UK National Ecosystem Assessment Follow-on project (UK NEAFO) provides practical aids that will strengthen decision-making through adaptive management, and highlights priority areas requiring further research.

It establishes new knowledge about economic (p. 26-29) and shared values and cultural ecosystem services (p. 35-38), and examines how the delivery of ecosystem services could plausibly change in the future (p. 39-42). It also assesses the robustness of the various response options (p. 43-45) to such changes. Finally, the National Ecosystem Assessment Toolkit (NEAT Tree), which integrates and builds on the work of the UK NEAFO, helps decision-makers to embed the Ecosystem Approach into policies, programmes and plans. It helps both policy-makers and practitioners understand which tools are most suitable for a given point in the decision-making cycle (Ideas-Survey-Assess-Plan-Deliver-Evaluate), when to combine those tools with other tools, and which combinations may work best.

What challenges remain with regards to ecosystem research?

Current investments made by research sponsors across the UK are helping researchers to discover new ways of incorporating large datasets into modelling and operational tools in order to integrate findings from environmental process models into valuation frameworks. This important area requires more work by research-focused organisations, policy groups in government and government agencies, and by operational units. Indeed, there are significant cultural and operational barriers (p. 46-47; WPR 9; WPR 10) to the uptake and embedding of the Ecosystem Approach. In particular, there is a need for better communication about the benefits of the Ecosystem Approach and more consistency in the use of ecosystem services terminology (see Glossary). This will help to ensure businesses and the government's delivery agencies can translate research outputs into useful information and management options regarding the impacts of changes in ecosystem services on the economy and society. In addition, it is important to recognise different expectations among stakeholders: long-term versus short-term; global versus local.

Perhaps because it is difficult to organise and manage there appears to still be a reluctance to fully commit to interdisciplinary research. Although there has been some increase in the proportion of research funds going into large, collaborative initiatives, more could be done. Similarly, universities striving for excellence do not necessarily encourage staff to undertake interdisciplinary research. This may reflect the fact that there are still very few truly interdisciplinary journals with high 'Impact Factors', compared to the numerous specialist, discipline-based journals. Younger researchers often admit to feeling compromised in seeking to further their careers at the expense of making their research more relevant.

The Living with Environmental Change (LWEC) Ecosystem Task Force is developing a priority list of opportunities for future work that will consider a range of initiatives involving stakeholders, such as planners and businesses. Some Green Infrastructure initiatives are already delivering improved environments in cities (for example, Birmingham, p. 65; WPR 10.7.6.1) and are expected to generate health benefits, too. Assumptions about the consequences of managing the environment through the implementation of the Ecosystem Services Conceptual Framework and the Ecosystem Approach (as set out in the UK NEAFO) need to be tested and validated in order to develop an evidence base about interventions that will protect and enhance human and environmental health and well-being. Such research will need to

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[1] **Ecosystem services** are the benefits people obtain from ecosystems. These include provisioning services, such as food and water; regulating services, such as flood and disease control; cultural services, which encompass the environmental spaces and cultural practices that provide a range of material and non-material benefits; and supporting services, such as nutrient cycling, that maintain conditions for life on Earth

[2] The **Ecosystem Approach** addresses human-environment interactions, and "is a strategy for the integrated management of land, water and living resources to promote conservation and sustainable use in an equitable way" (Convention on Biological Diversity). The twelve principles articulating the Ecosystem Approach promote participation in decision-making of affected people, the management of natural resources at appropriate scales of space and time, and assessment of the breadth of outcomes using an 'Ecosystem Service' Framework, to describe the many benefits nature delivers to society.

include the impacts of extreme environmental events, as well as cumulative effects due to medium- and long-term environmental change. It also requires the consideration of varying approaches to how we manage ecosystems and their services. For this research to be relevant, however, there is a pressing need to understand changing patterns in the events themselves – are they becoming more frequent, are they human-driven, etc.

What are the priorities for interdisciplinary ecosystem research?

■ **A better understanding of how the capability of 'natural capital assets'[3] to produce ecosystem services changes (Figure R1).** Thinking about the underlying relationship between the flow of ecosystem services and the natural capital stock also highlights the importance of: (i) the risk that excessive use of ecosystem services takes the ecosystem over a threshold from which it cannot easily recover (precautionary red flag signals); (ii) identifying where the integrity of natural capital is a limiting factor on human welfare; and (iii) the overall understanding of the practical application of the concept of 'resilience' (WPR 1.4.2).

