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An introductory guide to valuing ecosystem services



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Foreword

Our natural environment is vital to our health and prosperity. Over recent years, much progress has been made towards getting a better understanding of the role of the natural environment in contributing to our economic performance as a country and as individuals. Environmental assets – like other assets – provide benefits that enhance economic performance, offer new opportunities for investment and employment, and improve living standards and quality of life. And – like other assets – enhancing or diminishing the condition of environmental assets increases or reduces the stream of benefits we can derive from them in the future.

Despite these advances, many indicators suggest we are using the natural environment in a non-sustainable way, that is, in a way that diminishes their condition. This partly reflects the choices we make as a society. But it also reflects the fact that we are not always good enough at informing those choices. In particular, the benefits the natural environment provides are not yet valued properly in policy and project appraisal across government. The new cross-government natural environment Public Service Agreement (PSA), ***Secure a Healthy Natural Environment for Today and the Future***, explicitly calls for the value of the services provided by the natural environment to be reflected in decision-making.

This Introductory Guide looks at how the framework for the valuation of the natural environment could be improved by offering a comprehensive and systematic means to ensuring that ecosystems and the services they provide are taken into account in policy appraisal. It builds on traditional valuation approaches by explicitly considering the environment as a whole – bringing together land, water, air, soil and biodiversity – and recognising that their linkages provide a wide variety of services and benefits that are not specific to any one part. The approach stresses that changing any one part of our environment can have consequences, both positive and negative, and often unintended for the ecosystem as a whole.

This Guide is a first step towards Defra's aim to embed impacts on the natural environment in decision-making. It is purposely 'introductory', recognising that further testing and development is needed to operationalise this approach in policy appraisal across government.

Comments on this guide are very welcome and should be sent to economics@defra.gsi.gov.uk.



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December 2007

Executive Summary

- i The aim of this Guide is to provide an introduction to the valuation of ecosystem services. It builds on previous approaches to valuing the environment but takes a more systematic approach to the assessment of impacts on the natural environment. The central theme of this work is to ensure that the true value of ecosystems and the services provided are taken into account in policy decision-making.
- ii Ecosystem services are defined as services provided by the natural environment that benefit people. While there is no single, agreed method of categorising all ecosystem services, the Millennium Ecosystem Assessment framework is widely accepted and is seen as a useful starting point.
- iii Ecosystem services provide outputs or outcomes that directly and indirectly affect human wellbeing, and these considerations can link well to taking an economic approach. The underlying case for the valuation of ecosystem services is that it will contribute towards better decision-making, by ensuring that policy appraisals fully take into account the costs and benefits to the natural environment and by highlighting much more clearly the implications for human wellbeing, while providing policy development with new insights.
- iv Some of these ecosystem services are well known including food, fibre and fuel provision and the cultural services that provide benefits to people through recreation and appreciation of nature. Other services provided by ecosystems are not so well known. These include the regulation of the climate, the purification of air and water, flood protection, soil formation and nutrient cycling. These services are not generally considered within policy appraisal at present and represent an area where a greater and more systematic focus would be very useful.
- v The appraisal of new policies, programmes and projects all require environmental impacts to be taken into account. The approach to the valuation of ecosystem services presented in this Guide is not intended to be an additional step within the appraisal process but, instead, a common methodology that can be used in order to consider the impact of our actions on the environment. The environmental impacts currently taken into account in policy appraisal can generally fit well within this broad framework.
- vi This broader framework allows a shift in emphasis from a focus mainly on valuing environmental damage to highlighting the value of changes in the services provided by the natural environment. Ecosystem services contribute to economic welfare in two ways – through contributions to the generation of income and wellbeing and through the prevention of damages that inflict costs on society. Both types of benefits should be accounted for in policy appraisal. With a broader focus on valuing the benefits provided by ecosystems, policy options that enhance the natural environment are also more likely to be considered that demonstrate that investing in natural capital can make economic sense.

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- vii This Introductory Guide provides a practical introduction to the key steps to be undertaken in valuing ecosystem services in a policy appraisal context. The Guide takes an impact pathway approach to valuing ecosystem services. An overview of the impact pathway approach is presented below:

Overview of impact pathway of policy change



- viii In summary, the key steps are:
- 1 Establish the environmental baseline.
 - 2 Identify and provide qualitative assessment of the potential impacts of policy options on ecosystem services.
 - 3 Quantify the impacts of policy options on specific ecosystem services.
 - 4 Assess the effects on human welfare.
 - 5 Value the changes in ecosystem services.
- ix Following these steps can help to ensure a more systematic approach to accounting for impacts on ecosystems. Even an initial screening within a policy appraisal of what ecosystem services are affected, how potentially significant these impacts could be and developing an understanding of the key uncertainties and gaps in evidence can be useful first steps towards integrating these considerations into policy appraisal.
- x It is recognised that there is considerable complexity in understanding and assessing the causal links between a policy, its effects on ecosystems and related services and then valuing the effects in economic terms. Integrated working with policy, science and economics disciplines will be essential in implementing this approach in practice. The critical importance of the links to scientific analysis, which form the basis for valuing ecosystem services, needs to be recognised.
- xi A range of methodologies are available to value changes in ecosystem services. These values are considered in a Total Economic Value framework that takes into account both the use and non-use values individuals and society gain or lose from marginal changes in ecosystem services. As many ecosystem services are not traded in markets, and therefore remain unpriced, it is necessary to assess the relative economic worth of these goods or services using non-market valuation techniques.
- xii The type of valuation technique chosen will depend on the type of ecosystem service to be valued, as well as the quantity and quality of data available. Some valuation methods may be more suited to capturing the values of particular ecosystem services than others. Benefits transfer, which applies economic values that have been generated in one context to another context for which values are required, is also discussed. The use of such transfers is seen as being essential to the more practical use of environmental values in policy-making.

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- xiii The valuation methodologies discussed are not new in themselves. The challenge is in their appropriate application to ecosystem services. The ecosystem services framework emphasises the need to consider the ecosystem as a whole and stresses that changes or impacts on one part of an ecosystem have consequences for the whole system. Therefore, considering the scale and scope of the services to be valued is vital if we are to arrive at any meaningful values.
- xiv Key challenges in the valuation of ecosystem services relate to how ecosystems interrelate to provide services and to dealing with issues of irreversibility and high levels of uncertainty in how ecosystems function. All of this suggests that, while valuation is an important and valuable tool for good policy-making, it should be seen as only one of the inputs in decision-making.
- xv At the same time, the use of ecosystem services as a framework for valuation presents important opportunities to incorporate a wider range of environmental impacts in policy appraisal work in the future. Methodologies to deal with these challenges that account systematically for all the impacts on ecosystems and their services are very much in development. This does not mean that the valuation of ecosystem services cannot be taken forward now – and indeed the priority is that it should be. However, it is recognised that it will be a long-term challenge for those involved in policy appraisal to fully take into account all the impacts on ecosystems and ecosystem services.
- xvi The case study – a flood and coastal erosion risk management scheme – provides a good illustration of the many issues and lessons learned in applying the valuation of ecosystem services to a policy and project appraisal context. The case study is considered with reference to the impact pathway approach and illustrates how such an approach can work in practice. It demonstrates how the ecosystem services valuation framework can be material and useful, despite imperfect information, both in terms of selecting or ruling out certain options, and in directing attention towards the most important data gaps and uncertainties that may have a bearing on the results of appraisals.
- xvii This case study shows the uncertainty surrounding the absolute value of the ecosystem services resulting from uncertainty concerning both the physical changes in ecosystem services and the appropriate monetary values to apply to these changes. However, the work also demonstrates that the ‘perfect’ ecosystem service valuation may not be necessary for many appraisal purposes. Practical appraisals need to compare the relative magnitude of changes in the provision of ecosystem services across different options, and this can be possible even with limited availability and precision of scientific and economic information. In most cases, it should be possible to present a robust assessment, with suitable sensitivity analysis, highlighting the key uncertainties and exploring their implications.
- xviii This Guide is a first step in Defra’s aim to better integrate impacts on the natural environment in decision-making. It is purposely ‘introductory’ recognising that further testing and development is needed to operationalise this approach in policy and project appraisal in Defra, the Defra network and beyond.

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- xix The Introductory Guide has been published alongside ***Securing a Healthy Natural Environment: An Action Plan for embedding an ecosystems approach***¹ which includes specific priorities for Defra and others in moving towards an ecosystems approach in policy-making and delivery. The Action Plan provides a clear overview of the principles and benefits of an ecosystems approach and sets out key steps to take the work forward. Ensuring that the value of ecosystem services is fully reflected in decision-making is one of the core principles outlined in the Action Plan.
- xx Specific priorities for Defra and others in progressing the development of ecosystem services valuation include piloting the practical application of ecosystem services valuation in specific policy areas. If we can demonstrate that valuing ecosystem services is both practical and useful, in the longer term our aim would be to mainstream this approach in existing policy and project appraisal tools and guidance.

¹ <http://www.defra.gov.uk/wildlife-countryside/natres/eco-actionp.htm>

- i The aim of the Guide is to provide an introduction to the valuation of ecosystem services. It builds on previous approaches to valuing the environment but takes a more systematic approach to the assessment of impacts on the natural environment, encouraging a wider range of environmental impacts to be accounted for in policy appraisal.
- ii The central theme of this work is to ensure that the true value of ecosystems and the services they provide are taken into account in policy decision-making. There is much evidence to suggest that, in the UK, we currently find it difficult, in practice, to take full account of environmental impacts.² More effort is needed in valuing ecosystem services to better account for the costs associated with ecosystem degradation and to recognise the substantial economic benefits from better management of ecosystems. It is recognised that there are significant knowledge gaps in relation to the valuation of ecosystem services.³
- iii While valuing ecosystem services is not a new concept, it remains a developing area with much complexity. This is a reason for presenting this as an Introductory Guide and considering the need for more detailed appraisal guidance in the future than can take account of these developments.
- iv The valuation of ecosystem services should be seen within the broader context of an ecosystems approach, as is currently being developed by Defra.⁴ More detail can be found in the ecosystems approach Action Plan⁵ which aims to embed in policy-making and delivery in England an ecosystems approach to conserving, managing and enhancing the natural environment.
- v The work draws on the United Nations' Millennium Ecosystem Assessment (MA)⁶ which strongly supported the use of an ecosystems approach and provided a substantial evidence base for policy-making. The Millennium Ecosystem Assessment set out a typology of ecosystem services under four broad headings: provisioning, regulating, cultural and supporting services. However, the exact terminology relating to ecosystems services is less important than the point that ecosystems provide valuable services for people. There is no single way of categorising ecosystem services, but they can be described in simple terms as providing:
 - natural resources for basic survival, such as clean air and water
 - a contribution to good physical and mental health, for example, through access to green spaces, both urban and rural, and genetic resources for medicines
 - natural processes, such as climate regulation and crop pollination
 - support for a strong and healthy economy, through raw materials for industry and agriculture or through tourism and recreation
 - social, cultural and educational benefits, and wellbeing and inspiration from interaction with nature.

