

Defra Evidence and Analysis Series

**Quantifying and Valuing
Ecosystem Services**

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QUANTIFYING AND VALUING ECOSYSTEM SERVICES

A note for discussion

Prashant Vaze, Helen Dunn and Richard Price¹

Defra, September 2006

The labour of nature is paid, not because she does much, but because she does little. In proportion as she becomes niggardly in her gifts, she exacts a greater price for her work. Where she is munificently beneficent, she always works gratis.

David Ricardo, 1817²

Ecosystems services: linking environmental and economic performance

It is often asserted that effective environmental protection can be achieved only at the expense of productivity growth. But this misses the point that environmental assets - like other assets - provide benefits which enhance economic performance, offer new opportunities for investment and employment, and improve society's wellbeing.

This note sets out thinking on an ecosystems approach, offering a more sophisticated and more comprehensive understanding of the relationship between economic and environmental performance. This approach - which would replicate for the UK what the Millennium Ecosystem Assessment did at global level - would help us to understand how both current living standards and future economic opportunities depend on the condition of the natural environment. It will also help us to understand how the condition of our 'environmental assets' is enhanced or depleted by different types and intensities of use. In turn this gives us a sense of the risks to our ability to continue to consume these benefits into the future.

Valuing these different effects can help us to solve practical problems - for policy makers, local communities and for businesses. For example, are we under-protecting some parts of the environment and over-protecting others? Where is green space most and least valuable? How prescriptive should we be in regulating the commercial use of environmental assets, and where it is in businesses own interests to protect and enhance them?

It will be a challenge to make an ecosystems approach "operational" in the UK. But we believe that there are large gains to be made by taking decisions based on a better understanding of how the environment can support or constrain economic performance and opportunity. This will require much better alignment of research effort, particularly for natural scientists and economists.

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² David Ricardo: "On The Principles of Political Economy and Taxation", Note 10, 1817

Purpose of this note

1. The natural environment provides us with essential goods and services that benefit society and the economy. The value of these goods and services, and the natural assets that provide them, is often overlooked in decisions about resource use, not because they are not important, but because they are freely available rather than bought and sold through markets.

2. This note sets out Defra's proposed approach to quantifying and valuing these "ecosystem services" to help public sector decision making. We believe that it is a significant step forward because it forces us to identify not just tradeoffs between alternative uses of environmental assets – protection or development – but the key complementarities where the condition of environmental assets has a direct impact on economic opportunity and wellbeing. It gives us a way of understanding the relationship between environmental performance and economic performance in which one is not always set against the other

3. There are three main audiences for this note:

- It is written for policy makers with the objective of providing an approach which will help Government to take decisions on new policies, spending priorities, and target setting with better information about the impacts of policy on environmental assets and through them on economic opportunity and wellbeing.
- It is written for the international community of institutions which contributed to the Millennium Ecosystem Assessment, with whom we want to collaborate in developing a practical framework which helps to frame policy decisions. The issues raised in this note are not the unique concern of any one country. To make real progress we need to pool intellectual and research resources³.
- And it is written for the research community of social and natural scientists, who need to work together in a common framework to enable effective collaboration and research effort which is both well focused and has real impact in informing policy decisions.⁴

³ Rules governing economic accounting are set out in the System of National Accounts which agreed internationally. There has also been a major international effort to produce an equivalent system of environmental accounts

⁴ Our existing and planned research is set out in Annex 1

4. Our thinking is drawn from the Millennium Ecosystem Assessment⁵ (MEA), a comprehensive assessment of the state of the global environment drawing upon the expertise of some 1300 scientists from around the world. This framework provides a way of classifying the benefits we derive from the environment (Ecosystem services) and assessing their state.

Context

5. Major policies have both positive and negative effects on different aspects of the environment, and policy makers need to make difficult trade-offs between competing economic, social and environmental priorities. For instance the decision about whether new electricity generation should be powered by gas, coal, on-shore wind, hydro or nuclear has different impacts on climate change, visual amenity, water flows, local air quality, biodiversity and radioactive waste, as well as having different implications for the cost and reliability of energy supply. Moreover decisions which improve or worsen the condition of environmental assets have a knock-on economic impact through their effect on the services those assets provide.