■ **A better set of indicators for, and monitoring of, well-being and environmental change to improve empirical knowledge and inform adaptive management.** For example, the Monitor of Engagement with the Natural Environment (MENE) survey of visits to environmental spaces found that the effect of socio-economic status on the attainment of well-being was ambiguous (p. 32-35; WPR 5.7). The effect varies according to the type of well-being index considered and across datasets. Larger samples are required to investigate the effect of socio-economic status on various forms of well-being connected with human-nature interactions.

[3] **Natural capital** is the stock of natural ecosystems that yields a flow of valuable ecosystem goods or services into the future. In the UK NEAFO natural capital has been formally defined as "the configuration (in time, space, functionality and/or with other capital) of natural resources and ecological processes that contributes through its existence and/or in some combination to human welfare (WPR 1.3)." In this sense, natural capital can be placed alongside other types of capital including financial, physical (manufactured), human and social, as integral to our nation's economy and contributes to society's well-being.
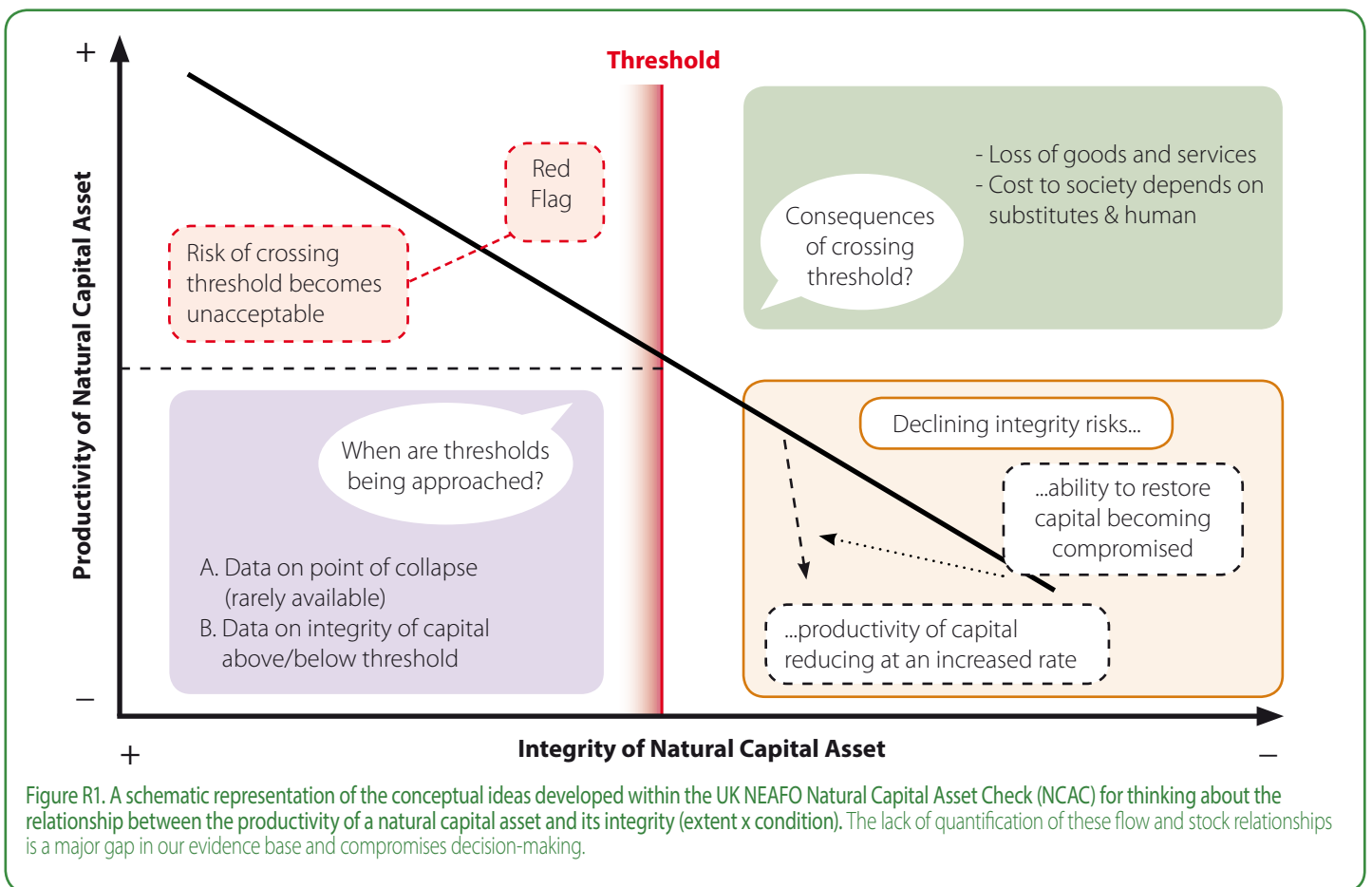

