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A unique resource – the UK NEA

Rising human resource demands and additional pressures such as waste generation, exacerbated by a spiralling global population and changing climate, are leading to dramatic, systematic declines in the natural world. Various authoritative studies have quantified both the status of and the trends in this ecological decline, while addressing implications for continuing human wellbeing. These studies include the Millennium Ecosystem Assessment (MEA)[1], The Economics of Ecosystems and Biodiversity (TEEB)[2] and ecological footprint studies that standardise measures of human demand and waste assimilation relative to biologically productive land and sea area, such as the United Nations Development Programme's Human Development Index (HDI)[3].

In 2009, the UK instigated its own National Ecosystem Assessment (UK NEA)[4], publishing a set of reports in 2011 that remain the only such national assessment globally. This led directly to a UK NEA Follow-on programme (UK NEAFO)[4], published in 2014, to address some knowledge gaps but above all to help communicate and spur action informed by the dense content of the first phase. Implicit in both phases of the UK NEA was not only the development but also the transfer of knowledge, particularly to bring into the mainstream both awareness and action to help reverse declining trends in ecosystems and their services as a contribution to resetting development on a more sustainable course.

The lack of political and media attention devoted to these ground-breaking studies (representing substantial public investment exceeding £1 million for each phase and very substantial voluntary commitments of time by participants) was, of course, profoundly disappointing. Left to politicians and media moguls alone, prospects for further action appear slim. More significantly, without practical and proportionate responses to what we now know, the prognosis for the natural world and for humanity's continuing security and wellbeing remains equally parlous.

This issue of environmental SCIENTIST summarises some of the scope and outcomes of the UK NEA and the UK NEAFO. The overall UK NEA programme has made a promising start, one that is incumbent on all of us now to advance to secure future wellbeing. I hope you find information of interest and use in this special issue, and above all that it inspires you to explore more of the UK NEA process and outputs, and how they can help us all make positive, sustainable change.

Mark Everard is Associate Professor of Ecosystem Services at the University of the West of England (UWE, Bristol) and a Vice-President of the IES. He has championed the evolution and international practice of ecosystem services since the 1980s. Mark is author of numerous papers and books, many on ecosystems and their services, including *Common Ground: Sharing Land and Landscapes for Sustainability* (Zed Books, 2011), *The Hydropolitics of Dams: Engineering or Ecosystems?* (Zed Books, 2013) and *Breathing Space: The Natural and Unnatural History of Air* (Zed Books, forthcoming). (mark.everard@uwe.ac.uk).

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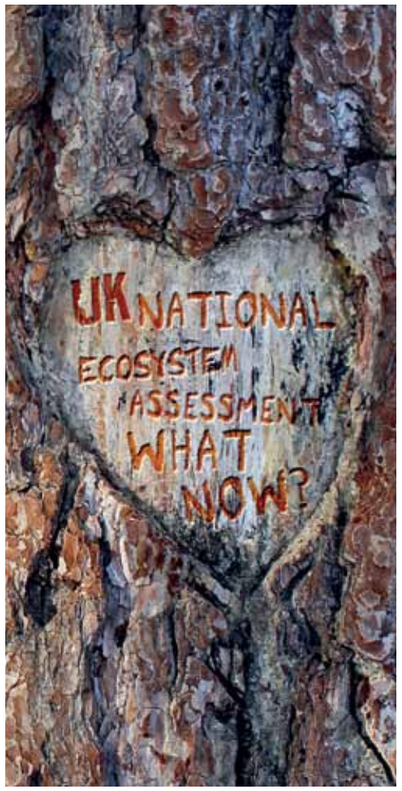

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Guest Editor Mark Everard
Editors Robert Ashcroft
Sub Editors Caroline Beattie (beattie.cas@gmail.com)

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Why assess the state of UK ecosystems and trends in the delivery of ecosystem services?

Steve Albon discusses the rationale behind the UK National Ecosystem Assessment, and its practical applications.

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Although the impact of economic growth on the natural environment has been a concern of environmental scientists and environmental economists for decades[1,2,3], the linkages between our changing natural environment and human wellbeing is only now becoming better understood. The Millennium Ecosystem Assessment (MA)[4], published in 2005, was the first global assessment to focus on changes in ecosystems, the impact of these changes on the delivery of ecosystem services (defined as the benefits people obtain from ecosystems, such as crops, fibre, freshwater, recreation, wildlife), and the consequences for people.

Given the overwhelming evidence that environmental degradation in most of the world's ecosystems has depressed many of the ecosystem services upon which human wellbeing depends, the UK House of Commons Environment, Food and Rural Affairs Committee recommended that a UK ecosystem assessment be undertaken. Two years later, in 2009, the UK National Ecosystem Assessment (UK NEA), a Living With Environmental Change (LWEC) partnership project between the UK government, the devolved administrations, and research councils, began work.

ASSESSING THE STATE AND THE VALUE OF NATURE

The UK NEA brought together 500 researchers from both natural and social sciences, as well as economics, to assemble the evidence on the state of and trends in UK ecosystems, and the delivery of ecosystem services, since 1945. The objectives also included identifying the drivers of change, exploring the wellbeing value in both monetary and non-monetary terms, encouraging stakeholder engagement, and raising awareness in society of the importance of the natural environment to human wellbeing and economic prosperity.

After two years of painstaking work the *Synthesis of Key Findings*[5] and a full *Technical Report*[6] of 1,500 pages, and weighing almost 5 kg (!), were published. The main conclusion of the UK NEA was that the natural world, its biodiversity and its constituent ecosystems are critically important to our wellbeing and economic prosperity. Yet they are consistently undervalued in conventional economic analyses and decision-making.

The work of the UK NEA influenced the commitments made in the White Paper, *The Natural Choice: securing the value of nature*[7], the first environment bill in England for nearly 20 years. These commitments included striving to be the "first generation to leave the natural environment of England in a better state than it inherited it", and establishing an independent Natural Capital Committee to "provide advice on when, where and how natural assets are being used unsustainably". There was also a commitment to build on the findings of the UK NEA with more research to:

i. further our understanding of the economic and social value of nature;
ii. develop tools and products to assist decision-makers in applying the lessons of the NEA; and
iii. support the inclusion of natural capital in the UK's National Accounts.

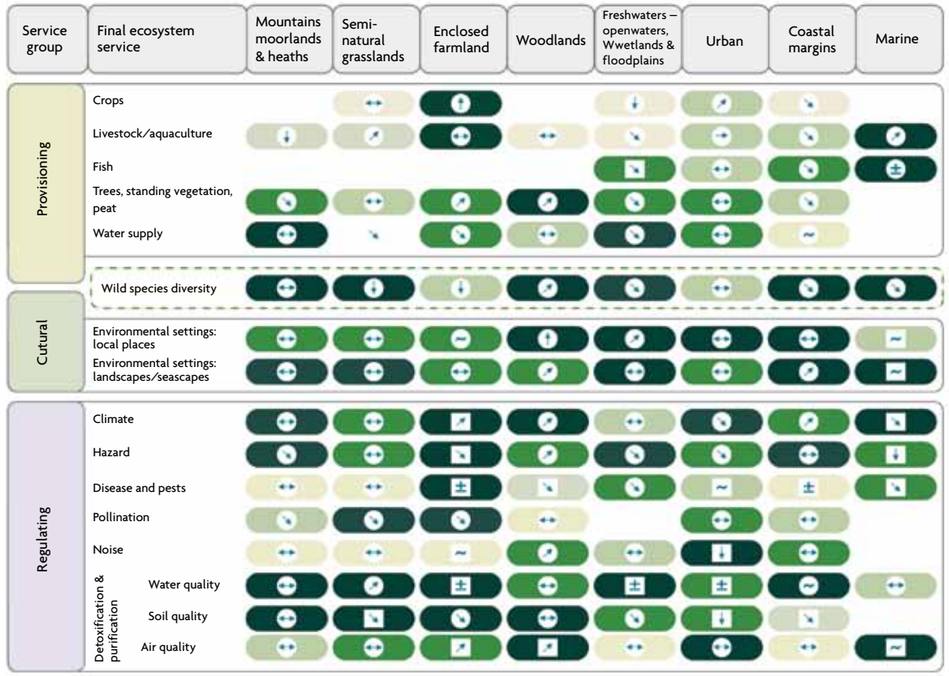
The UK NEA Follow-on (UK NEAFO) project reported in June this year[8], and the major findings are described in some detail in the articles of this issue of the environmental SCIENTIST. Here I draw out some of the key messages, first from the original UK NEA (see **Box 1**), and second from the UK NEAFO (see **Box 2**).

NATURE AND WELLBEING

Ecosystems and the services they deliver underpin our very existence. At the most fundamental level, other organisms create a breathable atmosphere and provide us with the food vital to our existence, as well as fibre, timber and a host of other raw materials. Ecosystems are of huge importance in other, less immediately obvious ways: in the breakdown of waste products, in controlling water supplies and in helping to regulate climate. They provide space for recreation and contemplation, and play a pivotal role in creating a sense of place that underpins the mental and spiritual wellbeing of many. Measuring the

BOX 1. KEY MESSAGES OF THE UK NATIONAL ECOSYSTEM ASSESSMENT (UK NEA[5,6]).

- The natural world, its biodiversity and its constituent ecosystems are critically important to our wellbeing 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 good-quality services, 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 wellbeing. It is important that these consequences are understood, so that we can make the best possible choices, for society now and for future generations; and
- 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 the adoption of a more integrated approach to ecosystem management, rather than the conventional sectoral approach.



Key:
Importance of Broad Habitat for delivering the ecosystem service

High | Medium – High | Medium – Low | Low

Direction of change in the flow of the service

Improving | Some improvement | Some deterioration | Deterioration | No net change | Improvement and /or deterioration in different locations | Unknown

▲ **Figure 1. The relative importance of broad habitats in delivering ecosystem services and the overall direction of change in service flow since 1990[5]. This figure is based on information synthesised from the habitat and ecosystem service chapters of the UK NEA *Technical Report*[6], as well as expert opinion. This figure represents a UK-wide overview and will vary nationally, regionally and locally. It will therefore also inevitably include a level of uncertainty. Arrows in circles represent high evidence for or confidence in the direction of service flow amongst experts; arrows in squares represent less evidence for or confidence in the direction of service flow. Blank cells represent services that are not applicable to a particular broad habitat.**

value of all the benefits society derives from ecosystems has proven hugely challenging, with the consequence that many ecosystem services have been consistently undervalued in economic analyses and decision-making, and some ecosystems become degraded.

CHANGES IN ECOSYSTEMS AND THE DELIVERY OF SERVICES IN THE LAST 60 YEARS

During the second half of the 20th century, the UK's population grew by about 25 per cent to over 60 million people, living standards greatly increased and technological developments and globalisation had major effects on behaviour and consumption patterns. The production of food from agriculture increased dramatically: wheat yields quadrupled and average milk yields doubled. However, other ecosystem services, particularly those related to air, water and soil quality, declined initially, though some have recovered in the last decade or two.

Attempts to address declines in ecosystem services through legislation and policy reform began relatively early on, notably with the 1949 National Parks and Access to the Countryside Act and the 1956 Clean Air Act, the latter a direct response to the observed impact of air pollution on human health. The 1981 Wildlife and Countryside Act was a landmark in recognising the importance of biodiversity in law, several years before the term itself became common currency. More recently, many of the responses within the UK have been driven by European Union policy directives.

PRESENT CHALLENGES AND FUTURE OUTLOOK

Despite improvements, many ecosystem services in the UK continue to decline or have shown little improvement. Expert judgment indicates that, assessed across the broad range of terrestrial and aquatic habitat types, about 30 per cent of services are currently declining and many others are in a reduced or degraded state (see **Figure 1**). The condition of many soils in the UK – absolutely fundamental to continued productivity and support of biodiversity – is considered degraded, mainly because of atmospheric deposition and inappropriate management. Although there is ongoing recovery of soil-buffering capacity, thanks to large decreases in sulphur deposition since the 1980s, there is continuing loss of soil carbon in arable systems and little or no decline in elevated levels of contaminants from industry and transport.

Pollinators, which provide ecosystem services estimated to be worth hundreds of millions of pounds annually, continue to decline. Marine fish catches remain low compared to historical levels and many issues remain regarding the wider ecological impacts of fisheries. And while interest in, and engagement with, the natural world has grown tremendously in some sectors of society, many among the current generation of young people are spending less and less time outdoors, as a result of the use of new technologies, concerns over child safety and the decrease in urban greenspace.

The need to manage our ecosystems so that we benefit from the full range of ecosystem services is to become more pressing, not less. A growing population in the UK will help maintain its role as an important trading nation, with significant flows of biomass across its borders, generating a substantial ecological footprint overseas, while simultaneously being affected by social, economic and ecological changes elsewhere. Also, the increasing impacts of climate change, which to date have had relatively little effect on the UK's biodiversity and ecosystems, mean that the future is likely to bring more challenges.

RESPONDING TO THE CHALLENGES

It is clear that we need to find new, more resilient ways of managing our ecosystems. Because of the long recovery times of many ecosystem services (soils, for example, form at an average rate of just one centimetre per century) actions taken and decisions made now will have consequences far into the future for ecosystems, ecosystem services and human wellbeing. It is important that these consequences are understood, so that we can make the best possible choices, for now and for future generations.

An important prerequisite for this is a better grasp of the values of the full range of ecosystem services, including cultural values based on ethical, spiritual and aesthetic principles. The values of most ecosystem services are currently omitted from national economic frameworks and local decision-making. Failure to include the valuation of non-market goods in decision-making results in a less efficient resource allocation.

Contemporary economic techniques now allow us to account for most of the market values and some of the non-market values of ecosystem services. In cases where comparisons can be made, the latter often far exceed the former.

Furthermore, the collective value of cultural goods linked to ecosystem services needs to be understood through a range of participatory and deliberative techniques, which use both quantitative and qualitative methods in multi-criteria analysis. Since the different wellbeing values of many ecosystem services vary from place to place, integration of the spatial dimension of ecosystem services in local decision-making would increase the potential for a more comprehensive value of these services to be realised.

In order to understand what the future might hold, a range of plausible scenarios were developed, some of which emphasise environmental awareness and

BOX 2. KEY MESSAGES OF THE UK NATIONAL ECOSYSTEM ASSESSMENT FOLLOW-ON (UK NEAFO[8])

- 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;
- 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 makes particular advances in valuing cultural ecosystem services that give rise to a range of material and non-material benefits to human wellbeing, but are frequently overlooked in decision-making;
- 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 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; and
- 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.

ecological sustainability, while others stress national self-sufficiency or economic growth and the removal of trade barriers. Applying the values derived for ecosystem services to these scenarios shows that a huge range of possible outcomes awaits us. Importantly, allowing decisions to be guided by market prices alone forgoes opportunities for major enhancements in ecosystem services, with negative consequences for social wellbeing. In contrast, recognising the value of all ecosystem services would allow the UK to move towards a more sustainable future, in which the benefits of ecosystem services are better realised and more equitably distributed.

A move to more sustainable development will need changes in individual and societal behaviour and the adoption of a more integrated approach to ecosystem management. This will require an enabling environment of appropriate regulations, technology, financial investment and education, and the involvement of a wide range of different actors, including government, the private sector, voluntary organisations and civil society at large. While there are still uncertainties, knowledge gaps and controversies in our evidence base, we already have enough information to start managing our ecosystems more sustainably.

NEW INFORMATION/TOOLS TO HELP DECISION-MAKERS

While the UK NEA compiled the evidence to reinforce the view that ecosystems, and the services they deliver, are important to our wellbeing, it provided little insight into how to use the knowledge in decision-making. Indeed we were faced immediately with the question of how to use the NEA. So between the summers of 2011 and 2012 the funding partnership, together with economic, natural and social science researchers, and the wider stakeholder community, set about formulating the remit of the UK National Ecosystem Assessment Follow-on (UK NEAFO)[8]. The overall aim was to provide deeper insights into approaches to valuation, including cultural values, and tools to help make the ecosystem service framework highly relevant to decision- and policy-making across all sectors and at a range of spatial scales. To help make the information more accessible to a wider range of audiences in the public, private and voluntary sectors, we constructed narratives to communicate what the UK NEAFO means for different users.

The UK NEAFO addressed four thematic areas.

- First, 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 evaluate the macroeconomic implications of the findings of the UK NEA.

- Second, exploration of the monetary and non-monetary values associated with cultural ecosystem services. As well as 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.

- Third, further development of the UK NEA scenarios, and the examination of a range of potential societal responses available to decision-makers to adapt and mitigate ecosystem change.

- Fourth, 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 end users to make the best use of the evidence.

The principal outcomes of the UKNEAFO are described in the following articles. ES

Steve Albon FRSE, is a population ecologist based in Scotland, where he is a Research Fellow at the James Hutton Institute. He co-chaired the UK National Ecosystem Assessment (2009–2011) with Bob Watson, and its Follow-on (2012–2014) with Bob Watson and Kerry Turner. Steve contributed to the development of the initial UK NEA conceptual framework, with Kerry Turner, Georgina Mace, Ian Bateman and others (steve.albon@hutton.ac.uk).

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Evolving a conceptual framework to explore the links between human wellbeing and the environment

Steve Albon and **Kerry Turner** outline the tools provided by the UK NEAFO for policy- and decision-makers.


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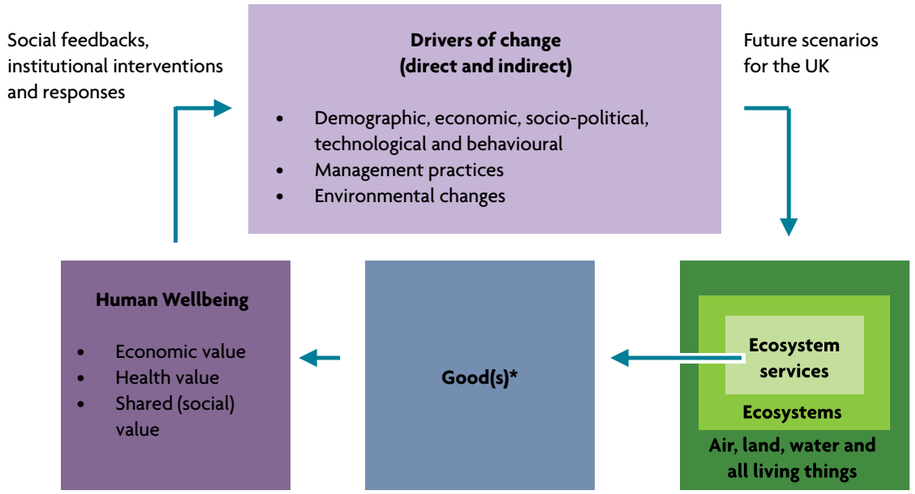
The UK National Ecosystem Assessment[1,2,3] conceptual framework is structured around the processes that link human societies and their wellbeing with the environment. It explores the drivers of change impacting on ecosystems, and the services (such as crops, water supply, climate regulation, wild species diversity, etc.) that flow from them to deliver a range of goods (such as food, fibre, drinking water, pollution control, recreation, etc.) that we value individually and as a society. Our wellbeing values feedback to influence many of the drivers of change, including demographics, economics, socio-politics and technological advances, as well as environmental change and management practices (see **Figure 1**).

ECOSYSTEM SERVICES

The UK NEA conceptual framework builds on the one adopted in the Millennium Ecosystem Assessment[4]: for example, it recognises the same four categories of ecosystem services (supporting, regulating, provisioning and cultural – see **Box 1**). However, it also incorporates a number of more recent advances in conceptual thinking. First, to assist in the economic valuation of ecosystem services, the framework focuses on 'final ecosystem services' developed to avoid the double-counting of services that are part of a suite of primary processes, including supporting services. Second, since a major objective was a systematic and comprehensive valuation of ecosystem services, the framework concentrates on the good(s) arising from those services that economists can value, but also incorporates flexibility to allow non-monetary valuation of services that cannot be meaningfully assessed in monetary terms. Third, the framework incorporates into the assessment elements that are more specifically relevant to the UK, including the



▲ **Figure 1. The conceptual framework for the UK NEA showing the links between ecosystems, ecosystem services, good(s), valuation, human wellbeing, change processes and scenarios. *Note that the term good(s) includes all use and non-use, material and non-material benefits from ecosystems that have value for people[1].**

classification of ecosystems based on the Countryside Survey[5] broad habitat types (see **Box 2**). Finally, a slightly different approach was taken to deal with biodiversity, separating out the underpinning natural processes that depend to a greater or lesser degree on biodiversity from landscapes, seascapes, habitats and wild species. These latter elements of biodiversity are part of our natural heritage and, through the pleasure they bring to many people, form a distinct kind of cultural ecosystem service.

