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postnote

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ECOSYSTEM SERVICES

The natural environment provides people with goods and services that are fundamental to human wellbeing. Damage to the environment is seriously degrading these services and this will have economic implications. This POSTnote outlines what ecosystem services are, and how provisions for maintaining them in the UK could be incorporated into policy frameworks.

Background

Human beings benefit from processes or structures within ecosystems that give rise to a range of goods and services called 'ecosystem services' (Box 1). These range from the relatively simple, such as crop pollination to the highly complex, such as maintenance of soil fertility, sinks for waste or regulation of the climate. Ultimately all human life depends on ecosystem services for fundamental necessities such as clean air, clean water and food production. Services can be grouped into four categories – supporting services, provisioning services, regulating services and cultural services (Box 1).

The Millennium Ecosystem Assessment

The Millennium Ecosystem Assessment (MA), a project initiated by the United Nations Environment Programme (UNEP) in 2001, set out to assess how human-made changes to ecosystems affected human welfare. It also sought to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human well-being. The findings were published in 2005 and have been the subject of recent House of Commons Environmental Audit Select Committee report[1].

Threats to ecosystem services

Humans have modified ecosystems more in the last 50 years than in any comparable period. Land use and habitat change often results in simplification of the ecosystem to increase the economic value of one ecosystem service, usually provisioning services such as food production. Extensive modifications, such as conversion to intensive agricultural land, can alter ecosystems and reduce their capacity to provide a broad range of services. This may have an impact on ecosystem services over a geographical scale wider than that of the original modification. The MA found that approximately 60% (15 out of 24) of the ecosystem services evaluated (including 70% of regulating and cultural services) are being degraded or used unsustainably. If current trends continue, there is likely to be further rapid degradation of ecosystem services in the 21st century. Although some economic benefits have resulted from ecosystem modification, degradation of ecosystem services has

Box 1. Ecosystems and services

An ecosystem may be considered as a unit within which an assemblage of living organisms interact with each other and with the chemical and physical environment. The resulting natural processes establish a series of complex ecological balances. Ecosystems may operate at a wide range of scales, from long-term global systems such as oceans, to very small, localised or ephemeral systems such as freshwater pools that persist for only short periods[2].

Some of the interactions both between organisms and with their physical habitats (biophysical interactions) result in ecological processes that interact at different scales to deliver 'ecosystem services' or 'natural capital' that have value to people. The Millennium Ecosystem Assessment grouped ecosystem services into four broad categories:

- **Supporting services**, such as nutrient cycling, oxygen production and soil formation. These underpin the provision of the other 'service' categories.
- **Provisioning services**, such as food, fibre, fuel and water.
- **Regulating services**, such as climate regulation, water purification and flood protection.
- **Cultural services**, such as education, recreation, and aesthetic value.

For example, the structures within woodland habitats can slow the passage of water into water courses, thereby contributing to the ecosystem regulating service of flood protection. The **ecological processes** that contribute to **ecosystem services**, in this case slowing the passage of water, are referred to as **ecosystem functions**[3]. The habitats and organisms that give rise to the ecological processes are usually described as the **ecological assets**, and these can be protected to ensure ecosystem services are maintained.

increased poverty for some, with fewer benefits from degraded ecosystems available to current and future generations. Damage to ecosystem services poses environmental risks, such as flooding or water pollution, which may have to be replaced by expensive engineered human services. However, some services such as climate regulation may be irreplaceable.

Protecting UK ecosystem services

In some areas of the UK, it is possible to find healthy functioning ecosystems providing significant services,[4] such as woodlands (see POSTnote 275). However, in other areas, such as some urban areas, ecosystems have been modified to such an extent that it is difficult to detect significant provision of many ecosystem services. Current ecosystem service provision is likely to be affected by climate change, and to offset this ecosystem service provision will need to be enhanced or restored even within heavily modified landscapes.[5]

EU legislation

Ecosystem services are not explicitly protected by EU legislation; however, directives do provide protection for some aspects. For example, the EU Habitats and Wild Birds Directives protect the status of the species and habitats listed in their annexes. Any damage to the status of these species or habitats may result in financial liability under the Environmental Liabilities Directive. Achieving good ecological status under the Water Framework Directive requires all the inputs and demands made on a river system to be managed to ensure good ecological status or potential of the water body. Protection of biodiversity is also being integrated into EU thematic strategies, such as the marine strategy.