6. To inform these decisions better, we need analysis which measures:

- how our existing consumption of environmental assets degrade their condition; and how far consistent over-consumption might jeopardize our ability to benefit from ecosystem services into the future?
- the cumulative, complex and interacting pressures we put on the natural environment; and
- allows us to internalise the values of ecosystem services into prices, and ultimately into decision making.

7. This paper sets out an approach to quantifying and valuing ecosystem services to help us understand how the condition of our 'environmental assets' is enhanced or depleted by different types and intensities of use. In turn this gives us a sense of the risks to our ability to continue to consume these benefits into the future. This helps us to understand whether some depletions of environmental condition are acceptable or even desirable; and whether there are benefits from

⁵ www.maweb.org

protecting or enhancing the condition of others – for example to improve air or water quality; or because sources of biodiversity have existing or potential commercial applications. Thinking in these terms means that – instead of asserting that all environmental assets are equally important (or unimportant) – we can answer policy questions such as:

- are we under-protecting some parts of the environment and over-protecting others?
- how much greenbelt do we need? And where is it most important to locate green space?
- how should we regulate the commercial use of natural resources? Should we be less prescriptive in some areas, and require investment to safeguard or improve environmental assets in others? Might it sometimes be in businesses' own interests to make such investment?
- how much should we, as a society, be investing in protecting biodiversity and how should we spend it?
- how do we allocate resources between the protection of sites of high nature value and more widespread habitat protection?

8. This approach is also relevant for addressing “economy wide” questions like how much should measures like GDP be adjusted by to compensate for loss of environment; what is the true value added of different economic sectors when we take account of their environmental impacts. Much of the thinking below can be used to answer such “economy wide” as opposed to site specific questions. However, some of the discussion on pricing does not apply when looking at the whole economy.

The conceptual framework

9. Ecosystems provide us with valuable services like fresh water regulation, photosynthesis, and nutrient cycling. The amount of ecosystem service provided depends on the quality and extent of the ecosystem and its physical and biological characteristics. There are several ways of defining and categorising ecosystems services – the Millennium Ecosystem Assessment (MEA) being perhaps the most widely accepted approach. The

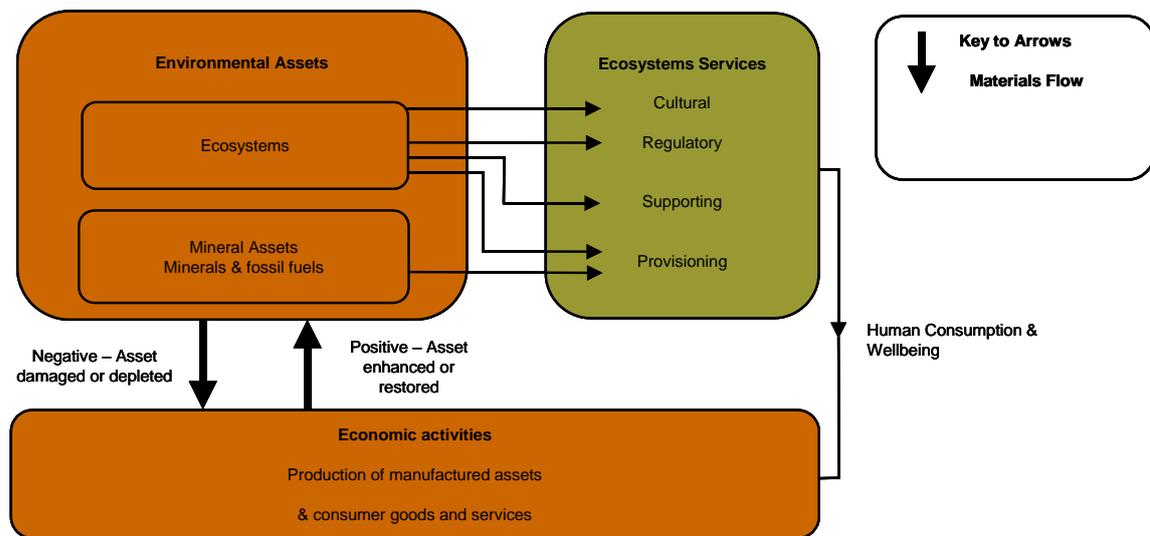
MEA identifies four categories of ecosystem service: **provisioning**, **regulating**, **supporting** and **cultural**. Table 1 gives examples of the services in each category. A fuller description is available in the extensive documentation about the MEA.