The UK National Ecosystem Assessment Follow-on (NEAFO) has further developed the ecosystem services conceptual framework to reflect our deepened understanding of the roles of governance and institutions in the decision-making process, and

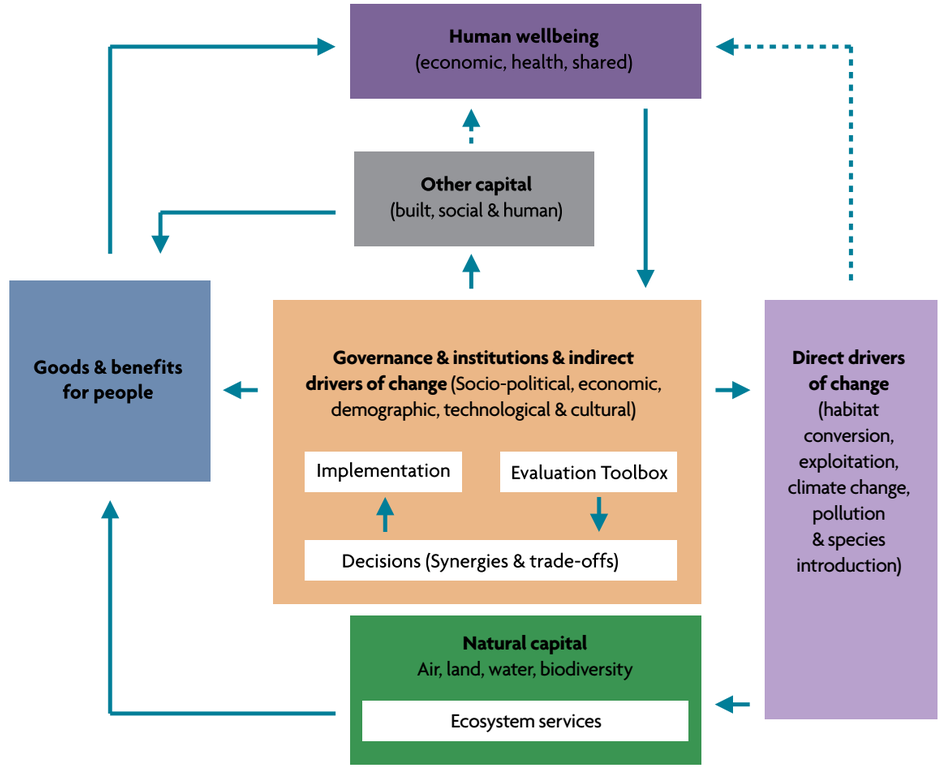
BOX 1: THE FOUR CATEGORIES OF ECOSYSTEM SERVICES[1]

Supporting services provide the basic infrastructure of life. They include primary production (the capture of energy from the Sun to produce complex organic compounds), soil formation and the cycling of water and nutrients in terrestrial and aquatic ecosystems. All other ecosystem services – regulating, provisioning and cultural – ultimately depend on them. Their impacts on human wellbeing are indirect and mostly long-term in nature: the formation of soils, for example, takes place over decades or centuries. Supporting services are strongly interrelated to each other and generally underpinned by a vast array of physical, chemical and biological interactions.

Regulating services provided by ecosystems are extremely diverse and include the impacts of pollination and regulation of pests and diseases on provision of ecosystem goods such as food, fuel and fibre. Other regulating services, including climate and hazard regulation, may act as final ecosystem services, or contribute significantly to final ecosystem services, such as the amount and quality of available freshwater. As with supporting services, regulating services are strongly linked to each other and to other kinds of services. Water-quality regulation, for example, is determined primarily by catchment processes and is thereby linked to other regulating services such as control of soil and air quality and climate regulation, as well as to supporting services such as nutrient cycling.

Provisioning services are manifested in the goods people obtain from ecosystems, such as food and fibre, fuel in the form of peat, wood or non-woody biomass, and water from rivers, lakes and aquifers. Goods may be provided by heavily managed ecosystems, such as agricultural and aquaculture systems and plantation forests, or by natural or semi-natural ones, for example in the form of capture fisheries and harvest of other wild foods. Supplies of ecosystem goods are invariably dependent on many supporting and regulating services. Provisioning services have historically been a major focus of human activity and are thus closely linked to cultural services.

Cultural services are derived from environmental settings (places where humans interact with each other and with nature) that give rise to cultural goods and benefits. In addition to their natural features, such settings are imbued with the outcomes of interactions between societies, cultures, technologies and ecosystems over millennia. They comprise an enormous range of so-called 'green' and 'blue' spaces, such as gardens, parks, rivers and lakes, the seashore and the wider countryside, including agricultural landscapes and wilderness areas. Such places provide opportunities for outdoor learning and many kinds of recreation. Exposure to them can have benefits that include aesthetic satisfaction, an enhanced sense of spiritual wellbeing and improvements in health and fitness. People's engagement with environmental settings is dynamic: meanings, values and behaviours change over time in response to economic, technological, social, political and cultural drivers. Change can be rapid and far-reaching in its implications.



▲ **Figure 2. The updated ecosystem services conceptual framework used for the UK NEAFO 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[3].**

the importance of built, human and social capital in transforming natural capital and the flow of ecosystem services into goods and benefits for people (see **Figure 2**). Also, this revised framework explicitly shows that other capital (human, social and built) is important in transforming ecosystem services into the goods and benefits that people value, as well as illustrating more of the interactions and feedbacks between the component parts of the 'whole' human–environment system.

THE ECOSYSTEM APPROACH

The current overarching ecosystem services framework produced in the UK NEAFO project is unlikely to help decision-makers without also considering the other principles of the broader Ecosystem Approach[6], which "is a strategy for the integrated management of land, water and living resources to promote conservation and sustainable use in an equitable way". The 12 principles of the Convention on Biological Diversity's Ecosystem Approach cover aspects of inclusivity, recognise that objectives are a societal choice, and advocate decentralisation of management to the lowest level, as well as maintaining ecosystem services, recognising functional limits, and balancing demands for use and conservation.

Furthermore, the UK NEAFO integrated approach is designed to help users make informed choices by presenting adaptive management principles to guide inclusion of the ecosystem services framework in policy- and decision-making. 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. It illustrates how actions to support and manage our ecosystems can be tailored in response to new knowledge. The adaptive management principles are supported by a decision support system toolbox (DSS) providing a coherent set of functional methods and tools that 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.

ADAPTIVE MANAGEMENT PRINCIPLES

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

BOX 2. THE UK'S BROAD HABITATS

Ecosystems vary widely because of differences in the interaction of biological, chemical and physical factors at anyone location. In practice ecosystems are usually defined by the scope of the function, process or issue being studied. For the purposes of the UK NEA, broad habitat types based on those from the Countryside Survey were used for classifying ecosystems. The eight different broad habitats are described briefly below.

Mountains, moorlands and heaths cover 18 per cent of the UK land area. Lowland heaths are highly fragmented, while mountains and upland moors and heaths provide the largest consolidated semi-natural habitats in the UK.

Mountains, moorlands and heaths are the source of around 70 per cent of the UK's drinking water, hold an estimated 40 per cent of UK soil carbon, and include some of the country's most iconic landscapes.

Semi-natural grasslands once covered a large proportion of the UK's land area, largely the result of low-intensity traditional farming. The extent of semi-natural grasslands is now extremely reduced, with high-diversity grasslands comprising a mere 2 per cent of UK grassland (≥1 per cent of total land area). Semi-natural grasslands are highly valued culturally – the South Downs, dominated by chalk down-land, receives around 40 million visitor days a year.

Enclosed farmland is the most extensive form of land use in the UK, accounting for around 40 per cent of land area, and producing around 70 per cent of the UK's food. Most is managed for cereal, cattle and sheep production. Half the area of enclosed farmland is arable land, mostly in eastern England. Almost all the rest is nutrient-enriched grassland, mostly in wetter, western parts of the UK. As well as playing a crucial role in provisioning services, enclosed farmland is also of great cultural significance and is a major determinant of landscape in much of lowland UK.

Woodlands include managed plantations as well as ancient semi-natural woodlands. Woodlands cover 12 per cent of the UK's land area, making the country one of the least wooded in Europe. At least 80 per cent is less than 100 years old and just 5 per cent is classified as ancient woodland. Much planting in the past century has been of coniferous trees (often non-native). Only in England is woodland dominated by broadleaved species. Much of the woodland estate is managed as a source of timber, but woodlands are increasingly valued for their delivery of other ecosystem services, particularly recreation and carbon storage.

Freshwaters include lakes, rivers, wetlands and floodplains. In the UK there are more than 389,000 kilometres of rivers, 200,000 hectares of permanent lakes and nearly half a million small ponds. There are also estimated to be at least 390,000 hectares of fen, reedbed, lowland raised bog and grazing marsh and nearly 1 million hectares of floodplain. Freshwater habitats are a major source of water for a wide range of uses and are important for recreation, including angling, boating and other water sports, and in hazard (notably flood) regulation.

Urban areas in the UK cover just under 7 per cent of land area. They are home to eight out of 10 people, often living at extremely high population densities. Greenspace is very limited in extent, and access to it is unequally distributed. It thus assumes disproportionate cultural significance. Urban areas depend very largely on other habitat types for provision of most of their ecosystem services.

Coastal margins, comprising sand dunes, machair, saltmarsh, shingle, sea cliffs and coastal lagoons, cover just 0.6 per cent of the UK's land area. Culturally, coastal margins are of immense significance. There are over 250 million visits per year to the UK coast, of which around one third are to natural habitats. These areas are also important in coastal defences, sediment transport and as nursery grounds for fish.

Marine habitats in the UK cover more than three and a half times the land area. They are highly variable, comprising a very wide range of sub-habitats. Inshore marine habitats are of great cultural importance, offering many opportunities for tourism and recreation. Offshore habitats support fisheries and provide a wide range of other ecosystem services, such as avoidance of climate stress and waste breakdown and detoxification.

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 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 intervention 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 – this is called 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 TOOLS

The DSS toolbox developed in the UK NEAFO is a set of assessment techniques that can be used in the decision-making process to:

i. Establish baseline conditions and trends for ecosystems and their services;
ii. Identify key policy issues;
iii. Prepare for future changes, for example through the use of scenarios;
iv. Create indicators of the state of ecosystems (stock) and changes in the supply of services (flow) over time;
v. Enable a scientific, economic and socio-cultural valuation and appraisal of policy options using various tools, including models;
vi. Interrogate and present data and analysis using appropriate methods; and
vii. Establish good monitoring and review procedures.

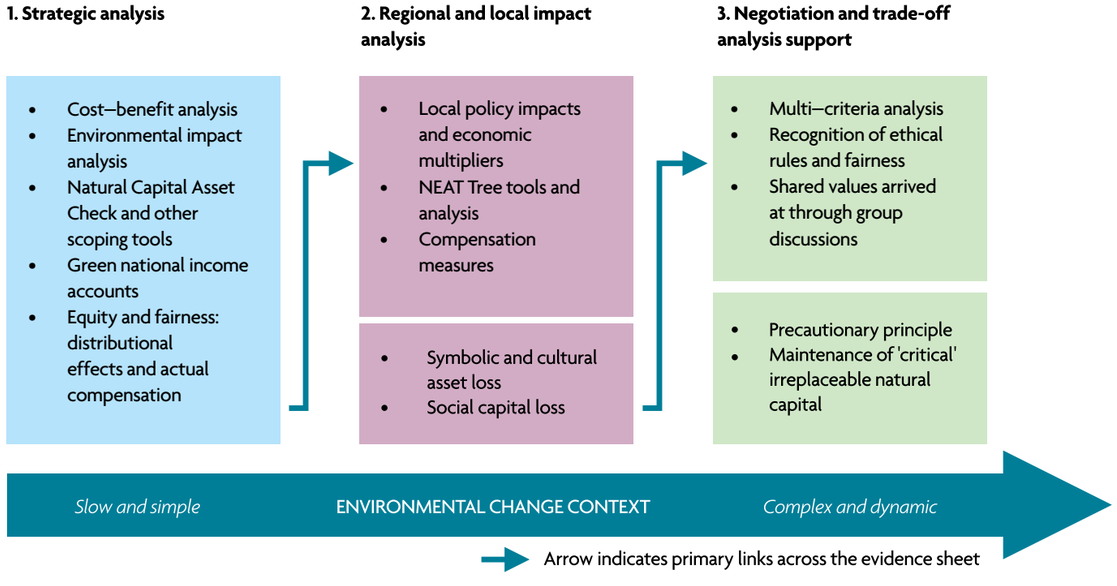
The toolbox puts into practice the Ecosystem Approach and consists of six categories of assessment techniques used or developed in the UK NEAFO. These techniques include:

1. Scoping;
2. Scenario building;
3. Modelling;
4. Indicator setting;
5. Valuing and
6. Data formatting, selecting approaches and methods, interrogating evidence and presenting findings.

THE BALANCE SHEET APPROACH TO DECISION-MAKING

The UK NEAFO developed the balance sheet approach as a means of collating, analysing and presenting data and evidence within the policy process. 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 (see **Figure 3**). 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 3. 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[3].**

▲ **Figure 4. Wetlands are a threatened habitat type which provide numerous important ecosystem services. (© Susan Robinson)**

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.

ENGAGING WITH WIDER AUDIENCES THROUGH NEAT

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.

The National Ecosystem Approach Toolkit (NEAT tree)[7] links the implementation of the 12 principles within projects, programmes and policies with tools that support the decision-making process. 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. ES

Steve Albon FRSE, is a population ecologist based in Scotland, where he is a Research Fellow at the James Hutton Institute. He co-chaired the UK National Ecosystem Assessment (2009–2011) with Bob Watson, and its Follow-on (2012–2014) with Bob Watson and Kerry Turner. Steve contributed to the development of the initial UK NEA conceptual framework, with Kerry Turner, Georgina Mace, Ian Bateman and others.

Kerry Turner DSc CBE, is Professorial Fellow in the School of Environmental Sciences, UEA, Norwich. He specialises in Environmental/Ecological Economics and Management and was a contributor to and Co-Chair of the UK National Ecosystem Assessment Follow On Programme. Kerry contributed to the development of the initial UK NEA conceptual framework, with Steve Albon, Georgina Mace, Ian Bateman and others. Kerry was responsible for much of the thinking behind the component parts of the wider Ecosystem Approach in the UK NEAFO, including the Decision Support System toolbox. He was awarded the CBE for services to sustainable development in 2000.

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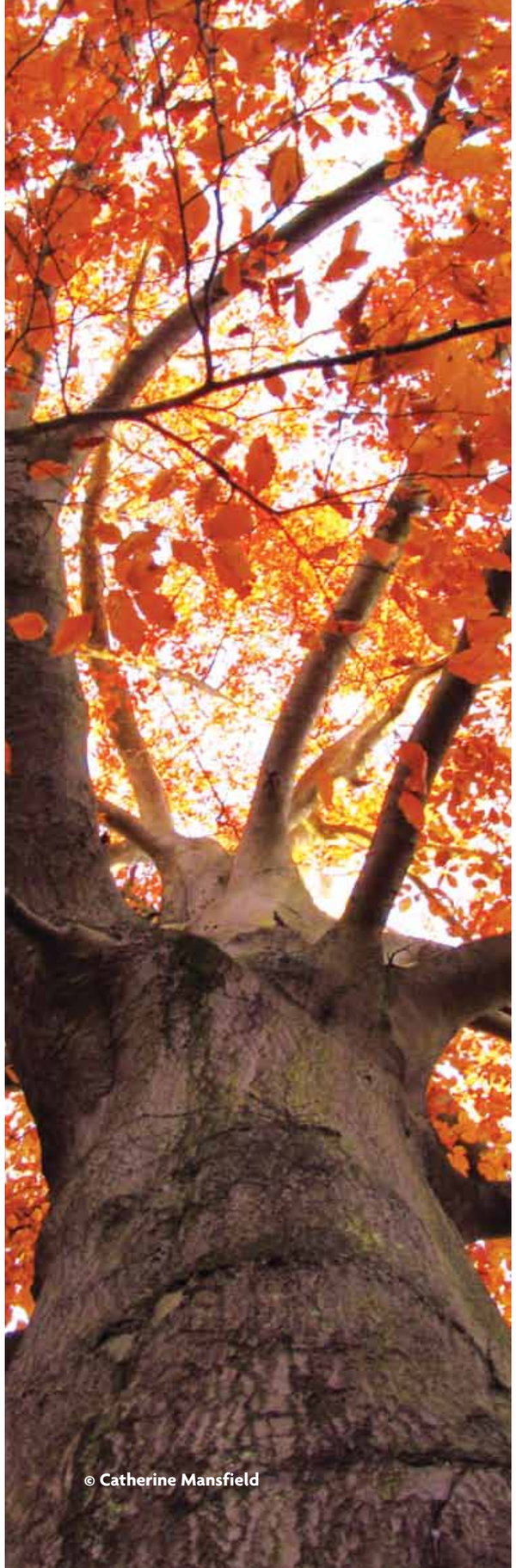

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The case for a Natural Capital Asset Check

Ian Dickie and **Sarah Krisht** outline a way of improving environmental appraisal and providing better decision-making support.

What do a fish and a bee have in common? What connects them? You may think "nothing" at first, and then realise that actually the answer might be quite complex. They have many similarities and differences but, to an economist, one thing they have in common is not that complicated to understand: fish and bees are components of "natural capital", a term that represents a way of thinking about elements of the natural environment. Natural capital has been defined as those elements of nature that either directly provide benefits or underpin human well-being[1,2]. This highlights the fact that natural capital generates value for people. A more technical definition is proposed by

BOX 1: TECHNICAL DEFINITION OF NATURAL CAPITAL

Natural capital is a configuration of natural resources and ecological processes that contributes, through its existence and/or in some combination, to human welfare.

- 'natural resources' refer to the biotic (living) and abiotic (non-living) components of nature that can contribute to human welfare;
- 'ecological processes' refer to the characteristics that maintain an ecosystem;
- 'through its existence' recognises the benefits people attribute to the continued existence of the natural environment, its wildlife, landscapes, etc.;
- 'some combination' reflects the interaction between the living and non-living components of the environment, but also the combination of natural assets with other forms of capital in a way that makes these assets productive; and
- 'human welfare' refers to the benefit or value that accrues to people.

the UK National Ecosystem Assessment Follow-on (UK NEAFO) which includes *how* natural capital generates value for people (see **Box 1**).

THE NATURAL CAPITAL ASSET CHECK

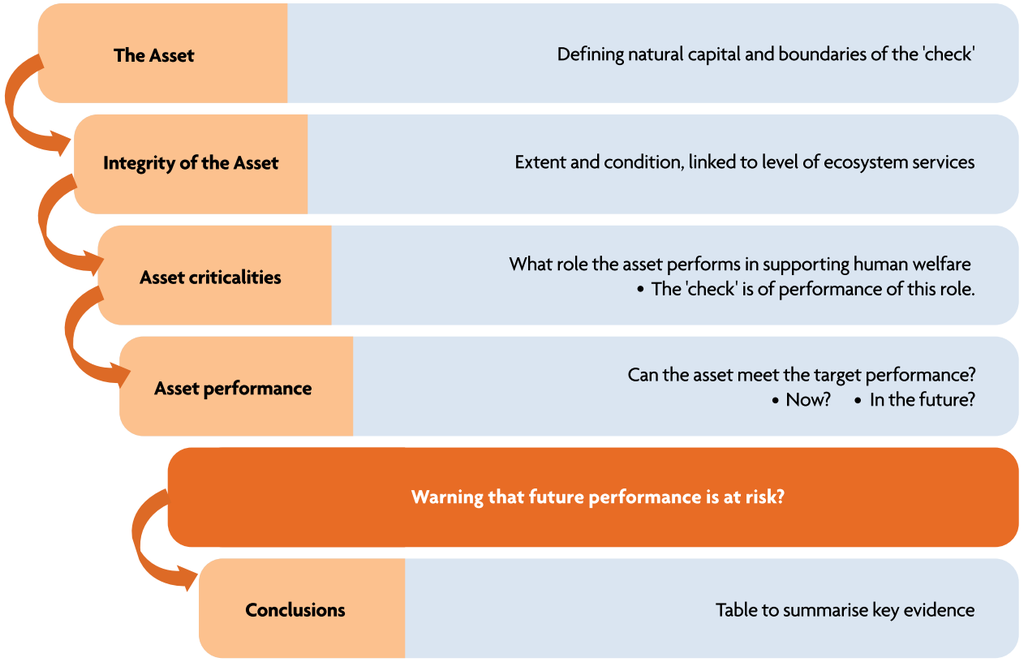
Natural capital was the subject of a Work Package Report[3] of the UK NEAFO. The report used the technical definition in **Box 1** to examine how to improve economic appraisal and give better support to decision-making by incorporating the characteristics of natural capital. To do this, a Natural Capital Asset Check (NCAC) tool was developed which built on a previous scoping study[4]. The Natural Capital Asset Check tool addresses these questions through five steps, which are summarised in **Figure 1**.