Figure R1. A schematic representation of the conceptual ideas developed within the UK NEAFO Natural Capital Asset Check (NCAC) for thinking about the relationship between the productivity of a natural capital asset and its integrity (extent x condition). The lack of quantification of these flow and stock relationships is a major gap in our evidence base and compromises decision-making.

- A better understanding of how to connect people and decision-makers, from neighbourhood to national levels. The well-being and health benefits of spending time in domestic gardens and public green and blue outdoor spaces have been underplayed in a range of local decisions and approaches to leisure, health and environmental management. For instance, the UK NEAFO highlights that residents of Greater London gain more in terms of well-being from visiting green spaces than people in other regions, but why this should be the case is unknown (WPR 5.6). Nonetheless most local plans have still to take this into account. Currently, there is limited information on how the condition of either domestic gardens or parks influences well-being. Gardens and open green and blue spaces should be considered as a network, and, together with the functional value for biodiversity of non-accessible space (such as railway embankments), would appear a fruitful area for collaborative research between the social and natural sciences.

What are the priorities for further economic research regarding ecosystem services?

- Better mapping of both the direct and indirect dependencies of economic sectors on ecosystem stocks and flows in order to understand the impacts of changes in ecosystem services on the wider economy. In all economic sectors there is a need for specific quantification of the changes in macroeconomic performance which can be attributed to changes in quantities and qualities of ecosystem inputs (direct effects) (WPR 2). We also need a better understanding of the potential for substituting other resources for natural capital used in production and consumption.

- Further valuation of a number of important habitats, ecosystem services and related goods and benefits which currently have few or no valuation estimates (e.g. estuaries, coasts and wider marine). Furthermore, other politically sensitive goods and benefits, such as sea defence and erosion prevention, have an ageing database of a decade or more old (WPR 4.6.6). Although 'benefits transfer' may offer some pragmatic assistance in covering a limited number of these knowledge gaps, this procedure is unlikely to be a perfect solution because both temporal and cultural biases remain.

- Direct consideration of how deliberation and social learning influence the shaping and sharing of our values. Despite ongoing improvements in framing questions and survey techniques, the Achilles heel of contingent valuation and similar approaches remains the tendency of participants to overstate what they would be willing to pay for maintaining ecosystem services in comparison to what they would really want to pay in real life. In the UK NEAFO Forth and Marine Protected Areas case studies, group-based deliberation substantially reduced Willingness-To-Pay (WTP), yet WTP appeared to better reflect participants' underlying, deeper-held values (p. 35-38; WPR 6.4.2 and 6.4.4).

What are the priorities for further social science research regarding ecosystem services?

- A comprehensive review of the key barriers to, and opportunities for, embedding ecosystem knowledge into decision-making. The UK NEAFO review of formal appraisal methods (Impact Assessment [IA]; Strategic Environmental Assessment [SEA]; and Environmental Impact Assessment [EIA]), shows that institutional cultures and behaviours at individual, organisational and societal levels determine how knowledge is, or is not, used in appraisals (WPR 9). However, more in-depth case studies are needed to better understand the patterns of knowledge use, and the associated barriers and enabling measures, in a wider range of decision support processes, systems and tools. This is important not only in the institutional context described for appraisal, but also in sectoral and operational contexts.

- A better consideration of equity issues in ecosystem research. New investigations are needed to better understand the winners and losers from the current spatial distribution of ecosystem services, and the impacts of particular interventions, such as Payments for Ecosystem Services (PES) on both social and environmental justice (WPR 3; WPR 8).

- Further use of participatory mapping (where people are asked to annotate maps with opinions, art, media and other evidence for why a place is special to them) to animate and expand our understanding of cultural ecosystem services among communities. Creative approaches influenced by research in the arts and humanities not only provide new forms of evidence for decision-makers, but also help to engender stewardship of local natural resources, especially when incorporated into a learning curriculum (WPR 5.5).