2 For example, see the National Audit Office Briefing for the Environmental Audit Committee: *Regulatory Impact Assessments and Sustainable Development*, May 2006

3 CEM University of Nottingham, (2006). *The Ecosystem Concept and the Identification of Ecosystem Goods and Services in the English Policy Context – A Review Paper*
<http://www.defra.gov.uk/wildlife-countryside/natres/pdf/ecosys-concept.pdf>

4 There is no single definition of an ecosystems approach. The Defra Action Plan *Securing a Healthy Future: An Action Plan for embedding an ecosystems approach* highlights a set of common principles for a generic 'ecosystems approach' that can be applied in a wide range of policy areas and decision-making contexts. This includes ensuring that the value of ecosystem services is fully reflected in decision-making.

5 <http://www.defra.gov.uk/wildlife-countryside/natres/eco-actionp.htm>

6 <http://www.maweb.org/en/index.aspx>

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Audience for this Guide and how to use it

- vi This Introductory Guide to valuing ecosystem services is designed to reach a broad audience. The intention is that it will start engaging policy-makers, economists and scientists across Government and Agencies and will encourage those involved in policy appraisals and the decision-making process to take better account of the value of ecosystem services.⁷
- vii The Guide provides a set of steps that can be applied to any policy appraisal context which includes a checklist of ecosystem services and approaches to the assessment of values. Some chapters necessarily have a more technical bias. However, summaries are provided at the beginning of each chapter to present the key points in a non-technical manner. Further references are given at the end of the Guide.
- viii Although the Guide recognises the challenges in the valuation of ecosystem services, we should nevertheless be looking for opportunities now, in current policy appraisal, for greater consideration of the impacts of policy change on ecosystems and ecosystem services.

Structure of this Guide

- (ix) The structure of the main parts of the Guide is as follows:

Chapter 1: The case for the valuation of ecosystem services provides a brief overview of ecosystem services and the links to human wellbeing and develops the case for the valuation of ecosystem services in policy appraisal.

Chapter 2: Policy appraisal and the environment – the wider context provides further context on policy appraisal and the environment, giving a brief overview of the main guidance and provides more detail on where the valuation of ecosystem services could fit into the existing environmental appraisal process.

Chapter 3: The ‘impact pathway’ approach to the valuation of ecosystem services provides an overview of the key steps to be taken in valuing the impacts on ecosystem services which includes identifying policy options and the current baseline; assessing the impact of policy options on the provision of ecosystem services, and valuing the changes in ecosystem services.

Chapter 4: Valuation of ecosystem services considers economic valuation techniques including the use of benefits transfer, and presents the Total Economic Value framework discussing how its use fits in with valuation of ecosystem services.

⁷ While the purpose of this Introductory Guide is focused particularly on improving how we take account of impacts on ecosystems and ecosystem services in a UK context, it can be applied to a broad range of contexts, including internationally.

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Chapter 5: Key challenges and opportunities looks at some of the key challenges in the valuation of ecosystem services, including the interdependence of ecosystems and ecosystem services; spatial and temporal issues in valuing changes in ecosystem services; and environmental limits and cumulative effects. It also highlights the opportunities for incorporating a wider range of environmental impacts in policy appraisal.

Chapter 6: Case study provides a summary of a case study – drawing on work by the Environment Agency on flood risk management – that explores how valuing ecosystem services can be incorporated into a policy appraisal context. Further details can be found in the 2007 report for Defra: *Policy Appraisal and the Environment: An Introduction to the Valuation of Ecosystem Services – Wareham Managed Realignment Case Study*, which is published alongside this Guide.

Chapter 7: Next steps highlights some steps that can be taken in terms of future work and the application of this Introductory Guide.

Chapter 1: The Case for the Valuation of Ecosystem Services

Summary

Ecosystem services are defined as services provided by the natural environment that benefit people. While there is no single, agreed method of categorising all ecosystem services, the Millennium Ecosystem Assessment (MA) framework is widely accepted and is seen as a useful starting point. Ecosystem services provide outputs or outcomes that directly and indirectly affect human wellbeing and these considerations can link well to taking an economic approach.

The underlying case for the valuation of ecosystem services is that it will contribute towards better decision-making by ensuring that policy appraisals fully take into account the costs and benefits to the natural environment and by highlighting much more clearly the implications for human wellbeing while providing policy development with new insights.

Some of these ecosystem services are well known, including food, fibre and fuel provision and the cultural services that provide benefit to people through recreation and appreciation of nature. Other services provided by ecosystems are not so well known. These include the regulation of the climate, purification of air and water, flood protection, soil formation and nutrient cycling. These are not generally considered within policy appraisal at present and represent an area where a greater and more systematic focus would be very useful.

What are ecosystem services?

- 1.1 An **ecosystem** can be defined at the most basic level as a natural unit of living things (animals, plants and micro-organisms) and their physical environment. The living and non-living elements function together as an interdependent system – if one part is damaged it can have an impact on the whole system. Ecosystems can be terrestrial or marine, inland or coastal, rural or urban. They can also vary in scale from the global to the local. At the continental level examples include rainforests, deserts and coral reefs. Closer to home we might think more in terms of different types of habitats (e.g. woodlands, grassland, marshes, heathland, rivers, peat bogs) though this can also extend to the urban environment (e.g. parks and gardens, rivers and streams). In many cases, ecosystems overlap and interact.
- 1.2 **Ecosystem services** are defined as services⁸ provided by the natural environment that benefit people. Some of these ecosystem services are well known including food, fibre and fuel provision and the cultural services that provide benefits to people through recreation and cultural appreciation of nature. Other services provided by ecosystems are not so well known. These include the regulation of the climate, purification of air and water, flood protection, soil formation and nutrient cycling.

⁸ The definition of ecosystem services refers to both goods and services.

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1.3 The Millennium Ecosystem Assessment (MA) identifies four broad categories of ecosystem services:

- provisioning services
- regulating services
- cultural services
- supporting services.

1.4 While there is no single, agreed method of categorising all ecosystem services, the MA framework is widely accepted and is seen as a useful starting point. Table 1.1 provides further examples of the different types of ecosystem services within these broad categories.

Table 1.1: MA categories of ecosystem services and examples

Category	Examples of ecosystem services provided
Provisioning services i.e. products obtained from ecosystems	<ul style="list-style-type: none"> • Food e.g. crops, fruit, fish • Fibre and fuel e.g. timber, wool • Biochemicals, natural medicines and pharmaceuticals • Genetic resources: genes and genetic information used for animal/plant breeding and biotechnology • Ornamental resources e.g. shells, flowers
Regulating services i.e. benefits obtained from the regulation of ecosystem processes	<ul style="list-style-type: none"> • Air-quality maintenance: ecosystems contribute chemicals to and extract chemicals from the atmosphere • Climate regulation e.g. land cover can affect local temperature and precipitation; globally ecosystems affect greenhouse gas sequestration and emissions • Water regulation: ecosystems affect e.g. the timing and magnitude of runoff, flooding etc. • Erosion control: vegetative cover plays an important role in soil retention/prevention of land/asset erosion • Water purification/detoxification: ecosystems can be a source of water impurities but can also help to filter out/decompose organic waste • Natural hazard protection e.g. storms, floods, landslides • Bioremediation of waste i.e. removal of pollutants through storage, dilution, transformation and burial
Cultural services i.e. non-material benefits that people obtain through spiritual enrichment, cognitive development, recreation etc	<ul style="list-style-type: none"> • Spiritual and religious value: many religions attach spiritual and religious values to ecosystems • Inspiration for art, folklore, architecture etc • Social relations: ecosystems affect the types of social relations that are established e.g. fishing societies • Aesthetic values: many people find beauty in various aspects of ecosystems • Cultural heritage values: many societies place high value on the maintenance of important landscapes or species • Recreation and ecotourism
Supporting services, necessary for the production of all other ecosystem services	<ul style="list-style-type: none"> • Soil formation and retention • Nutrient cycling • Primary production • Water cycling • Production of atmospheric oxygen • Provision of habitat

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- 1.5 Supporting services are those that are necessary for the production of all other ecosystem services. The important point to emphasise is that they differ from provisioning, regulating, and cultural services in that their impacts on people are indirect. This has implications for how we take into account the value of changes in supporting services, as highlighted in Chapter 4.
- 1.6 Biodiversity and ecosystems are closely related concepts. There is significant evidence on the linkages between changes in biodiversity and the way ecosystems function.⁹ Biodiversity underpins all ecosystem services, but it can also be a service in itself (e.g. the existence value of a species under cultural services). Biodiversity is also considered to have insurance value by providing resilience in the face of current or future shocks to ecosystems and the services they provide.

Links between ecosystem services and human wellbeing

- 1.7 A key strength of the MA is in its conceptual framework, which links ecosystems and the services to human wellbeing. Ecosystem services provide outputs or outcomes that directly and indirectly affect human wellbeing and these considerations can link well to taking an economic approach.
- 1.8 For the purposes of this Introductory Guide, our primary focus relates to economic valuation. Economic valuation attempts to elicit public preferences for changes in the state of the environment in monetary terms and can therefore provide evidence that is appropriate for use in a cost-benefit analysis. Ecosystems and their associated services have economic value for society because people derive utility from their actual or potential use and also value services for reasons not connected with use (i.e. non-use values) such as altruistic, bequest and stewardship motivations.
- 1.9 This concept of value focuses on the contribution to human welfare – an anthropocentric view – which is seen as the most relevant to policy-making. While it is recognised that the natural environment has intrinsic value i.e. is valuable in its own right, such non-anthropocentric value is, by definition, beyond any human knowledge. However, while an anthropocentric approach is limited to capturing the value to human welfare, it is important to note that this value may include preferences that individuals have that relate to the wellbeing of animals, plants etc. It is also important to note that the application to policy appraisal is not related to the total value of ecosystems but, rather, to valuing changes in ecosystem services.

⁹ Hooper D, Chapin F, et al. (2005), *Effects of Biodiversity on Ecosystem Functioning: A consensus of current knowledge*. Ecological Monographs **75**(1): 3-35

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The case for the valuation of ecosystem services

- 1.10 The underlying case for the valuation of ecosystem services is that it will contribute towards better decision-making, ensuring that policy appraisals fully take into account the costs and benefits to the natural environment.
- 1.11 Many indicators suggest that we are using the natural environment in a non-sustainable way. Ecosystems can be characterised as environmental assets that, like other capital assets, provide a flow of services over time. If these services are consumed in a sustainable manner, the capital can be kept intact. In recent decades, however, ecosystems have been under increasing pressure as a result of human activity; the MA found that **'nearly two thirds of the services provided by nature to humankind are found to be in decline worldwide. In effect, the benefits reaped from our engineering of the planet have been achieved by running down natural capital assets.'**¹⁰ The HM Treasury report, *Long-Term Opportunities and Challenges for the UK: Analysis for the 2007 Comprehensive Spending Review*,¹¹ recognised that natural resources and the global climate are under pressure and that environmental damage has the potential to undermine long term prosperity in the UK and in all countries.
- 1.12 Valuing ecosystem services serves a number of purposes. Valuing the benefits – both current and future – from the natural environment illustrates its significant contribution to wellbeing and the high dependency of society on its ecological base. In one sense, the natural environment is of infinite value since it underpins and supports all human activity. However, for policy-making, the more relevant application of valuation is to *marginal* changes in the environment.
- 1.13 In a policy appraisal context, valuing ecosystem services can help in: determining whether a policy intervention that alters an ecosystem condition delivers net benefits to society; providing evidence on which to base decisions on 'value for money' and prioritising funding; choosing between competing uses, e.g. of land use; assessing liability for damage to the environment; and in wider communication e.g. to the public and land managers on the value of the environment. Adopting an ecosystem services framework may provide new insights for policy development, for example, in understanding how conservation policies in the future can be best targeted to deliver our environmental priorities. It may also help in creating markets for services, including payments for ecosystem services, as valuation provides evidence to underpin the development of such policy instruments.
- 1.14 Although guidance already exists to help capture some of these environmental impacts, using an ecosystem services framework potentially allows the analyst to capture the full range of environmental impacts more systematically, linking ecological effects to changes in human welfare. While many environmental impacts are incorporated within policy appraisal and progress has been made in valuing these impacts, in practice it has proved difficult to incorporate impacts on ecosystems with the risk that the value of these impacts are not fully accounted for in decision-making.¹² The use of ecosystem services as a framework is seen as an opportunity to overcome some of these difficulties, but many challenges remain. Regulating services represent one particular category of ecosystem services that is not generally considered within policy appraisal at present and where a greater focus could be very useful.

