Ecosystem Services and the Ecosystem Approach

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Introduction

Alison Holt and Tom Webb

The phrase 'Ecosystem Services' is fast becoming ubiquitous, especially in policy circles, so you would be excused for groaning on seeing the title of the feature that leads this issue. However, its current prevalence has real significance for all ecologists. Ecosystem services were central to the Millennium Ecosystem Assessment, reflecting the undeniable shift that has occurred in our thinking regarding the conservation of our environment.

For a long time, conservation was centred on the loss of biodiversity through the degradation of the terrestrial and aquatic environment, driven by the fact that we ecologists love the species and the habitats that occur there. This has now definitively shifted to a more anthropocentric concern that we are losing the vital foundations of human existence. This shift is understandable: arguing for the conservation of biodiversity because we feel it should be respected and looked after simply doesn't work in a world of 6.8 billion people interested in economic growth. Instead we are now striving to put a price on nature to allow it to mean something in a world where the dollar sign rules, the alternative being that nature is valued at $0, and not included in the many decisions that end up compromising the environment's ability to provide services.

Although many have already embraced the concept of ecosystem services, it has also met with some controversy. In particular, some see valuing components of nature as reductive and dangerous. There has also been resistance to the new ways of working necessary to take this approach, such as working across disciplinary divides and focussing on applied problems rather than blue-skies questions. Finally, the fact that the concept has been taken up so readily by policy-makers has surprised ecologists, especially given that there is as yet rather little scientific understanding of how ecosystem services are provided and used in space and time.

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Significant steps have been taken to address this knowledge gap, however, and following the success of our 'Marine' issue last year, we have dedicated this edition of the ***Bulletin*** to ecosystem services, the second of the Society's four policy priorities. We hope that you will be impressed with the breadth of research that we highlight, emphasising both the progress in the science of ecosystem services and the policy of the ecosystem approach to environmental management.

The articles in this feature are international and encompass work on both aquatic and terrestrial environments, addressing questions including, can the ecosystem approach really help us to achieve sustainable environmental management? How have ecologists reacted to this paradigm shift? What new approaches are they using and how do they perceive their role? The first article focuses on the ***Theory*** of ecosystem services, where a framework for understanding the relationships between multiple ecosystem services is presented. In ***Case studies*** we include descriptions of interdisciplinary projects in China, Tanzania and the UK. These illustrate the practice of employing the ecosystem approach in Northern and Southern nations, as well as the development of novel tools for making service trade-off decisions and ultimately demonstrating the connection between humans and nature. In the transition from science to ***Policy*** we show that building interfaces is crucial to making the ecosystem approach work, and highlight how various organisations are building partnerships across policy and academia to make the approach operational. Finally, we include several ***Personal perspectives*** illustrating how ecologists need to adapt to new ways of working and how it can feel when we do.

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Theory

Understanding the Relationships among Multiple Ecosystem Services can improve Ecosystem Management

Elena M. Bennett

We all depend on the services provided by ecosystems, including products such as food, freshwater, and fibre; nonmaterial benefits such as places for recreation and inspiration; and benefits obtained by regulation of ecosystem processes, such as flood control and climate regulation (*Millennium Ecosystem Assessment [MA] 2005*). Without these services, humanity can't exist. In some cases, we can provide technological substitutes for services, but ultimately even these substitutes are dependent on other ecosystem services in some way.

People do lots of things to enhance the provision of ecosystem services. We plough fields and add fertilizers and manure to increase agricultural production of one area, we build trails and post signs to improve the recreational capacity of a forested area just outside of town, we plant trees to increase carbon storage. Typically, when we take these actions, we are thinking of only one service. For example, in agricultural areas, we try to maximize food provision while largely ignoring biodiversity, recreation, high quality water, and other services that may also be provided by this same landscape. Rarely are we thinking of more than one or two services.

Considering only one service at a time is a problem because interactions among ecological processes link the production of one ecosystem service (ES) to another. That is, ecosystem services are typically provided in bundles rather than independently, and different ecological regimes produce alternative bundles of ES (Raudsepp-Hearne *et al*, in prep.).

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One landscape may be intensively farmed for production of pork, and this landscape would provide a bundle of services made up primarily of agricultural production in the form of corn and pork, perhaps with low water quality and few opportunities for recreation. Another nearby area might be maintained primarily for recreation and provide a bundle of services consisting of high quality water, opportunities for recreation, and carbon sequestration.

When we attempt to change one service without considering the effect that our actions will have on other services provided in the same landscape, we often find ourselves surprised by the results – we get more of the one service we were trying to enhance, but other services can change in unexpected ways. For example, adding fertilizers to agricultural fields does increase crop production, as expected, but it also decreases nearby water quality when fertilizers runoff into those aquatic ecosystems.

A benefit of the ecosystem service approach to managing landscapes is that it encourages attention to multiple services, and therefore to multiple benefits that can accrue from one landscape and their interactions. Multiple objectives are important because we are asking landscapes, especially agricultural landscapes, to do a lot for us. We want our landscapes to grow food and provide recreation and carbon storage and clean drinking water and many other services, all at the same time. Considering ecosystem services allows us to think about multiple objectives in a way that many other conservation frameworks do not. However, current research on ecosystem services, as well as current management of those services, tends to focus on only one service at a time.

Our new paper outlines a framework for understanding the relationships between services (Bennett et al. 2009). We suggest a classification based on the two types of mechanisms causing relationships: 1) effects of drivers on multiple ecosystem services (i.e., common drivers) and 2) interactions among ecosystem services. Drivers of ecosystem service provision can affect a single ecosystem service, with only trivial effects on other services of interest, or they can have significant effects on multiple services at once (shown along the x-axis Figure 1.). That is, increasing fertilizer use (a driver) can have a significant negative effect on local provision of clean water (service #1) in addition to the intended effect of increasing crop yields (service #2). Along with effects of drivers on multiple ecosystem services, relationships among services can be caused by direct interactions among the services (shown along y-axis of the figure). The interaction among services can be unidirectional (the level of provision of service A affects the level of provision of service B) or bidirectional (the level of provision of service A affects the level of provision of service B, and the level of provision of service B affects provision of service A). For example, a positive unidirectional interaction is the one by which retaining forest patches near coffee increases pollination, which in turn increases coffee production (Ricketts *et al.* 2008); increased coffee production does not have an impact on pollination.

We know that ecosystem services have relationships and that some actions cause provision of one service to increase but another to decline. And we know that a benefit of using the ecosystem services concept to improve management is to help us consider relationships among multiple services so that we can avoid trade-offs and enhance synergies. Our new framework allows us to distinguish mechanisms causing the relationships between services and thereby to improve ecosystem management. For example, if we know that a trade-off between two services is caused by a shared driver and that there is no true interaction among the services involved, then management must address the driver and its effects on one or both services. If, on the other hand, the trade-off is initiated by the effect of a shared driver, but enhanced by a true interaction among the services, then simply managing the driver is unlikely to minimize the trade-off in the long-term. In the figure, the effect of drivers and interactions in Sectors 2, 3, and 4 might all lead to a relationship among services that appears similar (e.g., a trade-off), but would require very different management strategies to effectively address the relationship.

Ecosystem management that attempts to maximize one ecosystem service at a time may make ecosystems more vulnerable to regime shifts, resulting in substantial declines in other services (*MA 2005*). Ecosystem management that considers multiple services at once helps avoid these problems and can help us to get what we need from our ecosystems in a more sustainable manner.

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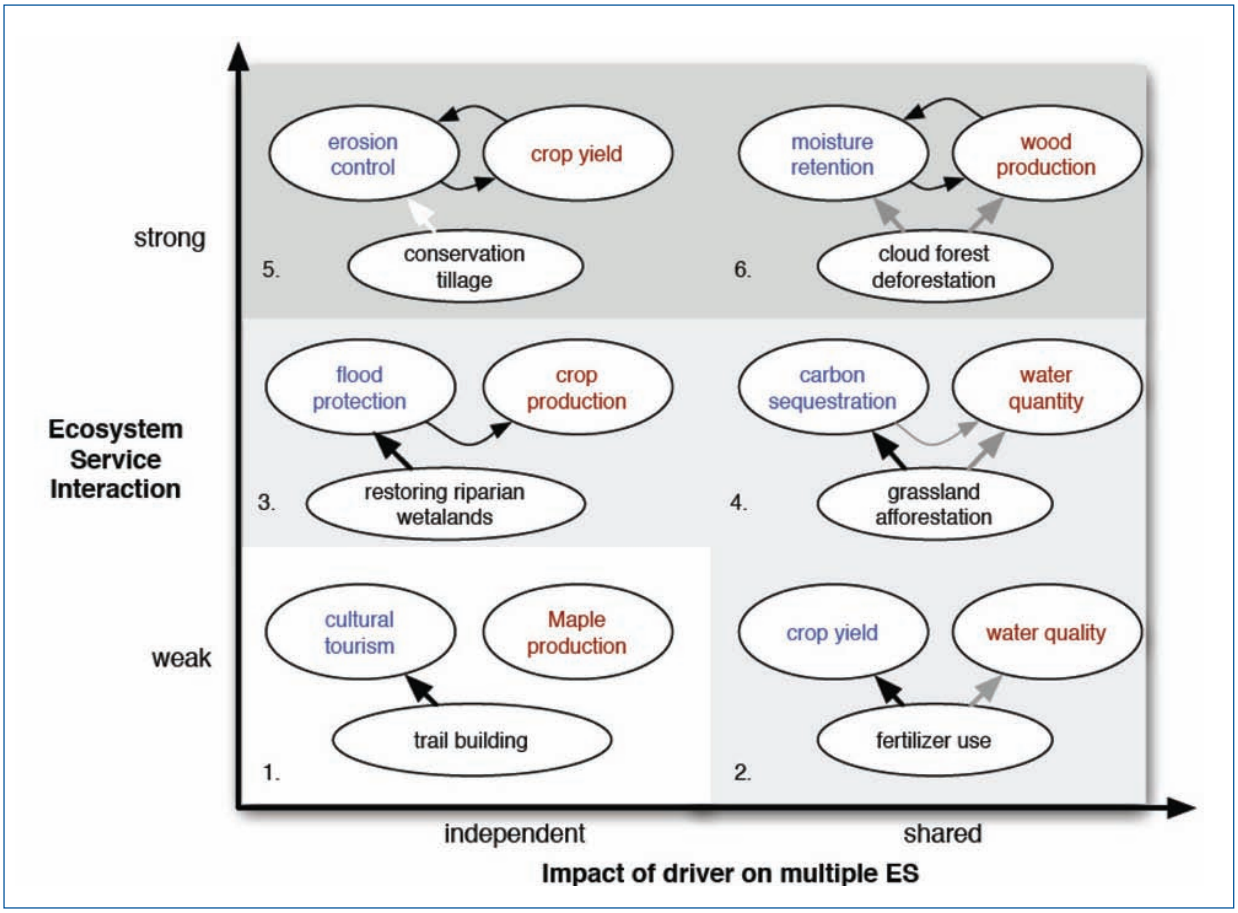
Figure 1. *The supply of ecosystems services can be related either to interactions between ecosystem services due to responding to the same driver of change. Black arrows indicate a positive effect and grey a negative effect. In the lower left-hand sector (Sector 1), a driver (trail-building) affects cultural tourism (Service A), which has no interaction with maple syrup production (Service B). In the Sector 2, the drivers affect both services, but these services have no interaction with one another. In the example presented here, fertilizer use has a positive effect on crop yield and a negative effect on water quality. However, the driver also might affect both positively or both negatively. Moving up along the y-axis, Sectors 3 and 4 show examples in which the services have a unidirectional interaction. That is, the level of provision of service A affects the level of provision of service B, but not vice versa. Sectors 5 and 6 show a bidirectional interaction among services in which the level of provision of service A affects the provision of service B and the level of provision of service B affects the provision of service A. In all cases, this interaction can be positive or negative.*



