The science–policy interface: the role of scientific assessments—UK National Ecosystem Assessment

BY ROBERT TONY WATSON1,2,*

1Department for Environment, Food and Rural Affairs, Area 1a, Nobel House 17, Smith Square, London SW1P 3JR, UK
2Tyndall Centre, Environment Department, University of East Anglia, Norwich NR4 7TJ, Norfolk

This paper discusses the science–policy interface, emphasizing the role of evidence and scientific assessments. It then presents the key findings from the UK National Ecosystem Assessment (NEA), which provided much of the evidence for the Natural Environment White Paper for England as a case study. It also influenced the development of the biodiversity strategy for England. The NEA demonstrates the importance of a multi-disciplinary team of experts to prepare and peer review assessments and the importance of input from funding agencies and relevant stakeholder groups in co-designing and reviewing. Much of the text and all of the figures in the NEA section are taken from the Synthesis Report of the NEA, which I drafted as co-chair of the NEA.1

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1. State of the environment

There is no doubt that the Earth’s environment is changing on all scales from local to global, in large measure owing to human activities. The stratospheric ozone layer has been depleted, the climate is warming at a rate faster than at any time during the last 10 000 years, biodiversity is being lost at an unprecedented rate, fisheries are in decline in most of the world’s oceans, air pollution is an increasing problem in and around many of the major cities in the world, large numbers of people live in water-stressed or water-scarce areas, and large areas of land are being degraded. Much of this environmental degradation is due to the unsustainable production and use of energy, water, food and other biological resources and is already undermining efforts to alleviate poverty and

*robert.watson@defra.gsi.gov.uk

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stimulate sustainable development, and, worse, the future projected changes in
the environment are likely to have even more severe consequences.

This paper is based on my personal experiences as a researcher, a research
programme manager at NASA, chair, co-chair or director of international
assessments (stratospheric ozone depletion, the Intergovernmental Panel on
Climate Change, the Global Biodiversity Assessment, the Millennium Ecosystem
Assessment and the International Assessment of Agricultural Science and
Technology for Development) and national assessments (UK National Ecosystem
Assessment (NEA)), a science advisor in the White House, World Bank and the
UK Department for Environment, Food and Rural Affairs (Defra), and a technical
advisor for the US government in international negotiations of multi-lateral
environmental conventions. It is not an assessment of the literature on the role of
assessments in the science–policy interface, hence contains very few references.

Credible scientific information is essential for informed policy formulation
and implementation. This requires national and international multi-disciplinary
research programmes and assessments, and mechanisms to ensure that decision-
makers are appropriately involved in the co-design and co-production of research
activities and assessments, and exchange of knowledge. In the UK, Defra is
the lead department for many environmental issues, but works closely with
most other departments to develop national policies and input to international
policies, especially the Department of Energy and Climate Change, Department
for Transport, Department for International Development, Department for
Communities and Local Government, Department of Health, Cabinet Office,
Foreign and Commonwealth Office and HM Treasury. Go-Science and the
government departments’ chief scientific advisors play a key role in ensuring that
policy decisions are based on credible peer-reviewed evidence. At the international
level, there are numerous environmental agreements and conventions, including,
for stratospheric ozone depletion, climate change (United Nations Framework
Convention on Climate Change), biodiversity (United Nations Convention on
Biological Diversity), wetlands (Ramsar), and land degradation (United Nations
Convention to Combat Desertification). The work programmes and regulatory
protocols of the conventions are largely based on the international assessment
processes discussed later in this paper.

The issues of stratospheric ozone depletion, climate change, loss of biodiversity
and degradation of ecosystem services, local and regional air pollution, and
land and water degradation are interconnected and are undermining economic
growth, poverty alleviation and the livelihoods of the poor; food, water and energy
security; human health; and personal, national and regional security.

Understanding the interconnections among these environment and develop-
ment issues is essential in order to develop and implement informed cost-effective
and socially acceptable policies, practices and technologies at the local, regional
and global scale. Given that these environmental issues are closely interlinked
we must ensure that policies and technologies to address one environmental
issue positively, and not negatively, impact on other aspects of the environment
or human well-being, i.e. it is important to identify climate change response
measures that are also beneficial to biodiversity and do not adversely affect
biodiversity, and vice versa. Cost-effective and equitable approaches to address
these issues exist or can be developed, but will require political will and moral
leadership. While the substantial measures needed to prevent environmental

degradation from undermining growth and poverty alleviation are not yet in place, a combination of technological and behavioural changes, coupled with pricing and effective policies (including regulatory policies), are needed to address these global challenges at all spatial scales, and across all sectors.