National policy to protect natural resources

The UK government's 2005 Sustainable Development Strategy identified a strategic approach to natural resource protection and environmental enhancement as one of four priority areas for the government. Current conservation policies focus primarily on individual components of ecosystems, such as species at risk, often in small pockets of high-value habitat. However, future policy may need to consider whole ecosystems that are at risk, taking action over larger areas of habitat to enhance ecosystem services. Action over a wide scale will also be required to maintain ecosystem services in response to climate change.

The Department for Environment Food and Rural Affairs (Defra) is now in the process of developing an 'ecosystems approach' (Box 2), to conserve, enhance and manage the natural environment, in consultation with a group of relevant stakeholders. This will lead to publication, at the end of 2007, of an Action Plan to embed an ecosystems approach in policy and delivery by Defra and its delivery partners.

Issues

In line with the principles of the UK Sustainable Development Strategy, government policy decisions could benefit from a better understanding, recognition and reflection of the contributions of ecosystem services to economic and social welfare. However, there are difficulties in determining how a market-driven economy can take account of ecosystem services that may not have market values and incorporating this into policy making. Equally there are difficulties in understanding how ecosystem services can be maintained or restored through policy or other measures due to the complexity surrounding the study of ecosystems in general.

Box 2. Ecosystems Approach

An 'ecosystems approach' being developed by Defra draws on the Convention of Biological Diversity definition – 'a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way'. However, it would seek to broaden the application away from the biodiversity perspective, putting an emphasis on maintaining the health of ecosystems (Box 3) as well as the sustainable human use of the environment, for present and future generations.

The primary policy areas where the ecosystems approach will be embedded are likely to include:

- The Marine Bill White Paper, through a marine planning system and marine conservation zones;
- The revised strategies for upland areas and for nutrient management;
- The Rural Development Programme;
- Regulatory Impact Assessments; and,
- Sustainability assessments within the planning system.

Defra has commissioned a number of research projects and case studies to develop a system of relevant economic metrics, environmental indicators, social data and other methodologies to inform decision making for terrestrial ecosystems[6]. These include an assessment of the economic value of England's terrestrial and aquatic ecosystem services and a review of the evidence available on their current state and trends affecting them. It also includes a number of localised case studies to explore how an ecosystems approach might be applied in different contexts. Examples are the development of the Kent Thameside area, the management of a river catchment and of an area of high conservation importance.

Box 3. Ecosystems and resilience

Ecosystems are complex dynamic systems, which move between states over different time frames. In response to different types of disturbance, such as species loss, fire, changes in nutrients, drought or harvesting, ecosystems can shift to an alternative state, such as from forest to grassland. The shift can occur abruptly or gradually in response to increasing pressures over long periods e.g. desertification. The point at which a shift occurs is known as an ecosystem threshold or limit, at which point changes in ecological processes may affect ecosystem service provision such as food production.

The magnitude of a particular type of disturbance that can be absorbed by an ecosystem is referred to as ecosystem resilience. It has been suggested that the resilience of ecosystems can be reduced by gradual modifications, making them less able to absorb disturbance events and increasing the likelihood of abrupt shifts[7]. However, although ecosystem resilience can be derived from simple theoretical mathematical models it is not yet possible to apply it to all ecosystems as a practical predictive tool to determine actual ecosystem thresholds or limits. Ecosystems cannot therefore be referred to as stable, healthy or resilient in a quantified way at present, and there is little agreement over the scientific definition of these terms.

The ecology of ecosystem services

In order to develop a sufficient scientific understanding to manage the impacts of human activities on ecosystem services, there needs to be a better understanding of the 'ecology of ecosystem services'[8], including:

- linking specific ecosystem services to specific **ecological processes** (**ecosystem functions**);
- the time and geographic scales over which relevant **ecological processes** occur;
- the environmental factors that influence **ecological processes**; and,
- the species or other **ecological assets** that underpin **ecological processes**.