¹⁰ Statement from the MA Board: <http://www.millenniumassessment.org/documents/document.429.aspx.pdf>

¹¹ http://www.hm-treasury.gov.uk/spending_review/spend_csr07/spend_csr07_longterm.cfm

¹² This has been recognised in the context of air pollution, for example, which causes significant damage to human health and ecosystems. Presently, the valuation of ecosystem impacts due to air pollution is very limited or non-existent. Recent European Commission work has been looking at the scope for valuing changes in ecosystems so that these impacts can be accounted for in cost-benefit analysis of air-quality policies: http://ec.europa.eu/environment/air/valuation/index_en.htm

Chapter 2: Policy Appraisal and the Environment – The Wider Context

Summary

The appraisal of new policies, programmes and projects requires environmental impacts to be taken into account. The approach to the valuation of ecosystem services presented in this Guide is not intended to be an additional step within the appraisal process but, instead, a common methodology that can be used in order to consider the impact of our actions on the environment. The environmental impacts currently taken into account in policy appraisal can generally fit well within this broad framework.

This broader framework allows a shift in emphasis from a focus mainly on valuing environmental damage to highlighting the value of changes in the services provided by the natural environment. Ecosystem services contribute to economic welfare in two ways – through contributions to the generation of income and wellbeing and through the prevention of damages that inflict costs on society. Both types of benefits should be accounted for in policy appraisal. With a broader focus on valuing ecosystem services, policy options that enhance the natural environment are also more likely to be considered, demonstrating that investing in natural capital can make economic sense.

Introduction

- 2.1 Government action has a major impact on society through the implementation of a wide range of policies, programmes and projects. Appraisals seek to measure the impact of government action and provide an assessment of whether new proposals are worthwhile. They can apply to policies, programmes and projects.¹³ They aim to ensure that government action is justified both by considering whether any government intervention is required and by determining that the proposed course of action is the best available option.
- 2.2 The appraisal of new policies, programmes and projects all require environmental impacts to be taken into account. While much progress has been made in the last 10-15 years in ensuring that environmental impacts are incorporated into policy appraisal and integrated into the main policy appraisal guidance, there remains much scope for further improvement.
- 2.3 The approach to the valuation of ecosystem services outlined in this Guide is a more comprehensive means of taking into account all environmental impacts and can therefore be applied to the appraisal of any type of intervention.

¹³ Policies are high-level plans of action incorporating general objectives, such as improving water quality or combating climate change. Programmes are collections of procedures or actions aimed at achieving policy objectives, whereas projects are separate components within a programme, for example, the widening of a specific road.

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The process of policy appraisal and the environment

- 2.4 HM Treasury's *Green Book: Appraisal and Evaluation in Central Government*,¹⁴ [Treasury Green Book] provides overarching guidance on how to appraise and evaluate government intervention, setting out the main stages in the appraisal process.
- 2.5 Within this process, environmental impacts should be taken into account at all stages. For any new proposal, effects such as a change in greenhouse gas emissions, a change in air or water quality and the effect on different habitats or wildlife need to be considered alongside other costs and benefits. The Treasury Green Book states that 'the effects on the environment should be considered, including air and water quality, land use, noise pollution, and waste production, recycling and disposal'.¹⁵
- 2.6 For all policy proposals in the UK, an impact assessment detailing the costs and benefits of action needs to be undertaken. The Impact Assessment Guidance¹⁶ provides a specific format and guidance on how impact assessments should be carried out. Within the Impact Assessment Toolkit,¹⁷ there are particular sections on how environmental effects should be considered. Further information on guidance on environmental impacts in specific policy areas can be found on the Defra website¹⁸, which includes impacts on climate change, water including flood risk, waste management, air quality, noise, landscape and biodiversity.

Valuation of environmental impacts in policy appraisal

- 2.7 Some environmental effects can be valued relatively easily e.g. air quality impacts on the quantity of agriculture production, and this change in production can be valued using market prices. Another example might be the market value of forest products. More often, however, there is no direct market for environmental goods and services; these are referred to as non-market goods and services. It may still be possible to place a value on such environmental effects, and a number of different valuation techniques have been developed (described further in Chapter 4). Valuing environmental impacts enables them to be incorporated into a monetary cost-benefit analysis. Such effects can be weighed up against other monetised costs and benefits to establish the relative net benefit of the proposal.

14 http://www.hm-treasury.gov.uk/economic_data_and_tools/greenbook/data_greenbook_index.cfm

15 See also Annex 2 of the Treasury Green Book, which describes the approach taken to valuing non-market impacts.

16 <http://bre.berr.gov.uk/regulation/ria/>

17 <http://bre.berr.gov.uk/regulation/ria/toolkit/>

18 <http://www.defra.gov.uk/corporate/regulat/impact-assessment/envguide/index.htm>

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2.8 In the UK, increasing emphasis has been placed on the monetisation of environmental impacts in policy appraisal and much progress has been made. For example, specific monetary values are now used to take account of the shadow price of carbon, the impacts of air pollution on human health and disamenity values from noise. Other Government Departments and Agencies have also developed detailed guidance to ensure that environmental impacts are taken into account in policy and project appraisal. Examples are provided in Table 2.1.

Table 2.1: Guidance on specific environmental impacts in policy appraisal

Department/ Agency	Environmental Impact/Policy area	Description and link to guidance
Defra	Air quality	Guidance on the environmental impacts of air quality including recommended damage cost values to apply: http://www.defra.gov.uk/environment/airquality/panels/igcb/index.htm
	Climate change	Greenhouse gas policy evaluation and appraisal guidance: http://www.defra.gov.uk/environment/climatechange/uk/ukccp/pdf/greengas-policyevaluation.pdf Details on the recommended carbon values to apply in policy appraisal: http://www.defra.gov.uk/environment/climatechange/research/carboncost/index.htm
	Flood risk management	Flood risk management project appraisal guidance: http://www.defra.gov.uk/environ/fcd/pubs/pagn/default.htm
	Waste	Review of the environmental and health impacts of waste, including evidence on valuation: http://www.defra.gov.uk/environment/waste/research/health/index.htm
Department for Transport	Appraisal of transport projects	Methodology for taking account of environmental impacts: http://www.webtag.org.uk/webdocuments/3_Expert/3_Environment_Objective/index.htm
Environment Agency	Flood risk management	<i>Flood and Coastal Erosion Risk Management: Economic Valuation of Environmental Effects:</i> forthcoming publication
European Commission	Various initiatives to provide guidelines for the assessment of environmental costs and benefits	Guidance on external costs of fuel cycles (energy/transport): http://www.externe.info/ Guidelines in the Water Framework Directive (WFD) context: http://www.aquamoney.ecologic-events.de/ MethodEx: best practice in external cost assessment, extending ExternE analysis to agriculture, industry, waste and other sectors: http://www.methodex.org/

2.9 Valuing environmental effects can be complex. Sometimes, therefore, impacts cannot be presented in monetary terms. In general, where possible, environmental impacts should be valued in monetary terms. However, where this is not possible, these impacts should be presented in quantified terms; and if this is not possible, there should be a qualitative assessment of the potential impacts.

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The wider decision-making framework

- 2.10 This Introductory Guide on valuing ecosystem services is focused mainly on the links to policy appraisal through cost-benefit analysis. However, other decision-making procedures have been developed to take account of environmental impacts including:
- Environmental Impact Assessment (EIA)
 - Strategic Environmental Assessment (SEA)
 - Life-Cycle Analysis (LCA)
 - Risk Assessment
 - Cost-Effectiveness Analysis
 - Multi-Criteria Analysis (MCA).
- 2.11 It is not the purpose here to outline all the different appraisal techniques in detail. For further discussion, see *Review of technical guidance on environmental appraisal*.¹⁹ A good summary of recent developments can be found in the 2006 review by the OECD.²⁰
- 2.12 These appraisal techniques have different objectives and decision rules. While there are some significant differences in these approaches compared to cost-benefit analysis, it is important to understand some of the complementarities. In particular, some of the outputs from EIAs and SEAs can, in principle, provide important inputs for a cost-benefit analysis as well as evidence in its own right (see Box 2.1 below). However, an issue may be that, generally, these assessments are currently conducted separately from any cost-benefit analysis.
- 2.13 The Treasury Green Book highlights the use of multi-criteria decision analysis when faced with a mix of monetary values, quantified data and qualitative considerations. Weighting and scoring can be used to bring data expressed in different units into the appraisal process. This approach usually involves an explicit relative weighting system for the different criteria relevant to the decision.²¹ This is not explored further in this guide but is relevant to the broader decision-making context. Recent work for the Sustainable Development Research Network, *Emerging Methods for Sustainability Valuation and Appraisal*²² covers a range of valuation methods, some of which are linked closely to multi-criteria analysis approaches.

19 Eftec (1999), *Review of Technical Guidance on Environmental Appraisals*: <http://www.defra.gov.uk/environment/economics/rtgea/index.htm>

20 Pearce D, Atkinson G and Mourato S (2006) *Cost Benefit Analysis and the Environment: Recent developments*, Chapter 18. OECD

21 For further information on MCA, see *Multi-Criteria Analysis: A Manual*:

<http://www.communities.gov.uk/archived/publications/corporate/multicriteriaanalysismanual>

22 <http://www.sd-research.org.uk/post.php?p=129>

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Box 2.1: EIAs and SEAs in the decision-making framework

Environmental Impact Assessment (EIA) is an assessment of the impact of a project on the environment. It provides a systematic means of collecting information on the environmental effects and evaluating this information, with the conclusions used as a tool in decision-making. Strategic Environmental Assessment (SEA) is similar to EIA but works at a more strategic level, typically considering entire programmes or policies. The advantage of an SEA is that it can look for synergies between projects and evaluate alternatives in a more comprehensive manner. It can also potentially address the cumulative effects of projects. EIAs and SEAs both focus on providing quantified evidence highlighting the significance of the environmental impacts, although they do not generally seek to provide monetary estimates of the impacts. One of their purposes is to look at alternative means of minimising the environmental impacts without altering the benefits of the project or policy. *The OECD's 2006 Review, Cost-Benefit Analysis and the Environment: Recent Developments*, shows that although EIAs/SEAs do not provide a comprehensive evaluation procedure (they exclude non-environmental impacts and costs and do not deal with how impacts vary with time), they both nevertheless play a key role in the evaluation of impacts and can also potentially provide essential input to a cost-benefit analysis.