2. The role of evidence in policy formulation

High-quality multi-disciplinary evidence (e.g. from the natural and social sciences, economics, technology and law) is essential for informed public policy formulation and implementation. Comprehensive interdisciplinary scientific programmes at the national and international level are essential; however, in most instances, the social sciences are underfunded, as is scientific research in most developing countries. Coordination and integration of the international scientific programmes of the International Council of Science (ICSU) and the International Social Science Council (ISSC) are required, i.e. the World Climate Research Programme, the International Geosphere Biosphere Programme, the International Human Dimensions Programme, Diversitas and the Earth System Science Programmes. ICSU and ISSC are currently working with the scientific community and funding agencies to intellectually and managerially integrate these programmes into a multi-disciplinary programme called Future Earth. Joint public and private sector funding of research is highly desirable to ensure that the research programmes are meeting the needs of both the public and private sector and the findings are owned by both groups. The open exchange of scientific information is essential, especially given the global public goods nature of this type of research.

The scientific community needs to recognize the complexity of the socio-political system and political realities, and the political context of decision-making, and that inter- and intragenerational equity issues are critically important. It also needs to understand the values, needs and aspirations of society and decision-makers and to understand that the long-term goal of a sustainable world will take time to achieve. There is also a need for both scientists and politicians to recognize that our scientific knowledge will never be perfect, thus decision-makers need a consensus view of the state of scientific knowledge, including what is known, unknown and uncertain. Hence, national and international scientific, technical and economic assessments, prepared and peer reviewed by the best experts in the world from all stakeholder groups, are essential to inform decision-makers. Assessments need to describe the current state and projected changes in the environment and the implications for human well-being. Thus, there is a need to link environmental issues such as climate change, loss of biodiversity and degradation of ecosystem services to what people care about—food, energy, water and human well-being and security. They also need to assess the consequences of inaction, but demonstrate that in many cases, e.g. human-induced climate change, quasi-cost-effective solutions exist and that the cost of inaction exceeds the cost of action. There is a need to recognize that technologies and policies are normally necessary to address environmental issues, but behaviour change is essential. To ensure that all relevant stakeholders are armed with the information they need to take action, more effective communication with decision-makers (governments, private sector and the non-governmental organizations (NGOs)) and the public is essential, both directly and through the media.
3. National and international assessments

An assessment is a critical evaluation of information for the purposes of guiding decisions on complex public policy issues. The scope of the assessment should be defined by the full range of stakeholders, especially decision-makers in the government and the private sector. The assessments should be policy relevant, not prescriptive and provide the information needed for action in a digestible form. They should be conducted by a credible group of experts with a broad range of disciplinary (natural and social scientists, economists and technologists) and geographical experience (experts from developed, developing and economies in transition). They should be chosen through an open and transparent process from a wide range of stakeholder groups, but act in their individual capacity. And the assessments should reduce complexity but add value by summarization, synthesis and evaluating what is known and widely accepted from what is not known (or not agreed). For issues such as biodiversity, they should relate to the situation at a particular time and in a given geographical domain.

National and international assessment processes need to be credible, transparent and legitimate, with well-defined principles and procedures. There should be participation by all relevant stakeholders, including governments, private sector, civil society and NGOs, the scientific community and international organizations, and the governing bodies for an international assessment must be geographically balanced. Hence, there is a need to build trust with those we are trying to influence that makes an outreach communications strategy vital, starting at the beginning of the process.

The scope of an assessment should be holistic and address risk assessment, risk management and communication. The assessments should be multi-thematic (environmental, technological, social, economic), multi-spatial (local to global) and multi-temporal, i.e. historical to the future, employing plausible futures, using a consistent conceptual framework that encompasses spatial and temporal scales, and that links drivers of change to environmental issues to human well-being. The assessments must be evidence based, not based on ideological value systems, and represent different views, identifying uncertainties and areas of controversy. They should use traditional and institutional knowledge, and local, regional and global perspectives, as appropriate.