Table 1: Ecosystem Services categories

- **Provisioning services:** The products obtained from ecosystems, including food, fibre, fuel, genetic resources, biochemicals, natural medicines, pharmaceuticals, and fresh water
- **Regulating services:** The benefits obtained from the regulation of ecosystem processes, including air quality regulation, climate regulation, water regulation, erosion regulation, water purification, disease regulation, pest regulation, pollination, natural hazard regulation
- **Cultural services:** The non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences - thereby taking account of landscape values
- **Supporting services:** The services that are necessary for the production of all other ecosystem services including soil formation, photosynthesis, primary production, nutrient cycling and water cycling

10. Economists distinguish between capital goods (or assets) such as machinery, vehicles and buildings which provide the physical infrastructure for economic activity, and consumer goods and services such as food, household goods and electricity. The idea of environmental assets and ecosystem services is analogous to the economists' idea of capital and consumption.

Figure 1: Economic and environmental assets and the flow of services



11. Ecosystems and natural resources (including wild animal and plant populations) can be thought of as environmental assets which provide people with a flow of ecosystem services which directly or indirectly contribute to our well being. We care about the loss and degradation of these assets because this compromises their ability to deliver valuable 'ecosystem services'. If the condition of environmental assets declines, costs are likely to be imposed elsewhere either to deal with the consequences (worse air quality; reduced availability of water resources) or to replace the asset with another way of providing the service. Figure 1 shows how these concepts fit together.

12. Government policies (e.g. planning, national parks and greenbelts), public investment (e.g. roads, flood defences) and private sector investments guided by Government policy (e.g. waste facilities, energy plant, homes) all have an effect on ecosystems – indeed all development has an impact on ecosystems – and hence on the flow of ecosystem services. All of these cause a change in the ecosystem and hence in the ecosystem services being provided. Table 2 below shows the steps in quantifying and valuing the change in ecosystem services.

Table 2: Steps in measuring and valuing changes in environmental assets and ecosystem services

1. Identify the location and type of environmental assets under pressure by the policy or land use change
2. List the ecosystem services (using the MEA classification) provided by the assets, identifying the range of economic and social benefits provided to society
3. Consider which of these are impacted by the policy change or land use change
4. Consider whether we run the risk of breaching any environmental limit or threshold⁶
5. Quantify the effect on environmental services of a proposed change
6. Consider what is the best method for valuing the change in the environmental service (see below)
7. To what extent does the change in environmental service leave people better or worse off, is the service locally abundant so we can easily use other sources?
8. Identify the number of people, or the range of effect
9. Value the change in economic benefits

13. Finding the appropriate value to put on environmental assets is a substantial challenge. Firstly space matters, *ecosystem services* and *location* are associated in a complex way. Services like recreation are intimately linked to the land upon which they occur. The opposite is true of oxygen generation since the gas can diffuse globally so the location of production is unimportant. The change in “appearance” of an ecosystem, say through the construction of a new housing estate, affects the land on which construction takes place and surrounding areas whose sightlines are

⁶ In economic terms, environmental limits are the levels beyond which it is considered that further pressure on the environment will lead to unacceptable consequences or irreversible change. Environmental limits can be ecological thresholds – levels beyond which a marked harmful change occurs, such as the collapse of an ecosystem. However, some ecosystems do not exhibit distinct thresholds, and loss of ecosystem services or degradation of environment assets may instead be a gradual process. In these cases environmental limits are often based on value judgements – levels at which it is judged that the loss of benefits from an ecosystem are no longer acceptable.

affected. Because of the way birds and animals roam across space, changes to species rich area of land can damage the integrity of much wider habitats if the space is a necessary component of a system of linked sites.

14. In Annex 2 we propose an approach to valuing environmental services. Our approach (stage 5 in the above list) first asks *how does a policy affect the ecosystem services produced by an environmental asset?* This information should be part of a project's environmental impact assessment or a policy's regulatory impact assessment. Stage 6 is about the appropriate valuation technique for different types of environmental service.