- Better understanding of the links between culture, social interaction and personal motivations with regards to the benefits the natural environment provides us. Attitudes may be different from behaviours: an unwillingness to pay does not necessarily mean that something is unvalued, for instance (WPR 6).

- More and better methods for assessing the wide range of shared values of nature. This includes trying to understand trade-offs between natural, financial and social capital, each of which has its own metrics, interest groups and governance structures. Such evidence-generation should involve decision-makers to ensure that approaches, methods and results are considered valid, relevant and useable. In this way, a wider social valuation of public policy alternatives can be achieved, and the considerable collective meanings, significance and value of nature can be recognised and safeguarded.

What are the priorities for further natural science research regarding ecosystem services?

- Quantifying the underlying functional relationships between ecosystem service delivery and natural capital asset condition, including when thresholds are likely to be approached and the consequences of crossing these thresholds. For example, in the case of soils, although there are well-established indicators for the status of most of their associated ecosystem services, the precise functional relationship between the productivity of any one of these services and soil quality as the natural capital asset is less certain (WPR 1.4.4 and 1.4.5). Functional relationships are likely to be dynamic, non-linear and influenced by changing drivers and lag effects.

- A greater understanding of the capacity of different natural capital assets to recover from degradation in order to guide management to restore their productivity. Evidence is also needed to remove uncertainties about whether habitat recreation or restoration will return all ecosystem functions.

- More use of horizon scanning and visioning exercises when devising objectives for the environment as part of an adaptive management process. We need to improve knowledge to support this process, which will require a degree of 'learning by doing' (for example, implementing a Marine Protected Area; studying a coastal realignment case).

- Better integration of current land use and biogeochemical models in order to explore ecological impacts and the implications for ecosystem goods and services. In particular, more needs to be done to link terrestrial catchments to coastal and marine environments, especially with respect to nutrient flows and exchanges between habitats.

What could the research community do now to help?

- Address key barriers to institutional inflexibility, encouraging a move from working in 'silos' towards greater integration and improved institutional thinking that helps to embed the Ecosystem Approach.

- Initiate 'challenge-led' research requiring substantial cooperation across academic disciplines to deliver the potential added value of integrated, systems thinking. This approach requires greater engagement with a wide end user community in order to increase the impact of policy and management practices, and help prioritise the agenda for research.

- Develop further programmes, training and personal development opportunities that invest in interdisciplinary research opportunities across research councils, government departments and their agencies. Trans-disciplinary training will help a new generation of scientists tackle the challenges the UK NEAFO highlights. Additionally, researchers, funders, government and business will need to provide opportunities for research findings to be translated into new ways of working in the real world.

- Explore the added value of extending existing programmes, knowledge and data through the examination of the direct and indirect drivers (especially extreme events) of changes in environmental conditions, and their consequences for ecosystem resilience and well-being. Candidates programmes for carrying out this additional research include the Natural Environment Research Council (NERC) programmes on Macronutrients, NERC Biodiversity Ecosystem Services for Sustainability (BESS), and the joint NERC, Economics and Social Research Council (ESRC), and Department for International Development (DfID) sponsored programme, Ecosystem Services for Poverty Alleviation.

- Encourage the LWEC Ecosystem Task Force to take up the issues and research needs highlighted above, as well as to determine what knowledge exchange actions could make use of existing research. Help develop outline proposals for specific further research that will help to embed ecosystems thinking into decision-making and management options within government, business and other sectors.