Case Studies

Valuing Ecosystem Services in the Eastern Arc Mountains of Tanzania

Ruth D. Swetnam, Andrew R. Marshall and Neil D. Burgess

As ecologists we all value nature extremely highly. Although we hold it in high regard many of us would be reluctant to attach a monetary value. Some would perhaps even regard nature as priceless. However for governments who aim to develop sound conservation policies, subjective impressions of value are extremely complicated to juggle against other more tangible economic figures. For this reason there are growing efforts to value 'ecosystem services' or 'natural capital' in an attempt to provide decision-makers with a broader set of arguments for conserving the natural world.

Udzungwa red colobus monkey Procolobus gordonorum. *Photograph by A. Marshall*

'Valuing the Arc' (VtA) is a 5 year interdisciplinary research programme funded by the Leverhulme Trust and the Packard Foundation which is measuring, modelling and valuing ecosystem services produced and sustained by the Eastern Arc Mountains, a global biodiversity hotspot in eastern Tanzania and south-eastern Kenya (Burgess et al. 2009). One early, unpublished estimate from the Government of Tanzania placed the value of the Eastern Arc Mountains to the Tanzanian economy at $620M/yr. The aim of VtA is to improve on this estimate through the systematic assessment and modelling of a broader range of ecosystem services. The programme is addressing the following questions:

a. What services are provided by the Eastern Arc Mountains, and where exactly are they being produced?
b. Who benefits from the different ecosystem services provided by the Eastern Arc and where are these people located?
c. How much are these services worth?
d. How might these benefits change over space and time if different policy objectives are pursued?
e. How much does it cost to maintain these services and who is paying?
f. How can the costs of conserving these services (for example, by protecting catchment forests) be equitably shared between those (such as nearby farmers) whose behaviour will determine their future delivery, and those who are using them further downstream?

Our first task was to develop a conceptual framework for service valuation which clarified how we defined services and where and when they can be valued (Fisher et al., 2009; Turner et al., in press). This framework subsequently underpinned a programme of fieldwork that has been used to guide the development of models and methods of valuation across our study area (Figure 1).

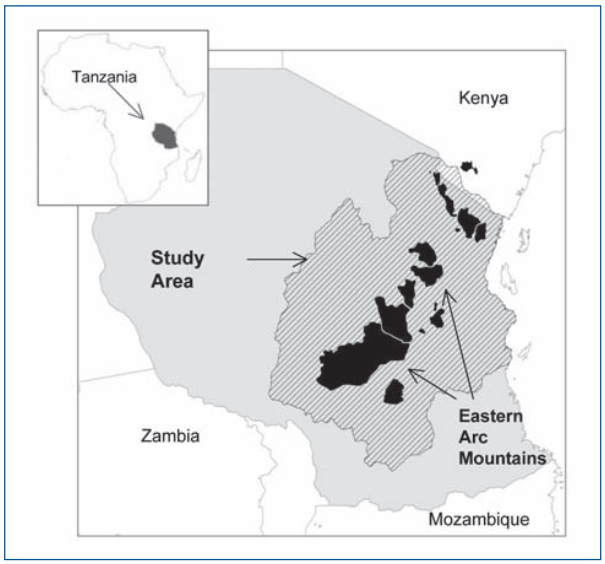


Figure 1: *Study region in eastern Tanzania with the Eastern Arc Mountains highlighted in black.*

Which ecosystem services are important in the EAM?

Our focal services are carbon storage and sequestration, the regulation of water flow, the provision of timber and non-timber forest products (including building poles, firewood,

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Forest-agriculture mosaic in the Eastern Arc. Photograph by A. Marshall

charcoal, and foodstuffs such as mushrooms or tubers), nature-based tourism, and pollination. For each service we are building coupled biophysical and socioeconomic models to describe how the production, flow, use and value of that service are expressed across the Eastern Arc Mountains. These different services are linked within a common GIS database which now stores a range of spatial datasets both biophysical and socio-economic in nature. Many have been collated from existing studies, others have been newly collected for the project, while a third set have been derived or modelled from the other two.

Approach

For each of our target services, the same sequential approach is being taken with a data collation and collection phase designed to support the development of spatially explicit models of production, flow, use and value (Figure 2). Mapping production (i.e. where is a service produced) is relatively straightforward for most services and this stage of the work is supported by fieldwork observation, remotely sensed data and existing distribution maps. Mapping the flow of services from the point of production is more challenging, and takes a number of forms, from mechanistic hydrological models which predict water availability throughout a catchment, to econometric models which describe the movement of charcoal or timber from a source in woodland to urban markets such as Dar es Salaam. The subsequent valuation of these services is equally complex and has included market surveys, interviews with tourism operations, and questionnaire surveys of farmers. Accessibility of each resource is a key factor in its use and spatial models of forest disturbance which account for transport networks, population and markets are currently being refined to feed into this assessment.

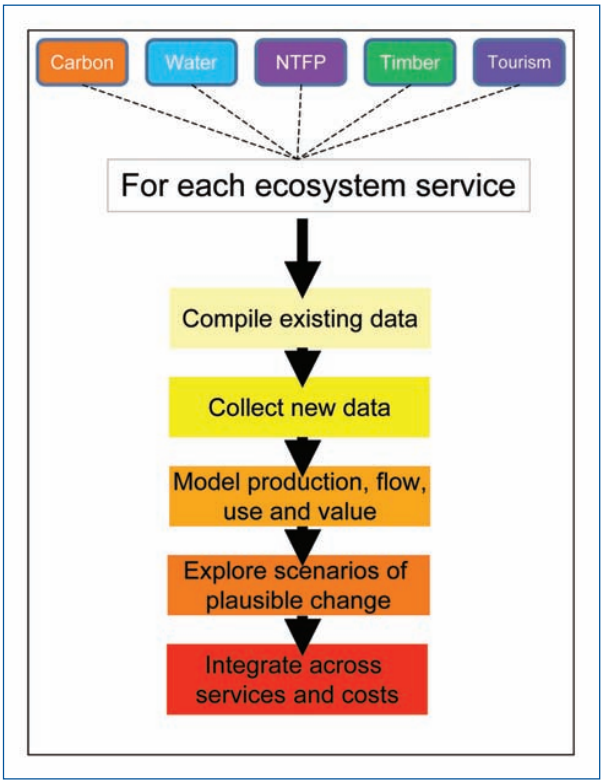

Figure 2: *Sequential approach to valuation for each target service in the Valuing the Arc project.*

Having an understanding of both the production and current value of ecosystem services is useful as a baseline, but policy-makers cannot make decisions based simply on gross estimates of service values: instead they need information about possible changes to these values arising from alternative policy decisions. To this end, VtA has undertaken a process of participatory scenario-building to develop two Tanzanian specific socio-economic scenarios of change which have been expressed spatially in the form of 'new' land-cover maps for 2025. Having created these outputs, they will now be used with our production and flow models to explore how service delivery may change in the future depending on the choices taken now.

Where does ecology fit in to the Valuing the Arc programme?

An understanding of ecosystem functioning is important to many aspects of the modelling we are undertaking. In particular, the structure of the forests and woodlands of the EAM are important determinants of carbon storage (how much is stored in above-ground, below-ground and in the soil). The amount of carbon depends on a complex

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Pitsawing. Photograph by A. Marshall

interplay of environmental and human influences, which we are modelling to determine past and present trends and to predict future scenarios. The existence of the forest has a major impact on hydrology; the cloud-forest found in the mountains probably captures additional water as well as acting as a vegetative 'sponge', which regulates quality and flow of water, especially in the dry season. The biological diversity of the EAM is well recognised and its protected areas exist to try to maintain the many endemic species of flora and fauna of the region, which in themselves provide important services to the local population through the provision of supplementary food and medicinal plants.

Where next for VtA?

We are currently three years into our five year programme and the mapping of the production of our focal services should be completed by the end of 2009. Simple models of production are now in place for all of the services and these are currently being improved and refined to incorporate the effects of degradation, accessibility and climate. Valuation work is ongoing and will interact with different outputs throughout the final stages. Most recently, the preliminary outputs of the carbon module have already provided input to Tanzania's negotiations at the UNFCC Conference of Parties in Copenhagen. VtA is also playing an active role in the policy debate regarding the implementation of the REDD (Reduced Emissions from Deforestation and Degradation) process in Tanzania (Burgess et al, submitted).

It is our hope that VtA will contribute to the development of best practice in ecosystem service analysis and valuation both in Africa and elsewhere, and will specifically inform the policy debate surrounding environmental protection and poverty alleviation in Tanzania.

See http://valuingthearc.org/ for further details.