There needs to be an open and transparent peer-review process, involving experts and representatives from governments and other stakeholders with review editors overseeing the process to ensure that peer-review comments are taken into account by the authors in an appropriate manner. Acceptance and approval processes must be well defined, as must procedures to deal with controversial issues and areas of disagreement. One area where improvements could be made is to explain the implications of uncertainty to decision-makers for policy formulation.

One of the most important features of an assessment is a well-written summary for decision-makers and a synthesis report that is written in a jargon-free language addressing the key issues of relevance to decision-makers in government, the private sector, NGOs and the public at large.

Adequate financing is required to ensure a well-functioning secretariat and appropriate participation of relevant experts.
Key international assessments which have influenced national and international policy formulation include:

— the international stratospheric ozone assessments that have had a profound influence on national and international policy formulation, including the establishment of the Convention for the Protection of the Ozone Layer and its Montreal Protocol and subsequent amendments and adjustments, resulting in a global ban of literally all halogenated, ozone-depleting substances. These assessments covered the impact of human activities on the ozone layer, the impacts of ozone depletion on human health and ecosystems through an increase in ultraviolet B reaching the Earth’s surface, and the economic and technical feasibility of substitutes. While non-governmental and independent, they have a mandate to provide information to the Montreal Protocol, ensuring ownership by governments;

— the Intergovernmental Panel on Climate Change (IPCC) led to the establishment of the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol and has strongly influenced many national policies including the UK Climate Change Bill. The IPCC assessments cover the impact of human activities on the climate system, the impacts of climate change on socio-economic sectors, ecosystems and human health and adaptation options, and the economic and technical feasibility of transitioning to a low-carbon economy. The IPCC is a UN intergovernmental process, independent of, but responding to, the needs of the UNFCCC, with a bureau comprising government representatives;

— the Millennium Ecosystem Assessment (MA) has influenced numerous national policies and the work programme of the Convention on Biological Diversity, and led to the likely establishment of the Intergovernmental Platform on Biodiversity and Ecosystem Services. The MA covered the status and trends in biodiversity, ecosystems and their services, plausible future scenarios, options for action, and sub-global assessments. The MA was a non-governmental assessment, with a multi-stakeholder bureau, but responded to the needs of the biologically related environmental conventions (e.g. the Convention on Biological Diversity, the Ramsar Convention on Wetlands and the Convention on Migratory Species), and the Convention to Combat Desertification; and

— the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) stimulated significant discussion among governments, NGOs and the private sector about the future of agriculture and food security. The IAASTD assessed the environmental and social aspects of the current agricultural systems at the global and regional level, and future challenges. The IAASTD was an intergovernmental process with a multi-stakeholder bureau.

In addition to influencing policy formulation and implementation, these assessments have also had a significant influence on national and international research programmes by identifying key uncertainties.
Figure 1. Conceptual framework for the NEA showing the links between ecosystems, ecosystem services, good(s), valuation, human well-being, 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.

There are advantages and disadvantages of the different governance arrangements for international assessments. The assessments described above range from non-governmental (ozone assessments and the MA), to intergovernmental (IPCC), to a hybrid version of an intergovernmental process (IAASTD). In my opinion, the best structure is that of the IAASTD, as it ensures voice and ownership by the widest range of stakeholders given their involvement in the management structure.

4. The UK National Ecosystem Assessment

The UK NEA was prepared and peer reviewed by over 500 experts, and is the most comprehensive assessment of the UK’s natural environment and resources ever undertaken. It strongly influenced the development of the Natural Environment White Paper for England and developed a set of principles for incorporating ecosystem services and their value within conventional government decision-making (discussed in the conclusions section of the paper).

The design of the UK NEA was in large measure based on the Millemium Ecosystem Assessment, including the conceptual framework. The conceptual framework, which is shown in figure 1, was used to critically assess the status and trends of UK ecosystems and their services (provisioning, regulating, cultural and supporting) looking back 60 years and looking forward 50 years...
using six plausible future scenarios, assessed the economic values and shared social values of ecosystem services, and evaluated a set of response options (Austen & Malcolm 2011).

5. Key findings from the UK National Ecosystem Assessment

The benefits that we derive from the natural world and its constituent ecosystems are critically important to human well-being and economic prosperity, but are consistently undervalued in economic analysis and decision-making.