Annex

Acronyms and Abbreviations

AHRC	Arts and Humanities Research Council
BAU	Business As Usual
BBS	British Bird Survey
BESS	Biodiversity and Ecosystem Service Sustainability
BTO	British Trust for Ornithology
CBD	Convention on Biological Diversity
Defra	Department of Environment Food and Rural Affairs
DMV	Deliberative Monetary Valuation
DPSIR	Drivers-Pressures-State-Impact-Response tool
DSGE	Dynamic Stochastic General Equilibrium
DSS	Decision Support System
DVF	Deliberative Value Formulation Model
EIA	Environmental Impact Assessment
ESF	Ecosystem Services Framework
ESRC	Economic and Social Research Council
FBI	Farmland Bird Index
FC	Forestry Commission
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GVA	Gross Value Added
IA	Impact Assessment
IUCN	International Union for Conservation of Nature
MCA	Multi-Criteria Analysis
MENE	Monitor of Engagement with the Natural Environment survey
MPAs	Marine Protected Areas
MV	Market Value
NCAC	Natural Capital Asset Check
NEAT Tree	National Ecosystem Approach Toolkit Tree
NERC	Natural Environmental Research Council
OECD	Organisation for Economic Cooperation and Development
ROAMEF Model	Rationale-Objectives-Appraisal-Monitoring-Evaluation-Feedback model
SEA	Strategic Environmental Assessment
SV	Social Value
TIM	Integrated Land Use Model
UK NEA	UK National Ecosystem Assessment
UK NEAFO	UK National Ecosystem Assessment Follow-on
UNEP-WCMC	United Nations Environment Programme World Conservation Monitoring Centre
VNN	Valuing Nature Network
WTP	'Willingness-to-pay'

Glossary

Adaptive Management: A systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices. In active adaptive management, management is treated as a deliberate experiment for purposes of learning.

Balance Sheet Approach: An audit approach seeking to build a robust evidence base for policy appraisal.

Biodiversity (a contraction of biological diversity): The variability among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part. Biodiversity includes diversity within species, between species, and between ecosystems.

Conceptual Framework: Is a concise summary in words and pictures of the relationship between people and nature including key components of interactions between humans and ecological systems. Conceptual frameworks assist in organising thinking and structuring work when assessing complex ecosystems, social arrangements and human-environment interactions.

Cultural services: The nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience, including, e.g. knowledge systems, social relations, and aesthetic values.

Cultural values: The collective norms and expectations that influence how ecosystems accrue meaning and significance for people.

Decision-maker: A person whose decisions, and the actions that follow from them, can influence a condition, process, or issue under consideration.

Direct use value (of ecosystems): The benefits derived from the services provided by an ecosystem that are used directly by an economic agent. These include consumptive uses (e.g. harvesting goods) and non consumptive uses (e.g. enjoyment of scenic beauty). Agents are often physically present in an ecosystem to receive direct use value. (Compare Indirect use value).

Goods: Are all use and non-use, material and non-material outputs from ecosystems that have value for people.

Driver, direct: A driver that unequivocally influences ecosystem processes and can therefore be identified and measured to differing degrees of accuracy. (Compare Driver, indirect).

Driver, indirect: A driver that operates by altering the level or rate of change of one or more direct drivers. (Compare Driver, direct).

Ecosystem: A dynamic complex of plant, animal, and microorganism communities and their non-living environment interacting as a functional unit.

Ecosystem Approach: A strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use (Convention on Biological Diversity).

Ecosystem assessment: A social process through which the findings of science concerning the causes of ecosystem change, their consequences for human well-being, and management and policy options are brought to bear on the needs of decision-makers.

Ecosystem management: An approach to maintaining or restoring the composition, structure, function, and delivery of

services of natural and modified ecosystems for the goal of achieving sustainability. It is based on an adaptive, collaboratively developed vision of desired future conditions that integrates ecological, socioeconomic, and institutional perspectives, applied within a geographic framework, and defined primarily by natural ecological boundaries.

Environmental economy: Comprises (i) primary industries directly dependent on environmental resources, such as agriculture, forestry, fishing and mineral extraction; (ii) industries that are dependent upon a high quality environment, such as tourism, recreation and leisure; (iii) conservation organisations, government agencies and local authorities, which help to create quality of life and attract investment; (iv) businesses focusing on environmental technologies (waste management, water purification and sustainable energy).

Environmental spaces: The places, localities, landscapes and seascapes in which people interact with each other and the natural environment.

Ecosystem resilience: The level of disturbance that an ecosystem can undergo without crossing a threshold to a situation with different structure or outputs. Resilience depends on ecological dynamics as well as the organisational and institutional capacity to understand, manage, and respond to these dynamics.

Ecosystem service: The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services such as nutrient cycling that maintain the conditions for life on Earth. The concept "ecosystem goods and services" is synonymous with ecosystem services.

Goods: Are all use and non-use, material and non-material outputs from ecosystems that have value by people.

Gross Domestic Product: The market value of all officially recognized final goods and services produced within a country in a year, or over a given period of time.