The basic approach of this tool is to address the following questions for a particular natural capital asset:

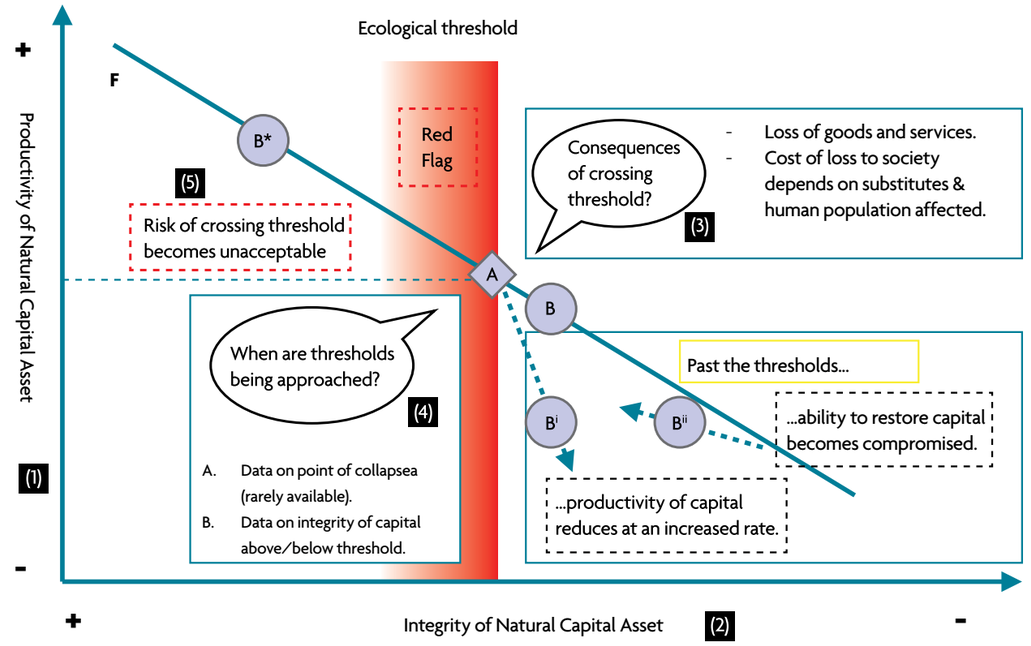
1. How much of the natural capital asset do we currently have? (*Extent*)
2. What does the natural capital asset produce? (*Productivity*)
3. How do our decisions affect the extent and productivity of natural capital over time? (*Trend*)

Particular importance is placed on trend because, in this respect, the Natural Capital Asset Check considers thresholds and/or trade-offs in the relationships between natural capital assets and the goods and services they produce. A threshold can be defined as a discontinuity whereby a small change in a pressure or driver can lead to a large change in the integrity (i.e. the extent and condition) of a natural capital asset with consequences for the benefits it provides[2]. A threshold is a property of a system that can be ecological/biophysical or socio-economic, and as such they are distinguished from targets, which are socially determined objectives.

The goods and services produced by natural capital assets are key contributors to society's wellbeing, but may be compromised if natural capital assets approach a threshold (signalled by a 'red flag'). For other key contributions to our wellbeing, like economic activity, we check the condition of the underlying assets that support it. For example, educational qualifications, research and development (R&D) and spending and business investment data inform us about trends in the underlying condition of the built and human capital that support economic activity. A Natural Capital Asset Check aims to provide similar information about the underlying condition of the natural environment including whether a particular asset is approaching a threshold; information that, currently, decision-makers often lack.



▲ **Figure 1. Steps in a Natural Capital Asset Check[3].**



▲ **Figure 2. Thresholds and the Natural Capital Asset Check[3].**

IDENTIFYING THRESHOLDS

Knowing that data on exactly where thresholds lie is rarely available, an asset check helps to make use of the best data available. For instance, 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 of asset recovery; and
- Economic factors, including the value of goods and services produced from the natural capital asset and the availability of substitutes.

The approach to processing information about thresholds within a Natural Capital Asset Check is reflected in **Figure 2.**

Thresholds are approached as the integrity (i.e. the condition and extent) of natural capital declines as illustrated by line F, which shows a simplified linear relationship. Each step of the Natural Capital Asset Check outlined in **Figure 1** is mirrored in **Figure 2.**

Step (1) defines the natural capital asset based on the goods and services it produces, applying the definition of natural capital;

Step (2) considers the integrity of the natural capital defined by its extent and condition;

Step (3) considers how the integrity of the natural capital influences the goods and services it produces, including whether there are thresholds in this relationship and the consequences of crossing them;

Step (4) considers available data on where thresholds lie (i.e. point A in **Figure 2**). This data is rarely available to inform decision-making, but observations of different examples of natural capital management (e.g. points B, B*, B^{i} or B^{ii}) can provide data on systems that are above and below different types of thresholds; and

Step (5) combines preceding data to consider whether natural capital is being managed in a way that poses risks to society (e.g. through risks of crossing thresholds with significant consequences). This highlights a challenge for ecologists: to understand thresholds and, in particular, to be able to detect the earliest warning signs that thresholds are being approached, i.e. 'red flags'. This is highlighted in **Figure 2** by the increasing density of red shading as the threshold is approached.

A NATURAL CAPITAL ASSET CHECK FOR LAKES AND RESERVOIRS

The design of the Natural Capital Asset Check tool was tested through its application to nine case studies relating to fish stocks, bees and other pollinators and many other things in between, which capture a range of different elements of natural capital at various scales.

For example, a Natural Capital Asset Check was carried out for lakes and reservoirs involving data at a national or river basin district scale as well as some individual site examples. This asset check case study provides a good example of the existence of different thresholds. A major challenge in managing lakes and reservoirs is nutrient enrichment, and there are different thresholds in relation to the provision of different services.

- Certain species are adapted to low-nutrient conditions, and nutrient enrichment can damage the biodiversity conservation value of freshwater lakes in the UK. These thresholds can be defined through conservation targets in UK Biodiversity Action Plans. Once a threshold is passed, the capacity of systems to recover may be impaired;

- The recreational use of lakes is impaired by nutrient enrichment that causes algal blooms. There are at least two thresholds when the recreational ecosystem services derived from a lake have a non-linear response to the increase in nutrient levels:

    - First, algal blooms can limit biological diversity and reduce recreational users' enjoyment of a lake. Once a bloom has occurred, the damage to other species in the system may take a significant period of time to recover after nutrient levels have receded to pre-bloom levels; and

    - Second, some algal blooms can give rise to human health risks, ending the use of the lake for water-contact recreation activities and possibly all water-edge activities (e.g. dog-walking).

This example illustrates how various datasets are required in undertaking a Natural Capital Asset Check. However, the asset check can function with different environmental data, which are rarely complete. Key data gaps can help refine research questions.

WIDER APPLICATIONS

A Natural Capital Asset Check can be applied to different elements of natural capital, including particular ecosystem services (e.g. pollination), habitats (e.g. seagrass beds), or assets (e.g. soils), or a subset of the ecosystem services from a habitat (e.g. recreational services from urban green space). It can also be applied at different scales: nationally, regionally or locally. However, its application to very diverse and/or larger scale (i.e. national) natural capital assets will be complex and data-intensive, and may therefore only be feasible as part of detailed policy reviews. Asset checks that focus on a specific ecosystem service (e.g. pollination) appear to work better, but such a narrow focus risks ignoring trade-offs between services. These trade-offs should at least be noted, even if not quantified.

An asset check summarises evidence on the underlying condition of the natural capital assets that will support valuable future ecosystem services. Examples of applying the Natural Capital Asset Check provide evidence on how this thinking can help future environmental management, including understanding natural capital, managing its performance and supporting long-term planning.

The analysis in a Natural Capital Asset Check can provide important contextual information to help scope the development of national environmental accounts. First, a Natural Capital Asset Check helps to identify the various parameters (such as the properties of the asset, the services that it produces, and relevant metrics) that can guide the structure of ecosystem accounts. Second, a Natural Capital Asset Check 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.

While extensive data on ecosystems and their services have been compiled over time, our understanding of the productive relationships that define natural capital is still limited in many areas. However, the UK NEAFO's asset check case studies show examples of where declines in integrity of capital (e.g. fish stocks and their spawning habitat) can be linked to its productivity (e.g. fish landings). This evidence helps decision-makers work towards a definition of unsustainable use and supports better management of our natural capital. ES

Ian Dickie is a Director at eftec (Economics for the Environment Consultancy). He manages projects related to habitat banking and biodiversity finance, the economics of marine conservation and forestry as well as wildlife trade and invasive species issues. He is also a member of Sustainability Committee of the Institute of Chartered Accounts of England and Wales (ICAEW). (ian@eftec.co.uk)

Sarah Krisht is a Researcher at eftec. She works on projects related to natural capital valuation and national ecosystem accounting, the economics of marine conservation and of bathing water quality improvements, as well as the use of economic analysis in the regulation of chemicals. (sarah@eftec.co.uk)

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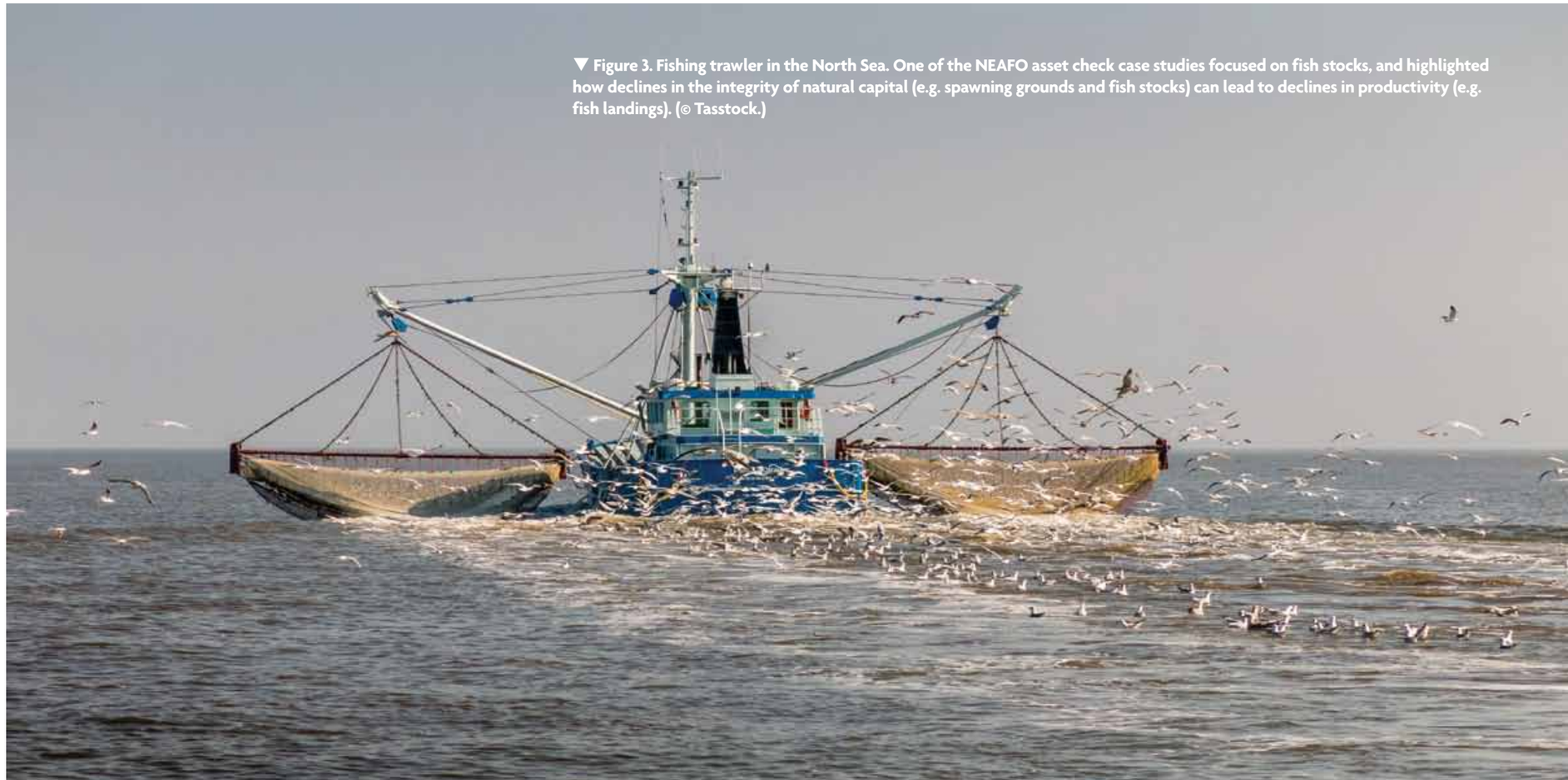

▼ **Figure 3. Fishing trawler in the North Sea. One of the NEAFO asset check case studies focused on fish stocks, and highlighted how declines in the integrity of natural capital (e.g. spawning grounds and fish stocks) can lead to declines in productivity (e.g. fish landings). (© Tasstock.)**

Realising the economic value of ecosystems

Mark Everard summarises work under the UK NEAFO on the economic value of ecosystems and their services.

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▲ **Figure 1. Red Tarn in the Lake District, England. The uplands are important for many crucial, but often overlooked, supporting and regulating ecosystem services which must be incorporated into economic valuations of ecosystems used by policy-makers. (© Zbynek Jirousek)**

Getting a robust grip on the economic implications of changes in ecosystems, the services they supply and how they can be more sustainably managed was a key and significant theme under the UK NEAFO. Two Work Packages addressed economic implications, the *Macroeconomic implications of ecosystem service change and management: A scoping study*[1] *and the Economic value of ecosystem services*[2]. Some key points emerging from each of these research reports are summarised below.

MACROECONOMIC IMPLICATIONS OF ECOSYSTEM SERVICE CHANGE AND MANAGEMENT

Governments are increasingly concerned about the condition of the natural environment and the use of natural resources, as this determines the sustainability of economic development and social progress. This UK NEAFO scoping review was aimed at guiding research priorities for understanding the effects of ecosystem service change and management in the UK on the macroeconomic performance of key sectors and the UK economy as a whole. Under the 2011 UK NEA, a general conceptual framework was developed to link ecosystem services with human well-being in the UK (as explained earlier in the issue by Steve Albon and Kerry Turner).

Macroeconomics is concerned with measuring the condition and performance of the economy of a country at the national scale and within its regions and key sectors. However, macroeconomic models typically fail to consider the likely impacts of changes in ecosystem services on economic performance.

To examine the relative importance of natural capital to the macroeconomy, it is crucial to understand the degree to which it can be substituted by the other forms of capital in the production of final goods. However, substitution between natural capital and other forms of capital is not always feasible, or at least sustainable. For example, no amount of money can ultimately compensate for the loss of photosynthetic primary production and oxygen generation, nor for collapse of the global climate system. As a consequence, our historic tendency to 'trade' marginal elements of climate resilience and other essential yet finite services for financial growth is, we are learning, occurring at significant, rising and non-linear cost. Finding a pathway of economic growth that progressively reduces erosion of critical ecosystems and their services is therefore an absolute priority.

"our historic tendency to 'trade' marginal elements of climate resilience and other essential yet finite services for financial growth is, we are learning, occurring at significant, rising and non-linear cost. Finding a pathway of economic growth that progressively reduces erosion of critical ecosystems and their services is therefore an absolute priority"

▲ **Figure 2. The location of tree planting matters in terms of the overall set of benefits and costs associated with carbon storage, amenity and public enjoyment, water flow and multiple other ecosystem services. (© Mark Everard)**

The UK NEAFO research strand on the macroeconomic implications of ecosystems and their services included an expert consultation to assess the feasibility of mapping 'final' ecosystem services (those services that are most directly used by society) onto individual economic sectors, and hence the macroeconomy as a whole. Although it was possible to identify and describe these interactions in broad terms, currently available data and knowledge are insufficient to quantify and value comprehensively and confidently the flows of ecosystem services between and within the major economic sectors of the economy and the consequences for macroeconomic performance.

THE ROLE OF MODELLING

Various models were assessed for their suitability for incorporating greater consideration of the contribution of ecosystem services, and of changes in those services, to the macroeconomy. Those addressed in this research included: computable general equilibrium (CGE) models, dynamic stochastic general equilibrium (DSGE) models, econometric input–output models, and the systems dynamics approach. Each modelling method uses different economic theories and assumptions, and each also has its own particular limitations.

Further assessment of the potential for integration of ecosystem services and related valuation methods into these models is required. Significantly, this needs to include many services that are not directly exploited in the economy, such as the natural formation of soil or the cycling of nutrients and atmospheric gases that form essential underpinnings for more directly exploited services, including those deriving from agriculture and forestry. These often formerly economically invisible services include, in particular, supporting services and many regulatory services, the degradation of which can have substantial and far-reaching economic consequences.

Key findings from this economics research Work Package include 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. Mapping 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. No existing macroeconomic modelling method is adequate for dealing with the complex interactions between ecosystems and the macroeconomy, so further work is required to extend these models. Further research priorities include development and testing of suitable frameworks and methods for ecosystem–macroeconomy assessments, starting initially with selected key ecosystem services and economic sectors.

ECONOMIC VALUE OF ECOSYSTEM SERVICES

At its most fundamental, this UK NEAFO Work Package addressed the deceptively simple question: "What is the best use of land?". The answer to that question is, of course, complex, and needs to address the finite nature of the natural world and limited opportunities. Optimising the societal benefits of land use also requires appraisal of a far broader set of consequences, or in other words accounting for a broader suite of ecosystem services, than has formerly been the case. This includes consideration of the distribution of benefits and costs within and across society.

"for decisions to be both robust and efficient, they should avoid pre-determined options, instead taking account of the characteristics and corresponding values of the real world"

Case studies addressed under the UK NEAFO Work Package sought, where possible, to be synergistic with established government decision-making frameworks, integrating the co nsequences for a range of ecosystem services and their associated values into modelling methods.

A range of case studies were addressed in the full Work Package report. A case study considering a policy context in which each country within Great Britain decides to plant 5,000 hectares of new woodland per year from 2014 to 2063 (yielding 750,000 hectares) is summarised here, highlighting the benefit of this broader way of assessing outcomes and steering policy decisions. The case study modelled the relative benefits and implementation costs incurred under contrasting 'market value' and 'social value' policies.

THE COSTS AND BENEFITS OF AFFORESTATION

The 'market value'-driven forest planting policy scenario considered the situation if government were to seek to minimise the financial costs of meeting its afforestation targets, without considering 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 'best value' market-driven policy would seek to minimise the size of these subsidies after allowing for the value of any market priced goods (here timber) generated by the policy.

Under this scenario, therefore, the distribution of forest planting is skewed towards the agricultually less

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productive uplands. However, uplands are important for many wider (see **figure1**), generally overlooked services such as water storage and purification, carbon storage, and habitats for wildlife. Though annual implementation costs are relatively low (£79 million), there is a net negative return on investment (£65 million) when consequences for these overlooked services are considered.

By contrast, modelling of the 'social value'-driven policy scenario addressed a wide range of social benefits in the location of forest planting, including both market-priced goods (such as timber production and displacement of agriculture) and selected non-marketed goods (such as greenhouse gas emissions and storage, and recreation). The need to pay subsidies is recognised, but policy emphasis shifts to obtaining the best social returns on investment in natural capital. Forest planting under the 'social value'-based policy scenario redistributes forest planting nearer to urban centres, closer to where people have access to the multiple benefits they provide (see **Figure 2**). Annual implementation costs are relatively higher (£231 million), but there is a net positive return on investment (£546 million).

Further details of the distribution of afforestation under the 'market-value' and 'social value' policy scenarios are published in the UK NEAFO *Synthesis of the Key Findings*[3]. Comparison of likely outcomes under these two scenarios reveals that, when the wider benefits provided by the natural environment are brought into decision-making, taking account of benefits across policy areas, rather different outcomes may ensue. These tend to optimise public value and avert unintended negative outcomes across policy areas.