(a) Status and trends of the UK’s ecosystems and their services and the underlying drivers of change

The primary drivers of changes in UK ecosystem services (Bateman 2011a,b) during the past 60 years have been (i) the conversion and intensification of natural habitats, e.g. semi-natural grasslands, moors and heaths, wetlands and floodplains to farmlands; (ii) the exploitation of natural resources, especially marine fish; (iii) invasive species, e.g. tree pests and animal diseases; (iv) air and aquatic pollution, especially from nitrogen, sulphur and phosphorus; and (v) climate change, e.g. increased air and sea temperatures and changing precipitation patterns. These have largely been influenced by changes in demography (with an increasing and ageing population) and the economy (e.g. sustained economic growth and trade liberalization), technological advances (e.g. increased mechanization and use of agrochemicals), and socio-political (e.g. policy changes and reform) and behavioural changes (e.g. changing consumption patterns). These have collectively driven change, placing a greater demand on the goods and services provided by UK ecosystems, and ultimately influencing the way we manage our natural resources.

The emphasis placed on provisioning services to meet the increased need for food (crops and livestock), and to a lesser extent fibre, water and energy, for an increasing and wealthier population during the last 60 years, has resulted in the UK landscape changing markedly and a decline in biodiversity (Bateman 2011a,b) and the unintended degradation of many UK ecosystems (Bullock 2011; Church et al. 2011; Davies 2011; Edwards-Jones 2011; Firbank & Bradbury 2011; Fish et al. 2011; Haines-Young 2011; Jonathan & Tierney 2011). There has been an expansion of intensive agriculture, woodlands and urban areas, and the contraction and fragmentation of semi-natural grasslands, upland and lowland heaths, freshwater wetlands and coastal margin habitats. Changes in the extent and condition of habitats have significantly altered the ecosystem services they provide (figure 2). For example (i) within farmlands, crop and livestock production has increased significantly, but it has been accompanied by emissions of greenhouse gases, loss of landscape diversity, a decrease in soil quality and a reduction in farmland birds, plants and butterflies, although there have been recent improvements, notably reductions in greenhouse gas emissions and diffuse chemical pollution to freshwaters; (ii) the supply of timber from woodlands is increasing and, owing to recent changes in forest policy and woodland management, has been accompanied by enhancement of wild species.
Figure 2. Relative importance of broad habitats in delivering ecosystem services and overall direction of change in service flow since 1990. This figure is based on information synthesized from the habitat and ecosystem service chapters of the UK NEA Technical Report (ch. 5–16) as well as expert opinion. This figure represents a UK-wide overview and will vary nationally, regionally and locally. It will therefore also inevitably have a level of uncertainty: full details can be found in the Technical Report. Arrows in circles represent where there is high evidence for or confidence in the direction of service flow among experts; arrows in squares represent where there is less evidence for or confidence in the direction of service flow. Bland cells represent services that are not applicable to a particular broad habitat.
diversity, recreation, hazard control, air quality and climate regulation through the sequestration of carbon; (iii) the supply of water is decreasing from most habitats, e.g. freshwaters and wetlands, farmlands and semi-natural grasslands; and (iv) expansion of urban areas has reduced the supply of water and degraded regulating services for climate, hazards, soil quality and noise. Much activity in these areas was in direct response to market forces, but government policy and subsidies promoting production and infrastructure development also played an important part. Agricultural production began a period of rapid expansion that continued for several decades, with 70 per cent of English land now being farmed.

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. More recently, European Union (EU) policy has driven changes in national policy and legislation, which, along with technological developments and changing public and private sector attitudes and behaviours, have led to improvements in some ecosystem services. The Rural Development Programme, in particular the agri-environment schemes of the EU Common Agricultural Policy, and other EU environmental directives, such as the Water Framework Directive, have led to significant improvements in ecological status in the past 10–15 years. Changes in the intensity of land management, as well as a reduction in diffuse and point-source pollution and an expansion of protected areas, have probably contributed to slowing the decline of many species, as indicated by those used to monitor trends in ecosystem quality. Air and water quality have improved significantly over the past 50 years, largely because of direct regulatory interventions, resulting in reduced emissions and improving the condition of ecosystems.

Since the early 1990s, financial support to farmers under the EU Common Agricultural Policy has been partially decoupled from production to encourage wider stewardship of the countryside. Forestry policy has also moved away from a strong focus on production and, since the mid-1980s, has increasingly sought to provide a mix of services, including recreation and maintenance of biodiversity. Fisheries management has started to improve in the last decade or so.