15. Our preference is to make use of actual market prices where possible (especially for provisioning services), the cost of providing these services (for regulatory and support services) and to use questionnaire based techniques like contingent valuation only for cultural services. Stage 7 asks analysts to be systematic about the genuine local scarcity of an asset. Greenbelt policy protects agricultural land from encroachment by urban development, but what scarce resource are we protecting at any specific site? This approach helps us to be clear about the true value of environmental protection in individual cases and locations, as well as establishing principles for assessing the full economic and social impact of broader policy decisions.

What is new about using ecosystems services to value the environment?

16. Environmental economists already have sophisticated and mature techniques to value the environment. For over two decades analysts have used approaches (like contingent valuation, and hedonic pricing) to value environmental features like landscapes and nature reserves. There is a valid question about what new insights the ecosystem approach brings. We believe the approach can address three problems:

a. It forces us to be explicit about the relationship between environmental and economic performance, by assessing the services ecosystems provide to the economy and society; and the extent to which the exploitation of environmental assets enhances or depletes their condition.

b. *Environmental limits*: this approach explicitly considers whether a policy or land-use change risks breaching an environmental limit

c. *Benefits transfer*: by breaking down the environment to the individual services provided we can be more systematic in ensuring there is a stepwise quantification and valuation of the change in the quality and quantity of the environmental asset and can consider the interlinkages between environmental assets that cannot always be captured in an approach based on valuing individual environmental features in isolation. We hope this stepwise process will make the valuation easier to transfer from location to location.

The research agenda

17. A key context for this paper is the need to turn the ecosystems approach into something practical that can be used in decision-making and policy at a national, regional and local level. In order for such an approach to be successfully implemented in the UK there are a number of areas where the UK needs to undertake further work. This section particularly focuses on some of the key economic requirements. As noted earlier, a key issue is ensuring linking up evidence requirements from different disciplines. There is an opportunity for the UK Research Councils (particularly NERC & ESRC⁷) and others to make a valuable contribution to key components of the work.

18. In recent years there appears to have been a sustained effort to identify ecosystems and environmental assets – e.g. forests, wetlands and sometimes also the values of individual services. However it is clear that ecosystem valuation is not a straightforward exercise and the literature has progressed only a limited distance in tackling the key issues. Gaps in the evidence base suggest there may be a significant requirement for further primary valuation work; however it is clear that a strategic approach is required to determine the focus which also takes account of the purposes to which the evidence will be applied. The research studies commissioned through NEP are expected to make an important contribution to this debate, looking at England's ecosystems and its services.

⁷ Natural Environment Research Council (NERC) and Economic and Social Research Council (ESRC)

Research areas

Economic valuation in context of environmental limits

19. There is a need to understand better the role of economic valuation in a context where there are risks of environmental limits being reached. OECD (2006)⁸ looking at valuation of ecosystem services highlights that because of uncertainty, potential for irreversibility and non linearity, a decision making context favours a precautionary approach. However, work is required to understand what this means in practical application. Potential approaches include use of 'safe minimum standards', taking into account 'options' value and use of strong sustainability criteria would build on NEP phase I project on environmental limits.⁹

Identify appropriate valuation methodologies for ecosystem services

20. There is much guidance already available on the range of valuation techniques. However, in the context of ecosystem services there is a need to develop an improved understanding of which techniques are most appropriate under which circumstances. While it may be relatively straightforward to make use of market prices for provisioning services, what valuation techniques should be considered for regulating, supporting and cultural services? What are their benefits and what are the limitations? Work could build on various studies including recent work from English Nature.¹⁰

Identifying potential financing sources

21. Identifying how these benefits (and costs) are distributed across different stakeholders is a further key step. Understanding who gains and loses can provide important insights on the incentives of different individuals and groups. How can the beneficiaries of the decision be made to pay for the services they receive to ensure the ecosystem is conserved and its services are sustained? How can we internalise the costs of damage to ecosystems so that those who cause the damage are made to incur the costs?

⁸ Cost Benefit Analysis and the Environment – Recent Developments David Pearce, Giles Atkinson and Susanna Mourato, OECD 2006

⁹ R. Haines-Young; M. Potschin, and D. Cheshire (2006): Defining and identifying Environmental Limits for Sustainable Development. A Scoping Study. Final Overview Report to Defra, Project NR0102

¹⁰ English Nature (2006): England's Ecosystem Services; Report 701

Prioritisation of economic valuation evidence needs

22. Primary valuation studies can be expensive and resource intensive. However, improve the valuation evidence base there is likely to be a need for primary studies. Further work is required to look at the needs for valuation evidence at a strategic level and prioritise across those needs. This work would build on recent studies, including those conducted or being conducted through the NEP, work with key partners including EN, JNCC etc and with key research groups. The proposed valuation group in NEP phase II could be the lead group on this area.