Key findings emerging from the *Economic value of ecosystem services* Work Package were that, for decisions to be both robust and efficient, they should avoid pre-determined options, instead taking account of the characteristics and corresponding values of the real world, to determine the optimal use of scarce resources. Decisions also need to take into account all of the major drivers of, and impacts from, the changes they are considering, as assessed over a broader suite of ecosystem services. This may include assessment using economic values for those services that are amenable to this approach, but also determining means to factor less directly or readily quantifiable benefits into decision-making processes. Working with, rather than in ignorance of, the natural environment also allows decision-makers to see how alternative implementation strategies for policies can significantly enhance net societal value for money.

ACTING UPON THE ECONOMIC VALUE OF ECOSYSTEMS

As articulated in the executive summary of the government's Natural Environment White Paper, *The Natural Choice*[4], "Nature is sometimes taken for granted and undervalued", "This is why we must properly value the economic and social benefits of a healthy natural environment whilst continuing to recognise nature's intrinsic value" and "We will mainstream the value of nature across our society…".

Converting these broad aspirations into policy and practice clearly requires the development of workable principles, tools and case studies. These economic strands of UK NEAFO research provide significant steps towards achieving this transposition. They achieve this by progressing our capacity to address the implications of ecosystem services, and changes in those services, for the macroeconomy, through the development of some helpful models and operationally relevant case studies. However, making the broader societal transition towards bringing the value of nature into the mainstream of policy and practice depends on concerted political will and priority, and the grasping of initiatives and opportunities by other sectors of society.

ES

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Dr Mark Everard is Associate Professor of Ecosystem Services at the University of the West of England (UWE, Bristol) and a Vice-President of the IES. He has championed the evolution and international practice of ecosystem services since the 1980s. Mark is author of numerous papers and books, many on ecosystems and their services, including *Common Ground: Sharing Land and Landscapes for Sustainability* (Zed Books, 2011), *The Hydropolitics of Dams: Engineering or Ecosystems?* (Zed Books, 2013) and *Breathing Space: The Natural and Unnatural History of Air* (Zed Books, forthcoming). (mark.everard@uwe.ac.uk)

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▲ **Figure 1. Small fishing and pleasure boats moored in Barmouth Bay, Wales. (© Deniskelly)**

Coastal and marine ecosystem services

Jonathan P. Atkins, Daryl Burdon, Michael Elliott, Marije Schaafsma and **Kerry Turner** assess the understanding and importance of ecosystem services provided by the sea and the coast.

Many countries and the European Union have declared that their seas should be clean, healthy, safe, productive and biologically diverse[1]. The UK NEAFO describes a set of strategic-level principles and practical tools to help achieve this lofty aim and inform the sustainable management of coastal and marine ecosystem services. This is important, as coastal and marine habitats vary spatially and temporally and are influenced greatly by human activities and pressures. There are dynamic and complex interactions between coastal and marine habitats and the adjacent catchment and open sea.

Despite that, we have a less-than-perfect understanding of coastal and marine ecosystem functioning, the reactions to pressures and the contributions to human welfare. Nevertheless, following the findings of the UK NEAFO Work Package Report 4: ***Coastal and marine ecosystem services: principles and practice***[2], here we give the concepts integrating natural and social sciences related to coastal and marine ecosystems, and the ecosystem services that they provide. We also comment on their valuation in coastal policy practice in the UK and elsewhere. The information presented here is further discussed in Turner and Schaafsma (forthcoming), which discusses UK coastal ecosystem services from science to values and decision-making[3].

COASTAL AND MARINE ECOSYSTEMS: STRUCTURE, FUNCTIONING AND THREATS

Marine ecosystems form as the net result of structural elements or components manifest as a series of key rate processes and inter-relationships that constitute ecosystem functioning and that encompass both the living and non-living components[4,5]. Natural and human-derived change is then superimposed on these environmental and biological attributes (see **Table 1**). The natural functioning of the marine system then constitutes the upper part of the conceptual model presented here (see **Figure 2** and **Box 1**).

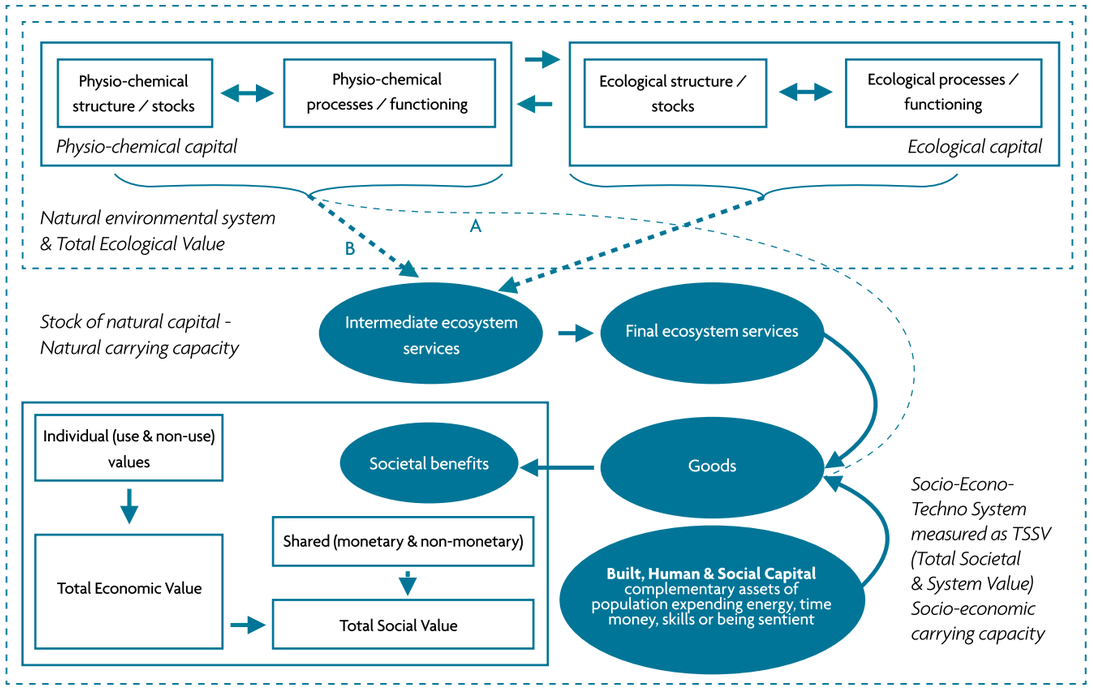
The coastal zone and marine ecosystems are subject to dynamic environmental change that occurs both ways across the land–ocean boundary and their essential functioning depends on the connectivity with the catchment and the open ocean[6]. They are subject to many pressures and hazards including climate change, ocean acidification, coastal erosion and flooding, sea-level rise, siltation, eutrophication overfishing and expansion of the built environment[7]. Globally, all coastal zone natural capital assets have suffered significant loss over the last three decades (e.g. 50 per cent of fresh and saltwater marshes, 35 per cent of mangroves and 30 per cent of reefs lost or degraded)[8].

COASTAL AND MARINE ECOSYSTEM SERVICES

As long as the natural system has an appropriate structure and is functioning properly, it provides a set of ecosystem services (see **Figure 2**). For example

BOX 1: UNDERLYING ASSUMPTIONS OR EXPLANATION FOR THE CONCEPTUAL MODEL

- The physico-chemical system sets up the framework to support/develop the ecological system but the latter then influences the physico-chemical system (feedback loop);
- Functioning relates to rate processes and thus flows, whereas structure relates to a commodity at a given time;
- The environmental system and (natural) capital is the product of the physico-chemical (natural) capital and the ecological (natural) capital; 'capital' in this case includes both structure and function;
- Ecological functioning is created by and in turn creates ecological structure;
- Ecological natural capital requires valuing by ecological valuation (which includes rarity, fragility, resilience, vigour, etc.) – c.f. economic valuation;
- Ecological stocks are a subset of ecological structure but are created by and in turn create ecological functioning;
- In economic and ecological terms, societal benefits are taken from the stocks without adversely reducing the stocks;
- Achieving benefits from services by society requires expenditure of human capital and complementary assets (skills/energy/money/time);
- The natural system can have ecosystem services in its own right not linked to societal benefits;
- 'Intermediate' ecosystem services follow from 'fundamental/basic' ecosystem processes as an economic rather than an ecological construct;
- 'Carrying capacity' is the ability of the natural or human system to hold/support the indicated attributes;
- The natural and socio-economic systems provide the carrying capacity that then supports the natural and socio-economic capital;
- The arrows should be read as something 'leading to' or 'producing' the subsequent box, and double arrows denote feedback loops;
- 'Goods' relate to an entity (*c.f.* structure) whereas 'services' relate to the processes producing that entity;
- Human capital is taken to include skills/education/knowledge, entities and the ability to use them;
- The values concept needs to include four aspects: anthropocentric instrumental value; anthropocentric intrinsic value; non-anthropocentric instrumental value; non-anthropocentric intrinsic value;
- By definition 'anthropocentric' means that it can often but not always be given a monetary value whereas 'non-anthropocentric' is not assigned a monetary value but rather carries with it ethical properties; and
- Whereas the physico-chemical and ecological systems relate to Good (Chemical or Ecological) Status under the Water Framework Directive, the physico-chemical, ecological and human systems relate to Good Environmental Status under the Marine Strategy Framework Directive.



▲ **Figure 2. Natural and social sciences: integrating concepts.[18]**

▼ **Table 1. Marine processes and inter-relationships**

Processes	Meaning	Examples
'Environment–biology'	The physico-chemical system (e.g. salinity, temperature, sediment, geology, hydrography, etc.) creates the fundamental niches for colonisation by organisms.	Reduced water currents will allow the development of muddy substrata which will be colonised by deposit-feeding organisms; biogeographic regimes and physico-chemical oceanographic processes and gradients will thus create the conditions likely to be colonised by organisms.
'Biology–biology'	The resultant community is modified by biological processes and interactions such as predator–prey relationships, competition, and recruitment processes such as propagule supply and settlement.	The mud-dwelling invertebrates then compete with each other for space but also provide food for wading birds and fish.
'Biology–environment'	The biology may influence the physico-chemical system and the import and export of materials into and out of the system.	Benthic invertebrates bioturbate and alter the sedimentary regime, leading to chemical changes; oxygen demand is created by a large number of organisms occurring together.
'Environment–environment'	One or more elements of the physico-chemical system impact upon other elements of the physico-chemical system.	Changes in the hydrographic regime (e.g. currents, tides, etc.) result in changes to the sediment structure on the seabed.

the waves, tides, sediments and water characteristics create the right conditions in which the prey of fish thrive and in turn support those fish. These ecosystem services provide a range of benefits that lead to a healthy and prosperous society (e.g. food and employment for fishermen) and so the term 'services' are the means of providing endpoints that are of interest as benefits to society[9]. The basic ecosystem structure and processes combine to produce intermediate services and final services that can lead to goods (benefits) that are consumed by humans, or which are essential for human welfare[8].

Figure 2 further indicates the contentious topic of whether only ecological aspects can deliver ecosystem services (denoted (A)) or whether ecosystem services can be derived from the physico-chemical system on its own (e.g. seabed aggregates for building materials, denoted as (B)). Irrespective of this, in order to derive benefits and goods from the ecosystem services requires built, human and social capital as the complementary assets in which energy, equipment, skills and effort. In other words, the marine system can produce fish but we have to learn how to catch and prepare it for food.

While there are several ways of defining ecosystem services, it has been suggested that ecosystem processes (a service that comes from other factors than the ecosystem itself) and ecosystem functions (the result of ecosystem process) lead to a generic classification based around intermediate services associated with indirect benefits, and final services associated with direct benefits[10]. This approach avoids any potential for double counting benefits, where there is competition and/or complementarities between ecosystem services, which is particularly important when it comes to scientific, analytical, monetary or other evaluation.

There are considerable effects of those hazards causing risk to the coastal and marine ecosystem services and societal economic benefits (value), but these have yet to be properly recognised and more precisely quantified and evaluated[2]. The ecosystem service classification system should be linked to policy and management and therefore different interpretations may be needed depending on the context[10]. The most widely recognised framework is that of the Millennium Ecosystem Assessment, which identifies four categories of ecosystem service:

- Provisioning services (e.g. food and raw materials);
- Regulating services (e.g. gas and climate regulation);
- Cultural services (e.g. leisure and recreation); and
- Supporting services (e.g. nutrient cycling)[8].

The UK NEA focused on the processes that link human society and wellbeing to the natural environment, and amongst other things, on the key role ecosystems play in delivering a diverse set of services that directly and indirectly underpin economic progress and human wellbeing. This distinguishes between processes, intermediate services, final services and goods and their benefits and was modified for the marine environment under the NERC-funded Valuing Nature Network Coastal Management project and workshops within the UK NEAFO project[2]. Coastal ecosystem natural capital stocks (the ecosystem structure and processes and links to the abiotic environment) are biologically highly productive and diverse (with many habitats and species), with a consequent flow of ecosystem services (the outcomes from the functioning of ecosystems) of significant value (in terms of benefits) to society.

"the use of coastal resources and their conservation is often highly contested, involving a range of different stakeholders"

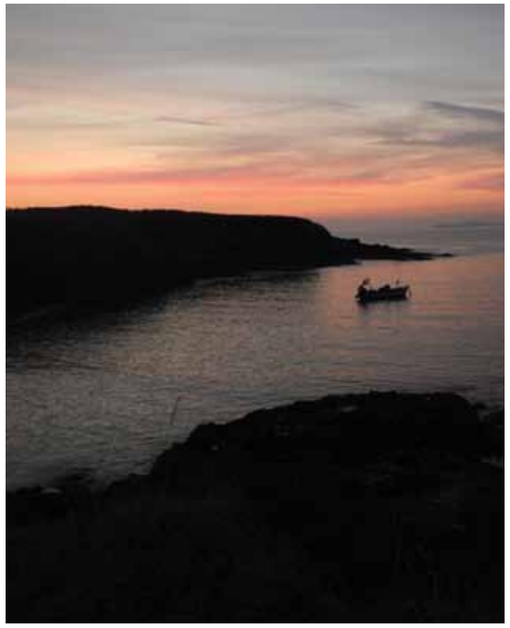
VALUATION OF COASTAL/MARINE ECOSYSTEM SERVICES

Ecosystem service indicators are required to determine the health of the marine ecosystem, its change due to the marine hazards, and its value to society. These reflect the marine state and/or performance, the natural capital stocks and the flow of ecosystem services of significant value (in terms of benefits) to human society. Hence indicators need to be specific not only to ecosystem services but also relate to the components and processes and goods/benefits. Therefore, since marine ecosystem services potentially provide societal benefits, it is appropriate to consider their value, giving increasing use by stakeholders. This is recognised by the EU 2020 Biodiversity Strategy, which emphasises the need "to value ecosystem services and to integrate these values into accounting systems as a basis for more sustainable policies". Both the EU Water Framework Directive and Marine Strategy Framework Directive also explicitly require economic valuation to be a central part of marine environmental management[11,12,13,14].

For some marine ecosystem services, market prices may reflect their value (e.g. fish landed for human consumption), but for others a market price either does not exist or is inadequate (e.g. spiritual and cultural wellbeing such as an appreciation of a beautiful seascape or the knowledge that blue whales exist). As discussed above, it is not appropriate to value basic marine processes and intermediate services without identifying explicitly the associated final ecosystem services and goods/benefits that have human welfare implications[2]. There are many methods of economically valuing ecosystem services and societal benefits such as contingent valuation, cost-of-illness, damage avoidance costs, market costs, travel costs and costs of carbon equivalence[15]. Many of the techniques are categorised as non-market valuation approaches as they do not rely on market prices; such methods are for some people controversial but are gradually gaining wider acceptance and are advocated for official policy evaluation[16,17].

CONCLUSION

Hence the monetary valuation of stocks and flows in particular is complex and has to rely on a range of accounting and socio-economic approaches, together with an underlying natural science understanding. Some services will not be amenable to monetary valuation, and the use of coastal resources and their conservation is often highly contested, involving a range of different stakeholders. Coastal areas are also socio-cultural entities, with specific historical conditions and symbolic significance and therefore the values expressed for such cultural entities may well manifest themselves through social groups, communities and even nations.



▲ **Figure 3. Market prices cannot be used as a proxy to establish the value of some ecosystem services, such as the spiritual or aesthetic appreciation of a beautiful seascape, such as this view from St Brides, Pembrokeshire. (© Mark Everard).**

There are considerable gaps in the current valuations of UK coastal and marine ecosystem services, including the benefits and especially social welfare assessment. These gaps relate to the biodiversity and seascape values (non-use existence values) of most global coastal and marine habitats, and some of the typical UK habitats, such as machair. ES

Dr Jonathan Atkins is a Reader in Economics at the University of Hull Business School. He has research interests in the economics of estuarine, coastal and marine environments, particularly ecosystem services and their economic valuation and management. (j.p.atkins@hull.ac.uk)

Daryl Burdon is the Senior Ecological Economist at the Institute of Estuarine and Coastal Studies (IECS), University of Hull, UK. Initially specialising in estuarine and marine ecology, Daryl has broadened his expertise into the fields of ecological economics, marine policy and legislation, and marine management. Much of Daryl's current research is related to the development and application of ecosystem service approaches to the estuarine, coastal and marine environment. (D.Burdon@hull.ac.uk)

Professor Mike Elliott is the Director of the Institute of Estuarine & Coastal Studies (IECS) and Professor of Estuarine & Coastal Sciences at the University of Hull, UK. He is a marine biologist with a wide experience of biological and environmental analyses, but especially with research interests in the assessment of human impacts, and in marine and estuarine management, policy and governance. (Mike.Elliott@hull.ac.uk)

Dr Marije Schaafsma is a Senior Research Fellow at the University of Southampton and holds an ESPA Early Career Research Fellowship. She is an environmental economist and is interested in decisions concerning ecosystem management and human development. She specialises in the application of economic methods to inform such decisions and trade-offs. (M.Schaafsma@soton.ac.uk)

Professor Kerry Turner DSc CBE is a Professorial Fellow in Environmental Economics and Management, in the School of Environmental Sciences, University of East Anglia. He has extensive research experience in interdisciplinary coastal/marine environmental issues. His expertise is in environmental/ecological economics and especially pioneering studies into the ecosystem services approach and its links to an Ecosystem Approach to environmental change management. (R.K.Turner@uea.ac.uk)

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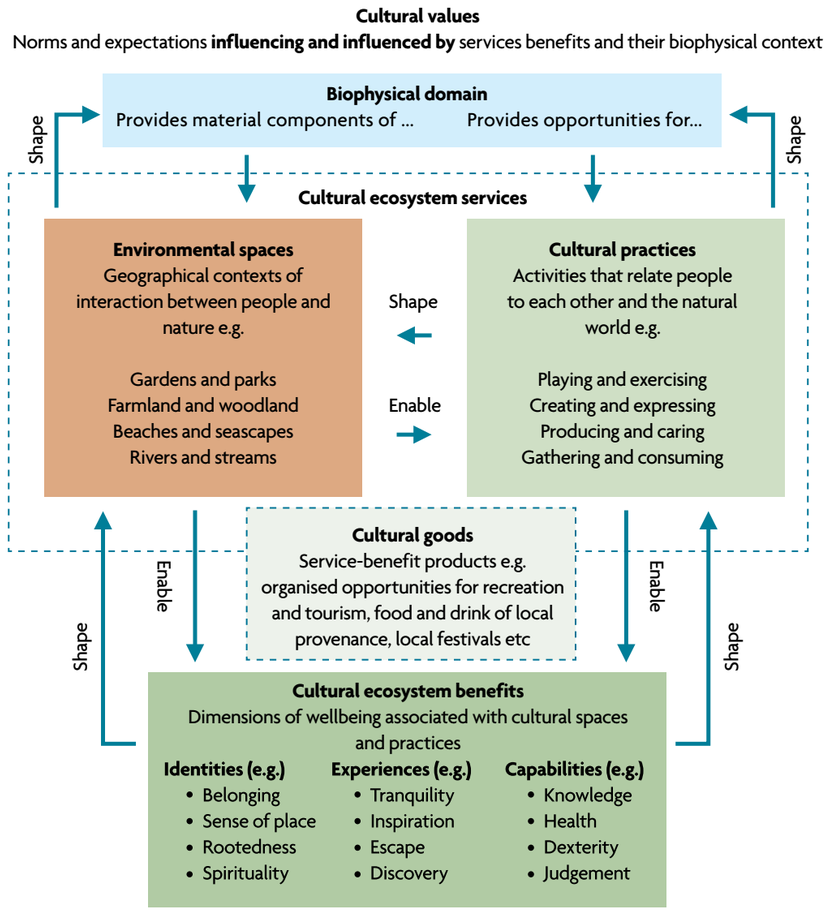
Cultural ecosystem services: stretching out the concept

Robert Fish and **Andrew Church** review how the cultural importance of ecosystems can be factored in to decision-making.