Where does the valuation of ecosystem services fit into the existing environmental appraisal process?

- 2.14 Given the policy appraisal context presented above, an important question to ask is: where does the valuation of ecosystem services fit into existing policy appraisal of the environment? The approach to the valuation of ecosystem services presented in this Guide describes a specific way of thinking about environmental impacts. It is not intended to be an additional step within the appraisal process but instead a common methodology that can be used in order to consider the impact of our actions on the environment. The environmental impacts currently taken into account in policy appraisal can fit well within this broad framework.²³ However, this framework will, in general, imply a much wider look at the impacts on ecosystems compared to current appraisal. It could, therefore, over time, be a useful framework that is widely adopted as a tool in the policy appraisal of environmental impacts.
- 2.15 This broader framework allows a shift in emphasis from a focus on valuing environmental damage (e.g. air pollution impacts etc.) to highlighting the value of services provided by the natural environment. Ecosystem services contribute to economic welfare in two ways – through contributions to the generation of income and wellbeing, and through the prevention of damages that inflict costs on society. The latter is characteristic of certain ecosystem services that provide insurance, regulation and resilience functions. Both types of benefits should be accounted for in policy appraisal.
- 2.16 Box 2.2 provides an illustration of the ecosystem services from forests and woodlands in England. It highlights a developing evidence base on the regulating services provided by forests and woodlands, including air quality purification, the reduction of soil erosion and pollution run-off. Some of these benefits are already being valued while, for others, more evidence is still required.

²³ There may be some exceptions to this. For example, the disamenity effects of noise pollution.

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Box 2.2: Ecosystem services provided by forestry

Well managed forests and woodlands deliver a range of social and environmental goods and services. Research for the Forestry Commission *The Social and Environmental Benefits of Forestry in Britain*,²⁴ published in 2003 showed that these benefits include:

- providing opportunities for open access outdoor recreation
- supporting and enhancing biodiversity
- contributing to the visual quality of the landscape
- carbon sequestration.

The report estimated the total value of annual benefits to people in Britain to be around £1 billion. This was based on both existing evidence and commissioned new surveys on public preferences for forestry. The table below shows the contribution from these social and environmental benefits.

Benefit	Annual value (£ million)
Recreation	£393 m
Biodiversity	£386 m
Landscape	£150 m
Carbon sequestration	£94 m
Total	£1023 m

All of these benefits could be categorised as ecosystem services, i.e. the services that are provided, in this case, by forestry and woodland in Britain. What is interesting is that, increasingly, attention is being drawn to other social and environmental benefits of forestry, such as improving air quality and regulating water supply and water quality. These can be described under the ecosystem services category of 'regulating services'. For example, under improving air quality, forests and woodlands 'clean' the air as trees trap harmful dust particles and absorb gases such as sulphur dioxide and ozone. Scientific evidence has shown that this absorption by trees can be considerable. The beneficial contribution of trees to improved air quality can be valued through the resulting improvements to human health. In addition, forests and woodlands can reduce soil erosion, stabilise riverbanks and reduce pollution in run-off. Fuller understanding, however, may be required before they can be quantified or valued.

- 2.17 With a broader focus on valuing the environmental services provided by ecosystems, policy options that enhance the natural environment are more likely to demonstrate that investing in natural capital, rather than man-made capital, can make economic sense. Box 2.3 illustrates this point.

24 The full report can be found at: <http://www.forestry.gov.uk/economics>

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Box 2.3: Peatland restoration to improve local drinking water

Peat ecosystems provide a variety of services, such as habitat for biodiversity (birds), carbon sequestration, and regulating roles in water supply and purification. By acting as a natural filter, less expenditure is necessary to maintain water quality.

In North-West England, it is estimated that lowland peat bogs represent only 10% of the original total, while there is evidence of significant losses of upland peat land between the 1940s and 1980s. This habitat destruction/degradation has been a result of land being drained for intensive farming use combined with private rights to peat cutting.

United Utilities (UU), a private water company, and the Royal Society for the Protection of Birds (RSPB) undertook a peat bog restoration project to reverse damage to an area subject to intensive farming, under the Sustainable Catchment Management Programme (SCaMP). UU owns about 57,000 hectares in the region, mainly upland blanket peat. A major part of the programme is to ensure sensitive farming practices are employed to prevent further degradation. The project has demonstrated clear benefits of restoration in terms of improved water colour and water quality, lower long-term costs to customers, reduced flood risk downstream, and enhanced aquatic, wetland and terrestrial biodiversity. Restoration of peat bogs was estimated to provide annual benefits of between £1.2 million and £2.6 million (based on costs of 'end of pipe' water treatment expected to be avoided). This case study therefore shows how private business can benefit from investing in the natural environment.

Source: *Institute for European Environmental Policy (2006)*, Value of Biodiversity: Documenting EU examples where biodiversity loss has led to the loss of ecosystem services.

Chapter 3: The 'Impact Pathway' Approach to the Valuation of Ecosystem Services

Summary

This chapter provides a practical guide to the key steps to be undertaken in valuing ecosystem services in a policy appraisal context. In summary, these steps are:

- 1 Establish the environmental baseline.
- 2 Identify and provide qualitative assessment of the potential impacts of policy options on ecosystem services.
- 3 Quantify the impacts of policy options on specific ecosystem services.
- 4 Assess the effects on human welfare.
- 5 Value the changes in ecosystem services.

Following these steps can help to ensure a more systematic approach to accounting for impacts on ecosystems. Even an initial screening within a policy appraisal of what ecosystem services are affected, how potentially significant these impacts could be, and developing an understanding of the key uncertainties and gaps in evidence can be useful first steps towards integrating these considerations into policy appraisal.

It is recognised that there is considerable complexity in understanding and assessing the causal links between a policy, its effects on ecosystems and related services and then valuing the effects in economic terms. Integrated working with policy, science and economics disciplines will be essential in implementing this approach in practice. The critical importance of the links to scientific analysis, which form the basis for valuing ecosystem services needs to be recognised.

Introduction

- 3.1 This chapter provides a practical guide to the key steps to be taken in valuing impacts on ecosystem services in a policy appraisal context. This essentially further develops existing approaches of environmental appraisal, attempting to evaluate the effect of policy on ecosystems and the subsequent impacts on the provision of services for society. By adopting a systematic approach to consideration of the services, the decision-maker can ensure that a holistic approach to the ecosystem is taken.

Types of decisions that can be considered

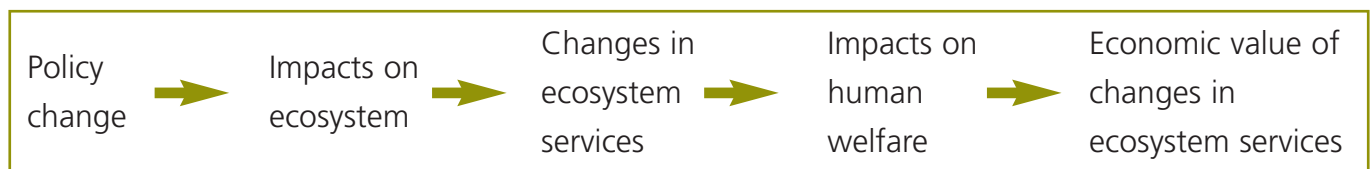
- 3.2 The valuation of ecosystem services can provide input for decisions at many different levels. This ranges from national and international policy decisions to regional and sub-regional decisions and local planning decisions. The challenge in each case is to identify all the ecosystem services that will be affected by the decision and to obtain sufficient information to conduct the ecosystem service assessment, including linking the assessment of changes in service provision to measures of changes in human welfare.
- 3.3 Decision-makers confront often complex decisions that require trade-offs between alternative land uses, objectives and timescales. The approach taken in this Introductory Guide will not lead to a simple resolution of such decisions, but should provide a consistent and systematic framework to ensure that decision-makers are confident that they have taken into account all aspects of the problem so that decisions are fully informed within the limits of the available information. It is not possible to conduct a perfect analysis, not least because understanding of the links between the pressures and impacts and between services and human wellbeing is incomplete and important data are often lacking.

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Overview of the impact pathway approach

3.4 In order to understand the value of an ecosystem it is necessary to characterise and quantify the relationships between ecosystems and the provision of ecosystem services, and to identify the ways in which these impact on human welfare. Figure 3.1 provides a very simplified overview of an impact pathway approach which looks at the links between ecosystems and the provision of services and how these services contribute to human welfare. These benefits can be translated into economic value using economic valuation techniques. This masks the considerable complexities in the causal links between these stages but is helpful as a guide to the overall approach.

Figure 3.1: Overview of impact pathway of policy change



- 3.5 Figure 3.1 should be read with marginal changes in mind, reflecting the types of changes that take place in the quality and quantity of ecosystem services as a result of policy decisions. In the context of cost-benefit analysis, typically, the changes in the value of ecosystem services between the baseline option (no change) and the other policy options would be assessed. This is also important as it demonstrates that the analysis needs to focus on identifying changes in ecosystems and the provision of ecosystem services resulting from policy options and valuing these changes rather than giving an assessment of all services currently provided by the ecosystems in question.
- 3.6 Box 3.1 takes this simplified impact pathway approach and applies it in greater depth in the policy appraisal context. Although these steps are presented sequentially, it is important to note the iterative nature of this process. For example, it will be important to understand what economic end points (i.e. ecosystem services that deliver benefits that have economic value) are likely to be affected by the policy change. This will have an impact on identifying the ecosystem services to be analysed and on informational requirements in earlier steps. Integrated working with policy, science and economics disciplines will be essential in implementing this approach in practice. The critical importance of the links to scientific analysis, which form the basis for valuing ecosystem services, needs to be recognised.
- 3.7 Clearly, in policy appraisal, in practice, it is unlikely to be feasible to value all impacts on an ecosystem and the services it provides. A practical framework needs to be developed that allows for a systematic approach to scoping out the most significant impacts on ecosystem services of a policy and identifying where further analysis should be directed.

Box 3.1: Key steps in the valuation of ecosystem services

1. Establish the environmental baseline.
2. Identify and provide qualitative assessment of the potential impacts of policy options on ecosystem services.
3. Quantify the impacts of policy options on specific ecosystem services.
4. Assess the effects on human welfare.
5. Value the changes in ecosystem services.

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3.8 These steps are discussed in detail below. All of these steps should be considered within the wider context of a policy appraisal framework. The aim is to integrate this assessment of impacts on ecosystem services with the wider costs and benefits of different policy options. Chapter 6 uses a case study²⁵ to illustrate how these broad steps can be undertaken in a practical policy setting.