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The Natural Capital Project

Heather Tallis, Wang Yukuan, Fu Bin, Zhu Bo, Zhu Wanze, Chen Min, Christine Tam and Gretchen Daily

After spending decades struggling to keep people out of nature, conservation is emerging on the global stage with a new vision for connecting people to nature. One of the largest efforts to date, the Millennium Ecosystem Assessment, proposed a vision of a world where people appreciate natural systems as vital assets, recognize these assets as critical for human well-being, and routinely include their values in decisions (MA 2003). This vision is starting to take hold in policy innovations worldwide. China, for instance, is investing over 700 billion yuan (£60 bn) in ecosystem service payments over 1998-2010 (Liu et al. 2008). Through pioneering local leaders to government bureaucracies, and through traditional cultures to new corporate initiatives, a tremendous variety of approaches is being deployed to incorporate natural capital into decisions (e.g. Kareiva and Marvier 2007; Ostrom 2007; Kleiner 2009). The big challenge is to replicate and scale these emerging models of success so they become part of everyday life (Daily and Ellison 2002; Goldman et al. 2008). The Natural Capital Project was designed to build on these innovative but highly site-specific efforts, and bring natural capital into the mainstream of everyday decisions around the world. This somewhat lofty goal requires rapidly advancing the science of ecosystem services, and turning the valuation of services into real, effective policy and finance mechanisms – a problem no one has solved on a large scale.

Launched in October 2006, the Natural Capital Project (NatCap) is a unique partnership between Stanford University, The Nature Conservancy, and World Wildlife Fund (www.naturalcapitalproject.org). In addition to these three core partners, we are working with others globally in the public, private and non-profit sectors. For example, our work in Tanzania is a collaboration with four Universities in the UK (Cambridge, East Anglia, York, Cranfield), two universities in Tanzania (Sokoine and Dar es Salaam), and a variety of local non-profit organizations.

As a group bringing academic research to a global laboratory of on-the-ground projects, we aim to make three major advances that together will transform how businesses, governments, and individuals interact with nature:

(1) Developing new knowledge & practical, credible tools. The new global focus on connections between people and nature suggests that investments in conservation will provide returns to people in the form of ecosystem services, or the benefits people receive from natural capital. While this idea is tantalizing, the research community needs to deliver knowledge and tools to show this connection is real and project how it will change in the future. NatCap has developed InVEST, a family of software-based tools for Integrated Valuation of Ecosystem Services and Tradeoffs. InVEST helps decision-makers quantify the importance of natural capital in biophysical, economic, and some social terms; generates maps of where and how benefits are delivered today; and assesses the tradeoffs associated with alternative scenarios or policy options for the future. NatCap is developing tools to accompany InVEST that help decision makers create scenarios and design policies.

(2) Moving from knowledge to action: demonstration projects. Through a suite of demonstration projects, we are developing cases that integrate natural capital into major

resource policies and decisions. These projects are designed to be sustained, replicated, and scaled, and thus to help embed natural capital approaches into formal business and government planning widely. InVEST tools are being used in resource decisions in China, Colombia, Ecuador, Indonesia, and the United States (California, Hawai'i). Early analyses are also being done to engage policy makers in Bolivia, Brazil, Canada, Mexico, Peru, Tanzania and other regions of the US (Oregon, Washington). The tools have proven useful with national governments, private landowners and corporations, and increasing demand for the tool indicates that the time is ripe for ecosystem service thinking to change the face of management across sectors and around the globe.

(3) Magnifying our impact: engaging leaders. This third area is new, and we will design a plan for achieving broader impact now that we have something new to offer in the tools realm. In the research arena, we are focused on building international, interdisciplinary science and outreach. We aim eventually to engage with global leaders in different arenas of society. The overall aim is to achieve a deep, lasting, and global transformation in how people think about and interact with nature.

InVEST: A Set of Tools

NatCap is developing the InVEST software system for quantifying ecosystem service values across land- and seascapes. This tool informs managers and policy makers about the impacts of alternative resource management choices on the economy, human well-being and the environment. InVEST can help answer tricky questions such as 'How would a new forestry plantation affect timber yields, biodiversity, water quality and recreation?', or 'How would expanding biofuels change a downstream city's drinking water supply?'. In the coming year, InVEST will also answer questions about the marine environment like 'Where should we put fishing zones, alternative (wave) energy farms, and aquaculture to reduce conflicts and provide the greatest benefits for biodiversity and coastal communities?' Climate change and population growth effects can be added to these questions as well.

InVEST is designed for use as part of an active decision-making process. The first phase involves working with decision makers and other stakeholders to identify critical management decisions and to develop scenarios of how an area might look under future management options, climate change or population growth. Based on these scenarios, a modular set of models quantifies and maps ecosystem services in a flexible way. The outputs of these models provide decision makers with maps and other information about costs, benefits, tradeoffs, and synergies of alternative investments in land- (e.g., Nelson et al. 2009) and seascapes.

Demonstration Projects

We have several projects underway around the globe where we are learning how useful these tools can be in the real world. In China, the government has recognized how valuable the natural environment is in providing public benefits, and is investing in natural capital through the design, and eventual implementation of a national system of 'Ecological Function Conservation Areas' (EFCAs). Our focus is on supporting the design of this system of priority areas that will inform conservation and development planning (Fig. 1, 2). At one of our key pilot sites, our local team is working with county-level government on master planning to improve zoning for development -- a major issue in China right now -- by integrating EFCAs into the zoning plan. We are also conducting socio-economic studies to understand the economic and social impacts of ecosystem service payments at the household level, especially for poverty alleviation (e.g., Li et al., in review; Liang et al., in review; Tai et al., in review). The results of these projects will be used by the government at several levels to refine policy and finance mechanisms, with the goals of achieving greater social benefit and avoiding unintended negative consequences.

In Colombia, planners are embracing ecosystem services from the local to the national level as well. We are working with the agriculture industry and local government to manage new water funds that direct payments from downstream water consumers to inhabitants of upstream watersheds, in exchange for changes in land management that are expected to improve water quality. This program is one of the first to consider the impacts climate change will likely have on water supply in the region. They are designing investments to target areas where water supply will likely be robust to climate change, setting the water fund up to act as a climate adaptation strategy. At the national level, the government is remaking their resource licensing and mitigation policy for all major infrastructure development in the country, including agriculture, energy, mining, and transportation. With help from our local partners, we are developing the framework they will use and applying InVEST to assess ecosystem service impacts and find places to target mitigation in a demonstration case for the mining sector.

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Success

There are many global efforts underway now to achieve the vision of the MA: DIVERSITAS, IPBES, PECS, and TEEB, to name a few. Though they make up an alphabet soup of inter-governmental, multi-lateral efforts, they hold real promise for changing the way people and institutions take resource decisions. We are working to tie NatCap efforts to these global initiatives to help drive changes in the way everyday projects are designed and policies are made at all levels of government and in the private sector. The main goal is to get people thinking regularly about ecosystem services as part of the direct cost or benefit of every decision. It is our hope that this will be as routine and easy to understand as our daily weather forecasts. Nations will be building infrastructure, catching fish, developing energy, growing food, and harvesting timber in ways that minimally impact biodiversity and ecosystem services. When there are impacts, people will provide offset payments for conservation of natural capital elsewhere. In response to feedback from policy leaders, new basic research will be launched to address some of their critical concerns, such as in the soil fertility, water quality, health and poverty arenas. Mistakes will still be made, but in general the connections between nature and human well-being will be explicitly represented in a wide variety of decision support tools, web-based tradeoff calculators, and government and business practices. In the world we are working towards, decisions will likely still be all about the bottom line, but pursuing the bottom line will no longer be a race to the bottom.

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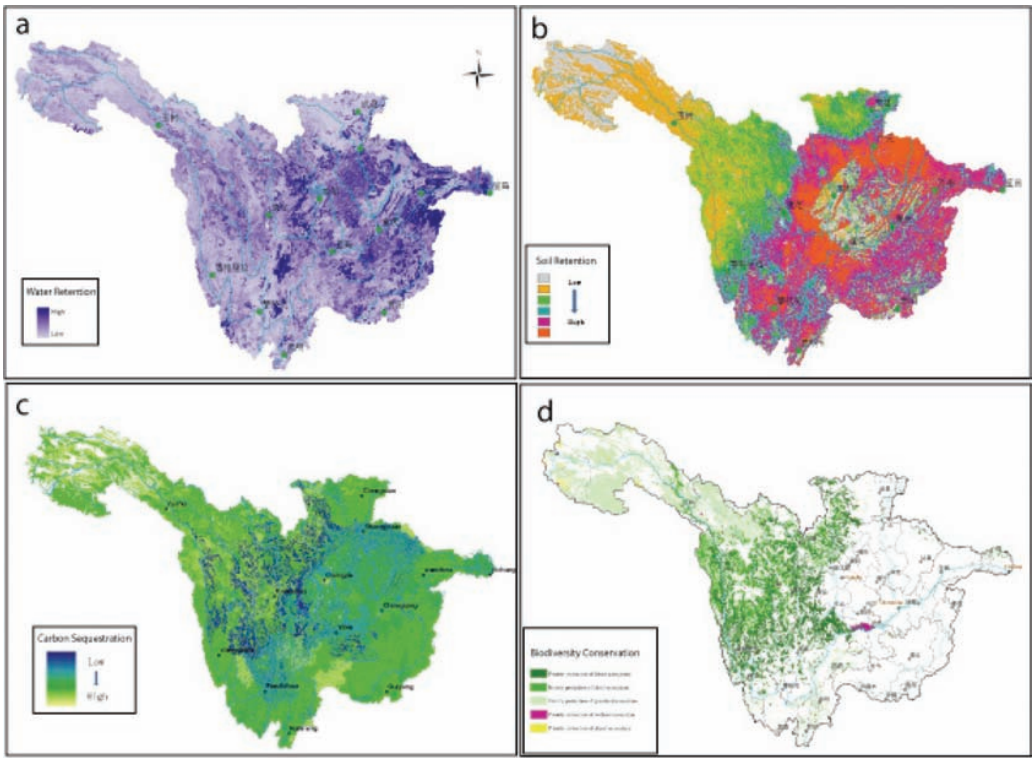

Figure 1 (Tallis et al). *Application of InVEST to the Upper Yangtze River Basin (UYRB) in China. The upper basin of about 1 million km² feeds water into one of China's major agricultural regions that produces 35% of the nation's grain. This upper region is undergoing rapid change as a result of the rapidly growing Chinese economy (10% per year for the last 20 yrs), affecting the 400 million people in the Yangtze River Basin as a whole. We are using InVEST to map critical ecosystem services, including (a) water retention and (b) soil stabilization to overlay with (c) carbon sequestration and (d) biodiversity priorities developed with other tools for the region.*