Gross Value Added: The total of all revenues from final sales and (net) subsidies which are incomes to businesses. It measures the value of goods and services produced by each individual producer, industry, or sector in the country. It is used in the estimation of GDP, which is a key indicator of the state of the whole economy, measuring the annual value of the total amount of economic activity in a country.

Human well-being: See Well-being.

Land use: The human use of a piece of land for a certain purpose (such as irrigated agriculture or recreation). Influenced by, but not synonymous with, land cover.

Natural capital: The stock of natural ecosystems that yields a flow of valuable ecosystem goods or services into the future. In the UK NEAFO natural capital has been formally defined as

"the configuration (in time, space, functionality and/or with other capital) of natural resources and ecological processes that contributes through its existence and/or in some combination to human welfare (WPR 1,3)." In this sense, natural capital can be placed alongside other types of capital including financial, physical (manufactured), human and social, as integral to our nation's economy and contributes to society's well-being.

Responses: Human actions, including policies, strategies, and interventions, to address specific issues, needs, opportunities, or problems. In the context of ecosystem management, responses may be of legal, technical, institutional, economic, and behavioural nature and may operate at various spatial and time scales.

Policy-maker: A person with power to influence or determine policies and practices at an international, national, regional, or local level.

Trade-off: Management choices that intentionally or otherwise change the type, magnitude, and relative mix of services provided by ecosystems.

Scenario: A plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about key driving forces (e.g. rate of technology change, prices) and relationships. Scenarios are neither predictions nor projections and sometimes may be based on a "narrative storyline." Scenarios may include projections but are often based on additional information from other sources.

Shared values: The UK NEAFO's definition of shared values illustrates five dimensions of value (i) the concept of the value, i.e. whether it is an overarching life principle or fits a particular situation; (ii) the value provider, i.e. whether it comes from an individual, group or whole society; (iii) the intention of the value, i.e. whether it is self-rewarding or not; (iv) the scale of the value, i.e. whether it is held individually or at a societal level; (v) and the process used to elicit the value, i.e. whether it has come from a deliberative process (group-based discussion), or gleaned from another source.

Sustainable use (of an ecosystem): Human use of an ecosystem so that it may yield a continuous benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations.

Value: The contribution of an action or object to user specified goals, objectives, or conditions.

Valuation: The process of expressing a value for a particular good or service in a certain context (e.g. of decision-making) usually in terms of something that can be counted, often money, but also through methods and measures from other disciplines (sociology, ecology, and so on).

Well-being: A context- and situation-dependent state, comprising basic material for a good life, freedom and choice, health and bodily well-being, good social relations, security, peace of mind, and spiritual experience.

Work Packages of the UK NEAFO

1. Developing the evidence base for a Natural Capital Asset Check: What characteristics should we understand in order to improve environmental appraisal and natural income accounts?

2. Macroeconomic implications of ecosystem service change and management: A scoping study

3. Economic value of ecosystem services

4. Coastal and marine ecosystem services: Principles and practice

5. Cultural ecosystem services and indicators

    a. Arts & Humanities Annex: Arts & Humanities perspectives on cultural ecosystem services

    b. Arts & Humanities Annex: Additional cultural values work

    c. Arts & Humanities Annex: Cultural ecosystem services: A keywords manual

6. Shared, plural and cultural values of ecosystems

7. Operationalising scenarios in the UK National Ecosystem Assessment Follow-on

8. Robust Response Options: What response options might be used to improve policy and practice for the sustainable delivery of ecosystem services?

9. Embedding an Ecosystem Services Framework in appraisal: Key barriers and enablers

10. Tools – Applications, Benefits and Linkages for Ecosystem Science (TABLES)

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The UK National Ecosystem Assessment Follow-on (UK NEAFO), carried out between early 2012 to early 2014, develops and communicates the work of the UK National Ecosystem Assessment (UK NEA). Published in 2011, the UK NEA was the first analysis of the UK natural environment in terms of the benefits it provides to society and continuing prosperity.

Contact details

The UK National Ecosystem Assessment Secretariat was based at United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) in Cambridge.

More information about the UK NEA and UK NEAFO can be found at **http://uknea.unep-wcmc.org** which UNEP-WCMC will maintain after publication. Information can also be found on the UK Government website (**www.gov.uk/ecosystems-services**) and Living with Environmental Change website (**www.lwec.org.uk/**).

If you have any questions about the UK NEA please email **nea@unep-wcmc.org**.

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