▲ **Figure 1. A conceptual framework for cultural ecosystem services.**

Ecosystems are replete with cultural value and significance, but how can environmental managers take account of this within decision-making? The concept of cultural ecosystem services offers one powerful way of conveying that natural systems underpin a range of life-enriching and life-affirming benefits to people. As part of research conducted for the National Ecosystem Assessment Follow-on we have endeavoured to take a fresh look at the cultural dimensions of ecosystem management, developing a new framework for exposing the links between cultural ecosystem services, natural capital and wider cultural values.

CONCEPTUALISING CULTURAL ECOSYSTEM SERVICES

Cultural ecosystem services are actively created and expressed through people's interactions with ecosystems, and can be specifically understood as the contributions that ecosystems make to human wellbeing in terms of the identities they help frame, the experiences they help enable and the capabilities they help equip. The key dimensions of our conceptual framework for the NEAFO are summarised graphically in **Figure 1**. It makes distinctions between:

- **Cultural values:** collective norms and expectations that influence how ecosystems accrue meaning and significance for people;
- **Environmental spaces**: the places, landscapes and seascapes in which people interact with each other and the natural environment;
- **Cultural practices:** expressive, symbolic and interpretive interactions between people and the natural environment; and
- **Cultural benefits:** dimensions of human wellbeing that can be associated with these interactions between people and the natural environment.

Our overall argument is that environmental spaces and cultural practices should be considered mutually reinforcing cultural services through which cultural benefits to wellbeing arise. Ecosystems are understood here to provide the physical and non-human components of these spaces, and the opportunities for cultural practices associated with them. At the heart of our approach is the idea that the many and varied cultural goods and benefits associated with ecosystems arise from a series of cultural practices and the related cognitive, non-cognitive and embodied interactions occurring between people and a range of (culturally constructed) environmental spaces. This approach is consistent with wider developments in the cultural ecosystem services literature[1,2,3].

ENVIRONMENTAL SPACES

In practical terms environmental spaces may be delineated in a variety of ways: a stretch of footpath, a street, a hill, an expanse of green space, a protected shipwreck, a marine conservation zone, a national park or a nucleated settlement. All of these may plausibly provide ways of locating cultural benefits in their wider geographical context and can be associated with a range of culturally defined attributes (such as beauty, tranquillity, distinctiveness) that may be explored in the context of contributing natural capital.

Approaches to classification and definition will vary according to underpinning purposes and resources, but a general philosophical point is that what counts as geographical context or attribute of significance to decision-makers, communities and individuals will often rest on prevailing – deeply historical – ways of giving a place a value. While no single taxonomy of spaces and attributes exist to delineate these cultural contexts of human interaction and ecosystem benefit, accumulating convention and experience allow individuals, groups and institutions to make, re-make and discriminate over places according to established registers of cultural value.

In this sense a landscape or seascape given 'national park' or 'world heritage' status is not an absolute definition of cultural value, but neither is it purely arbitrary. Part of the task for researchers and decision-makers, therefore, is to stay alert to countervailing tendencies: places and things forgotten, obscured or indeed incongruent with prominent spatial frames, such as the unofficial countrysides and edgelands of the urban hinterland[4,5].

CULTURAL PRACTICES

As **Figure 1** conveys, environmental spaces both enable, and are shaped by, cultural practices, by which we mean the large symbolic, expressive and interpretive realm of human interactions with nature. Practices may be physical/embodied, textual/mediated and linguistic/discursive. Again cultural practices reflect and constitute cultural values and are a discernible way that culture can be said to manifest itself, both at particular moments in time (e.g. recreational activity) and as part of a broad cultural realm of lived experience (e.g. a whole way of life)[6]. In the framework, these practices serve as the mechanism binding together cultural benefits to their biophysical/cultural contexts of production. Our framework distinguishes between four (often interrelated) types of cultural practice:

- **Playing and exercising:** activities of non-work leisure time involving informal and physical interactions between people and the natural environment. These may be sedentary, active, social and solitary such as walking, dog walking, climbing, running, cycling, sitting, looking, listening, picnicking and paddling;
- **Creating and expressing:** activities of non-work leisure time defined by the conscious construction of symbolic artefacts and processes. This may include solitary pursuits inspired by natural environment such as drawing, painting, photography, writing, poetry, as well as organised performances and participation in customs and rituals that draw on/reflect the natural environment in some way: music, drama and storytelling;
- **Producing and caring:** activities that span and blur both work/non-work engagements with the natural environment. The multitude of environmental and land based professions are included in this category as are more informal physical conservation and management of features of natural environment: cultivating land for food production, fishing, bird-watching, environmental volunteering, citizen science, gardening and, participation in agri-environmental stewardship; and
- **Gathering and consuming:** activities spanning passive and active engagements with the natural world that occur in both work and non-work contexts, such as: consuming food and drink of local provenance, collecting wild food, fibre and ornaments, consuming non-conversational media and genre about a place, e.g. local art/artefacts/popular media/performances.

To reiterate, these cultural practices are understood by the framework as occupying a mutually constitutive role in the formation of cultural services and cultural benefits. Places, landscapes and seascapes enable cultural practices to occur but are also created through them. Equally, the identities, experiences and capabilities enabled through these practices also actively construct and reconstruct the character of cultural practices. And as **Figure 1** conveys, these services are subject to specific kinds of economic construction and transaction that place

many of these elements within the realm of market-based goods. In the framework, cultural ecosystem services are not reducible to the formal economic sphere but neither are they outside it.

CULTURAL ECOSYSTEM BENEFITS

Despite the emphasis in most applications of the cultural ecosystem services concept on the issue of intangible benefits from nature, researchers and decision-makers have generally struggled to disentangle what these many and diverse outcomes for people might be. The broad classification of identities, experiences and capabilities moves beyond the United Nations Millennium Ecosystem Assessment's definition of cultural ecosystem services as the non-material benefits of human interaction with the natural environment[7] and represents a further development of the definition forwarded by Chan *et al.*[8], thus:

- By **identities** we are highlighting the signifying qualities of ecological phenomena and how these come to be enmeshed in processes of identity formation. For instance, ecosystems are replete with cultural meanings through which people understand themselves and their relationship to the world around them. An example of a cultural benefit that coincides with these symbolic roles of ecosystem would be the idea of belonging: ecosystems play a role in the process of place identification through which ideas of affiliation and attachment develop;

- By **experiences** we are concerned with the way ecological phenomena are encountered and understood through events. Experiences are benefits felt mentally or physically through contact with ecosystems. Examples of an experiential cultural benefit might include feelings of calm or of spiritual enrichment arising from encountering some physical attribute of ecosystems, or an experience of nature deemed aesthetically pleasing. These contacts are not only embodied and proximate (such as the production of an experience through a walk in the forest or diving underwater), but also occur in disembodied and distant ways as well (such as the benefits associated with consuming nature through a television programme); and

- By **capabilities** we are focusing on the role that ecological phenomena play in shaping individual and social capacities to understand and do things. For instance ecological phenomena are used in processes of knowledge acquisition at the level of general intellectual and scientific advancement (such as making sense of biodiversity), but also in patterns of individual development, such as the acquisition of personal skills and knowledge through which people flourish as individuals (such as wisdom, judgment, insight) and advance their situation in

ANALYSIS

▲ **Figures 2 & 3. The cultural benefits derived from ecosystems are so diverse and plural (the significance of sighting a hunting kingfisher or a visit to an urban park will vary between individuals) these services require a variety of approaches to measurement.**

▲ **Figure 4. Outdoor recreational activity is one way in which we have contact with ecosystems. (©Chlorophylle)**

life (for example through gainful employment). The idea of capabilities is therefore about capturing how people and human cultures more generally equip themselves, through nature, to prosper.

Cultural benefits will often lack the apparent internal consistency of other arenas of ecosystem assessment. They also lack well-defined measurement boundaries. For example, an experience of nature (e.g. aesthetic pleasure) can be read through the lens of identity (e.g. the construction of valued place identities) just as a capability (e.g. the ability to catch a fish) can be read through the lens of experience (e.g. a feeling of oneness with nature) and so forth. In practical terms it may be logical to explore how these benefits affect wellbeing as a whole and mutually reinforce each other in particular geographical contexts rather than attempt to separate them artificially.

CONCLUSIONS

Understanding and accounting for cultural ecosystem services is an essentially interpretive and plural issue: what environmental spaces and cultural practices matter, where and why is always open to cultural revision and debate. The challenge facing the decision-maker and environmental manager is how to approach culture in ecosystem management in ways that reveal, recognise and dignify this inherent diversity whilst avoiding the idea that culture is simply outside the ambit of systematic appraisal when developing and approaches to and options for ecosystem management. In the NEAFO we suggest at one level the framework implies the need for methodological plurality: interplaying and blending together sources and forms of evidence that straddle official and informal, tangible and intangible, as well as cognitive and physical elements of human interactions with a range of environmental spaces.

The disaggregation in terms of spaces, practices and benefit, however, does provide items and processes that can be measured, as well as offering a 'checklist' of cultural issues that need to be considered within ecosystem assessment and management. This conceptual framework for cultural ecosystem services lends itself to a range of assessment approaches that can provide a varied and robust evidence base to aid decision-making. ES

Robert Fish researches and teaches in the Politics Department at the University of Exeter and will shortly be joining the University of Kent as a Reader in Human Ecology. A social scientist and human geographer by training, Robert's research interests are in the cultural and environmental aspects of sustainable land management. He has been closely involved in Defra's recent work to embed an ecosystems approach into policy- and decision-making processes and is lead author of UK National Ecosystem Assessment Follow-on research into indicators for cultural ecosystem services.

Andrew Church is Professor of Human Geography and Director of Research and Developement for Social Sciences at the University of Brighton. His research is in the field of geography and culture–nature relations. Andrew was a coordinating lead author for the UK National Ecosystem Assessment chapter on cultural ecosystem services and Principal Investigator for the UK National Ecosystem Assessment Follow-on research into indicators for cultural ecosystem services. He is currently working on an Arts and Humanities Research Council Connected Communities project on Hydrocitizenship.

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IES: new members and re-grades

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Gabor Antony	Senior Air Quality Consultant
Lawrence Bell	Laboratory Manager
Thomas Burkitt	Operations Manager
Runako Charles	Senior Sustainability Officer
Steven Fleiss	Senior Environmental Consultant
Simon Gillard-Eastop	Technical Officer
Robert Hodgson	Consultant (Contaminated Land)
Robert Jackson	Environmental Engineer
Michael Lawson	Geoenvironmental Engineer
Nicola Levy	Sustainability Consultant
Dawn Love	Head of Environment & Sustainability
Peter Meyer	Director
Colin O'Connor	Principal Engineer, Acoustics/Environment
Harshvaden Patel	Energy Manager
Andrew Priestley	Senior Geo-environmental Consultant
Rosemary Willatt	Sustainability Consultant
Anastasia Wood	Senior Technician
Christopher York	Partner

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Mykola Gerasymenko	Technical Director
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Victoria Porter	Finance Admin Clerk

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Sanaa Arif Hobeichi	Remote Sensing Specialist
Joscelyn Attenborough-Jones	Environment and Energy Co-ordinator
Pamela Buchan	Freelance Researcher
Ayan Chakravartty	Environmental Scientist - Air Quality & Carbon
Mark Chappell	Graduate
Chibuike Chigbo	Lecturer /Project Supervisor environmental science
Frances Coles	Graduate
Ami Cooper	Graduate Geo-environmental Consultant
Joel Costa Esteves	Graduate Environmental Scientist
Robert Davies	Graduate
Matthew Dempster	Hydrogeologist
Adekunle Dosumu	PhD student
Alicia Dunning	Graduate
Anna Gillespie	Part-time Research Assistant
Ava Grossman	Graduate
Luke Hands	Environmental and Quality Manager
William Hargrave	Environmental Scientist
Ibrahim Haruna	Graduate Environmental Consultant
Lise Hiscock	Project Scientist
Katherine Jenner	Graduate Engineer
Paul Jones	Graduate
Susan Lattanzio	Postgraduate student
Shane Longworth	Environmental Advisor
Hannah Luxton	Graduate
Marco Mattiuzzo	Market Reasearcher
Ross Paterson	Graduate Production Assistant
Alice Saunders	Trainee Accountant
Myles Tatlock	Consultant
Bethany Vaughan	Graduate
James Wakefield	Sales and Service Centre Advisor
Cheuk Wan	Project Administrator
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Taking account of the shared and cultural values of ecosystem services

Jasper O. Kenter and **Mark S. Reed** analyse the impact on land managers, businesses and decision-makers of people's collective and individual values relating to landscapes.

Drinking water, energy, crop pollination, climate stability and mental and emotional wellbeing are all benefits that nature provides for human beings. How different individuals and communities relate to them depends on personal, shared and cultural values. These values are not always explicitly expressed through conventional surveys or reflected in economic valuation – they often become clear only after people talk with others about what matters most to them. So if natural assets are to be managed for the benefit and wellbeing of all, we need to work to understand the values that individuals and communities attach to them.

What are shared values? The UK National Ecosystem Assessment Follow-on (UK NEAFO[1]) has developed a framework that can help decision-makers identify the shared values held by communities. This includes seven different types of shared values, some of which overlap:

- **Transcendental** values are the principles and overarching goals that guide us, going beyond specific situations. Examples include honesty, security, enjoying life, social status and harmony with nature;

"if natural assets are to be managed for the benefit and wellbeing of all, we need to work to understand the values that individuals and communities attach to them."

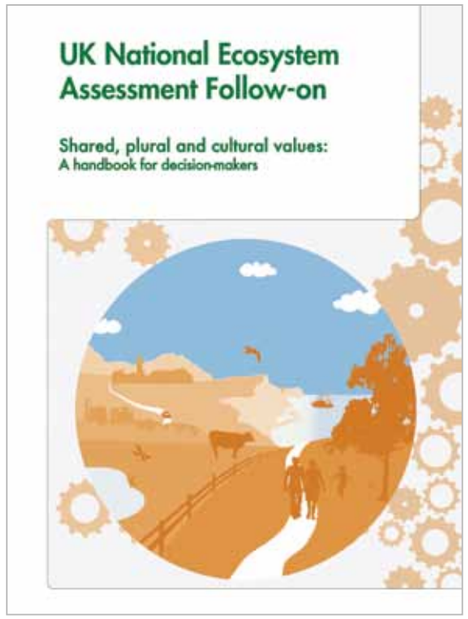
- **Cultural or societal** values are culturally shared principles, virtues and goals, as well as a shared sense of what is worthwhile and meaningful;
- **Communal values** are held in common by the members of a community (based on geography, faith, belief or activities, for example);
- **Group values** are expressed in a valuation process by a group of people through consensus or majority vote, or more informally;
- **Deliberated values** are those that individuals or groups express as a result of deliberating with one another, typically involving discussion and learning;
- **Other-regarding values** express the sense of importance attached to the wellbeing or moral standing of others (humans, other living creatures, and the natural and historical environment); and
- **Value to society** is the benefit, worth or importance of something to society as a whole.

Taken together, these different types of shared values (also referred to as 'social' or 'shared social' values) represent those that we come to hold and assign through our interactions with others in one way or another. They inform and shape a concept of the common good.

WHY DO SHARED VALUES MATTER?

Shared values are important for everyone involved in making decisions.

- **Businesses** need to know what behaviours their customers want and expect from them. Brand and reputation can affect their customers' opinions and their willingness to continue to buy goods and services;
- **National government and its agencies** need to understand the social impacts of future policies and how they are likely to be perceived by the public;
- **Local government** can benefit from looking beyond traditional consultation processes so as to understand the plurality of values that communities hold;
- **Research funders** need to ensure that their research priorities reflect social and cultural as well as economic and environmental priorities. They also need to ensure that commissioned research resonates and connects with the values that underpin decisions in policy and practice;
- **Land managers** can benefit from understanding the shared values that different groups of people hold for particular places. Otherwise these values may only become apparent once decisions have been taken and provoke conflict. Such decisions may be challenged in court or planning permission may be delayed or withheld; and
- **Non-governmental organisations and community and activist groups** often have close connections to local communities, and understanding the shared values can help such organisations manage their assets and communicate their key messages more effectively.



▲ **Figure 1. UK NEAFO handbook for decision-makers[2]**

IMPORTANCE FOR DECISION-MAKERS

There is likely to be particular added value to taking a shared-values approach when:

- Issues or ecosystem services under consideration are complex;
- There is a lot of uncertainty;
- Values are likely to be subtle and implicit;
- Evidence is contested; or
- A large number of different stakeholders are involved.

When considering shared values, a number of underlying principles need to be taken into account. It is important to remember that:

- It is not possible to boil all types of value down to a single value, be that economic or expressed in other ways. Different types and dimensions of value are not directly comparable;
- The values that people express when asked as individuals in conventional consultations or valuation exercises are a subset of their values. They are unlikely to represent all of their deeply held values and beliefs, including those that they hold collectively with other people; and
- Many values are implicit and require a process of deliberation and/or learning to be recognised.

▼ **Table 1: Overview of methods that can be used to assess shared, plural and cultural values**

Technique		Description
Deliberative	In-depth discussion groups	Group discussions (often repeated and usually involving four to eight people), during which participants shape the terms of the discussion, develop themes in ways relevant to their own needs and priorities.
	Citizens' juries	A small cross-section of the general public who come to a considered judgment about a stated policy issue/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 technique designed to observe the evolution of the views of a large citizen test group as they learn about a topic. Typically the group votes on the issues before and after an extended debate.
Analytical–deliberative	Participatory modelling	The involvement of stakeholders in the design and content of analytical models that represent ecosystem services and their benefits under different spatial and temporal conditions.
	Deliberative monetary valuation	Techniques that use formal methods of group deliberation to come to a decision on monetary values for environmental change. May be allied to survey-based techniques (contingent valuation or choice experiments) or use a non-econometric approach to establish values (e.g. by incorporating citizens' juries).
	Deliberative multi-criteria analysis	Techniques that involve groups of stakeholders designing formal criteria against which to judge the non-monetary and (sometimes) 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 considers or creates a physical or digital map to indicate landscape features that are valuable (and/or problematic). Participants may also rate or rank these features for importance. Map layers can also incorporate photo, video, artwork, poetry, etc.
	Storytelling	Participants are asked to tell stories about their experiences of or in relation to places. These may be reflected upon in a group setting to discuss values related to these experiences.
	Interviews	Participants are interviewed about their values, beliefs and preferences. Group interviews allow for deliberation and are similar to in-depth discussion groups. However, in group interviews, the terms are set by the interviewer rather than the group.
Interpretive	Media analysis	The use of a range of textual analysis tools (particularly content, frame and discourse analysis) on (mass) media outputs and social media content over a selected period of time.
	Desk-based cultural history study	A wide range of qualitative techniques including ethnography and participant observation, genealogy, life-history methods, dramaturgical analysis, textual analysis of various sorts including discourse, content and frame analysis.
	Other interpretive methods	A wide range of qualitative techniques including ethnography and participant observation, genealogy, life history methods, dramaturgical analysis textual analysis of various sorts including discourse, content and frame analysis.
Psychometric–deliberative	Values compass	This method asks participants to consider which of their individual transcendental values are most important by ranking or rating them, and then asks them to discuss the degree to which these values are important for the community, culture or society. Values can also be ranked or rated on a group basis.
Psychometric	Subjective wellbeing indicators	These can be used to assess how and the degree to which places contribute to wellbeing, and are thus highly suitable for assessing the value of cultural ecosystem services using a quantitative non-monetary metric.
	Other psychometric	Psychometric testing refers to the measurement of psychological phenomena and processes, such as knowledge, experience, attitudes, values, beliefs, norms. Psychometric models can be used to better understand the impact of deliberative processes on values.

▲ **Figure 2. Standing stones at Down Tor, Dartmoor. It is important to consider cultural values, which give a shared sense of what is meaningful and worthwhile, as well as more easily monetised values in decision making. (© Helen Hotson)**

HOW CAN SHARED VALUES BE ASSESSED?