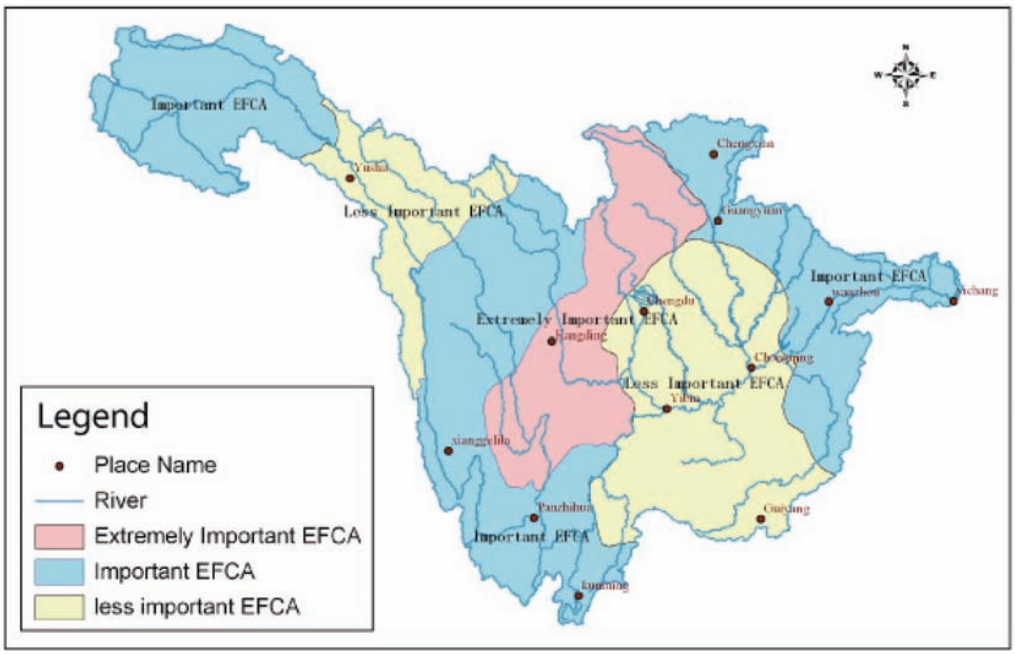

Figure 2 (Tallis et al). *Map of the priority Ecosystem Function Conservation Areas for the Upper Yangtze River Basin, China, based on an integrated assessment of ecosystem service provision and value.*

Ecosystem Services and the Ecosystem Approach

The Location and Conservation Status of Habitats Important for Providing Multiple Ecosystem Services

Paul R. Armsworth

Conservation strategies and land use policy discussions increasingly are framed around ecosystem service concepts, where the phrase ecosystem services refers to the flow of life sustaining and enhancing goods and services that ecosystems provide to society. The UK Population Biology Network (**www.ukpopnet.org**), an ecological science network funded by the Natural Environment Research Council and Natural England, funded a research project that aims to develop the science base for studies of ecosystem services in the UK. The project is premised on data resources on which studies of ecosystem services can build being relatively rich in the UK compared to other regions.

The first results from the project focus on mapping biophysical variation in the extent to which habitats across the UK support different ecosystem services (carbon storage, agricultural production, recreation, and maintaining biodiversity – which both plays a role in supporting other ecosystem services and in some circumstances is considered a service in its own right.) Ongoing work is integrating available data and hydrological models to include services tied to freshwater quality and quantity.

Early results were reported in two publications in Summer 2009. Anderson et al. examine spatial covariation in the provision of different ecosystem services across the UK. Many writings on ecosystem services hold out hope for discovering policy win-wins whereby protecting a specific habitat will provide simultaneous improvements in multiple ecosystem services. However, Anderson et al.'s results suggest scope for such win-wins will be rather limited. Pairwise correlations of ecosystem services revealed mostly weak or negative correlations among habitats important for providing different services and there was little overlap in locations identified as "hotspots" for individual services.

By exploiting the comparative richness of the data available, Anderson et al. were able to test how sensitive their findings were to the spatial resolution and extent of the data available. One of the most striking results was their discovery of pronounced regional variation in correlations among ecosystem services, suggesting that simple generalities about these relationships may prove hard to come by.

Taking a different tack, a second study by Eigenbrod et al. (2009) examined how effectively the existing conservation infrastructure in England, as represented by the network of protected areas, protected landscapes and agri-environment schemes, is positioned to protect habitats important for providing different ecosystem services. This network has developed gradually as different elements have been added, each to meet specific policy goals, but the network is now relied upon to provide diverse goods and services that may differ from those that it was originally designed to protect.

Eigenbrod *et al*'s study revealed that the existing network of protected sites was situated well to provide some ecosystem services, but very poorly for improving delivery of others. Protected sites in England are situated preferentially in upland areas and cover carbon rich peaty soils. Sites enjoying statutory protection (including Local Nature Reserves, National Nature Reserves, Special Areas of Conservation, Special Protection Areas, Sites of Special Scientific Interest and Ramsar sites) are positioned particularly well to deliver the biodiversity benefits. But recreation benefits, which depend on proximity to population centres, are less well-provided by these existing conservation measures.

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Policy

Science-Policy Interfaces: a Crucial Component of the Ecosystem Approach

Sybille van den Hove

The governance and management of our relationships with complex environmental systems (which, by definition, include the socio-economic and cultural human systems that are at the source of many pressures bearing on ecosystems) requires a 'paradigm shift' (Olsen *et al.*, 2006) moving from sectoral and piecemeal tactics towards more holistic approaches. Such a paradigm shift underlies current efforts at all levels to move towards ecosystem approaches to environmental governance.

Many definitions of the ecosystem approach have been put forward. In the framework of the Convention on Biological Diversity (CBD) for instance, it is defined as: "*a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. […] It is based on the application of appropriate scientific methodologies focused on levels of biological organization, which encompass the essential processes, functions and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of ecosystems.*"[3] Whichever the definition chosen, the ecosystem approach strives to account for the interconnectedness of ecological processes and socio-economic processes. It is a both a heuristic and a policy tool through which we endeavour to grasp the complexity of our relations to the environmental system of which we are a part, in an attempt to render these relations more sustainable.

A necessary condition for the implementation of the ecosystem approach is the existence of, and access to, relevant knowledge. This includes natural science knowledge about ecosystems, social science knowledge about societies, and interdisciplinary scientific knowledge about the socio-ecological systems. But it also includes other types of knowledge that are not necessarily of a scientific nature: local, indigenous, political, moral and institutional knowledge.

The above indicates that, by its very nature, the ecosystem approach belongs to the intersection between the scientific and the policy realm. Science and policy are intersecting and coevolving domains of human activity. To address ('manage') this intersection between science and policy and the problems it poses, some processes are implemented—spontaneously or not—which happen precisely at the intersection and which I call 'science–policy interfaces'. Science-policy interfaces are defined as social processes which encompass relations between scientists and other actors in the policy process, and which allow for exchanges, co-evolution, and joint construction of knowledge with the aim of enriching decision-making (van den Hove 2007). These considerations hint at the importance of effective science-policy interfaces to support the development and the implementation of an ecosystem approach. More precisely, such science-policy interfaces are crucial to support both policy and research, because: (i) they allow for the exchange and co-evolution of scientific and policy knowledge, and the inclusion of other types of knowledge; (ii) they facilitate the timely translation of research into policy advice and contribute to the early use of research results in practice; and (iii) they ensure strategic orientation (and funding) of research to address societal issues and in support of policies.

There are still many discussions about what an ecosystem approach entails and how it should be implemented in practice. Because of the co-evolution of science and policy, the answer to these questions –in general and in each specific case, at whatever level of governance– will not come from research alone, nor will it be found only in the policy domain. In this context, science-policy interfaces are particular places (processes) where ecosystem approaches can be defined and designed and where practical experiences can be exchanged and reflected upon, in the spirit of adaptive management. And, as stressed above, the interfaces are also components of the ecosystem approach itself, where the different stakeholders will jointly construct and exchange the information to support this approach. This includes for instance information about biodiversity, ecosystems and their abiotic environment; ecosystem functions; ecosystem services; human activities; anthropogenic impacts, including synergetic effects; thresholds and tipping points; scenarios of evolution of the socio-ecological system in question; values; behaviour; institutions; etc.

To support the development of the ecosystem approach, it is not one science-policy interface that is needed but a multiplicity of processes, which can operate at different levels or across them, which can be closer to either the policy or the scientific process, which can be more or less formal and institutionalised, and which operate at different stages of

3 http://www.cbd.int/ecosystem/ (accessed December 2009)

the research and/or of the policy process. Many of these interfaces are intertwined or embedded in one another. Some already exist, some need to be invented or re-invented to better fit the needs of an ecosystem approach.

Thus a key challenge of any ecosystem approach lies in the proper functioning of the necessary science-policy interfaces. Of course the devil is in the detail of setting them up in practice. A first step is the recognition of their importance to ensure that they will be included from the outset in the design and the implementation of the ecosystem approach. As for the design itself, there is no silver bullet, no one size fits all science-policy interface, hence creativity, openness, adaptability and humility are of the essence. In particular, actors from both sides of the science-policy intersection will need to constantly reflect upon, and often reinvent, their respective roles.

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Ecosystem Services – Strong Allies to Promote Biodiversity Restoration in Peatlands

Aletta Bonn

The concept of ecosystem services has taken conservation by storm. Not only is the scientific literature proliferating, but UK policy and practice is quickly adopting the ecosystem service concept (see John Hopkins, this issue). In fact, ecosystem service arguments are becoming strong allies in promoting biodiversity conservation on the ground. How does this work in practice? Taking the case of UK peatland restoration, four key points come to mind. While peatland restoration focuses primarily on biodiversity targets, incorporating ecosystem services brings added value by (1) facilitating and broadening partnerships, (2) opening up new sources of funding, (3) developing understanding and focusing research, and (4) informing policy.

(1) By communicating the relevance of ecosystem services of peatlands, we can broaden the scope of peatland projects, bring more players to the table and facilitate cross-sectoral involvement of stakeholders. Peatlands play a pivotal role in climate mitigation as the UK's largest terrestrial carbon store, equivalent to *circa* 20 years of UK CO_2 output (Worrall, pers. comm.). Restoration can safeguard these carbon stores, reduce emissions and potentially enhance long-term green house gas sequestration. Furthermore, upland peatlands are source habitats for about 70% of UK drinking water, and restoration may improve freshwater quality and aid flood mitigation. In addition, the majority of peatlands are designated as National Parks or Areas of Outstanding Beauty, and restoration may enhance recreational experience and maintain the historic environment. Management for food provision and field sports may also profit from restoration.