Step 1: establish the environmental baseline

- 3.9 The policy appraisal process will have identified specific policy options to take forward for analysis. The first step in valuing the impacts on ecosystem services is to develop an environmental baseline²⁶ (which will usually relate to the baseline or the 'do nothing' option in policy appraisal). The environmental baseline will identify and categorise ecosystems and their services, providing a baseline from which to identify the location and type of ecosystem services impacted on by the policy options. Take, for example, a specific policy affecting a wetland; a baseline assessment can characterise the nature and scale of this wetland, its interdependence with other ecosystems and the services provided, such as flood control services and filtration of pollutants as well as the potentially affected population.
- 3.10 Ecosystem services are identified and grouped into functional categories (as described in Chapter 1): provisioning, regulating, cultural and supporting. Since ecosystems are dynamic, an important issue to be addressed is the definition of the 'baseline' relating to the current condition. In some cases, this will, in itself, vary over time, and it will be necessary to ensure this temporal pattern is accounted for in the valuation of ecosystem services.
- 3.11 Box 3.2 provides a summary of some of the information available for establishing the environmental baseline. Wherever the data come from, it is important to maintain a high degree of transparency on their source and robustness of the data and highlighting areas of particular uncertainty.

Box 3.2: Information sources on the state of the environment

Data on the state of the environment are available from many sources. With the advent of the Environmental Information Regulation, and Freedom of Information, together with State of the Environment Reports produced by national and regional bodies, a wealth of environmental information is available. Some of the sources are detailed in the Defra-funded *Inventory and Assessment of Existing Resources* (<http://www.defra.gov.uk/wildlife/countryside/natres/research.htm>) which examined the degree to which existing databases of natural resources could be used to compile an inventory of UK natural resources and the extent to which this knowledge could be, or is being, used to assess both the state of these resources, and the trends in and threats to them. The new EU INSPIRE Directive will help ensure that publicly funded information is catalogued and made accessible. In many cases, it may also be necessary to develop synthetic data using mathematical models based on our best understanding of how the environmental systems operate.

²⁵ The Wareham Managed Realignment Case Study is published alongside this Guide.

²⁶ The concept of a 'baseline' should not be interpreted as indicating a status quo that might suggest that ecosystems are currently in an acceptable condition or not. For the purpose of policy appraisal, the baseline helps to identify the starting point for measuring ecosystem service impacts arising from policy change.

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Step 2: identify and provide qualitative assessment of the potential impacts of policy options on ecosystem services

3.12 The second step looks to identify and provide a qualitative assessment of the potential impacts of alternative policy options on ecosystem services. An initial checklist of services is proposed in Table 3.1 for use with an illustrative scoring approach. Depending on the policy area you are concerned with, and on specific circumstances, it will be necessary to include or exclude specific services, or to split some of the services further for effective calculation.

Table 3.1 Initial checklist of ecosystem services for consideration

Category	Baseline/ 'Do nothing' policy option 0	Policy option 1	Policy option 2	Policy option 3
Provisioning services				
Food				
Fibre and Fuel				
Genetic resources				
Biochemicals, natural medicines, pharmaceuticals				
Ornamental resources				
Fresh water				
Regulating services				
Air-quality regulation				
Climate regulation				
Water regulation				
Natural hazard regulation				
Pest regulation				
Disease regulation				
Erosion regulation				
Water purification and waste treatment				
Pollination				
Cultural services				
Cultural heritage				
Recreation & tourism				
Aesthetic value				
Supporting Services				
Soil formation				
Primary production				
Nutrient cycling				
Water cycling				
Photosynthesis				

<u>Score</u>	<u>Assessment of effect</u>
++	Potential significant positive effect
+	Potential positive effect
0	Negligible effect
-	Potential negative effect
--	Potential significant negative effect
?	Gaps in evidence

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- 3.13 When assessing impacts it is important to take a sufficiently broad view of the ecosystem and the spatial scale of possible impacts – the appropriate scale may well differ from that first implied by the policy change. The required spatial scale is likely to depend on the specific ecosystem service under consideration. This issue is particularly important in relation to regulating services, which can act over a wide spatial scale. For example, the impacts may be further downstream of the change, such as the flood risk benefits downstream of a wetland.
- 3.14 The purpose of this initial stage is to provide a preliminary qualitative assessment of which services are likely to be affected by a policy area and the likely importance of these changes. Each policy option could be scored – based on existing evidence and expert judgement – according to the potential significance for different ecosystem services, highlighting positive and negative impacts as well as negligible impacts and evidence gaps.
- 3.15 The key to this stage is that the assessment considers all ecosystem services. For many of these services, there may be no impacts at all. However, the point of this approach is to ensure a comprehensive view is taken at the start. It is also a means to identify, at an early stage of the analysis, where uncertainties and evidence gaps may be. It is important to attempt to assess as many aspects of the ecosystem services as possible, in order that the whole ecosystem is considered.
- 3.16 At an early stage in the analysis, consideration needs to be given to how different services may interact. There may be complementarities as well as conflicts between services. Understanding of these issues is important in ensuring there is no double-counting of benefits or avoiding including benefits of two competing services. Some services might be incompatible (e.g. water extraction and groundwater recharge) and so combining these values would over-estimate the ecosystem service benefits.

Step 3: quantify the impacts of policy options on specific ecosystem services

- 3.17 The preliminary qualitative assessment of the impacts on ecosystem services should allow priority to be placed on quantifying the impacts on specific ecosystem services.
- 3.18 It is now necessary to determine the extent to which the ecosystem provides the service and how the policy options may impact on that provision. It can be very difficult to quantify the level of ecosystem services provided by each option. However, in a policy appraisal context, it is generally the change that takes place in the different ecosystem services as a result of the policy options that is of interest, rather than the absolute level of service provided.
- 3.19 In some cases, the level of service provision may be proxied by the extent of habitat in different policy options. The relationship between area of habitat and service provision may be linear. For example, if 10 hectares of woodland provide 10 times the amount of atmospheric regulation as 1 hectare (all else being equal). As the area increases, the quantity of service provision per unit area remains constant. However, a different relationship could be envisaged for a service such as recreation, where a wood of 10 hectares might provide more varied recreational possibilities than, for example, 10 woods of 1 hectare each. This could mean that the increase in service provision with area is non-linear.
- 3.20 Some regulating services may be very hard to measure in biophysical terms and, in many cases, it will not be possible to provide a quantitative assessment as there is not an adequate evidence base. This highlights the importance of undertaking a qualitative assessment or making use of modelling or expert judgement based on past experience. It also emphasises the need for further research.

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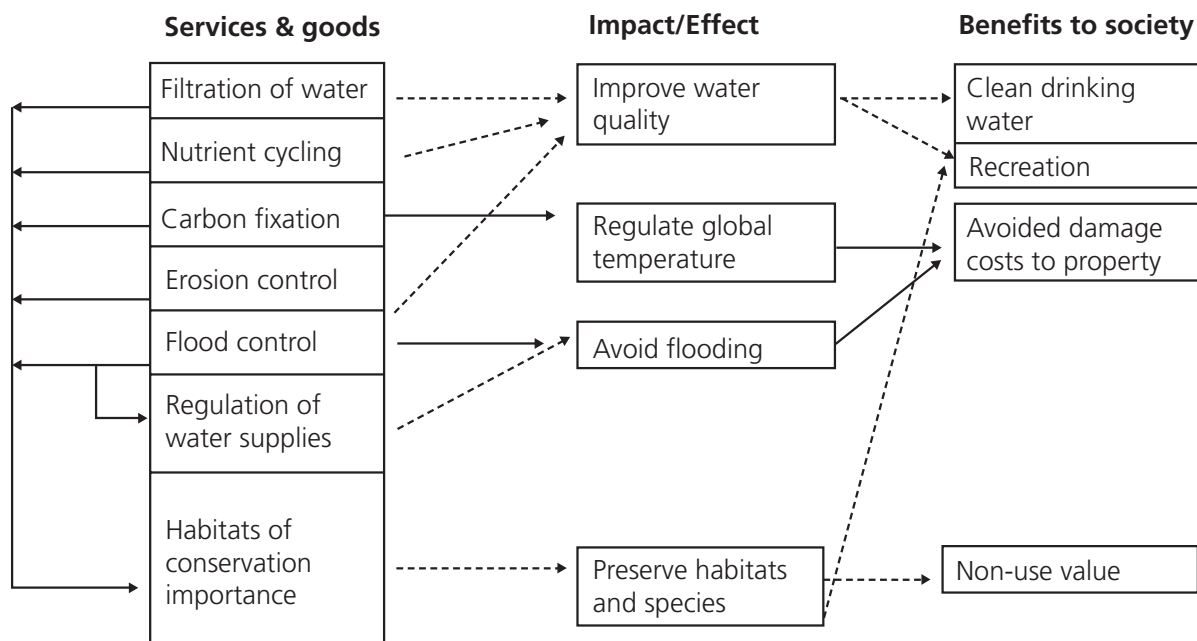
3.21 There is also an important distinction as well between 'intermediate' and 'final' services, particularly when considering the links to benefits and economic value. Supporting services (e.g. nutrient cycling) are a good example of intermediate services that will impact on other services; supporting services will therefore not be valued directly but by taking account of the impact on these other ecosystem services that are directly 'consumed'. This underlines the complexities of being able to fully account for all changes to ecosystems and services in a policy appraisal. It also emphasises the need to clearly identify all the linkages over the impact pathway in order to avoid double-counting impacts that can act on the same economic end points.

Step 4: assess the effects on human welfare

3.22 Step 4 links the impact of ecosystem services to end points that have an impact on human welfare. When assessing the impact of ecosystem services on human welfare, it is critical to focus not only on the ecosystem services but also on the benefits that derive from these services, as that is what affects welfare directly. It is therefore the benefits rather than the services per se that we want to value.

3.23 Figure 3.2 illustrates some of the complex interactions between services and their economic endpoints in a wetland context. For example, an ecosystem service provided by wetlands is filtration of water, which improves water quality; a resulting benefit to society that can be valued is cleaner drinking water. An economic analysis is the last stage of an often detailed qualitative and quantitative impact assessment.

Figure 3.2: Wetland function interactions



Source: Eftec et al. 2006. *England's Ecosystem Services: A preliminary assessment of three habitat types: broad leaved woodland, the inter-tidal zone and fresh water wetland.*

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- 3.24 As with the previous steps, it is very important to give consideration to the potential for double-counting benefits where there are overlaps between services that impact on similar economic end points. Undertaking a mapping exercise as illustrated in Figure 3.2 can be extremely useful in aiding this process. As highlighted previously, this point is also relevant to other steps within the impact assessment process and discussed further in Chapter 4.
- 3.25 It is also important to identify the groups of people in society who will be affected by changes in ecosystem services as this will determine how these impacts will be valued and over what population the values are to be aggregated. Again, the spatial scale to identify the affected population will differ according to the ecosystem service being valued and could be on a local, regional or international scale.