A variety of methods may be used for different kinds of situation and at different stages of consultation to help stakeholders express their views and underlying values (see **Table 1**). They fall into six main groups:

- **Deliberative** – such as in-depth discussion groups; citizens' juries;
- **Analytical–deliberative** – such as participatory modelling where stakeholders work with academics to develop models that take into account a range of variables involved in a proposal;
- **Interpretive** and potentially deliberative – such as participatory mapping using geographical information systems (GIS) or techniques such as storytelling;
- **Interpretive** – such as analysis of media coverage or the study of cultural history from documents;
- **Psychometric–deliberative** – such as using a 'values compass' to consider the importance of different transcendental values to a community; and
- **Psychometric** – such as using questionnaires to assess the wellbeing benefits of green or blue spaces.

A handbook developed by the NEAFO provides suggestions for decision-makers on when and how shared values can be taken into account in their decision-making by:

- Providing examples of both existing methods that are likely to be familiar to many decision-makers (e.g. from *The Green Book*[3] and *The Magenta Book*[4]) and new approaches;
- Showing ways in which multiple tools and methods can be used together in specific policy venues and contexts; and
- Encouraging decision-makers to integrate shared values into their decision-making processes.

IMPLICATIONS FOR DECISION-MAKERS

- If decision-makers take account of a greater diversity of values, decisions are likely to be more representative of the values of those that they affect, and may also be less contested;
- Focusing just on individual and economic values can limit the validity of valuation and consultation, especially if these views are dominated by the most articulate, affluent or politically powerful voices;
- Different methods are suitable for eliciting different types of value. A comprehensive assessment requires a mixed-method approach. For example, shared values can be assessed by combining desk-based studies of historical data with (social) media analyses and focus groups to assess likely public reaction to a controversial policy decision. They can also be assessed by combining non-monetary valuation techniques (like multi-criteria analysis) with deliberative monetary valuation techniques in project appraisal;
- The process itself can sometimes help to identify new and hitherto unsuspected values and may also lead to new and unexpected solutions to problems;
- The process can also help to identify groups whose values are not being considered, and identify ways of engaging them more effectively by focusing more on the values that motivate those groups.

The NEAFO handbook can help decision-makers to implement this approach. ES

Dr Jasper Kenter is Lecturer in Ecological Economics and Head of the Laurence Mee Centre for Society and the Sea at the Scottish Association for Marine Science. He is an expert in deliberative, participatory and non-monetary methods for valuing ecosystem services. His cross-disciplinary research on environmental values has received awards from the European Society for Ecological Economics and the Society for Conservation Biology. To contact him visit www.jasperkenter.com or email jasper.kenter@sams.ac.uk.

Mark S. Reed is a Professor of Interdisciplinary Environmental Research and Director of the Knowledge ExCHANGE Research Centre at Birmingham City University, and Research Manager for the IUCN's UK Peatland Programme. Prior to this he was Director of the Aberdeen Centre for Environmental Sustainability at the University of Aberdeen and a Senior Lecturer at University of Leeds. He specialises in knowledge exchange, stakeholder participation and the value of nature.

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Scenarios research under the UK NEAFO

Roy Haines-Young, Jamie Tratalos, Marion Potschin and **Mark Everard** outline the way that scenarios help to develop thinking around present and future issues.

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The UK NEA Follow-on (UK NEAFO) programme sought to develop and communicate the evidence base of the 2011 UK NEA[1], to encourage its wider use in decision- and policy-making. An important part of this was to look at how change might impact on the management and governance of ecosystem services. Thus the NEAFO took the set of scenarios developed during the initial UK NEA to see how they could be used to help people to better understand, manage and communicate the consequences of changes in ecosystem services at different scales[2].

THE UK NEA SCENARIOS AND THEIR USE

The scenarios developed under the UK NEA programme brought together a wide range of drivers of potential future changes. In all, six scenarios were developed (see **Figure 1**). Collectively, they describe a range of plausible futures shaped by different drivers of change that reflect the concerns that stakeholders in the first phase of the NEA wanted to explore about the future, such as the impact of economic growth, resource scarcities on the management of ecosystem services and the effects of different policy objectives relating to the strength of environmental protection. The UK NEAFO research sought to use the scenarios to stimulate deliberative *processes* amongst decision-makers and to design different analytical *products*, such as maps of quantitative models, to challenge conventional thinking.

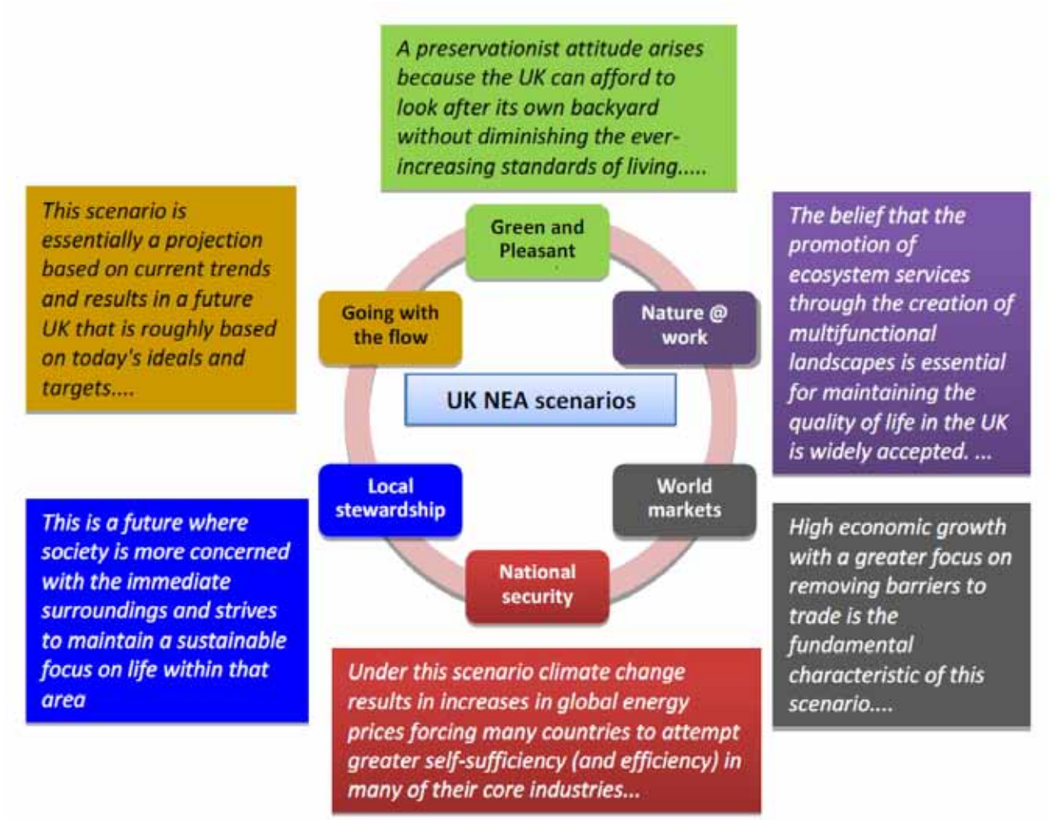
THE NEA SCENARIOS IN ACTION

The UK NEAFO work on scenarios included a series of meetings with stakeholders to examine whether the scenarios could be used to stimulate social learning and deliberative styles of decision-making. Thus people were asked whether they found the scenarios plausible, challenging and relevant, and what new thinking they were able to foster. The evidence collected from these meetings suggested that the majority of people found the scenarios to be effective deliberative tools that were useful for exploring a range of issues. In particular, the scenario storylines enabled workshop participants to develop rich narratives about the ways in which people might live in the different worlds, to consider likely timelines, to think more deeply about regional and local differences, and to explore how the scenarios could frustrate or facilitate the embedding of the Ecosystem Approach in decision-making.

The conclusion that was drawn from the work with stakeholders was that UK NEA scenarios were a useful entry point for discussions about the future of ecosystem services in the UK: they provided a background against which discussion and exploration could occur. Moreover, the workshop discussions exposed previous unanticipated insights about, for example, how the National Security scenario, with its emphasis on resource efficiency, was actually 'greener' than it initially appeared. Discussions also showed that the Local Stewardship scenario required some degree of central control and regulation if local decision-making was to work efficiently in achieving landscape-scale outcomes. The UK NEA scenarios thus proved their worth, not merely as pedagogic but as creative vehicles for considering the likely consequences of governance paradigms and ensuing decisions, actions or inaction.

During the UK NEA Follow-on phase, it was found that the scenarios were being used actively in live policy debates. Organisations such as the Scottish Government, the Forestry Commission and Defra's Noise Futures group had started to use them in their discussions about planning for future change. Such developments were considered especially important because the UK NEAFO work programme for scenarios was designed to also link directly to the more general work in NEAFO on policy response options. In that context, the scenarios were to be used as a framework against which to 'stress test' policy response options.

The research undertaken with the Response Options team in the NEAFO revealed that the scenarios provided a suitable platform for gaining deeper insights about what kinds of decision were more likely to be resilient across a range of possible futures. However, it was also



▲ **Figure 1. The six UK NEA scenarios with brief descriptions, reproduced from the UK NEAFO[1,2]**

found that the routine application of the stress-testing approach by policy customers in their everyday work was demanding, although they clearly did have value at a broad, strategic level. It was concluded that there was an opportunity for the scenarios to be used more extensively through commissioned work. The meetings with policy advisors in Northern Ireland's Department of Environment and more general audiences showed that, with careful tailoring, the six scenarios were also relevant and useful at a local level.

DEVELOPMENT OF SCENARIOS AS PRODUCTS

The UK NEA scenarios were initially used to make both qualitative and quantitative projections. The quantitative work mainly involved modelling how land cover would change under the different scenarios[1]. These data in turn were used to analyse changes in marginal economic values for some ecosystem services during the initial phase of the UK NEA. The Follow-on provided the opportunity to progress this work and to address some of its limitations.

The scenarios were therefore extended and enriched by using them as a framework to run a range of models that could be used to identify how ecosystem services might change under the different assumptions about the future. The aim was that, by developing new analytical products, novel insights about the future worlds described in the scenarios could be generated. This research covered four topic areas:

1. Flood and drought risk, based on an analysis of changes in river flows)
2. Biodiversity, focusing on farmland birds;
3. Marine ecosystem services; and
4. Cultural ecosystem services.

FLOOD AND DROUGHT RISK

This work looked at the effects of land-use change under each of the UK NEA scenarios on river flows, by modelling hydrological discharge within 34 catchments across the UK using SHETRAN[3]. Four hydrological indicators were calculated for each catchment:

1. Average annual discharge;
2. Flood hazard;
3. Measures of the magnitude of unusually high flows; and
4. Measures of the magnitude of unusually low flows.

The outcome indicator for flood hazard was the interval between floods of a size currently occurring every 30 years. The models were run under both high and low climate change land cover variants. In general, the 'green' scenarios, Nature@Work and Green and Pleasant Land, as well as National Security, were associated with lower flows than currently occur (when measured using any of the four indicators), although there was a great deal of variability between catchments for any given scenario. Taken together, the modelling outcomes suggested that, in managing change, a balance needs to be struck between alleviating the likelihoods of increased drought and increased flooding, depending on the likely effects of these phenomena in the catchment. In other words, an understanding of local contexts matters.

BIODIVERSITY – FARMLAND BIRDS

The research explored the relationship between land use data produced during the first phase of the UK NEA and models of farmland bird populations, using 1 km x 1 km squares covered by the Breeding Bird Survey[4] (BBS) and the Winter Farmland Bird Survey[5] (WFBS). Functional space models were applied to estimate annual population growth rate under each scenario of each of the 19 farmland bird species used to calculate the farmland bird index[6].

Overall, land use change across the scenarios had relatively little impact. The only statistically significant change was for declining species under the Green and Pleasant Land scenario where, perhaps paradoxically, though seemingly related to the use of land for other nationally important purposes, bird population growth rates declined significantly. Using a mechanistic model[7], a likely significant decline in the ecological value of lowland agricultural areas for seed-eating farmland birds was found across all the NEA scenarios, but the greatest impact was for scenarios with the highest monetised values for ecosystem services as measured by the first phase of the UK NEA (Nature@Work, Green and Pleasant Land). This appears to be due to the fact that, compared with the baseline, the area of arable crops declines most sharply under these scenarios. This was due partly to changes in land use but also because of conversion of arable land to other habitats important for a broader set of ecosystem services, such as woodland.

Taken together, these results imply a trade-off between overall value for ecosystem services and conservation of farmland birds, and highlight the need to consider the specific impacts of land use change on biodiversity alongside other ecosystem services.

MARINE ECOSYSTEM SERVICES

Preliminary modelling undertaken during the first phase of the UK NEA was extended in the Follow-on to produce spatially explicit models of change for three important marine ecosystem services: fisheries landings, aquaculture production and carbon sequestration. The aim was to compare outcomes for 2015, 2030 and 2060 under four of the UK NEA scenarios across UK territorial waters with the current baseline. It was found that there was a high degree of uncertainty associated with the models, mainly due to a lack of suitable data and poor knowledge of the drivers of change.

Thus, in many cases, in the absence of robust quantitative models, qualitative descriptions of the UK NEA scenarios were combined with expert knowledge to estimate changes in the three types of ecosystem service. Fish landings were considered likely to be only marginally lower or higher by 2060 than they are today under three of the four scenarios: Nature@Work, Local Stewardship

▲ **Figure 2. Flooding on farmland in Essex, January 2013. (© Peter Smith)**

and National Security. By contrast, under the World Markets scenario, projected landings were assessed as likely to decline significantly by 2060, due to a lack of regulation combined with high levels of investment from private capital. In the light of this, it was interesting that aquaculture was projected to be at higher levels under World Markets than under any of the other scenarios, although all of the scenarios suggested higher levels than at present. Carbon sequestration was considered most likely to be impacted by the World Markets and Natural Security scenarios due to higher CO_2 emissions causing an increase in ocean acidification. Though tentative, the conclusions of these analyses mark a significant first step in attempts to map and project the impact of possible future change on marine ecosystem services.

CULTURAL ECOSYSTEM SERVICES

Research on how cultural ecosystem services might respond to different scenarios built on the earlier phase of the NEA that made use of the Monitor of Engagement for the Natural Environment (MENE) dataset[8]. The aim was to explore the relationship between the supply of cultural spaces in the landscape and people's preferences for different types of natural spaces and practices in them. A Bayesian belief network (BBN) was developed to allow users to explore these relationships interactively and to look at the potential impacts of changes in socio-demographic structure of the kind described by the UK NEA scenarios.

This research suggested that people tend to select locations with higher woodland cover than the average for the surroundings, when they travel intermediate distances from their home, but that this tendency declines when they travel longer distances. Woodland cover is projected to double under both Nature@Work and Green and Pleasant Land scenarios, and both provide more opportunities to visit woodland close to home than under scenarios such as World Markets. The analysis shows that, on the basis of the current geography of people and woodlands, the way planting is targeted under Green and Pleasant Land has the potential to deliver greater joint benefits from biodiversity change and cultural ecosystem services than Nature@Work.

"The scenarios clearly had the potential to contribute to decision-making processes by enabling both experts and non-experts to discuss issues and learn from each other."

▲ **Figure 3. Salmon farm in the Highlands of Scotland. Levels of aquaculture are projected to rise under all six of the NEAFO scenarios. (© PHB.cz)**

THE LESSONS FROM NEAFO ON SCENARIOS

The work in NEAFO showed that the distinction between the use of scenarios to stimulate deliberative *processes* and to encourage the development of novel analytical *products* was a useful one. The scenarios clearly had the potential to contribute to decision-making processes by enabling both experts and non-experts to discuss issues and learn from each other. Moreover, the use of the scenario assumptions as a framework within which new analytical products could be developed, using quantitative and qualitative modelling, enabled the scenario narratives to be enriched and new insights to be derived from them.

A key conclusion therefore to emerge from this strand of UK NEAFO research was that both process and product dimensions should actively be explored in the design of any ecosystem assessment, if scenarios are to be used to help people understand, manage and communicate the consequences of changes in ecosystem services at different scales. Although scenarios are ostensibly about the future, they have the potential to improve our understanding of today's issues and hence our responses, given the uncertainties that lie before us. ES

Roy-Haines-Young is Professor in Environmental Management and Director of the Centre for Environmental Management (CEM) in the School of Geography, University of Nottingham. Although trained as a natural scientist, he has sought to develop a stronger social content in his recent work. He has worked extensively with policy makers in central government and its agencies, and recognises the need to develop a science that is responsive to the wider public debates about environmental issues (Roy.Haines-Young@nottingham.ac.uk)

Jamie Tratalos worked on Scenarios and Cultural Ecosystem Services within the UK National Ecosystem Assessment Follow-on, after GIS and ecology posts in local government, UK universities, the UN, the British Antarctic Survey, and a health care informatics consultancy. He now works at University College Dublin's Centre for Veterinary Epidemiology and Risk Analysis.

Marion Potschin is Deputy Director of the Centre for Environmental Management and Senior Research Fellow in Sustainability and Landscape Development at the University of Nottingham. Originally trained as a natural scientist, for the last 20 years she has been committed to inter- and transdisciplinary approaches to research and teaching on landscape issues, and more recently on ecosystem services.

Mark Everard is Associate Professor of Ecosystem Services at the University of the West of England (UWE, Bristol) and a Vice-President of the IES. He has championed the evolution and international practice of ecosystem services since the 1980s. Mark is author of numerous papers and books, many on ecosystems and their services, including *Common Ground: Sharing Land and Landscapes for Sustainability* (Zed Books, 2011), *The Hydropolitics of Dams: Engineering or Ecosystems?* (Zed Books, 2013) and Breathing Space: *The Natural and Unatural History of Air* (Zed Books, forthcoming).

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Response options: incorporating the Ecosystem Approach into robust and adaptable decision-making

Mark Everard and **Iain Brown** emphasise the importance of systems thinking.

How can society better respond to the challenges posed by what we know about the status and trends in the natural environment? First we need improved recognition in decision-making at all levels of the vital importance of the environment in sustaining human wellbeing. Of course, the challenge also extends to what we do not know, particularly planning for an uncertain and changeable future.

We need to think more about internalising ecosystem services considerations, and also future-proofing these response options so that they do not exacerbate existing problems or reduce flexibility to adapt and build synergies. Responses therefore need to be applied across the full spectrum of societal policy areas and activities, many of which have traditionally overlooked both their dependence and their impacts on ecosystems.

Potentially, a decision-maker has many levers that can be used to influence human–environment interactions. The response options include:

- Top–down statutory regulation and levies;
- Bottom–up initiatives such as quality assurance networks or community-based partnerships;
- Formal incentives; and
- Voluntary market-based schemes such as payments for ecosystem services (PES) or offsetting.

Each type may be best suited to different issues and contexts. In terms of ecosystem-based management, some responses are more directly aimed at maintaining 'natural' ecosystem function (even though most ecosystems are no longer natural) whilst others, particularly newer schemes, are more service-related, connecting to economic and wider wellbeing benefits for humans.

SYSTEMS THINKING

The interconnectedness of socio-ecological systems means that conflicts and inefficiencies are likely to result if decision-makers address only narrow outcomes, overlooking the potential for unintended adverse consequences (externalities) elsewhere. A particular exemplar of this effect occurs where concentration on provisioning ecosystem services, such as food and fibre production, leads to a decline in many other ecosystem services (carbon storage, habitat for wildlife, natural beauty, soil formation and fertility, etc.) The consequences are that system resilience and net societal value are progressively undermined. Such problems are only likely to worsen if each organisation or sector develops responses in isolation.

As all externalities are interconnected, it is essential for response options to be selected or adapted on a more systemic basis to inform appraisals about collateral impacts, and consequently guide more sustainable, equitable and economically efficient decisions. However, cause-and-effect relationships in ecosystems are inevitably complex and confounded by time lags. Consequently, some response options are inherently risky (e.g. some market-based schemes) where they implicitly assume they can provide no net loss of functions and services. Who should bear this risk? How will this risk change in the future? Can we combine response options to reduce the risk?

A TYPOLOGY OF RESPONSE OPTIONS

The role of science in deciphering and communicating complex environmental change to decision-makers has often been constrained because of a mismatch between broad holistic questions, typically posed in policy formation, and narrow reductionist questions that are susceptible to scientific method[1]. To address this mismatch, the UK NEAFO research on typing and adapting response options[2] used scientific methods, working in a stakeholder context, to review the role of different types of response options in the context of knowledge requirements and knowledge exchange, and to determine which options work best in synergy to address particular problems. At the heart of this are requirements to be both robust and adaptable, both for foreseen and unforeseen changes.