Discussion on multiple benefits of peatlands with stakeholders at Sustainable Uplands, RELU/Moors for the Future event (photo: M Reed)

This widening of the horizon of peatland restoration beyond biodiversity targets has increased the understanding and awareness that their protection and enhancement is relevant to people, locally and nationally. Thereby, multiple policy targets and business interests are addressed, such as

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climate change goals, water quality interests, Water Framework Directive, Soil Strategy and various public service agreements (PSAs). This has enabled new public-private partnerships between local and national government (e.g. County Councils, National Park Authorities, Welsh Assembly), government agencies (e.g. Natural England, Environment Agency), NGOs (e.g. RSPB, National Trust, Moorland Association), water industries as well as private land managers and owners in several major landscape scale restoration projects across the UK. These include the Exmoor and Dartmoor Mires-on-the-Moors restoration project, Flow Country, Lake Vyrnwy LIFE project, Moors for the Future, Peatscapes, SCaMP, Yorkshire Peat Project, and others. As Koontz & Bodine (2008) identify, cultural and socio-political factors can form the greatest barriers to ecosystem management, not necessarily scientific or technical knowledge. Therefore, by identifying benefits of peatland restoration to a range of ecosystem services for people, these landscape restoration partnerships have helped to channel energies, overcome differences and align goals to form collective visions to promote peatland restoration action and change.

2) Adopting the ecosystem service concept has also facilitated additional funding through partnerships and developed new finance avenues. While core peatland restoration funding is still mainly targeted to fulfill biodiversity goals, especially the PSA target to bring 95% of the area of Sites of Special Scientific Interest (SSSIs) in England into favourable or recovering condition by December 2010, between 10-50% of the project funds of the above named projects is derived from organisations with business interests or primary targets other than biodiversity conservation, such as water companies, Environment Agency and others. The joint partnership has also triggered core match funding to attract successful multi-million grants from the Heritage Lottery Fund or EU LIFE projects. Other possible finance tools could include voluntary carbon reduction markets with verification programmes and discussions by several projects underway (see also Worrall et al 2009) or corporate social responsibility (CSR) schemes, such as started by the Cooperative Bank supporting *Sphagnum* propagation for peatland restoration through the Moors for the Future partnership. As Goldman et al (2008) discuss, ecosystem service projects can support biodiversity and diversify options. The authors argue that this additional funding does not draw down limited funding resources for conservation, but, in contrast, rather engages a more diverse set of funders.

3) The ecosystem service concept has also encouraged strong links between restoration projects and academic research to develop understanding of provision and quantification of ecosystem services. Strong synergies between restoration for biodiversity and ecosystem services, especially regulating and cultural services, such as carbon storage, seem intuitive and have been shown for a range of ecosystems (e.g. Chan et al 2006, Rey Benayas et al 2009). However, evidence is still limited and scattered. Depending on spatio-temporal scales and types of restoration, relationships may be noisy, non-linear or include trade-offs. To strengthen the evidence base and justify restoration for multiple benefits, many projects are actively engaging with universities and aim for more rigorous monitoring to develop best practice. However, there is still a long way to go. Demonstration projects by Defra, Environment Agency and Natural England, a Scottish government peatland research review, and significant activities in Wales are underway. Here, developing focused research through active communication and two-way learning early on between practitioners, researchers and funders is needed to facilitate successful moves forward.

Upland peatland (photo: B Wilkinson, Moors for the Future)

While monitoring restoration success for biodiversity and ecosystem services can take years and decades, modelling approaches can help to understand change. Stakeholders of the above peatland restoration projects have actively engaged in research projects, e.g. the 'Sustainable Uplands' or 'Hill Farming and Biodiversity' RELU consortia, UKPopNet or the recent Defra Peat Ecosystem Services phase I project, to jointly develop scenario based approaches to evaluate future change. These have increased understanding on both sides and first results are incorporated into practical adaptive management. The current UK National Ecosystem Assessment (NEA) should also provide a strong basis to fuel science programmes, as well as steer practical conservation and restoration, also for peatland habitats.

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4) Finally, the ecosystem service concept can inform policy and highlight cases for potential payments for ecosystem services. The new cross government 'Natural Environment' PSA 28 target (Public Service agreement) and the inception of Natural England as a new government body in 2006 are testament of this policy change to adopt an ecosystem approach in all environmental decision making. Biodiversity targets remain strongly relevant and seen in context with other aims such as soil, water and air quality, recreation and food production. This cross government commitment is encouraging, especially as policy – in particular agricultural policy (Condliffe 2009) – and distortion of markets towards provisioning services, have been drivers for overexploitation and degradation of peatlands in the past. It will now be important to develop robust measures to allow sustainable management and conservation of peatland biodiversity and ecosystem services to become mainstream.

Nonetheless, it may be wise to keep both concepts of biodiversity and ecosystem services in part separate and complementary. Despite the benefits of the ecosystem service concept discussed above, there are concerns that concentrating on utilitarian values of ecosystems might overshadow biodiversity conservation aims. Subsuming all aspects of biodiversity within the ecosystem service concept was not seen as useful by stakeholders in several recent workshops, as some intrinsic or supporting qualities may be hard to capture.

In summary, UK peatland restoration programmes are readily adopting the ecosystem service concept, as restoration is likely to offer win-win solutions to improve biodiversity and supply of ecosystem services, broaden engagement by stakeholders, foster new partnerships and develop novel funding avenues. There is a strong call to the science, policy and practice community to support this now with targeted research, rigorous monitoring and two-way knowledge exchange, so that this new alliance is built on strong foundations.

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Views expressed in this article are those of the author and do not necessarily reflect those of the organisations or partners.

The New Conservation Paradigm: Climate Change, Ecosystem Services, Economics and Humanity

John Hopkins

Since the inception of Natural England as the government's new statutory natural environment advisor for England in October 2006 I have been surprised to find myself involved in what I think is the most significant shift in conservation policy and practice for several decades. I have used the overworked term paradigm here to describe this change, as the ongoing process relates not only to a shift in ideas but also gradually the development of new decision making principles. To my mind this conforms to Kuhn's (1970) broad original concept of paradigm, albeit in a policy context. Ecosystem services are a part but not all of the new paradigm, so I am taking a wider view here to put them in context.

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To interpret this change an understanding of the established approach to conservation is required. I suggest, somewhat simplistically, this is characterised by two fundamental principles. Firstly, conservation objectives have been largely set to maintain the ecological *status quo*. If an improvement in biodiversity is decided upon this often aims to restore a past condition by historic bench marking. The second principle is that conservation activity is an intrinsically valid goal for society to pursue. The utilitarian benefits of conservation activities have not normally been a consideration in policy or resourcing in developed economies.

Confidence in our ability to maintain current or past conditions has been shaken by the widespread evidence that climate change is unavoidably driving change in the abundance and distribution of species (e.g. Hickling *et al.* 2006; González – Megías *et al.* 2008). On the coast sea level rise and subsequent losses of intertidal habitats provides a clear UK example of irrevocable ecosystem level impacts of climate change (Natural England 2008). Maintaining the *status quo* for all species and habitats or a return to historic conditions seems no longer practical in the long term. There is therefore a need for a new focus upon the management of nature which does not close-off future prospects for high levels of biodiversity. We need to consider possible future states of the natural environment and the alternative paths towards them.

But other non-ecological factors powerfully drive a future orientation in environmental thinking. We can anticipate with some confidence global population growth, less certain energy and food supplies, water shortages and the gradual exhaustion of many natural resources, not least mineral phosphate which underpins current high levels of agricultural production. These pressures are being taken increasingly seriously as their effects become apparent. For example between 2004 and 2007 the area of oilseed rape grown in the UK for biofuel increased twenty fold to 240,032 ha. (National Non-Food Crops Centre 2009); and over-abstracted ground waters already occur in parts of central and northern England not just the dry south east (Environment Agency 2009). Conservation planning needs to think forwards to anticipate and address these issues if we are to find space for nature in a future of greater resource competition.

The publication in 2005 of the *Millennium Ecosystem Assessment* therefore introduced the concept of ecosystem services to an audience of policy makers in which resource competition and multi-functional use of land and water was becoming a prominent issue. This resulted in a dramatic increase in the use of the term in policy documents. From a conservation perspective this interest is largely because ecosystem services analysis supplements the ethical case for conservation (which remains valid and widely supported in the UK and EU – see European Commission, 2007). We have begun to explore more systematically the reality that protection of the natural environment also provides a range of public and private benefits as diverse as engendering mental and physical health, crop pollination and coastal flood defence. Previously environmental protection has been seen only in terms of cost. Ecosystem service analysis opens the prospect of seeing the natural environment as an integral part of society and the economy and emphasises the reality that whilst the natural environment can exist without the economy, the economy cannot exist without the natural environment (Natural England 2009).

A logical corollary of this new emphasis upon ecosystem services is a need to quantify the ways in which they contribute to human well being. I spend increasing amounts of my working with government economists, and economic analysis is a significant component of the paradigm shift in conservation. Further, it takes only a quick look through back issues of *Ecological Economics* and other environmental economics journals to see that the development of the ecosystem services concept has significantly been in the hands of the economists and their interest reaches back well before 2005.

For better or worse public policy has so far been much more influenced by economists than ecologists and I see this greater emphasis on economics in government as a significant sign that environmental issues are being taken more seriously. However considerable challenges remain in developing economic methods which can adequately capture the non-market value of most ecosystem services and integrating the findings of environmental scientists into economic analysis, given very little environmental research has been carried out with the support of economic valuation in mind. The lack of engagement between economists and ecologists is currently a major impediment to progress and on Natural England business I often find myself the only natural scientist in a room of economists.

I believe the small but growing interest in social and psychological processes in environmental decision making will play a significant future role in completing the paradigm shift. As scientists we have trained ourselves in the analysis and interpretation of data. From this perspective the quantitative outputs of economics look to be a rational basis for decision

making. But we are tackling Anthropocene problems with Palaeolithic minds. Our inability as a species to perceive risk in terms of objective data is notorious and has a profound impact upon policy decisions by democratic governments. Similar subjectivity plays a major role in shaping attitudes to the environment as well, and so influences decisions about its management. Understanding the interplay of social and psychological factors which influence attitudes and behaviour is much needed if ecological research is eventually to have full impact (Clayton and Myers 2009).