Biodiversity and ecosystem services

Information is needed to understand the consequences of the accelerating loss of species and the actions required to maintain or restore ecosystem services. The majority of experimental data linking biodiversity and ecosystem services relates to grasslands[9]. These data suggest that a diverse mixture of plant species yields a greater mass of living matter than a single species. They also suggests that the higher species richness helps to buffer against some environmental changes, such as nutrient changes in soils.

Although such studies provide evidence that biodiversity is a key aspect in maintaining the **resilience** of ecosystems (Box 3), this has not been shown for all ecosystems or linked to ecosystem services. The greater the number of steps in an **ecological process** the harder it is to understand the role played by biodiversity within that process. Moreover, most ecosystem services are underpinned by more than one **ecological process**. There is a need to identify empirical ecosystem studies (experiments, observations and models) that would really advance understanding over the next 10 to 20 years. The UK Biodiversity Research Advisory Group, part of the UK Biodiversity Partnership formed as the UK Government's response to the Convention on Biological Diversity, has suggested an extensive research programme in this area[2].

Integrated approaches to ecosystem services

Ecosystem services arise from complex interactions within and between ecosystems over local to global scales. While the study of single ecosystems is complex enough, studying the interactions between ecosystems in a given area, such as a river catchment, is even more difficult[3]. However, such studies are necessary to allow the development of an integrated ecosystems approach (Box 2), which considers an entire range of ecosystem services and possible trade-offs between them[10]. This requires that relevant ecosystem functions are monitored at the right scale to determine trends in ecosystem services in response to management measures (Box 4). It would also include use of a strategic framework in the planning system, which could consider actively how to restore or maintain ecological services[5]. For example, the Shoreline Management Plans for England have already, in principle, incorporated the theory of managed realignment that sets back the current location of some coastal protection behind a natural frontage of intertidal habitat that is resistant to wave energy.

The role of agricultural policy

Agriculture will continue to be a key policy area in relation to ecosystem services, and Defra is working to incorporate this into relevant strategies (Box 2). The effects of agricultural modification of ecosystems will need to be considered, particularly in relation to food and energy production, waste disposal, carbon sequestration, habitat creation, landscape management and water cycle management.

Box 4. Indicators of ecosystem service provision

Appropriate indicators will be needed to assess the conditions and trends of ecosystem services across the UK and the success of policies implemented to maintain or restore them. However, uncertainties over the links between ecological processes and ecosystem service provision raise questions over which parameters to monitor. At the basic level there needs to be a comprehensive inventory of **ecological assets** in the UK (e.g. soil types) and their status, mapped at the right scale to develop both monitoring systems for ecosystem functions and the regulatory tools to ensure their protection. Given all the potential **ecosystem functions** that could be monitored, it may be necessary to prioritise the **ecological processes** underpinning key ecosystem services for monitoring, such as those relating to water quality, flood management and carbon sequestration.

One possible existing source of information is the UK Countryside Survey by the Centre for Ecology and Hydrology. The survey assesses habitat and landscape features, vegetation, water courses, soils and land cover providing information on environmental change. Four surveys were carried out between 1978 and 1998. Although the most recent has shown the loss of habitat stock has slowed, its inclusion of indicators of habitat quality showed significant changes in some habitat types, mostly due to excess nutrient input (eutrophication). However, this information is not gathered at all the relevant scales or mapped, and has not been clearly linked to the levels of ecosystem service provision. Some measures of the views of ecosystem service users will also need to be included. One example is the Countryside Quality Counts initiative, which used inputs from public consultations as one way of assessing changes in countryside quality and the degree to which these affect the **cultural ecosystem service** of 'local distinctiveness'.

It is likely that payments for ensuring continued provision of ecosystem services will form a significant proportion of future agricultural incomes. Further research is needed to determine the effectiveness and potential of agri-environment policy measures (see POSTnote 254) such as the Defra Entry Level Stewardship Scheme in maintaining ecosystem services. For example, United Utilities are developing, in association with the Royal Society for the Protection of Birds (RSPB), the Sustainable Catchment Management Programme (SCaMP), which aims to develop an integrated approach to river system management within two key areas of Bowland and the Peak District to benefit both water cycle management and biodiversity. This includes working with relevant farmers to promote sustainable land management techniques to reduce diffuse pollution. However, the scheme is being limited by constraints in funding for relevant agri-environment measures.