The UK NEAFO research grouped response options by attribute, including:

- Spatial context;
- Extent of legal underpinnings;
- Enforcement mechanisms;
- Whether the relationship between the decision-maker and those they seek to influence is closed and direct or, involving intermediaries, is open and indirect; and
- Whether monetisation is carried out (see **Table 1**).

This allows us to consider how response options can be adapted and combined to address changing contexts for the management of risk and uncertainty[3].

RESPONSE OPTIONS AS SYSTEMIC INTERVENTIONS

This typology of response options is helpful in determining their strengths and weaknesses relative to different contexts and sustainability challenges. In practice, some situations clearly require a combination of response options, both formal and informal, to achieve the necessary influence. For example, the guidance of land use today depends on a mix of formal systems (e.g. regulation and levies), informal influence (e.g. farm advice and published good management practices) and markets (including mainstream commodity markets as well as subsidies and market-based instruments).

Combined measures are often also required to achieve coherence between spatial scales, for example in resolving catchment-based planning to meet statutory requirements (such as EU Water Framework Directive objectives) that set a broader spatial context for localised community decision-making in smaller sub-catchment units and also for the more effective local targeting of subsidies.

Responses may also evolve over time and morph into each other, for example scientific research improves knowledge of causes and effects, triggering common-law cases, which may eventually precipitate the introduction of new statutory subsidy schemes and/or legislation.

It is particularly important to recognise that different types of response options may be more or less suited to safeguarding different ecosystem services and to different situations. Consequently, over-reliance on one response type, a common occurrence where institutions have traditionally relied on a limited tool set, can inadvertently drive explicit or more frequently implicit trade-offs between ecosystem services, potentially

ANALYSIS

▼ **Table 1. Generic typology of response options for managing environmental change**

Response option type	Characteristics	Attributes	Examples
Protected areas	Defined zones that have restrictions on their use or conservation-based obligations	• Variable spatial scale • Statutory underpinning • Enforced by penalties • Top–down • Closed relationships • No monetary values	Natura 2000 sites, marine conservation zones
Statutory regulation	Legally enforced universal minimum quality standards	• Universal spatial scale Statutory underpinning • Enforced by penalties • Top–down • Closed relationships • No monetary values	Drinking water, bathing water, air quality, food safety, fishing quotas
Levies	Taxes to support environmental standards or improvements	• Variable spatial scale • Statutory underpinning • Enforced by penalties • Top–down • Closed relationships • Monetary values assigned	Aggregate Levy Fund, Landfill Tax, Climate Change Levy
Direct payments and incentives	Payments to support a particular use or management practice based upon service provided	• Variable spatial scale • No legal underpinning • Enforced by penalties • Top–down • Closed relationships • Monetary values assigned	Agri-environment schemes (EU), payments for ecosystem services (PES)
Market-based schemes	Trading of goods and services on an open market	• Variable spatial scale • No legal underpinning • Enforced by persuasion • Top–down and bottom–up • Open relationships • Monetary values assigned	Carbon trading, biodiversity offsetting
Spatial/integrated planning	Combined cross-sectoral planning instruments to maximise resource efficiencies and opportunities	• Variable spatial scale • No legal underpinning • Enforced by persuasion • Top–down and bottom–up • Open relationships • No monetary values	Green infrastructure, integrated catchment planning, integrated coastal zone management
Good management practice	Guidelines for adoption by managers to establish best practices	• Variable spatial scale • No legal underpinning • Enforced by persuasion • Bottom–up • Closed relationships • No monetary values	Integrated farm management, natural flood management
Voluntary standards and quality assurance	Independent schemes that provide accreditation for maintaining minimum standards via a quality marque	• Variable spatial scale • No legal underpinning • Enforced by persuasion • Top–down and bottom–up • Closed relationships • No monetary values	Forest Stewardship Council, Marine Stewardship Council
Networks and partnerships	Formal and informal arrangements of multiple stakeholders based upon a common shared interest.	• Variable spatial scale • No legal underpinning • Enforced by persuasion • Top–down and bottom–up • Open relationships • No monetary values	Campaigns, professional development, demonstration projects, citizen science, eco-schools
Education and knowledge exchange	Formal and informal schemes to communicate and share knowledge.	• Variable spatial scale • No legal underpinning • Enforced by persuasion • Top–down and bottom–up • Closed relationships • No monetary values	Campaigns, professional development, demonstration projects, citizen science, eco-schools
Technology	Investment in new technology and associated infrastructure to improve management.	• Variable spatial scale • No legal underpinning • Enforced by persuasion • Bottom–up • Open and closed relationships • No monetary values	Precision farming, renewable energy, water treatment, recycling and waste reduction
Scientific research and development	Investment in key science topics	• Variable spatial scale • No legal underpinning • Enforced by penalties • Top–down and bottom–up • Open and closed relationships • No monetary values	Ecosystem function and ecosystem services
Common law, civil law or constitutional law	Legal rights and responsibilities based upon precedent (common law); general rules (civil law); constitution	• Universal spatial scale • Statutory underpinning • Enforced by penalties • Top–down • Open relationship • No monetary values	Conservation covenants

undermining net societal value. This may be exemplified by response options based on notional safe limits (e.g. regulation) or monetary values, which may be less suitable for maintaining relatively intangible cultural ecosystem services.

Combining response options may therefore be propitiously developed through bundling for optimal delivery of multiple ecosystem services. This is most strongly developed at present in PES schemes, which may involve bundling multiple services to the same buyer or consortium, or layering services in parallel to multiple buyers. More commonly, a dominant PES market may be defined for an individual ecosystem service (now commonly referred to as an 'anchor service'[4]), on which 'piggy-backed' co-benefits that are not paid for can be optimised (e.g. payments for catchment-scale protection of surface water quality may be enacted through management measures that also provide unpaid benefits for biodiversity, fisheries, ecotourism and landscape amenity).

Reference to the response option typology can help us determine how a similar type of bundling of different responses can help achieve optimisation of ecosystem service outcomes in any given management context, and which may achieve optimal resilience.

STRESS-TESTING RESPONSE OPTIONS

The UK NEAFO research on response options also included a 'stress-testing' method. It assessed the robustness of different response options, taking the form of stakeholder workshops exploring a range of socio-economic scenarios and also exploring performance under different trajectories of climate change.

The robustness of response options under current climate trends and a business-as-usual socio-economic scenario was used as a dynamic reference baseline against which to assess performance under alternative scenarios. Robustness of response options was characterised by their flexibility and adaptability to adjust to changing conditions, and their utility in heterogeneous local environmental contexts. Adaptability becomes increasingly valuable as the magnitude and rate of future change diverges to a greater degree from business as usual.

▲ **Figure 1. Upland agriculture in the UK is generally subsidised through some form of agri-environment scheme (AES). Direct payments and incentives are one type of response option for managing environmental change. (© pavel vashenkov)**

The scenario analysis revealed that clear advantages are likely to stem from reliance not on single response options, but on bundles – integrated, cohesive combinations of response options, both within and across societal sectors, to maximise their individual strengths and to compensate for their individual weaknesses. This requires cross-scale integration of both top–down and bottom–up responses, including for example incentivisation schemes twinned with regulation, which may be guided by common adoption of an Ecosystem Approach to facilitate more systemic interventions.

RESPONSE OPTIONS FOR THE FUTURE

We know that a business-as-usual scenario is very unlikely to prevail in the future, although it provides a reference to establish what additional actions are required as better insurance under different future trajectories. Stress-testing research highlighted that response options in common current usage are likely to encounter major challenges in maintaining the sustainable provision of ecosystem services in an uncertain future. A key determinant of the outcome of their usage will be the rate and magnitude of change: a faster rate of change will be particularly difficult for those response options that are slow to adjust to changing circumstances, or that are based on uniform standards of perceived norms or trigger levels, or that are founded on preconceived notions of ecosystem service optimisation.

In terms of natural capital, the stress-testing approach can help to determine when we may need to assign 'red flag' situations, constituting crucial buffers as we approach indicators that ecosystems are reaching a critical stage of undesirable change. To respond constructively and sustainably to pressures driving these changes, further innovation and collective learning is urgently required in scheme design, improvement in the systemic framing and synergistic combination of response options, and the incorporation of adaptive management focused on output-based measures for delivery of a wider spectrum of ecosystem services than has formerly been considered.

This broadening cognisance of consequences – across connected supporting ecosystems, ecosystem services and their diverse beneficiaries, and across scales of space and time – is integral to the Ecosystem Approach, the twelve complementary principles of which may continue to facilitate the design of complementary responses and also help to overcome problems associated with current narrowly defined response options and their selective, uncritical and often habitual use by institutions. Multiple benefits are more likely if decision criteria and their evaluation take better account of changing external drivers that may modify both human behaviours and environmental processes[5]. ES

▲ **Figure 2. The stress-testing approach can help to predict when 'red flag' packages of buffer measures may need to be put in place to prevent systems reaching critical thresholds of undesirable change. (© sarahdesign85)**

Dr Mark Everard is Associate Professor of Ecosystem Services at the University of the West of England (UWE, Bristol) and a Vice-President of the IES. He has championed the evolution and international practice of ecosystem services since the 1980s. Mark is author of numerous papers and books, many on ecosystems and their services, including *Common Ground: Sharing Land and Landscapes for Sustainability* (Zed Books, 2011), *The Hydropolitics of Dams: Engineering or Ecosystems?* (Zed Books, 2013) and *Breathing Space: The Natural and Unnatural History of Air* (Zed Books, forthcoming). (mark.everard@uwe.ac.uk)

Dr Iain Brown is a senior research scientist working at the James Hutton Institute site in Aberdeen. He leads projects and provides policy advice on climate change, land use and environmental change, with particular emphasis on application of the Ecosystem Approach.

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Mainstreaming ecosystem science into policy and decision-making

Alister Scott explains the role and potential of the NEA and the NEAFO in advancing the value of nature and the environment in the context of planning policy and decision-making.

Ecosystem science has long influenced research and practice for the management of the natural environment[1,2,3]. However, it is only recently that it has gained prominence as a policy-shaping framework through the UKNEA[4,5] and the Natural Environment White Paper[6]. The UKNEA, for the first time, provided a comprehensive assessment of the state and value of the UK's natural environment, concluding that the services provided by nature were in significant decline, in part because nature is consistently undervalued in decision-making in general and in land use planning matters in particular.

This paper highlights how the science behind the UKNEA has been translated and adapted into guidance and tools within the National Ecosystem Assessment Follow-on programme (NEAFO) with a particular focus on the hitherto neglected built environment professions to assess the opportunities and challenges to mainstreaming the value of nature into policy and decision-making.

FROM DISINTEGRATED TO INTEGRATED THINKING

At present the built and natural environment professions and disciplines exist largely in their own worlds, each with their own theories, governance, institutions, policy and guidance. This is important, as virtually all ecosystem thinking has been funded, developed and implemented in relative isolation within the natural environment domain under the support of Defra[7]. Thus, within the built environment domain, the vocabulary and philosophy of ecosystem science is alien, and is consequently perceived as largely irrelevant to their prime concerns.

Instead, other paradigms such as spatial planning and building information modelling provide the 'lenses' for structuring their work. As a consequence, accounting for the value of nature in policy and decisions has remained quite weak when compared to the contemporary primacy for economic growth[8]. Whilst regulatory impact assessments help ensure environmental considerations are taken into account in policies, plans, projects and programmes, there is a prevailing narrative that the environment is nothing more than a constraint to be overcome, a perceived cost to development[9].

However, looking at the environment through the broader lens of ecosystem science, more holistic and systemic approaches to policy interventions begin to emerge, informed by the complex interactions and interdependencies that exist in nature. These approaches allow, in theory, the full consequences, costs and benefits of interventions to be assessed explicitly. Thus, the natural environment is revealed as a provider of goods and services with multiple environmental and associated human wellbeing benefits[10]. Omitting consideration of the diversity of these benefits risks overlooking and potentially jeopardising the interests of beneficiaries, including economic growth and intergenerational equity.

This broader world view, taking account of the systemic benefits provided by natural processes, challenges traditional notions of the environment as a constraint to development[11]. This becomes particularly relevant at a time when many decisions and policies are predicated on the primacy of economic growth and where, within that decision mode, the environment can easily become an overlooked externality.

TOOLS DEVELOPMENT UNDER THE UK NEAFO

Our brief within the UK NEAFO was, within the above context, to translate and adapt the science and evidence base of the UK NEA into a tools framework that could be usable by all policy- and decision-makers, and crucially not just those in the natural environment.

Whilst the twin concepts of natural capital and ecosystem services in theory provide mechanisms and possible delivery vehicles to help cross the artificial division between natural and built environments, they lack currency and traction in built environment professions. This makes them especially vulnerable to 'cherry-picking' to support particular policy position (policy-based evidence) where decision-makers value only what is measured or measurable rather than valuing what we, as a society, actually value now and into the future. Realising the latter at the expense of the former, through understanding the multiple benefits and assets provided by nature, is key to tackling the quality-of-life agendas that matter to most people.

Fortunately, there is guidance from the 12 Malawi principles of the Ecosystem Approach[12] which, when used collectively, help overcome potential abuses in policy- and decision-making. Thus these principles provided the building blocks for our UK NEAFO tools development work, set within a revised goal to mainstream the Ecosystem Approach into policy- and decision-making processes. This required an appreciation of how good policy and decisions are made, and what actually constitutes good practice in policy-making.

Policy-making models have generally been characterised by a top–down philosophy based on the goals of economic rationality or the pursuit of a common societal good within a traditional policy cycle of discrete stages[9,13]. Our co-produced 'NEAT tree' concept (see **Figure 1**) captures these ideals within such a policy-/decision-making cycle wherein each stage is populated with a contemporary refreshing of the Ecosystem Approach guidance, supported by lessons learnt from practical experiences (case studies) on the ground[14]. Crucial to this co-production philosophy was the creation of a transdisciplinary project team, crossing traditional research boundaries to include the insights and experience of academic, policy and practice representatives[15].

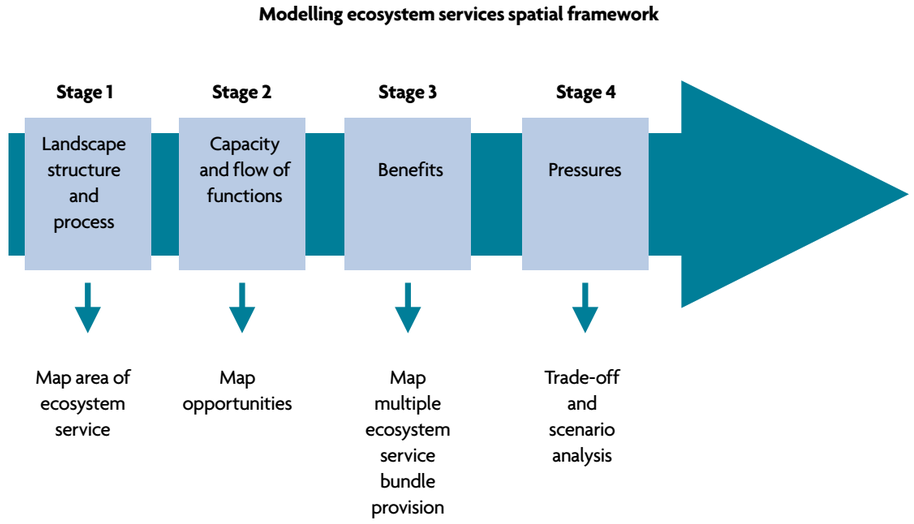
Nevertheless, there is a metaphorical elephant of the language of ecosystem science in the policy room when trying to engage with the built environment professions, which hinders interdisiciplinarity. Ecosystems convey an environmental relevance that alienates rather than unites. We therefore moved away from using such concepts to focus our front-end engagement using the policy cycle (NEAT tree) in conjunction with the current 'hooks' within the built environment that inform daily practice. It is from these hooks that we then build ecosystem thinking into the equation, highlighting the additionality that such thinking can bring to policy- and decision-making processes and outcomes.

WHAT ARE THE BUILT ENVIRONMENT HOOKS?

For those working in the built environment, the biggest current hooks are the National Planning Policy Framework (NPPF)[17] and its associated National Planning Policy Guidance (NPPG)[18]. These set out the way that policy (in the form of statutory local plans) and decisions (via planning applications) need to be made and has statutory clout. Thus working within this framework explicitly brings credibility within which we uncover further hooks to engage with and ultimately demonstrate how ecosystem science can make a valid and improved contribution (see **Table 1**).

Paragraph 109 of the NPPF[19] is highly significant in that it contains a commitment to recognising the value of

▲ **Figure 1. An adapted policy cycle for the NEAT tree[16].**



▲ **Figure 2. Translating paragraph 109 of the NPPF into a valid planning framework. (Adapted from Countryside Council for Wales and Environment Systems 2012[25])**

ecosystem services, a first for English planning policy. There is a key role here for improving the evidence base for local plans in terms of mapping and modelling both the amount and quality ecosystem services in a given area (see **Figure 2**). These maps serve as useful resources for exploring the spatial distribution of the services, identifying new opportunities for enhancing ecosystem services (e.g. Bridgend Council), managing trade-offs between different ecosystem services and targeting policy interventions (e.g. Birmingham City Council). Work by Natural England in their National Character Assessment[20] and Natural Resources Wales highlight the importance of developing the evidence base to then inform possible policy options, tools and opportunities. Here green infrastructure thinking has informed planning responses[21] and market-based instruments such as biodiversity offsetting[22] and payments for ecosystem services (PES) as potential delivery tools.

Set within the landscape-scale thinking that paragraph 109 of the NPPF recommends, wherein the "bigger, better and more joined up" goal proposed by Lawton[23] for biodiversity conservation prevails, there is considerable progress being made. However, there is emerging evidence that some vested interests are 'cherry-picking' particular ecosystem services and principles to justify a particular development, whilst overlooking genuinely systemic implications. For example, in the case of the HS2 rail project, Owen Paterson (Secretary of State for Environment, Food and Rural Affairs from 2012 to 2014) advanced the argument that natural assets are ultimately replaceable with others, a view that wholly fails to appreciate the non-substitutable nature of some ecosystem services, the irreplaceability of some of the ecosystems that provide them, and that there are environmental limits that, if breached, might lead to a tipping point[24].

▼ **Table 1. Hooks within the National Planning Policy Framework and the associated principles of the Ecosystem Approach**

Status	Hooks	Ecosystem Approach principles
Actual	NPPF Paragraph 109 – value ecosystem services	1, 4, 5, 6, 10
Potential	Duty to cooperate	2, 3, 7, 11, 12
Potential	Viability	4, 6
Potential	Localism	2, 7, 8, 12
Potential	Tools (regulatory and nudge)	1, 4, 6, 7, 8, 9, 10

The duty to cooperate[26] (DTC) is a legal requirement for satisfying the requirements for the statutory local plan process in England. The soundness of any local plan depends on the extent to which a planning authority has "engaged constructively, actively and on an ongoing basis to maximise the effectiveness of Local Plan preparation in the context of strategic cross boundary matters". However, despite the potential to engage on strategic matters[27], the DTC has been largely confined to housing market assessments concomitant with the requirement for objectively assessed housing need.

Using the principles of the Ecosystem Approach, in particular, having regard for adjacent effects, there is a clear opportunity to forge new partnerships, strategies and potential market instruments to deal with challenges of flooding, water quality and climate change mitigation and adaptation involving landscape-scale approaches (at a catchment level with investment in upstream thinking[28]). At present these opportunities are not fully exploited to help deliver more joined-up planning, which highlights an urgent role for engagement with the Planning Inspectorate (PINS). (PINS appoint inspectors to decide on the soundness of local plans. The evidence shows that matters outside housing have not led to any failure or postponement of a local plan.).

Viability[29] is a relatively new term encountered within the NPPF, one that is currently being used solely to ensure that projects are deliverable in terms of enabling developers to make economic profits. This overrides more social and environmental factors (e.g. affordable housing quotas and brownfield-first development) and is enshrined in legislation. Not surprisingly these viability cases are shrouded in commercial sensitivity and lack of transparency.

However, given the core principles of equity, social and environmental justice, limits and thresholds within the Ecosystem Approach, we argue that policy and decisions need equally to consider social and environmental viability, as costs can come later through a sole reliance on profits – for example. housing numbers versus greenspace requirements to help contain flooding and also enable recreational space. Indeed, such principles go back to the roots of the planning system.