Step 5: value the changes in ecosystem services

- 3.26 This step involves the application of economic valuation techniques to estimate the possible values attributed to ecosystem services. At a preliminary stage, this would almost certainly involve a review of the literature to see if existing valuation studies could be appropriately applied to the ecosystem service of interest. Care needs to be taken at this stage that there is no double-counting in the use of existing studies that value similar ecosystem services. For example, in the wetland case above, a value for cleaner drinking water may include the benefits of reduced health costs from water-borne diseases. Separately valuing the latter would involve double-counting. Where there is no relevant valuation evidence and the cost-benefit analysis is seen to depend significantly on the magnitude of the ecosystem service values, undertaking a primary empirical valuation study may be justified. Further detail on valuation approaches is provided in Chapter 4.
- 3.27 The overall aim in a policy appraisal context would be to estimate in monetary terms as many of the impacts on ecosystem services as possible in order to set these against all the other costs and benefits in the policy appraisal. It is important to note that there could be both costs as well as benefits associated with changes in ecosystem services; the assessment needs to cover both. Moreover, some services might be incompatible (e.g. water extraction and groundwater recharge) and so combining these values would over-estimate the ecosystem service benefits.
- 3.28 In general, it will not be possible to estimate all the economic values associated with changes in ecosystem services. This emphasises the critical importance of providing qualitative or quantitative information on the likely impacts, even if no values can be estimated. It also emphasises the importance of providing a sensitivity analysis, which can highlight the potential importance, or otherwise, of an ecosystem service change.
- 3.29 There are likely to be a number of stages in the assessment process within the policy appraisal context. At the early stages, there should be a preliminary or scoping assessment that identifies the broad impacts of a policy on ecosystems and their services and identifies what economic end points are likely to be affected. Initial evidence on the values of these impacts can be estimated. Further appraisal would depend on the nature of the policy decision and the importance of undertaking more detailed valuation of specific ecosystem services. Box 3.3 illustrates how a staged approach has been developed in policy guidance for flood and coastal risk management.

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Box 3.3: Guidance on the valuation of ecosystem services in flood and coastal erosion risk management

The Environment Agency (EA) has developed a handbook designed for appraisal practitioners dealing with flood risk and coastal erosion management (FCERM) decision-making (forthcoming publication). The purpose of this handbook is to provide guidance on estimating the economic value of the environmental gains and losses associated with FCERM schemes. Only environmental costs and benefits are within the scope of this handbook; it therefore links into wider guidance on overall appraisal of FCERM schemes. The handbook does not replace other analyses (e.g. EIA, SEA). In fact, the handbook shows that the assessment of economic values of environmental impacts builds on the evidence collected by EIA, SEA etc.

A key component featured in the handbook is the use of ecosystem services as a framework in appraisal. The user of the handbook is encouraged to think about the habitat and its ecosystem services affected by the FCERM options under consideration. A 'first cut' analysis of the evidence on economic value is undertaken to obtain a quick snapshot of what exists. Depending on the decision-making context, this 'first cut' may or may not be sufficient. When not sufficient, the handbook goes on to present guidance for the next stage – the 'second cut' – which provides a step-by-step guide to benefits transfer in the particular context of FCERM schemes. While the findings of the first cut are generally not sufficient for cost-benefit analysis, in most cases the second cut should be. A further stage allows the user to consider whether the 'second cut' provides sufficient information for their purposes. An alternative is to consider the commissioning of a new site-specific economic valuation study.

Chapter 4: Valuation of Ecosystem Services

Summary

This chapter focuses on the last stage of the assessment process, namely the methodologies available to value changes in ecosystem services. These values are considered in a Total Economic Value (TEV) framework, which takes into account both the use and non-use values individuals and society gain or lose from marginal changes in ecosystem services. As many ecosystem services are not traded in markets, and therefore remain unpriced, it is necessary to assess the relative economic worth of these goods or services using non-market valuation techniques.

The type of valuation technique chosen will depend on the type of ecosystem service to be valued, as well as the quantity and quality of data available. Some valuation methods may be more suited to capturing the values of particular ecosystem services than others. Benefits transfer, which applies economic values that have been generated in one context to another context for which values are required, is also discussed. The use of such transfers is seen as being essential to the more practical use of environmental values in policy-making.

The valuation methodologies discussed in this chapter are not new in themselves. The challenge is in their appropriate application to ecosystem services. The ecosystem services framework emphasises the need to consider the ecosystem as a whole, and stresses that changes or impacts on one part of an ecosystem have consequences for the whole system. Therefore, considering the scale and scope of the services to be valued is vital if we are to arrive at any meaningful values.

Overview of the valuation of ecosystem services

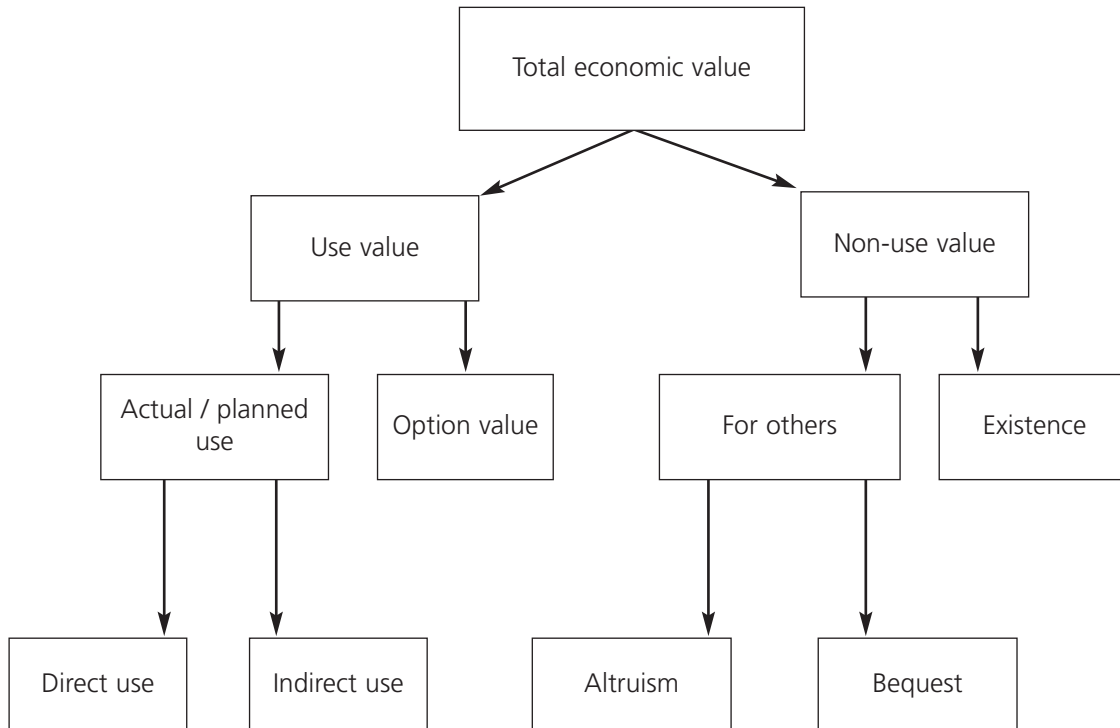
- 4.1 Valuation is the last stage of an often detailed assessment of the impacts on ecosystem services arising from a policy change. This is the main focus of this chapter, providing detail on the approaches to the valuation of ecosystem services.
- 4.2 The primary focus in this Guide relates to economic valuation because it is consistent with use in a cost-benefit analysis context. However, non-economic valuation approaches – deliberative and participatory methods – are summarised here and their complementary role discussed.

Total Economic Value

- 4.3 The value of natural resources is often considered within the framework of Total Economic Value (TEV), and this framework can be used to value ecosystem services.

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Figure 4.1: Total Economic Value framework



4.4 TEV comprises use and non-use values and is summarised in Figure 4.1. TEV refers to the total gain in wellbeing from a policy measured by the net sum of the willingness to pay (WTP) or willingness to accept (WTA).²⁷ The value that we are trying to capture for the purposes of appraisal is the total value of a *marginal* change in the underlying ecosystem services.

4.5 **Use value** includes direct use, indirect use and option value:

- Direct use value: where individuals make actual or planned use of an ecosystem service. This can be in the form of consumptive use which refers to the use of resources extracted from the ecosystem (e.g. food, timber) and non-consumptive use, which is the use of the services without extracting any elements from the ecosystem (e.g. recreation, landscape amenity). These activities can be traded on a market (e.g. timber) or can be non-marketable i.e. there is no formal market on which they are traded (e.g. recreation or the inspiration people find in directly experiencing nature).

²⁷ WTP/WTA refer to the monetary measure of the value of obtaining/forgoing environmental (or other) gain or avoiding/allowing a loss.

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- Indirect use value: where individuals benefit from ecosystem services supported by a resource rather than directly using it. These ecosystem services are often not noticed by people until they are damaged or lost, yet they are very important. These services include key global life-support functions, such as the regulation of the chemical composition of the atmosphere and oceans, and climate regulation; water regulation; pollution filtering; soil retention and provision; nutrient cycling; waste decomposition; and pollination. Measuring indirect use values is often significantly more challenging than measuring direct use values. Changes in the quality or quantity of a service being provided are often difficult to measure or are poorly understood.
- Option value: the value that people place on having the option to use a resource in the future even if they are not current users. These future uses may be either direct or indirect. An example would be a national park where people who have no specific intention to visit it may still be willing to pay something in order to keep that option open in the future. In the context of ecosystems and their services, option value describes the value placed on maintaining ecosystems and their component species and habitats for possible future uses, some of which may not yet be known. Option value can also be thought of as a form of insurance, e.g. a wide species mix in a particular habitat can provide an insurance function: as conditions change, different species may fulfil key ecological roles.

4.6 **Non-use value** (also known as passive use) is derived simply from the knowledge that the natural environment is maintained. There are three main components:

- Bequest value: where individuals attach value from the fact that the ecosystem resource will be passed on to future generations.
- Altruistic value: where individuals attach values to the availability of the ecosystem resource to others in the current generation.
- Existence value: derived from the existence of an ecosystem resource, even though an individual has no actual or planned use of it. For example, people are willing to pay for the preservation of whales, through donations, even if they know that they may never actually see a whale.

4.7 Non-use value is relatively challenging to capture since individuals find it difficult to 'put a price' on such values as they are rarely asked to do so. However, in some circumstances, non-use value may be more important than use value. For example, a study on the value of Natura 2000 sites in Scotland found that 99% of the overall value of such sites was non-use.²⁸

4.8 An additional element of value is that of **quasi-option value** (see Box 4.1). Quasi-option value refers to the value of information secured by delaying a decision, where outcomes are uncertain and where there is opportunity to learn by delay. In the context of uncertainty and irreversibility, it may pay to delay making a decision to commit resources. Although quasi-option value lies outside the TEV framework, it represents the value/benefit of better decision-making where there is potential to learn by delaying a decision. **The OECD's 2006 review, *Cost-Benefit Analysis and the Environment: Recent Developments* shows that quasi-option value is particularly relevant in the context of ecosystems – there is uncertainty, irreversibility and a major chance to learn through scientific progress in understanding better what ecosystems do and how they behave.**

²⁸ Jacobs 2004: *An Economic Assessment of the Costs and Benefits of Natura 2000 Sites in Scotland*. Edinburgh: Scottish Executive.

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Box 4.1: Quasi-option value

Quasi-option value refers to the value of information that can be secured by delaying a decision where outcomes are uncertain, where one or more benefits or costs are uncertain and where delay results in further information. For example, the development of a piece of forested land for agricultural use may result in known benefits in terms of crops that can be valued at market prices. The benefits of preserving the same piece of forested land may be unknown. Delaying the decision on the land development may enable us to learn more about the likely benefits of preserving the land (e.g. if it provides important ecosystem services such as habitat provision for threatened species). In such a situation, quasi-option value describes the benefit of the additional information that can be learned by delaying the decision to develop. However, finding examples of estimated quasi-option value in environmental economics literature is limited and further study is required.