Despite much recent discussion of ecosystem services and other elements of the new conservation paradigm it is difficult to find good examples of changes on the ground which incorporate the new thinking. This requires that the above elements are brought together in one place in a spirit of co-operation. To explore new ways of working, in November 2009 Natural England launched with a range of partner organisations three ecosystem services upland pilot areas (South Pennines, South West Uplands and Bassenthwaite) where we aim to explore what can be achieved within the new paradigm. Over time we have an ambition to expand this work to other ecosystem types and apply the lessons learnt to the rest of our work.

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Understanding Nature's Value to Cociety in the UK

Lucy Simpson

The UK National Ecosystem Assessment (NEA) provides the first analysis of the UK's natural environment in terms of the benefits it provides to society and continuing economic prosperity. Launched in May 2009, the UK NEA reached its first milestone in February, publishing on the website **http://uknea.unep-wcmc.org/** an update on progress and looking forward to the next steps. Presently, draft main findings on the status and trends of ecosystems (broad habitats) and ecosystem services (the benefits such habitats provide) in the UK over the past 50/60 years are being drawn together. A preliminary peer review of the draft chapters by various working groups, in January, has provided valuable input into the writing process.

Ecosystem services, the "benefits provided by ecosystems that contribute to making human life both possible and worth living" (MA, 2005), have become a hot topic in both scientific and political spheres. In 2005, the global Millennium Ecosystem Assessment (MA) highlighted the importance of ecosystem services to human well-being and recognized that many ecosystem services are in decline, being degraded and even lost. In response, the House of Commons Environmental Audit in 2007 recommended the Government carry out a full MA-style assessment for the UK to help identify and develop effective policy responses to manage ecosystem service

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degradation (House of Commons Environmental Audit, 2007).

A key feature of the two-year long assessment is that it is an inclusive process involving many government, academic, NGO and private sector institutions. Co-Chairs, Professor Bob Watson (Defra's Chief Scientific Adviser) and Professor Steve Albon (Macaulay Institute), are leading the assessment. Professor Watson brings to the NEA process his invaluable experience from Co-Chairing the MA and the Intergovernmental Panel on Climate Change (IPCC). A diverse group of academics – consisting of natural scientists, economists and social scientists – form the 27-member Expert Panel, providing expertise in all focus areas. The two hundred strong author team, managed by a group of Co-ordinating Lead Authors, includes scientists, economists and social scientists. These authors are drawn from a wide range of academic institutions, together with representatives from government agencies and NGOs. In addition, consultations with and involvement of a wide range of public and private sector decision-makers and stakeholders through a User Group help to shape the assessment process and ensure that the outputs will be relevant for different audiences. The organisations that commissioned the UK NEA – Defra, the devolved administrations of England, Northern Ireland, Scotland and Wales, together with some of the research councils – are providing guidance and oversight via the Client Group. Co-ordinating all the different assessment activities is an independent Secretariat, provided by the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC).

The UK NEA will create a compelling and easily understood explanation of the state and value of the UK's natural environment and ecosystem services. The assessment will be valuable to institutions and individuals to raise awareness of the importance of ecosystems and the services they provide to society. The final report (available February 2011) will include plausible futures, economic analyses and response options for policymakers and will assist in strengthening decision-making both at the local and national levels. The UK NEA will address twelve research questions (see Box 1.) and consider multiple spatial scales at the UK, country and catchment levels to ensure policy-relevant information is produced. The assessment will help to embed the concept of ecosystem services and the ecosystem approach in the minds of decision-makers at all scales from landowners to local government to companies to national administrations.

Box 1. Key questions the UK NEA will be addressing:

1. What are the status and trends of the UK's ecosystems/broad habitats and the services they provide to society?
2. What are the drivers causing changes in ecosystems/broad habitats in the UK and the services they provide to society?
3. What are the uncertainties, and knowledge/data gaps for understanding, monitoring and managing, including restoration, of ecosystem services in ecosystems/broad habitats in the UK?
4. What is the current knowledge and understanding of ecosystem services in the public sphere?
5. How have changes to ecosystems/broad habitats affected human well-being in the UK?
6. Who and where are the beneficiaries of current ecosystem services in the UK?
7. How does the location of beneficiaries of ecosystem services affect how the ecosystem services are valued and managed?
8. How might ecosystems and their services in the UK change in the future under plausible scenarios?
9. What are the future possible effects of changes in ecosystems on human well-being and who might be most affected?
10. What are the policy options to secure and improve the continued delivery of UK ecosystem services under plausible future scenarios?
11. What are the key ecosystem services upon which the UK depends that are not provided by UK ecosystems and what ecosystem services does the UK supply to other countries?
12. What are the policy implications of UK-dependence on non-UK ecosystems?

The UK NEA will also, it is hoped, influence academia. It will inform ecological research in several ways. Firstly, it will provide a unique synthesis of what is currently known, by collating existing information on ecosystems and ecosystem services and exploring the interlinkages between habitats, ecosystem services and biodiversity. In the assessment, terrestrial, marine and freshwater ecosystems are presented as eight collections of broad habitats, such as Enclosed Farmland (comprising arable, horticulture and improved grassland) and Woodland (comprising broadleaved and coniferous woodland). These broad habitats are recognised by national habitat reporting systems (for example, UK BAP) to aid sharing of data. The UK NEA will build on previous assessments such as the Countryside

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Survey by placing ecosystem services in the spotlight and focusing attention on how our natural ecosystems support their provision. Equally as important as highlighting what is known is to recognise what is not. Each habitat and ecosystem service chapter will identify knowledge gaps that will inform the Living With Environmental Change (LWEC)'s research agenda. As part of the LWEC initiative (**www.lwec.org.uk**), the UK NEA will provide new information on the UK's changing natural environment. Finally, the UK NEA aims to foster better inter-disciplinary co-operation between natural and social scientists and economists in order to enhance communication and understanding for future collaborations.

The UK NEA is broadly following the MA methodology (Ash *et al*. in press), which focused on linkages between ecosystem services and human well-being and the influence of direct and indirect drivers of change. It has been adapted for a UK context and has incorporated developments from recent studies, including post MA reviews, such as Carpenter et al. (2009), and The Economics of Ecosystems and Biodiversity's (TEEB) *Scoping the Science* report (Balmford *et al*. 2008).

There are a number of ways that interested parties can become involved with the UK NEA. For example, by participating in one of several stakeholder workshops that will be taking place throughout the UK in 2010. Also, by reviewing the draft outputs; draft chapters of the final report will be available to download from the UK NEA website in May 2010. Alternatively, in the final stages of the assessment the UK NEA Secretariat will be looking for organizations to communicate the results of the UK NEA to a range of different user groups. Please contact **nea@unep-wcmc.org** to express your interest in getting involved with any of the above.

For more details on the UK NEA please see **http://uknea.unep-wcmc.org/**.

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Lucy Simpson is a member of the UK NEA Secretariat that co-ordinates the assessment. The UK NEA Secretariat is housed within the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC; **www.unep-wcmc.org**) in Cambridge.

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The Natural Capital Initiative

Rosie Hails, Laura Bellingan, Ceri Margerison, Paul Leonard, Jim Harris, Laura Sutcliffe, Bruce Howard (corresponding author), Barbara Knowles

While the current economic crisis has focused attention on the state of global financial capital, it is vital to highlight and champion the stewardship of the natural capital provided by ecosystems that we so often take for granted. Significant shifts in the balance of the natural environment could have more devastating consequences for human welfare than alterations in the balance of financial markets alone.

The Millennium Ecosystem Assessment highlighted the severe degradation of 60% of the world's ecosystems, and stressed the need for a more sustainable approach to human social and economic development. In particular, it promoted the use of an 'ecosystem approach' as a guiding framework to achieve this. The ecosystem approach is a holistic strategy for the integrated management of land, water and biodiversity to promote conservation and sustainable, equitable development practices. It has the potential to transform public policy and business practice so that services provided by the environment are taken into account and suitably protected.

The Natural Capital Initiative (NCI) was created to stimulate and support the development of policies which will deliver good ecosystem management and grew out of a realisation that the co-operation and communication of multiple sectors is vital for success. It is a partnership between the Society of Biology, the Centre of Ecology and Hydrology, and the British Ecological Society and is guided by a diverse Steering Group under the chairmanship of Prof Rosie Hails MBE with experts from the fields of environment, health and economics. The UK Government has already taken steps to promote adoption of an ecosystem approach. NCI fully supports this policy, we hope that it will remain at the heart of government policy into the future and we will work with key Departments and individuals towards its delivery.

The NCI draws together business, public bodies, science and humanities researchers, economists and the public to deliver policy-relevant outputs in support of new ecosystem approach practices. Its activities are designed to

- create a forum for debate that is independent and inclusive;
- identify gaps in science, policy and its implementation and facilitate the debate about how to address these gaps;
- liaise with and advise other key government and research council initiatives, and
- engage the public with the ecosystems approach.

The initiative was launched in April 2009 with a three-day symposium entitled 'Valuing Our Life Support Systems' which explored principles and practices in assigning value to ecosystem services and the process of decision-making. The event involved over 250 people from organisations spanning the range of multinational businesses to non-profit conservation groups. On the first day, participants had the opportunity to discuss presentations by speakers including Professor Bob Watson (Chief Scientific Advisor, Defra), Professor Lord May of Oxford (Climate Change Commission), Professor John Beddington (HM Government Chief Scientific Adviser), Sir Graham Wynne (RSPB), Helen Phillips (Natural England) and Lucy Neville-Rolfe (Tesco plc). The discussions generated some clear messages for policy makers, planners, business leaders, and researchers, including a call for greater integration of environment and economics, involvement of the Treasury and improved cross-departmental planning by government. It was clear that new tools are needed to support an ecosystem approach in decision-making. Workshops on the following two days discussed rural land use, the urban planning systems and sustainable use of the marine environment. A report with recommendations[1] was published and is available on the NCI website at **www.naturalcapitalinitiative.org.uk** and the meeting was described by Holt and Hattam (2009)[2] (and see BES ***Bulletin*** 40(3):29 (August 2009) for meeting report).

In June a public discussion event on 'Sustainable Cities' was held at the British Library (BL). This event, which was organised by NCI in conjunction with the Science Council and BL, brought together key figures including the former Mayor of London, Ken Livingstone, researchers and planners and members of the public to discuss what 'greening' a city like London might mean in practice. Discussion panel members posted their thoughts on challenges for sustainable development and scientific support of policy development on YouTube[3] and an animated audience discussion proved the centrality of these topics in public concern.