Despite recent improvements, currently just over 30 per cent of services are declining and many others are in a reduced or degraded state and still far below their full potential, with adverse effects on human well-being (figure 2). A growing population, which will increase the demand for food and other basic services, coupled with human-induced climate change will place significant future pressures on many ecosystems and their services. Therefore, the need to manage our ecosystems is going to become more pressing, not less.

Responding to declines in ecosystem services will require the adoption of more resilient ways of managing ecosystems, and a better balance between production and other ecosystem services. Indeed, one of the major challenges is to increase food production, but with a smaller environmental footprint through sustainable intensification.

(b) How ecosystem services affect human well-being?

Society in general directly benefits from the full range of provisioning (Jones 2011), regulating (Mace & Bateman 2011) and cultural services
(Maltby & Ormerod 2011), and indirectly from the supporting services. For example (i) the increase in the provisioning services of food production (crops and livestock) has resulted in a wider selection of food at a reduced cost for everybody; (ii) carbon sequestration by soils and woodlands limits human-induced climate change; and (iii) ecosystems positively affect both the physical and mental health of social groups and the quality of life in general, often through access to the wider landscape and seascapes, and through use of urban green space, parks and gardens. Ecosystems provide (i) direct positive effects on the mental and physical health of social groups and the quality of life in general; (ii) indirect positive effects, including facilitating Nature-based activity and social engagement, and acting as a catalyst for behavioural change by encouraging the adoption of healthier lifestyles; and (iii) reduced air pollution.

Changes in ecosystem services have both positive and negative impacts on human well-being—for example, the conversion of salt marshes and dunes for agricultural land results in increased agricultural production, but locally it leads to loss of habitat for recreation and has potential implications for coastal defence against storm surges. The distribution of the beneficiaries of ecosystem services is not evenly spread. For example, carbon sequestration by woodlands benefits society at large, while access to woodlands for recreational purposes primarily benefits those in close proximity or with transport access, whereas loss of urban green space impacts most severely on lower income households.

(c) How does the UK depend on provisioning services from abroad?

The UK is not self-sufficient in meeting its food, fibre, water (embedded in products) and energy needs, and consequently depends significantly on non-UK ecosystem services, thus exporting a substantial environmental footprint (Norris 2011). The annual biomass flow from agriculture, forestry and fisheries through the UK economy is 150 million tonnes, based on domestic production of approximately 100 million tonnes, imports of 50 million tonnes and exports of 20 million tonnes. Therefore, approximately one-third of the biomass used by the UK is sourced from overseas. Approximately 66 per cent of the UK’s annual water demand of 102 billion cubic metres is met by overseas sources through embedded (virtual) water, three-quarters of which is due to production of agricultural biomass.

Depending upon future policy choices, the UK’s dependence on provisioning services from non-UK ecosystems could increase or decrease (see §5f and figure 3): for example, a storyline that focuses on national self-sufficiency would reduce our dependence on non-UK ecosystems and their services, whereas one that emphasizes local preservation of ecosystems could increase our dependence on non-UK ecosystems and their services. The UK is dependent upon a wide range of other non-UK ecosystem services, e.g. climate control, but these have not been analysed in this assessment.

(d) Public understanding of ecosystem services and the benefits they provide

A recent survey suggests that, in the UK, ecosystem services are not a meaningful framework for interpretation of human–environment relations for the vast majority of people, although the term has gained traction in science...
how might UK ecosystems and their services change under plausible scenarios?  
what would be the effect of such changes?

![Image](https://example.com/image.jpg)

Figure 3. The names of the six plausible scenarios used in the UK NEA.

and policy (Maltby & Ormerod 2011). Culturally, the concepts that have most meaning are those of Nature, place and landscape. The diverse groups of participants in the study shared a common language and understanding of Nature, i.e. the sky, seas, hills, mountains, forests, woodlands, rivers, streams, lakes, beaches and countryside, characterized by the presence of many different species of mammals, birds, insects and fish. They associated Nature with greenery, such as leaves, trees, grass, plants and fruit, and fresh air, clean air and cleanliness. Even though the public did not relate to the concept of ecosystem services, they do appreciate the benefits of provisioning services (e.g. the supply of food and clean water), regulating services (e.g. sequestration of carbon to mitigate climate change) and cultural services (e.g. recreation and urban green space).