- 4.9 **The TEV framework and the MA framework for categorising ecosystem services can be seen as complementary.** Table 4.1 shows how both approaches can be combined. The TEV framework is a useful tool for exploring what types of values for each ecosystem service we are trying to elicit. This helps in determining the valuation methods required to capture these values.

Table 4.1: Valuing ecosystem services through the TEV framework

MA framework		TEV framework			
MA Group	Service	Direct Use	Indirect use	Option value	Non-use value
Provisioning	Includes: food; fibre and fuel; biochemicals, natural medicines, pharmaceuticals; fresh water supply	*		*	
Regulating	Includes: air-quality regulation; climate regulation; water regulation; natural hazard regulation etc.		*	*	
Cultural	Includes: cultural heritage; recreation and tourism; aesthetic values	*		*	*
Supporting	Includes: Primary production; nutrient cycling; soil formation	<i>Supporting services are valued through the other categories of ecosystem services</i>			

- 4.10 Table 4.1 should be seen as illustrative rather than as a definitive guide to the classification of values arising from different ecosystem services. Chapter 3 highlighted the importance within a policy appraisal context of undertaking a mapping exercise from ecosystems and ecosystem services to economic end points affected by a policy.

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- 4.11 It is important to be aware of on going research work that is looking to provide more systematic approaches to valuing ecosystem services. For example, recent work²⁹ has emphasised the distinction between intermediate and final services.³⁰ Supporting services would be defined as intermediate services, as Table 4.1 shows, and should be accounted for through impacts on other services and therefore not valued separately. Other ecosystem services will be intermediate or final services depending on what economic end point is in question. For example, for angling, water quality is an intermediate service in the provision of fish, whereas for drinking water, water quality is a final service.

Methods of eliciting values

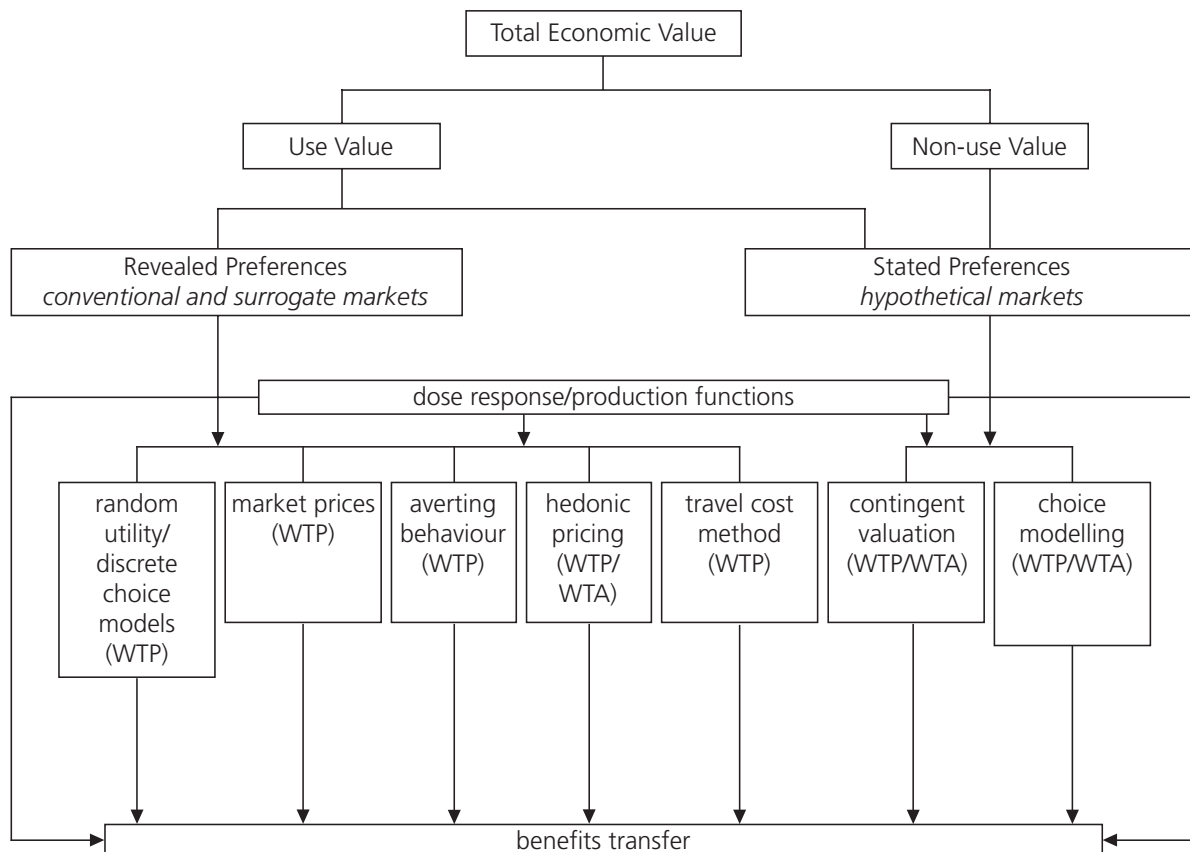
- 4.12 Valuation methods fall broadly into two main types: economic and non-economic valuation approaches.
- 4.13 **Economic valuation** attempts to elicit public preferences for changes in the state of the environment in monetary terms. The main types of economic valuation methods available for estimating public preferences for changes in ecosystem services are Revealed Preference (RP) and Stated Preference (SP) methods. Further references providing guidance on economic valuation and how to conduct valuation studies can be found at the end of this Guide.
- 4.14 Revealed preference (RP) methods rely on data regarding individuals' preferences for a marketable good which includes environmental attributes. These techniques rely on actual markets. Included in this approach are: market prices, averting behaviour, hedonic pricing, travel cost method, and random utility modelling. Market prices and averting behaviour can also be classified under pricing techniques (see paragraph 4.19).
- 4.15 Stated preference (SP) methods use carefully structured questionnaires to elicit individuals' preferences for a given change in a natural resource or environmental attribute. In principle, SP methods can be applied in a wide range of contexts and are the only methods that can estimate non-use values which can be a significant component of overall TEV for some natural resources. The main options in this approach are: contingent valuation and choice modelling.
- 4.16 **Figure 4.2** shows the different economic valuation techniques and their relationship with the TEV framework.

29 Fisher B, Turner R, Costanza R, Morling P, forthcoming: *A Systems Approach to Definitions and Principles for Ecosystem Services*. Ecological Economics.

30 With parallels with economic accounting/National Accounts frameworks, which utilise this distinction.

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Figure 4.2: Techniques for monetary valuation



Source: Review of Technical guidance on Environmental Appraisal, DETR, eftec (1999).

4.17 While the dose response/production function approach is not a valuation technique – valuation is applied to the outcome quantified through this approach – its importance as an approach is worth highlighting. Dose response/production functions tend to be an important element of several valuation approaches (for example, dose response functions linking air pollution to various health effects). The production function approach focuses on the relationship that may exist between a particular ecosystem service and the production of a market good. Ecosystem services are considered as inputs to the production process and their value is inferred by considering the changes in production process of market goods that result from an environmental change. This approach is capable of capturing indirect use value.

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- 4.18 Figure 4.2 shows that all these different valuation approaches can be used in **benefits transfer**.³¹ This refers to the process of taking evidence on the value of benefits/damages from one context (the 'study site') and transferring it to another context (the 'policy site'). The attraction of this process is to avoid conducting a primary study (which may be both time consuming and costly), if it is deemed robust enough to apply in the given policy assessment. This is discussed in more detail in paragraphs 4.30-4.39.
- 4.19 **Pricing approaches** provide a different, albeit overlapping, classification to TEV, referring to approaches that use observed market prices either as direct measures of economic value of an ecosystem service (e.g. market prices, avertive expenditure, damage costs avoided) or as a proxy for the value (referred to as cost-based approaches).
- 4.20 Cost-based approaches to valuing environmental goods and services consider the costs that arise in relation to the provision of environmental goods and services, which may be directly observed from markets. Included under this heading are: opportunity cost; cost of alternatives, and replacement costs. However, as these methods are based on costs, they do not strictly measure utility (and are therefore not included under the TEV framework), that is, they are non-demand curve methods and need to be used with care.
- 4.21 As an illustration, the cost of alternatives is an approach that considers the cost of providing a substitute good that would perform a similar function to an environmental good. For example, wetlands, which perform flood protection, may be valued on the basis of the cost of building man-made flood defences of equal effectiveness. Given that flood protection is one of many wetland services, the value of the wetland is at least as much as the cost of the man-made protection that would be required in the absence of the wetland. However, this approach is only a valid measure of value if: the man-made alternatives are equivalent in quantity and magnitude to the natural functions; the alternative is the least-cost alternative method of performing the function; and individuals in aggregate would be willing to incur these costs to obtain the services. Cost-based approaches can be useful in validating the scale of values obtained from measurement of direct utility.
- 4.22 **Non-economic valuation – deliberative or participatory – approaches** tend to explore how opinions are formed or preferences expressed in units other than money.³² The choice is not a case of either economic or non-economic valuation methods but of using a combination of both, as required by the context of the decision. Box 4.2 provides a short overview of these methods.
- 4.23 These deliberative or participatory methods obviously have a part to play in understanding people's preferences and the process of decision-making and may therefore influence policy choices. They do not, in general, easily fit into the more formal process of economic appraisal that aims to capture the TEV of ecosystem services and therefore are not elaborated on further in this Guide³³.

31 Could also be referred to more generally as 'value transfer' since the approach can be used to transfer values that estimate environmental costs as well as environmental benefits.

32 However, note that some of these methods are linked to monetary valuation e.g. deliberative monetary valuation, see Stagl S (2007), *Emerging Methods for Sustainability Valuation and Appraisal*. Report for the Sustainable Development Research Network.

33 It is important to note, however, that economic valuation studies that use stated preference methods, deliberative or participatory methods are often used in combination. The combined information allows for an improved understanding of the reasons for and motivations of respondents' valuation responses.

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Box 4.2: Deliberative or participatory valuation approaches

Deliberative or participatory methods apply more of a qualitative approach rather than focusing solely on assigning economic values. These can elicit values often by asking people to explain or discuss why they behave in a particular way or hold a particular view. The focus can be on what people think society should do, rather than on their personal behaviour. Examples of such methods include:

- qualitative semi-structured surveys, often undertaken face to face or by telephone, to explore rationales as well as opinions
- group deliberative discussions, including focus groups or deliberative forums, which spend time listening to the opinions of others with the aim of forming a collective view (which can be on monetary values). These groups can be expert/stakeholder groups or can represent the general public
- citizens' juries, in which participants give an informed opinion after considering evidence from experts/stakeholders and discussing the proposed issue
- health-based approaches which include several types of health-based approaches e.g. quality-adjusted life years or health-year equivalents. Value is measured in terms of health based impacts rather than WTP/WTA
- Q-methodology, which aims to identify typical ways in which people think about issues, including the environment. Rather than focusing on why individuals hold certain attitudes, it focuses on patterns of attitudes, shared perceptions etc. and develops 'typical' sets of views that may not exactly represent the views of any specific individual.

4.24 **Annex 1** provides a description of all the different economic and non-economic valuation methods available. For more detailed information, see also the report by Eftec, *Valuing our natural environment*, undertaken for Defra and published in 2006.