In addition to the events run to date, the NCI is assisting with the groundbreaking UK National Ecosystem Assessment. This assessment of the nation's natural capital will inform public policy into the future and assist in the accounting of

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ecosystem services in decision-making. As part of our public engagement activities Prof Paul Leonard participated in the Earthwatch Institute debate 'From Tsunami to Drought' in December and in January 2010, Prof Rosie Hails will lead a public discussion on the role of GM technology in global food security as part of BL's 'TalkScience' series. We are delighted that Dr Bruce Howard will be joining CEH as a full-time project manager for the NCI from Feb 2010.

Over the next three years, much of the Initiative's work will remain focused on drawing together diverse groups of experts around particular challenges to advance the ecosystem approach. In the short term these will respond to the key issues raised at the Valuing Our Life Support Systems symposium. Events will examine the integration of economics into conservation including the economic valuation of biodiversity and potential practices such as habitat banking, the links between social and natural capital, and those between human health and ecosystem services. In these endeavours we will collaborate with the Government's Foresight Project on Land Use Futures, the Living with Environmental Change (LWEC) programme, and assist in tackling issues already in the public policy arena, such as recasting of biodiversity targets following the passing of the 2010 goals of the Convention on Biological Diversity and reform of the EU Common Agricultural Policy.

The NCI runs an active website with information and resources on previous and forthcoming events, as well as related news items and information – we would like to encourage you all to communicate and become involved in protecting the value of our natural capital.

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Rosie Hails chairs the Natural Capital Initiative steering group and is a Section Head at the Centre for Ecology & Hydrology, which is funded by the Natural Environment Research Council. As well as conducting basic research she has worked at the interface between science and policy as a member of the Agriculture and Environment Biotechnology Commission, the Advisory Committee on Releases to the Environment, and the Environment Working group for the European Food Safety Authority.

She is a Fellow of St Anne's College, Oxford, a research associate of Oxford University and a visiting professor at Oxford Brookes University. She was awarded an MBE for services to environmental research in June 2000.; Dr Laura Bellingan Deputy Head of Science Policy at the Society of Biology; Ceri Margerison is Policy Officer at the British Ecological Society; Professor Paul Leonard is an Environmental Consultant; Jim Harris hold a Chair in Environmental Technology, Cranfield University; Laura Sutcliffe is a Policy Intern at the Centre for Ecology and Hydrology; Dr Bruce Howard (corresponding author, Email: brwa@ceh.ac.uk) is NCI Project Manager at the Centre for Ecology and Hydrology, Maclean Building, Benson Lane, Crowmarsh Gifford, Wallingford, Oxfordshire OX10 8BB; Dr Barbara Knowles is Senior Science Policy Adviser to the Society of Biology

Personal perspectives

Making Ecology Relevant to a Complex World

Kai M. A. Chan

Ecologists across the world are striving to make their research relevant to broader society and to facilitate the transformative change necessary for sustainability. An increasingly common approach is to cast conservation and resource management problems in the concept of ecosystem services (the processes and conditions by which ecosystems render benefits for people, directly and indirectly). But all ecological challenges are ultimately social problems with social solutions, so how can ecologists best contribute? They can *do problem-oriented interdisciplinary research that transcends academia while also seeking to broaden our fundamental understanding of social-ecological systems.*

Of course, any new approach brings fresh challenges, and this one brings three sets (integrating disciplines, simultaneously

solving problems *and* deepening understanding, and transcending academia). Based on my experiences and observations with some of the world's experts in these areas, I discuss these challenges facing ecologists seeking societal relevance, and possible winning strategies.

Integrating Disciplines

A great deal has been written on *interdisciplinarity*. The social nature of ecosystem services, sustainability, and applied ecological problems in general demands the inclusion of social sciences alongside natural sciences (see Queenborough & Cooke, p57 this issue). This raises the challenge of communication across disciplines which includes translating dense vocabularies full of different meanings and connotations for shared terms, different and often contradictory fundamental assumptions and approaches, and theoretical frameworks where meaning is relative to those fundamental assumptions. Then there are the challenges of publishing and presenting work, and establishing and maintaining an additional set of relationships with people of different disciplinary backgrounds.

In my experience, the central challenge from which all solutions follow is good relationships between gifted communicators with groundings in different disciplines and an interest in collaborating. Such relationships are best built through social gatherings centred around food and drink (for which we share a common passion), interdisciplinary seminar series, and interdisciplinary co-teaching and co-supervision. Because they present repeated opportunities for substantial discussion across disciplines, co-teaching and co-supervision are especially fruitful relationship-builders. My co-teaching and co-supervision with Terre Satterfield has been most enjoyable and fruitful. Terre is trained broadly as an anthropologist and has worked extensively on environmental values, conflicts, and risks. Together we are working to infuse ecosystem-service research with a broader social sciences perspective (Chan, Goldstein et al. in press).

The obstacle of interdisciplinarity is much more substantial with problem-inspired research. When the problem is central, it is unlikely that the relevant disciplines have already been united in an interdisciplinary field. Fifteen years ago, researchers from ecology and economics came together in the study of ecosystem services, in part to improve cost-benefit analyses with more comprehensive environmental valuation. But the union of ecology and economics is not sufficient for many ecosystem-service problems, which demand the inclusion of other natural and social sciences. In forging such new interdisciplinary ground, it is all the more important that the research team is centred around a hub of scholars, each of whom is conversant in multiple disciplines. Such hub-scholars are crucial and often strained, as they must keep up with multiple diverse literatures and also serve as central translators and relationship-builders.

Solving Problems and Deepening Understanding

For research to provide both specific and general solutions—answers in a particular place and in many places—it must be both use-inspired and seeking fundamental understanding. As Stokes (1997) showed using Pasteur as once-living proof, such dual-purpose research is not impossible. It is however a challenge. Application of research results is constrained by the temporal and spatial scales of decision-making, the kinds of levers available to management, and the various foibles of management and governance systems and their use of science. Advancement of understanding is generally constrained by available methods, tools, and expertise. Accordingly, use- and understanding-inspired research implies *both* sets of constraints, which together can be stultifying.

At least in the short term, we researchers have much less control over the scales and constraints of decision-making than over the approach to research, so we're more likely to achieve both application and knowledge advancement by letting the decision context drive the research process. I propose the following sequence:

a. *Choose a problem area* (e.g., marine ecosystem based management, EBM, on the west coast of Vancouver Island),
b. *identify an important problem* in that area (e.g., management of recolonizing sea otters and regenerating kelp forests),
c. *identify the kinds of knowledge available* and the likely value to the decision of these kinds of information (e.g., habitat preferences and life history parameters of otters, kelp, and interacting species),
d. *identify knowledge gaps and the kinds of methods and tools necessary* to achieve that understanding (e.g., the prey preference of sea otters; distribution of kelp-derived nutrients, and effects on productivity and growth), and *only then*
e. *identify the methods and tools* to test particular questions (e.g., stable isotope tracking of kelp-derived nutrients and natural experiments of impacts on intertidal invertebrate and fish growth and productivity).

While this sequence might seem to put application before fundamental understanding, my experience is that such a process inevitably reveals unknowns of fundamental interest. Those unknowns may not be the 'hottest' from an academic perspective, but they are relevant to real-world decisions. A great deal of marine ecological research has been conducted on the west coast of Vancouver Island, but the above research on kelp and otters promises to contribute directly to regional marine spatial planning.

Such an approach requires highly flexible researchers who are able to learn and apply a wide range of techniques, and to integrate the resulting knowledge into a cohesive whole. But it does not require a super renaissance (wo)man who can do everything: the flexibility can be an emergent property of the group, with principal investigators (PIs) choosing students and co-supervisors or committee members for those students based on their ability to apply the appropriate approach. The PIs can then lead the integration of the various components—which may alone not be conducive to use by decision-makers—into the whole, and they can relate this whole to decision-making.

In practice, tradeoffs between application and fundamental insight often arise. The time scales of some decision-making processes prohibit any true advance of understanding beyond the site in question. It's no mystery that consulting contracts (those that require answers in weeks or months) are not generally known for their contribution to fundamental academic science. Everyone has to make these choices individually; I personally accept consulting projects if (and only if) the importance of the local decision process seems to outweigh any missed opportunities for me to contribute to a greater general understanding.

Transcending Academia

For research to be truly relevant to decision-making, we must generally *make it so* by transcending academia. The kinds of information that scientists are typically trained to provide are rarely the kinds demanded by decision-makers, and processes for integrating that information into decision-making are generally absent or constraining. Accordingly, it falls on concerned researchers to work with government agencies, non-governmental organizations (NGOs), politicians, corporations, etc., to fit into the context of existing processes and structures.

The challenges of this are unsurprising: transacademic researchers must learn new norms and cultures, and they must build and maintain new sets of relationships. Again, this is much more complex than it sounds, because the real world is messy (there's a reason many researchers prefer to remain in the ivory tower). With any culture, some of the most important rules and values are unwritten and invisible from inside and out: insiders take them for granted and outsiders can't disentangle them from the cobweb of unknowns.

I discovered this invisibility the hard way on my second contract with an NGO. My first contract had operated just like a grant from a funding council, but my second was starkly different in ways that I hadn't anticipated in terms of timelines, reporting requirements, stipulations, and means of communication. I didn't know what I didn't know, and of course the university's industry liaison office couldn't tell me that. I had the twenty-page contract, but it was all fine-print Greek to me. After making a handful of mistakes that seem easily avoidable in hindsight, my team had spent hundreds of hours on a project that the partner could have legally chosen not to pay for. Thanks to good relationships with the funders and good fortune, I escaped this unscathed.

Despite the above complications, it's relatively straightforward to supply the kind of answers that decision-makers seek, but generally this advances neither fundamental understanding nor transformative change towards sustainability. Achieving these two crucial goals in addition to being useful is a far more demanding prospect.

The case of ecosystem-based management (EBM) illustrates the difficulty of doing it all. The concept has been under academic development for decades now as synthesized by inspiring interdisciplinary books (Waltner-Toews, Kay et al. 2008; McLeod and Leslie 2009). However, case studies within reveal just how little correspondence there is between EBM as theory and EBM as practice (Chan, Gregr et al. 2009).