The value of ecosystem services

The economic value of ecosystem services is never zero and can be very large. Several international and

conservation bodies, such as the IUCN and UNEP, are advocating the use of markets and payments for ecosystem services in order to ensure that beneficiaries pay for services and their providers are reimbursed, thereby creating incentives for continued service provision and ecosystem protection (Box 5).

Box 5. Ecosystem service valuation[11]

The Total Economic Value (TEV) conceptual framework views ecosystem goods and services as the flows of benefits to humans provided by the stock of natural capital. Values are assessed through the ways in which ecosystem services support people's own consumption (use values) and provide intangible human benefits (non-use values). Use values are further subdivided into:

- direct use values – value from direct human use of natural resources. These can be extractive use values from outputs such as timber or fisheries, and non-extractive use values from activities such as tourism and recreation;
- indirect use values – value from regulatory processes that indirectly provide support and protection to human activities, such as flood protection.

Non-use values are subdivided into:

- Altruistic values – derived from knowing that others can enjoy the goods and services from ecosystems;
- Bequest values – passing on ecosystem services intact to future generations; and,
- Existence value – the satisfaction to humans from knowing that ecosystems continue to exist.

In addition to use and non-use values, ecosystem services may have option values in relation to possible but as yet unforeseen uses such as species with pharmaceutical applications. Economic, deliberative and participatory methodologies are used to try to ascertain relevant values. These attempt to establish either an individual's willingness to pay (WTP) for an ecosystem service (or to avoid its degradation) or willingness to accept (WTA) compensation for the degradation of an ecosystem service (or forgoing an improvement or restoration of an ecosystem service). Five main sets of methodologies are employed, which will be appropriate depending on the application and data available:

- Market prices can be used to estimate the value of ecosystem goods and services that are traded in formal markets, such as timber and fish. The prices need to be adjusted for any market distortions;
- Cost methods, based on the cost of damage caused by the loss of an ecosystem service, or expenditure to prevent that damage, or the cost of replacing the ecosystem service altogether;
- Revealed preference methods, such as the travelling and access costs people are willing to pay to use an ecosystem for recreational purposes;
- Stated preference methods; such as surveys to determine people's willingness to pay for ecosystem services in hypothetical markets; and,
- Deliberative and participatory valuation methods ranging from group-based deliberative monetary valuation to citizen's juries.

Values for the many ecosystem services are not directly traded in markets must be derived through the last four sets of approaches. These often require extensive time, skills and data, and the findings are sometimes disputed. However, as the number of robust primary valuation studies of ecosystem services grows, it is feasible to transfer these estimates to assess values in other situations.

These techniques are already being applied. For example, the Natural Capital Project being jointly conducted by Stanford University, The US Nature Conservancy Council and the World Wildlife Fund, is attempting to map, and where possible value, ecosystem services across defined areas at a level that is understandable to people in those areas. In some of the project's case study areas (California, China and Tanzania), the ecosystem valuation and mapping may lead to establishing incentive payments to land managers to reimburse them for protecting and providing ecosystem services. However, there are considerable methodological challenges in assigning monetary value to ecosystem services, particularly in cases where the services or goods have no marketed value (Box 5), which Defra is seeking to address (Box 2). In addition, if such economic valuations are to be used as effective tools in policy decision making, ecosystem service assessments (Box 4) will also need to be fully integrated into the wider institutional arrangements[12]. This would include all decision making frameworks impacting on the environment, such as government strategies at the national, regional and local level, as well as planning, land management and property rights.

Overview

- The human modification of ecosystems is having a major impact on ecosystem services at the global level. There is an environmental limit of ecosystem degradation or loss beyond which ecosystem service provision will not be sufficient to provide benefits.
- There are significant gaps in knowledge concerning the provision, distribution and value of ecosystem services. The links between the underlying ecology and ecosystems services have yet to be clarified.
- There is a need to integrate the consideration of ecosystem services in policy and delivery across government. However, for some ecosystem services, even with improved knowledge and data, economic valuation will still be challenging.

Endnotes

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