The increasing membership of organizations such as the Royal Society for the Protection of Birds, which has increased from 10,000 members in 1960 to over 1 million today, and the UK’s 45 wildlife trusts with 800,000 members, illustrates an increasing appreciation and awareness of environmental issues.

(e) The economic value of ecosystem services

The economic, human health and social benefits that we derive from ecosystem services are critically important to human well-being and the UK economy, and each should be considered when evaluating the implications of changes in ecosystems and their services (Pretty 2011). However, the values of most ecosystem services are currently omitted from national economic frameworks and local decision-making, even though a conceptual framework is now available to account for most of the market and some of the non-market values of ecosystem services. A range of economic techniques can be used to assess the value of different ecosystem services, including via adjusted market prices, contribution to output, avoided costs, observed behaviour and stated preferences.
Effective conservation and sustainable use of ecosystems are critical for human well-being and a future thriving and sustainable green economy. Failure to include the valuation of non-market values in decision-making results in a less efficient resource allocation; however, a major challenge is to develop systems to appropriate the values of non-market ecosystem services to land managers. Integration of the spatial dimensions of ecosystem services within local decision-making would increase the potential for the true value of ecosystem services to be recognized. The values of some ecosystem services are spatially independent (e.g. the value of reduced greenhouse gas emissions or biological carbon sequestration), while others are highly spatially specific (e.g. the recreational value of woodlands is dependent on its proximity to high population centres).

(f) *How ecosystems and their services might change in the UK under plausible future scenarios?*

In order to understand what the future might hold, a range of plausible scenarios was developed, some of which emphasized environmental awareness and ecological sustainability, whereas others stressed national self-sufficiency or economic growth and the removal of trade barriers (Quine 2011). These plausible futures show that there is a huge range of potential outcomes for the state of the nation, its people and its ecosystems in the coming decades. Decisions that we all make now and in the immediate future will have a major impact on these outcomes. An important prerequisite for this is a better grasp of the values of the full range of ecosystem services. The values of most ecosystem services are currently omitted from national economic frameworks and local decision-making.

Six storylines employing very different policy priorities were developed (figure 3): (i) Green and Pleasant Land, in which a preservationist attitude to UK ecosystems was taken; (ii) Nature@Work, in which ecosystem services are promoted through the creation of multi-functional landscapes; (iii) Local Stewardship, in which society strives to be sustainable within its immediate surroundings; (iv) Go with the Flow, in which current trends are assumed to continue, and in which current principles and practices are not radically altered; (v) National Security, in which there is reliance on greater self-sufficiency and efficiencies; and (vi) World Markets, in which the goal is economic growth and the elimination of trade barriers.

Storylines that emphasized environmental awareness and ecological sustainability resulted in significant gains in the output of a broad range of ecosystem services, in contrast to storylines that emphasized national self-sufficiency or economic growth (figure 4). Land-use change and pollution are projected to continue to be major drivers of change for biodiversity and ecosystem services, although by 2060 climate change is also predicted to be a significant driver of ecosystem services and of losses and gains of species throughout the UK.

(g) *The economic implications of the different plausible futures*

Applying the economic values derived for ecosystem services, using the conceptual framework shown in figure 5, to these scenarios shows that a huge range of possible outcomes awaits us (Smithm 2011). Each of the UK
NEA scenarios was assessed in terms of the changes they induce from the present day. Assessments examined five major ecosystem services: (i) agricultural food production; (ii) net change in greenhouse gases from land use; (iii) open access recreation; (iv) urban green space amenity; and (v) biodiversity (assessed using birds as indicator species). These assessments demonstrate the ability of methods developed for the UK NEA to assess the relative economic implications of different storylines. The type of analysis provided by the UK NEA is vital if we are to ensure more economically efficient decision-making and sustainability.

Even recognizing the limitations of the UK NEA analyses (e.g. not all goods and services are valued), the analyses demonstrate that simple reliance upon market prices is likely to yield an inaccurate assessment of the overall economic value of different scenarios to society. If market values only are taken into account then storylines that emphasized national self-sufficiency or economic growth resulted in the largest economic gains in the short- to medium-term owing to increased agricultural production. Conversely, if all monetized values are taken into account then the storylines that emphasized environmental awareness and ecological sustainability resulted in the largest economic gains to society, much of which are available over the long run. The assessments revealed significant spatial differences across the UK for each ecosystem service analysed.