In keeping with the theme of people-as-central, the approach that I've seen work best is again relationship-building. The great transacademic EBM and ecosystem-service researchers I've seen have begun by identifying decision-making partners who share a desire for progress in decision-making and its use of science, and sufficient common ground to foster mutual respect and a personal connection. The partnership between Gretchen Daily's group and Hawai'ian public and private decision-makers is one great example of a relationship that has yielded social-ecological understanding and real-world solutions (e.g., Goldstein, Daily et al. 2006; Daily, Polasky et al. 2009).

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Conclusion

Real-world relevance all comes back to people. If we are to make ecology a science central to sustainability in this complex world (Palmer, Bernhardt et al. 2004, 2005), we should build networks of strategic and lasting relationships. As we simultaneously cross disciplines and academic boundaries doing use-inspired and insight-oriented research, our successes will only be as strong as our connections with decision-makers and other academics.

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Incorporating the Human Dimension into Ecosystem-based Management: the Good, the Bad, and the Ugly

Alyne E. Delaney

In recent years, steps have been taken towards realizing true marine ecosystem-based management (EBM) in Europe. Depending upon the disciplinary and cultural backgrounds, the importance and 'why' of ecosystem based management varies among individuals; mirroring work in biodiversity, ecosystem based perspectives on management can include issues of biological, economic, and sociocultural importance. We know, of course, the seas and oceans provide habitat for a rich variety of life, and when including coastal ecosystems, provide more than half the productive output of the global economy. Finally, aspects of marine biodiversity, landscape, and heritage, also feature highly in the preferences expressed by individuals in valuation surveys and stakeholder interviews. Though the 'why' varies considerably, there is little disagreement as to the challenges involved in successfully realizing ecosystem-based management. Inclusion of human dimensions adds to the complexity with not only differing

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cultural views on why people and society should be included, but also particularly with the 'how' it can be accomplished.

Shore biodiversity, Isles of Scilly

The Good

Generally speaking, there is consensus on the importance of managing the marine ecosystem holistically. Steps towards this end are being taken on a variety of levels. For example, in fisheries, the International Council for the Exploration of the Sea's (ICES) Advisory Committee on Fisheries (ACOM) has moved from providing single species advice to multi-species advice, and efforts at EBM are underway. A number of initiatives have been implemented along these lines at the EU level, including reform of the Common Fisheries Policy (currently under review), better regulation of the quality of water entering the marine environment (Water Framework Directive), and protection of biodiversity (Habitats Directive (HD); the 2006 Communication on Halting Biodiversity Loss). These, along with adoption of a European Marine Strategy (Marine Strategy Framework Directive) and the European Integrated Maritime Policy, show that marine and maritime issues have moved towards centre stage in European natural resource management. The EU is calling for a global approach to sustain the oceans while working closely with existing management structures such as the regional initiatives of OSPAR in the NE Atlantic and HELCOM in the Baltic Sea. The overall vision for the future of Europe's marine environment is one which seeks to maintain biodiversity and provide diverse and dynamic oceans and seas which are clean, healthy and productive. This sounds 'good' does it not? It does, but with a catch, bringing us to 'the Bad.'

The Bad

The 'catch' surrounds the human dimensions of EBM: how can the human dimension be included? And even if it is possible, is it valid to link humans with the ecosystem? The Goods and Services approach provides one way to include some aspects of the human dimension, though by the nature of the method, it tends to prioritize goods and services which are easily converted into a monetary value (such as fisheries and oil and gas extraction), leaving more intangible services such as heritage and cultural identity excluded. We use quantifiable data for ease of synthesis and analysis, and because it is difficult to integrate qualitative and quantitative data, yet by not including both, important pieces can be left out of the puzzle. We should recall that, as Einstein once said, "All that counts is not countable. And all that is countable does not count." The integration of varied methods and data will continue to be a challenge.

And then the question, should humans even be included in an EBM framework? As I have found from attendance at multidisciplinary conferences and workshops, there is a minority view that including humans and society into resource management is inappropriate. Related to this is a view by some that social scientists act as 'advocates' for (human) communities, which is therefore 'bad.' Coming from a background in human ecology, I work from the assumption that humans are a part of the environment and thus we must include them as a part of the ecological system. Also on the practical level, to paraphrase a number of fisheries biologists "you cannot manage fish, you manage people." Following this, one must account for human behaviour and needs into the management process. Achieving ecosystem-based management is not easy; ensuring it is successful is even less so. Including all aspects of the ecosystem into the process will pay dividends in the long run.

Lajes boats on Pico Island in the Azores

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And the Ugly

Achieving successful ecosystem-based management will not be easy and indeed could be considered quite messy. Integrating disparate types and volumes of data and indicators remains challenging and will take time to be achieved. One vital issue surrounds understanding the EU's fragmented system of governance and management of marine activities. The current system hinders, rather than helps, in the creation of an ecosystem focused approach. This results from a historical sectoral-based approach to marine management. A more holistic vision for European seas, which includes ecosystem based management, will require an overhaul of the management framework (such work will be undertaken in ODEMM, an EU FP7 project, Options for Delivering Ecosystem-Based Marine Management). Such an overhaul should, of course, protect resources, biodiversity and ecosystem functioning, but it should also work to ensure social, economic and ecological sustainability, and deliver economic and social well being at the same time. The 'ugly' here involves the fact that there is no single, streamlined, straightforward solution; rather, a number of steps must be completed with the long-term in mind. And the integration of disparate types and scales of data will continue to provide challenges. The rewards, however, are great, and this provides a wonderful opportunity for social and natural scientists to continue working together for the achievement of successful ecosystem based management.

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Embracing the Ecosystem Services Approach: Opportunities and Challenges

Jim Rouquette

Natural England's chief scientist has described the ecosystem services approach as a 'paradigm shift' in how we deliver environmental conservation. Government departments, conservation agencies and NGOs are falling over themselves to embrace ecosystem services and the ecosystem approach. The BES is engaging with the approach too, with special sessions on ecosystem services organised at the last three annual meetings and ecosystem services (ES) now established as one of its areas of policy priority. And the National Ecosystem Assessment is now underway within the wider ecological community. But despite all the talk, there are still relatively few ecologists actually reporting on projects that they have undertaken. So what is it like to undertake a project that uses ES and is it a useful approach?

I was given an opportunity to work as part of an interdisciplinary team investigating the potential for integrated management of lowland floodplains, funded by the Rural Economy and Land Use (RELU) programme. In these areas the needs of flood management, farming systems and biodiversity conservation all place potentially conflicting demands on the land. We assessed the ecological, hydrological and socio-economic impacts of current management practices at eight study sites throughout England, and attempted to model the impact of different management scenarios using an ecosystem services framework (Posthumus *et al.* 2010). Services that we investigated included, amongst others, agricultural production, employment, flood storage, carbon balance, water quality, habitats, species, transport, settlement, recreational use and landscape value.

The needs of flood management, farming systems and biodiversity conservation place potentially conflicting demands on the land. Photograph courtesy of G. Wilson Revill, Birlingham, Pershore

Another area of our research investigated how biodiversity can be valued and priorities set for different areas. We assessed the value of habitats projected to occur under each of our scenarios using seven different valuation methods (Rouquette *et al.* 2009). Three methods derived values based on pre-defined priorities (Ecological Impact Assessment method, reserve-selection criteria, target-based criteria), two

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used stated preferences of stakeholders (stakeholder-choice analysis, reserve-selection criteria guided by stakeholders), and two methods derived monetary values based on revealed (agri-environment scheme payments) and expressed (contingent valuation) preferences. The methods gave broadly similar results and were highly correlated, but each method emphasised a different aspect of conservation value, leading to different possible outcomes in some cases.

Was the ecosystem services approach useful? Without question the answer is a resounding "yes". The approach enabled us to identify synergies and trade-offs in the management of these multi-functional landscapes. Some were expected, such as the conflict between increased agricultural production and environmental outcomes. Other relationships were less obvious and may challenge commonly held beliefs. There is for example, potential synergy between short duration flood storage (to deliver benefits to urban areas downstream) and agricultural production. Contrary to popular belief, there is potential conflict between flood storage and biodiversity.

River Wampool. © Copyright Simon Ledingham and licensed for reuse under this Creative Commons Licence

By identifying the key drivers and sensitivities operating in and on our system, we were able to highlight the implications for the design and implementation (i) of hybrid or composite land and water management scenarios that would be beneficial and robust under a range of future possible conditions, and (ii) of policy and support regimes that will make such scenarios appealing to the main stakeholders, especially land managers, conservationists, flood managers and local communities. Modelling alternative land use scenarios in this way can support decision-making by policy makers and planners. It can also be used to inform discussions amongst stakeholders about options that can serve a range of different interests.

It is highly unlikely that these outcomes could have been achieved by taking a purely ecological perspective. Indeed one of the strengths of the ES approach, which ecologists and conservation biologists should embrace, is that it explicitly recognises the value of biodiversity and other often overlooked non-economic services. It is this approach that will enable the conservation of biodiversity to be integrated into wider issues of land-use, development and planning.

Adopting the ES approach does, however, present many challenges. By its very nature it requires an interdisciplinary approach with all the associated challenges of working across disciplines. It is necessary to be conversant with a wide range of subjects or certainly open to different ways of working; progress can at times be slow; there are challenges in getting this type of work published in predominantly mono-disciplinary journals (although that problem appears to be improving); and there is no obvious career path for early career researchers (see interdisciplinary research feature in BES ***Bulletin*** 38(3): 2-13 (August 2007) for discussion of challenges. See also Andy Clarke's article on p64 in this issue). There are also numerous technical challenges to overcome.

On a more personal level, working on ecosystem services has been tremendously rewarding. There are still very few studies completed in this area, so the work often feels trail-blazing and cutting-edge; there are certainly plenty of challenges to overcome and the work is amazingly varied. Work on ecosystem services requires a holistic approach, rather than the reductionist approach so often taken in science, which is refreshing. It's also interesting to work on the interface with policy and to see the obvious policy implications.

I am now working on a new project, but one that bears similarities to my previous work. I am working as part of the URSULA (Urban River Corridors and Sustainable Living Agendas, www.ursula.ac.uk) project at the University of Sheffield, which is carrying out a major investigation into an urban river system. The project is working under the premise that there are significant social, economic and environmental gains to be made by integrated and innovative interventions in urban river corridors. My role, as one of the ecologists on the team, is to investigate the ecology of the river across the rural-urban gradient, to integrate aspects of environmental

economics, environmental science and social science, and to predict the impact of a variety of possible interventions. I am hoping to employ the ecosystem services approach once again to gain fresh insights into this interesting topic.

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