Benefits transfer

23. In a variety of policy decision making contexts, there is often a practical need to use benefits transfer when making an assessment of the costs and benefits of environmental impacts. This refers to making use of a valuation study conducted in a different context and applying it appropriately to the new policy context. Consideration of the need for developing more detailed guidance for economists on the methodology and use of benefits transfer would be helpful.

National accounting, 'genuine' savings

24. This approach focuses at an aggregate level on value of natural capital considering the present value of current and future flows of benefits from ecosystem services. 'Genuine' savings refers to an adjusted net savings rate taking account of activities which enhance wealth (such as expenditure on education) and activities which reduce wealth (including depletion of natural resources, pollution damages). Review of use of such tools in a UK context may be of value given that they provide important indicators of sustainability. This work might link up closely to that being developed by the World Bank.

25. By making further progress in these research areas we can begin to link ecological and economic models appropriately and determine methods that use the outputs from ecological modeling in appropriate formats for use in economic analysis. We can also develop our understanding of how we apply economic valuation tools in an appropriate manner to complex issues.

Annex 1:

Research completed and planned in the Natural Environment Programme

Through the Natural Environment Programme (NEP), Defra is currently seeking to improve its understanding and evidence base to support the development of an ecosystem based approach to conserve and enhance the natural environment.

The first phase of research under this programme was a series of scoping studies looking at underlying issues including environmental limits and pressures, and valuing the natural environment. A second phase of research to build on the scoping studies has now been commissioned and will run over the next 9 – 18 months. The projects under this second phase include:

- Inventory study on natural environment inventory data 2 (with a focus on social sciences)
- England's terrestrial ecosystem services and the rationale for an ecosystem based approach
- An assessment of the economic value of England's terrestrial ecosystem services and to develop methodologies for aggregating and using existing valuation evidence in an ecosystems context.
- Case studies to develop tools and methodologies to deliver an ecosystem based approach

Annex 2: Approaches to valuation

The economic value of an environmental asset can be measured by the value of the flow of services, both current and future. By focusing on the measurement and valuation of these services, rather than the asset itself, the ecosystem services approach provides a more systematic and perhaps more tractable way of studying the range and interaction of different impacts on the natural environment of different policies.

There is not one single answer to the question of how valuable an ecosystem is because it will depend on the context. Different contexts and hence approaches to valuation are highlighted in the box below. It is critical to understand the rationale in order to derive appropriate valuations. An assessment of the total value of benefits arising from an ecosystem will not generally help to understand what the costs and benefits of a specific policy change that impacts on that ecosystem.

Approaches to valuation¹¹

Rationale	Approach
To understand the contribution that ecosystems make to society—typically arises in a “national accounts” context	Determine value of total flow of benefits from ecosystems
To assess whether a policy intervention is worthwhile	Determine the net benefits of interventions that impact on ecosystems, fully taking into account the benefits and disbenefits to the ecosystem.

¹¹ See Assessing the economic value of ecosystem conservation, World Bank, Environment Department Paper, October 2004

Rationale (continued)	Approach
To identify the winners and losers, for distributional reasons	Assessment of how the costs and benefits of ecosystems are distributed.
To improve sustainability of conservation funding	Understand who benefits from conservation and magnitude of benefits – help to design mechanisms to capture some of these benefits.

Valuation and pricing techniques¹²

Recent work for English Nature on England’s ecosystem services¹³ has looked at the appropriateness of different valuation techniques for a range of ecosystem services. It distinguishes particularly between valuation and pricing approaches. It highlights that in certain cases it may be more practical and relevant to use pricing to estimate economic value, for example the regulation services provided by ecosystems where pricing techniques can be used to estimate avoided damage, replacement costs, price of water supply etc. However, only stated preference techniques are capable of capturing the non use values of habitats which can be a significant part of the total economic value.

¹² The discussion here focuses on economic valuation. The study on “Valuing our natural environment”, Eftc (2006) looked at both economic and non economic valuation.

¹³ English Nature (2006): England’s Ecosystem Services; Report 701