Localism[30] also provides a powerful hook, given its legislative importance in current policy discourses. Supported in both the NPPF and the Localism Act 2011, there are specific opportunities within neighbourhood plans which, once secured by a public vote, become a statutory considerations, in all development decisions and also through right-to-buy community ownership regimes. These provide important opportunities for

communities to identify and map the resources, services and assets they value. Here, the framing of ecosystem services into this equation offers opportunities to tie into existing policies, programmes, strategies and funding bids, notwithstanding the huge social capital required to carry through such endeavours[31].

Tools for mainstreaming[32] can be split into those that perform decision-support functions and those that promote incentive (nudge) outcomes resulting in behaviour changes. In terms of decision-support tools, environmental impact assessments (EIA)[33] and strategic environmental assessments (SEA)[34] are arguably the most powerful vehicles. SEA supports the statutory local plan[35] to ensure that EU environmental considerations are upheld. If ecosystem services ideas can be secured through the scoping and evidence bases of these tools, the value of nature is built into the process from the outset, transforming the idea of the environment as a constraint to growth to one that posits it progressively as a positive asset[10]. Within development management decisions, EIA can perform a similar function, dependent on the scale and significance of effects. Other tools such as community infrastructure levy[36] (CIL) and sustainable drainage systems (SuDS[37]) have much to offer in terms of promoting sustainability and enhancing ecosystem services, albeit currently lacking the legislative drivers for implementation.

THE ROLE OF DEFRA AND DCLG

This is where the disintegrated thinking is at its most evident: Defra and the Department for Communities and Local Government (DCLG) need themselves to recognise the benefits that ecosystem thinking can deliver in terms of ecological, social and economic connectivity. Here SuDS, green infrastructure, wildlife corridors, urban river restoration, and urban heat islands provide critical infrastructure for growth in terms of flood, water, health and climate change adaptation amongst a wider range of simultaneous ecosystem service co-benefits such as amenity and support for biodiversity. The CIL also promotes significant opportunities that could promote positive sustainable progress, addressing vital green and blue infrastructure that contributes to the 'liveability' and sustainability of urban developments. This is of particular importance in areas encompassing valuable and irreplaceable environmental resources, such as peatlands, moorlands and adjacent wetlands. However, development of these techniques necessarily needs to progress hand-in-hand with improved public understanding of the value of these assets. Ecosystem services concepts provide a valuable means to communicate with a range of public audiences about the range of benefits provided by natural systems and progresses, albeit that they need to be presented in simpler language.

Incentives or nudges are less commonly used in planning practice, but tools to promote this thinking do exist. One example is the expansion of payments for ecosystem services[38] markets, wherein a 'provider' or manager of an ecosystem service (such as the owner of a landscape unit) can secure or increase a desired ecosystem service (for example through improved ecosystem-centred land management practices) for potential 'consumers' (beneficiaries of that service) who are willing to pay for it on a voluntary but conditional basis. A global exemplar of a PES scheme in operation is provided by South West Water's 'Upstream Thinking'[39] programme, wherein a proportion of water service bill-payer income is circulated via the Westcountry Rivers Trust (a non-governmental organisation serving as a trusted intermediary) to farm businesses who electively undertake farm improvements above and beyond statutory obligations in exchange for a payment that then secures cleaner water for abstraction and cheaper treatment by the water company. Other examples that offer considerable potential subject to correct application of the Ecosystem approach guidance, are biodiversity offsetting and tax incremental financings[40].

▲ **Figure 3. Solely considering profit during land-use planning can have hidden costs later; it is important to incorporate green space for flood prevention and recreation. (© Ufuk Uyanik)**

GOOD PRACTICE

Table 1 shows how, by focusing on key policy hooks in the built environment, we can embed successfully all the principles of the Ecosystem Approach and, in the examples of duty to cooperate, viability and tools, highlight the additional value and insight that ecosystem thinking can bring to the current way of doing things. However, the transition towards ecosystem thinking and practice in the built environment sector will not happen overnight and we must be both realistic and pragmatic about what can be achieved. Our research here for the UK NEAFO[41] has followed and learnt from a variety of case studies[42]; each making their own way in this new learning environment.

By far the most common example of implementation is where ecosystem services have been 'bolted on' to an existing action plan. Though somewhat crude, this does constitute a vital first step towards the longer-term goal of more systemic practice. In other areas such as the South Downs National Park[43] and Birmingham City Council[44] ecosystem thinking is being more mainstreamed into evidence bases to support particular policy processes and outcomes. The key is creating the necessary learning and knowledge exchange space to share such good practice safely and to identify any barriers that are hindering progress. Crucially, through our project we have identified ecosystem champions as part of our research team who work in the built environment and thus who can serve as respected and influential ambassadors for sharing the good news. This is a key legacy of the project.

In many ways, the biggest barrier still to overcome is that of language. Ecosystem terminology is off-putting to many professionals currently working in the built environment sector and for those champions trying to secure the necessary traction and buy in. Hopefully, by using the policy cycle and the associated hooks within existing sector-focused policy priorities provides a positive step forward, enabling productive exchanges with people about applying ecosystems principles in their work. Perhaps the most exciting opportunity here is the progress that can be made linking the NPPF explicitly with the Natural Environment White Paper (NEWP)[6] through improved landscape-scale thinking. The shared language of securing multiple benefits unites and enables the built and natural divide to be bridged. However, our work has only just begun and we now need to boldly go... ES

▲ **Figure 4. Cuckmere Haven, East Sussex. In some parts of the UK, such as the South Downs National Park, ecosystem thinking is already being mainstreamed in the policy process. (© Honourableandbold)**

Alister Scott is Professor of Environment and Spatial Planning at Birmingham school of the Built Environment, Birmingham City University. His teaching and research interests revolve around improving the way policy and decisions are made. Set within interdisciplinary perspectives, Alister works in partnership with policy and practice professionals to address 'messy' problems. Current projects include developing tools for policy- and decision-makers as part of the prestigious National Ecosystems Assessment Follow-on project, managing environmental change at the rural urban fringe and improving participatory governance through the use of games, where RUFopoly has just secured ESRC funding for future developement.

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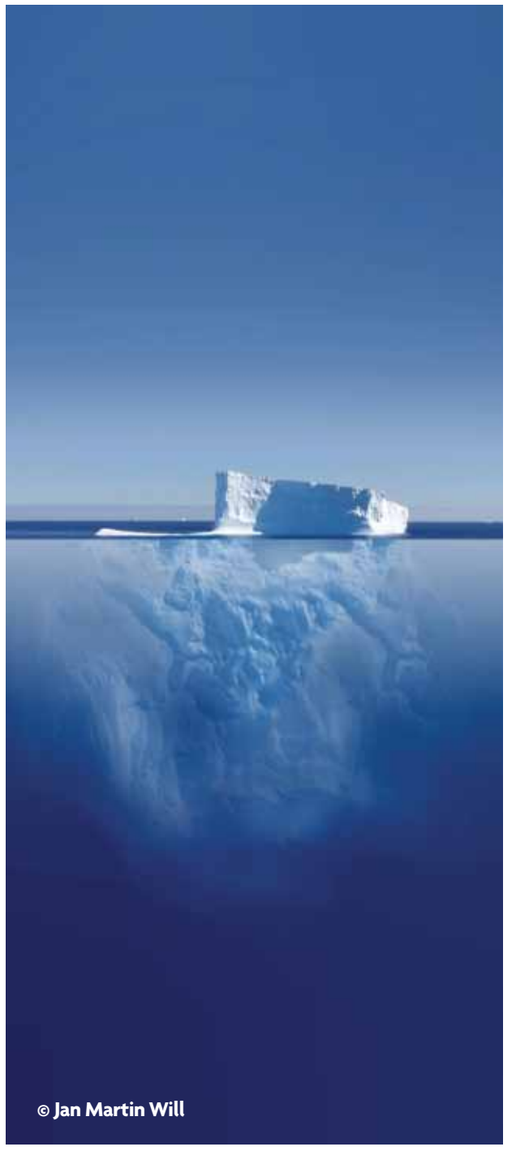
Communicating with plural audiences

Mark Everard highlights the importance of finding appropriate ways of spreading the word about the relevance of ecosystems to us all.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The stated intentions and aims of both the 2011 UK National Ecosystems Assessment (UK NEA)[1] and the 2014 UK National Ecosystems Assessment Follow-on (UK NEAFO)[1] included awareness-raising and knowledge transfer to broker change across all sectors of society.

COMMUNICATING THE UK NEA

Publication of the UK NEA in June 2011 was a global landmark, and it still remains the only such national assessment. At 1,466 pages, the hardback report is undoubtedly impressive. However, it is hardly accessible to lay and non-scientific readers. Making the contents available and usable for policy-makers, planners, educators, economists, business people and other constituencies presents a further challenge if the UK NEA's rich insights and lessons are to influence practice.

"these big tables with their various colours and arrows are not ideally suited for wider public comprehension and use."

One of the more accessible outputs of the 2011 UK NEA was an 85-page *Synthesis of The Key Findings*[2], summarising the NEA process and its key messages with some supporting detail. Some diagrams within the synthesis report were politically useful in displaying complex information all on one page, such as the importance of the eight broad habitat types for the provision of different ecosystem services and the direction of change in the flow of these services over the previous 60 years. However, compact though this summary information may be, these big tables with their various colours and arrows are not ideally suited for wider public comprehension and use.

The Department for Environment, Food and Rural Affairs (Defra) helpfully published reading paths for the 2011 UK NEA reports, adapted to the interests of different constituencies: policy-makers, businesses, educators and researchers, for example. However, wider awareness of these reading paths was low, and readers still had to grapple with a maze of technical content to reach the elements that were most useful for their priorities. Today, these reading paths are inaccessible if they exist at all in the labyrinth of the amalgamated GOV.UK website.

In conclusion, effort expended on communicating UK NEA outcomes to those who might have used them for sustainable change was slight, though a number of people involved with the NEA subsequently wrote and spoke about them in the various media.

COMMUNICATING THE UK NEAFO

The aims of the UK NEAFO programme were geared more strongly towards the uptake and mainstreaming of lessons across policy areas. This included expanding on the economic and social value of nature, integrating natural capital into UK accounts, and developing tools and products to operationalise the Ecosystem Approach. Consequently, the UK NEAFO paid greater attention to tuning outputs to user perspectives and needs.

Once again, a succinct 98-page *Synthesis of the Key Findings*[3] report was published. However, a significant change of approach was that Part III of this synthesis, 'Knowledge Exchange – What does the UK National Ecosystem Assessment Follow-on mean for different users?', comprised seven four-page summaries aimed at:

- The general public;
- Environmental non-governmental organisations (NGOs);
- Government;
- Government agencies;
- Local authorities;
- Businesses; and
- Researchers, research funders and research users.

The drafting of each four-page summary was led by an expert active in that community, supported by others from that background. Efforts were made to better attune the language, examples and messages in the synthesis summaries to these seven different constituencies. For example, leading the general public synthesis summary and given the guideline of a 14-year-old reading age, I tested drafts on a class of 14-year-olds who were extremely helpful in showing me just how high-handed 'experts' can be in judging what is comprehensible and interesting to this reading age!

Improvements could have been made in making these four-page reports available discretely, and by publishing them in appropriate media. Instead they were printed as a collated set towards the back of the main Synthesis report, which may not have made them immediately visible or accessible to the target communities.

BOX 1. 12 PRINCIPLES OF THE ECOSYSTEM APPROACH

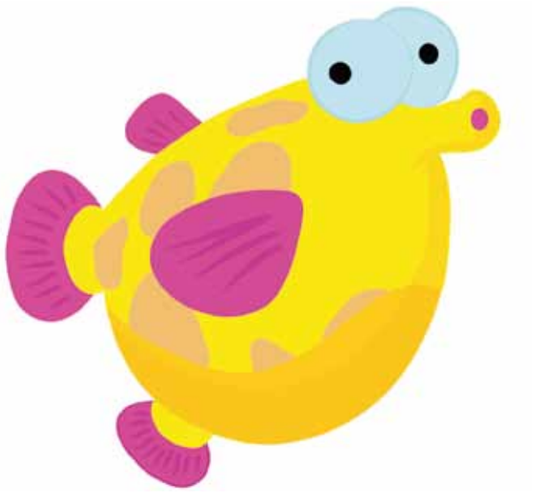
- **Principle 1:** the objectives of management of land, water and living resources are a matter of societal choices.
- **Principle 2:** management should be decentralised to the lowest appropriate level.
- **Principle 3:** ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.
- **Principle 4:** recognising potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context.
- **Principle 5:** conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the Ecosystem Approach.
- **Principle 6:** ecosystems must be managed within the limits of their functioning.
- **Principle 7:** the Ecosystem Approach should be undertaken at the appropriate spatial and temporal scales.
- **Principle 8:** recognising the varying temporal scales and lag effects that characterise ecosystem processes, objectives for ecosystem management should be set for the long term.
- **Principle 9:** management must recognise that change is inevitable.
- **Principle 10:** the Ecosystem Approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.
- **Principle 11:** the Ecosystem Approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.
- **Principle 12:** the Ecosystem Approach should involve all relevant sectors of society and scientific disciplines.

HOW WELL DID WE COMMUNICATE?

Of course, publishing a report is far from the end of communicating with plural audiences, particularly with those who need to take informed action.

As highlighted in the editorial, the outcomes of both phases of the UK NEA were greeted with profound political and media inertia rather than enthusiasm and uptake. Thank you once again to the self-styled 'greenest government ever'! This threatens not only to waste substantial public investment and the additional voluntary commitment behind the NEA process, but also opportunities for steering our collective activities onto a more sustainable pathway.

Through technical media such as environmental SCIENTIST, and more general media such as the BBC, via the radio broadcasts that I have made, a cross-section of sensitised publics may become interested or even



▲ **Figure 1. Douglas Adams' Babel Fish acted as a universal translator. Could the ecosystem services concept be 'the Babel Fish of nature'? (© Fariz_nitta)**

engaged in UK NEA outputs. But what about the majority who may be unaware of them, and to whom such communication may be entirely invisible?

FROM MULTIPLE TO PLURAL

The environment is far too important to be left to environmentalists alone. Indeed, if we in the broader environmental community, howsoever defined, are ultimately seen as the 'owners' of the Ecosystem Approach then all is lost. After all, the twelve complementary and interlinked principles of the Ecosystem Approach (see **Box 1**) set out by the Convention on Biological Diversity[4] speak not merely of the ecosystems that provide the most fundamental resources underpinning human needs. They also explicitly address issues of societal choice, decentralised management, the wider spatial and temporal ramifications of decisions, economic context, preparedness for inevitable change, consideration of all forms of knowledge, and the involvement of all relevant sectors of society in decision-making. All of us in society, environmentally astute and illiterate alike, ultimately share common interests and a common fate, co-dependent on and thereby conjoined as we are by the beneficence of nature.

A SYSTEM APPROACH

Senior colleagues and I have debated for some years whether we are bold enough to begin dropping the 'eco' prefix. The mere mention of 'eco-anything' suggests to many that this is all to be delegated to the 'greens'. But this is not what the Ecosystem Approach is about at all. Instead, we should be talking about a systems approach, within which there is an implicit understanding that supporting ecosystems stand as axiomatic alongside economic, social and equitable considerations. Is society ready yet to realise that ecosystems are a fundamental, not altruistic, concern?

NATURAL ANALOGIES

Three analogies I have used frequently during my past three decades involvement in developing and applying ecosystem service concepts seem appropriate to the challenge of communicating with plural audiences.

The first analogy is describing ecosystem services as 'the verb of nature'. We are not, as some mischievously or mistakenly perceive the concept, seeking to put a price on nature in describing its services. The UK NEA conceptual framework acknowledges the underpinning contributions of geodiversity and biodiversity across all layers, including to final services beneficial to people: ecosystem services are all about what nature does for us, hence describing them as 'the verb of nature'.

The verb analogy introduces to wider publics a key understanding both of what ecosystem services are (and also are not) but also, importantly, about the importance of the natural world for many of the services – fresh water, clean air, soil formation and fertility, recreational resources and natural beauty, natural flood control and so on and on – that we have for too long taken almost entirely for granted. The analogy brings nature 'in from the cold' for many who may have not to date questioned how reliant they are upon it.

The second analogy, and one that resonates strongly with participants in public dialogue work I have done around ecosystem services, is that of the iceberg. This relates to the vast bulk of ecosystem services that defy ready quantification and valuation, but which are essential for the resilience and functioning of all ecosystems and their capacities to provide us with those other services we more directly consume and value economically.

Particular amongst these are supporting ecosystem services and several of the regulatory services, which are recognised as 'intermediate services' in the UK NEA valuation model to ensure that they are not double-counted along with the 'final services' to which they contribute. It is nevertheless important that all such 'intermediate services' are included in some way in decision-making, as continuing to overlook or undervalue them risks perpetuating the very cycle of ecosystem degradation through oversight that the ecosystem services concept was developed to interrupt.

Interestingly, I have found that most members of the general public tend intuitively to understand the iceberg: that nature is always present unseen below the surface, supporting the 10 per cent or so of services that we use directly, and so its protection is a high priority as an investment in future security. By contrast, I have found the concept harder to communicate to technical and policy audiences, who tend already to have a focus on a subset of services nearer market (such as food, timber and exploitable water resources) or already embraced by regulations (including management of flood risk, water quality and pollution control), but perhaps less so on the systemic workings of nature from which these focal services arise as integral elements. The central thrust of the transition to decision-makers recognising and incorporating the value of ecosystems and their services is precisely about recognising the 'submerged' 90 per cent of this metaphorical iceberg of nature that bears our weight and supports more visible and tangible needs now and into the future.

A third analogy on which I have commonly drawn is that ecosystem services are a kind of "Babel fish of nature", borrowing from *The Hitchhiker's Guide to the Galaxy*[5]. The practical use of this fish was that, when inserted in the ear, a person could instantly understand anything said to them in any language.

All analogies are germane to the important mission of communicating with plural audiences using references meaningful to them, and certainly reaching out beyond the relatively narrow technical circles within which the UK NEA and UK NEAFO are currently understood. The third analogy, the role of the ecosystem services framework as a universal translator, is perhaps the most important.

THE BABEL FISH OF NATURE

The origins of contemporary ecosystem services concepts in the late 1980s specifically sought to capture the multiple ways that different people use and value what the natural world does for them. Harmonisation under the UN Millennium Ecosystem Assessment[6] in the mid-2000s of many pre-existing ecosystem service typologies from across global bioregions and habitat types into a consistent ecosystem services categorisation followed the same objective. This was to reflect multiple benefits and diverse value systems, ranging from those that are more tangible (food, fuel, fresh water and so on) through the more culturally subjective (such as spiritual value, aesthetics, sense of place and community formation) to the underpinning life support services sustaining all others (soil formation, pollination, natural hazard regulation and others). The value and importance of ecosystems can thus become evident to a wider cross-section of people by recognition of and communication around the particular value systems they hold.

This diversity of values and value systems in different sectors of society, from local to global scales, is axiomatic in the concept of ecosystem services. We allow it to be subverted by a narrower focus on unitary values, be they monetary or other, at our considerable peril. Developments under the UK NEAFO in expanding on cultural values, and also shared and plural values, make a useful contribution here, as does the focus on practical tools through which decision-makers can elucidate the diversity of societal values through dialogic processes, better to inform robust and more inclusive and sustainable management outcomes.

Communicating to plural audiences remains challenging, but is essential for engaging all in society in more connected decision-making, technological innovation and choice. Communicating is also essential for resource use and management practices that better safeguard and help rebuild natural infrastructure fundamental to longer-term wellbeing. We have to learn to communicate more intuitively and with greater impact about the many ways in which nature confers meaning and value – whether in business, technology, art and music, local and central government, academia, rural communities, retail or as consumers – so that all of society can take appropriate action based on their unique perspectives and essential contributions to achieving a sustainable future. ES

Mark Everard is Associate Professor of Ecosystem Services at the University of the West of England (UWE, Bristol) and a Vice-President of the IES. He has championed the evolution and international practice of ecosystem services since the 1980s. Mark is author of numerous papers and books, many on ecosystems and their services, including *Common Ground: Sharing Land and Landscapes for Sustainability* (Zed Books, 2011), *The Hydropolitics of Dams: Engineering or Ecosystems?* (Zed Books, 2013) and *Breathing Space: The Natural and Unnatural History of Air* (Zed Books, forthcoming). (mark.everard@uwe.ac.uk)

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