Therefore, a key challenge will be to get the economics right. Contemporary economic and participatory techniques allow us to take into account the monetary and non-monetary values of a wide range of ecosystem services. These techniques
The report also recognizes that utility, ethics and aesthetics are basic principles that guide human behaviour and, as such, are incommensurable; that is, ethical and aesthetic principles cannot be adequately expressed in terms of a sum of money (Vira 2011; Van der Wal 2011). At the same time, environmental decision-makers have to make choices which require trade-offs to be made between them. In future, the collective and non-monetary value of cultural goods linked to ecosystem services will need to be understood using a range of participatory and deliberative techniques, such as multi-criteria analysis, that require the use of both quantitative and qualitative methods.
(h) How can we secure and improve the continued delivery of ecosystem services?

No national-, regional- or global-scale environmental issue (e.g. air and water quality) has ever been successfully addressed without an appropriate enabling framework using a mix of regulations, technology, financial incentives and behavioural changes, whereas local voluntary initiatives have proved invaluable by instigating a range of local conservation activities and improving the delivery of some ecosystem services. A move to sustainable development will require changes in individual and societal behaviour and adoption of a more integrated approach to ecosystem management (Weighell 2011).

Many of the recent improvements in ecosystem services and biodiversity conservation have happened as a result of effective regulation. These have been driven by various EU policy directives such as the Rural Development Programme, and in particular by the EU Common Agricultural Policy’s agri-environment schemes, complemented by the Nature directives and an increase in the area and condition of protected areas.

Responding to the pressures to provide food, water and energy security, while at the same time conserving biodiversity and adapting to rapid environmental change, will require getting the valuation right, creating functioning markets for ecosystem services, improving the use of our resources and adopting new ways of managing those resources.

In future, the management of ecosystem services will need to be resilient and adaptive to societal (e.g. demographic), environmental (e.g. climate change) and land use (e.g. increased use of bioenergy) changes. Therefore, the underlying indirect and direct drivers of change must be considered. The transition to a more sustainable use of ecosystems and their services can be facilitated by taking a more integrated, rather than conventional sectoral, approach to their management, recognizing that some difficult trade-offs will have to be made between individual ecosystem services. Integration can be facilitated by taking a multi-functional approach adaptable enough to recognize the scale of response required, from local to global, and open and transparent enough to facilitate dialogue and collaboration between a wide range of different actors. Governments, the private sector, voluntary and civil society at large all have key roles to play in the transition to a more sustainable use of ecosystems.

6. Conclusion

The bottom line is that we already have enough information to start managing our ecosystems more sustainably and good evidence of the benefits of doing so; contemporary society is less sustainable than it could be.

The UK NEA conceptual framework incorporates a number of recent innovations in ecosystem assessment, including ways of avoiding double counting the economic value of services and goods, the potential to also consider non-monetary values of health value and shared (social) value and a morphological approach to constructing scenarios of plausible futures. While there are
uncertainties, knowledge gaps and controversies in our evidence base, we have sufficient information to manage our ecosystems, and the flows of services from them, more sustainably.

In order to refine our understanding of the fundamental ecosystem processes underpinning the delivery of ecosystem services, we need both to extend our observations and experimental manipulations and also to improve our models of the key mechanisms. Better holistic ecosystem models offer a potential way forward for understanding some of the uncertainties and highlighting the sensitivities of multiple interacting drivers on ecosystems, the processes within them, and the flow of services and goods. Currently, we are unable to comprehensively quantify the relationships between UK biodiversity and the ecosystem services it supports; in particular, we need to understand better the role of microbial and fungal diversity.

AUTHOR PROFILE

Robert Tony Watson

Robert Watson’s career has evolved from a research scientist at the Jet Propulsion Laboratory, USA; a programme director at NASA, USA; a scientific advisor in the OSTP, White House, USA; chief scientist at the World Bank; to his present positions as a Professor of Environmental Sciences and Strategic Director for the Tyndall Centre at the University of East Anglia and Chief Scientific Advisor to the UK Department for Environment, Food and Rural Affairs. He has chaired, co-chaired or directed national and international scientific, technical and economic assessments of stratospheric ozone depletion, biodiversity and ecosystems, climate change, and agricultural science and technology. Robert Watson was elected as a Fellow of the Royal Society in 2011.

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