Economic valuation methods for ecosystem services

4.25 The previous section provided a general overview of economic valuation methods for valuing ecosystem services. Now we review the applicability of these methods in the context of specific categories of ecosystem services. It is important to note, however, that this should be seen as a broad guide only. In each specific case, depending on the assessment of the impacts on ecosystem services carried out earlier, consideration needs to be given to the appropriate valuation method.

4.26 Table 4.1 illustrated how the TEV framework can be a useful tool for exploring what type of value we are trying to elicit for each ecosystem service. This helps in determining the valuation methods required to capture these values. For certain ecosystem services, only some valuation methods may be applicable. In addition, not all methods capture all elements of TEV. These points are summarised in Table 4.2.

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Table 4.2: Choice of valuation methods for different ecosystem services

Valuation method	Element of TEV captured	Ecosystem service(s) valued	Benefits of approach	Limitations of approach
Market prices	Direct and indirect use	Those that contribute to marketed products e.g. timber, fish, genetic information	Market data readily available and robust	Limited to those ecosystem services for which a market exists.
Cost-based approaches	Direct and indirect use	Depends on the existence of relevant markets for the ecosystem service in question. Examples include man-made defences being used as proxy for wetlands storm protection; expenditure on water filtration as proxy for value of water pollution damages.	Market data readily available and robust	Can potentially overestimate actual value
Production function approach	Indirect use	Environmental services that serve as input to market products e.g. effects of air or water quality on agricultural production and forestry output	Market data readily available and robust	Data-intensive and data on changes in services and the impact on production often missing
Hedonic pricing	Direct and indirect use	Ecosystem services that contribute to air quality, visual amenity, landscape, quiet i.e. attributes that can be appreciated by potential buyers	Based on market data, so relatively robust figures	Very data-intensive and limited mainly to services related to property
Travel cost	Direct and indirect use	All ecosystems services that contribute to recreational activities	Based on observed behaviour	Generally limited to recreational benefits. Difficulties arise when trips are made to multiple destinations.
Random utility	Direct and indirect use	All ecosystems services that contribute to recreational activities	Based on observed behaviour	Limited to use values
Contingent valuation	Use and non-use	All ecosystem services	Able to capture use and non-use values	Bias in responses, resource-intensive method, hypothetical nature of the market
Choice modelling	Use and non-use	All ecosystem services	Able to capture use and non-use values	Similar to contingent valuation above

Source: Based on eftec (2006) *Valuing our Natural Environment*

4.27 Some valuation methods may be more suited to capturing the values of particular ecosystem services than others. For example, market prices are often used for valuing provisioning services, while stated preference studies are well suited to capturing non-use values (e.g. existence value of a rare species). In many valuation contexts, more than one technique is likely to be employed (for example, the direct-use values of cultural services may be captured by revealed preference methods such as travel cost, while stated preference methods will capture the non-use values associated with cultural services). The method(s) used will very much depend on the services being valued and their context, and should be selected in consultation with experienced economists.

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- 4.28 While stated preference techniques can, in principle, be applied to any context, they can be limited by the ability of respondents to understand the nature of the service. Eftec's 2006 publication, *Valuing the Natural Environment*, shows that the relationship between cause and effect for many complex ecosystem services is not well understood, and therefore respondents, in a valuation exercise may well not appreciate the impact that an ecosystem service might have on their wellbeing.
- 4.29 While some pricing approaches such as cost-based techniques need to be used with care (see paragraphs 4.20-4.21), these approaches can offer a pragmatic approach to valuation. *England's Ecosystem Services*, a report for Natural England in 2006, showed that pricing techniques are seen to have widespread relevance in valuation of ecosystem services, particularly in the case of valuing changes in regulating services.

Use of benefits transfer

- 4.30 Benefits transfer is a process by which the economic values that have been generated in one context – the 'study site' – are applied to another context – the 'policy site' – for which values are required. As highlighted in Figure 4.2, benefit transfer values can be derived in principle from all economic valuation approaches.
- 4.31 A greater use of benefits transfer is seen to be the key to the more practical use of environmental values in policy-making. There are good examples in policy appraisal in the UK, where benefits transfer has been successfully applied (e.g. the social cost of carbon, damage costs per tonne of air pollutant; noise values for transport appraisal).
- 4.32 There are a number of ways of transferring values from the study context to the policy context:
- transferring an average WTP estimate from one primary study
 - transferring a WTP function
 - transferring WTP estimates from meta-analyses.
- 4.33 The simplest (the average value transfer) is to use the estimated average WTP from the study context (either unadjusted or adjusted). The use of unadjusted average WTP assumes that the average WTP is applicable both at the study site and the policy site. However, there may be numerous reasons why this might not be the case.³⁴ An alternative is therefore to adjust the WTP estimates in some way (e.g. for income differences).
- 4.34 Function transfer³⁵ makes more extensive adjustments to account for the differences in, for example, the service provided, the socio-economic characteristics of the affected population and the valuation context. The resultant WTP is therefore more relevant to the policy context.
- 4.35 An approach that builds further on the function transfer approach is the use of meta-analysis, which takes the results from a number of studies and analyses them in such a way that the variations in WTP found in those studies can be explained.

³⁴ For example, the socio-economic characteristics of the populations, the physical characteristics of the sites and the valuation context (i.e. the proposed changes in the quality and/or quantity of the policy and study good/services that are valued) may all be different.

³⁵ This uses the benefit function (or bid function) relating WTP to various characteristics of the site and the population.

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- 4.36 There are a number of steps involved in undertaking a benefits transfer study:
- i literature review. This is undertaken to find appropriate valuation studies that might be applied to the policy context. There are a number of databases (e.g. the Environmental Valuation Reference Inventory (EVRI), see Box 4.3) that provide information on relevant studies that might be used for benefits transfer.
 - ii selection of appropriate study. As discussed above, the study site should be as close a match as possible to the policy context if the results from the transfer are to be useful and credible. This is a crucial aspect of the benefits transfer process.
 - iii adjustment of WTP values. If necessary, using the income or function transfer may be used, as described in paragraph 4.34.
 - iv aggregation. Once WTP values have been estimated for the policy site, they then need to be aggregated over the population relevant to the policy context. Careful consideration should be given to any populations that derive non-use values, in addition to those who derive use values.
- 4.37 The use of benefits transfer is a key issue in policy appraisal as it can reduce the need for primary valuation studies for each cost-benefit study undertaken. For policies, programmes and projects with multiple non-market impacts, conducting original studies is unlikely to be feasible. A good use of benefits transfer values should be part of a scoping assessment of the costs and benefits. At this stage, it is possible to see whether a more in-depth analysis/valuation is required. When a decision depends heavily on the accuracy of the valuation of the environmental benefits, primary valuation work may be justified.

Box 4.3: The Environmental Valuation Reference Inventory (EVRI)

EVRI is a comprehensive benefits transfer database that consists of over 1900 valuation studies. It is co-ordinated by Environment Canada and can be accessed at <http://www.evri.ca> with a customised search engine, and includes a reference library on benefits transfer theory. Additional information about EVRI can be found on the Defra website at: <http://statistics.defra.gov.uk/esg/evri/evri/default.htm>.

Over a quarter of the database currently comprises European studies (with over 10% of the database comprising UK studies). The UK tries actively to increase the number of studies on the database, for example, by asking consultants to input studies they have conducted for Defra.

In addition to providing information on individual studies, summary disaggregations can also be carried out e.g. by continent or by environmental asset (e.g. air, land, water, animals). Although, this is not currently possible explicitly by ecosystem service, this may be possible in the future.

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- 4.38 While there are good examples of the use of benefits transfer in policy appraisal, the validity and accuracy of benefits transfer is a key issue. There is a need for improved understanding of when transfer works and when it does not, as well as reviewing options that would improve the accuracy of benefits transfer. For instance, it would not be appropriate to transfer generic landscape values to a road transport scheme that impacted on a unique landscape. However, it may well be possible to transfer values from one more typical landscape to another, having adjusted e.g. for income differences. In addition, careful consideration needs to be given at this stage to ensuring there is no double-counting of benefits. This can occur when a number of benefits transfer values are applied that relate to services that overlap.
- 4.39 A new development in benefits transfer is the use of Geographic Information Systems (GIS). This can facilitate the linking of valuation data to existing socio-economic and demographic information, enabling the better transfer of valuation functions. For example, in valuing recreational benefits, a GIS approach is able to map all of the principal determinants of value – the characteristics and accessibility of sites, their substitutes and complements; and population and socioeconomic statistics. Tests have shown that value function transfers using the GIS approach are more robust.³⁶

³⁶ See Defra Economic Valuation of the Environment Seminar, October 2006.

Chapter 5: Key Challenges and Opportunities

Summary

This chapter provides an overview of some of the key challenges as well as opportunities in the valuation of ecosystem services in practice.

There are particular complexities inherent in understanding how ecosystems interrelate to provide services and in dealing with issues of irreversibility and high levels of uncertainty in how ecosystems function. All of this suggests that, while valuation is an important and valuable tool for good policy-making, it should be seen as only one of the inputs in decision-making.

At the same time, the use of ecosystem services as a framework for valuation presents important opportunities to incorporate a wider range of environmental impacts in policy appraisal work in the future. Methodologies that account systematically for all the impacts on ecosystems and the services they provide are very much in development to deal with these challenges. This does not mean that valuation of ecosystem services cannot be taken forward now – and indeed the priority is that it should be. However, it is recognised that it will be a long-term challenge for those involved in policy appraisal to fully take into account all the impacts on ecosystems and ecosystem services.

Introduction

- 5.1 While the valuation of ecosystem services provides a more systematic approach towards the assessment of environmental effects in policy appraisal, it is recognised that considerable challenges still remain if this approach is to be fully incorporated into policy appraisal. In practice, there are many uncertainties and missing data and links in each step of the process, as well as a number of issues such as accounting for cumulative effects and environmental limits. This chapter discusses some of these key challenges.

Interdependence of ecosystems

- 5.2 One major challenge relates to the inter-dependence of ecosystems and their services. This includes both the interdependency within an ecosystem and the interdependency between ecosystems. In the former, various components of an ecosystem interact to provide either a service or services. Any policy that impacts on any part of this interaction may therefore have unintended consequences for the ecosystem and the services it generates. In the case of the latter, various ecosystems may also interact to contribute to the provision of a service or services. Any policy that impacts on one ecosystem may have complex and indirect consequences, both for other ecosystems and/or ecosystem services. This is an important issue in a policy context as changes may have effects beyond the ecosystem or services initially in focus.
- 5.3 For valuation, this means that the economic value of any one service may depend on its relationship with other services, and therefore an assessment of the value of one service may not easily take account of how other services are being affected.

Spatial issues in analysis

- 5.4 The chosen spatial area for consideration can have a critical impact on the conclusions of the analysis. An ecosystem's function and its ability to supply services to a particular human population are often best evaluated across its full extent, which may not coincide well with the spatial scale that a policy context might imply. For example, water quality for a given community may depend more on the condition of the upstream portions of the catchment than on the areas within the community. As a result, the analysis will need to carefully

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consider the spatial scale required for ecological analysis, particularly when linking indirect to direct drivers of change or ecosystem services to human wellbeing. Because ecological and societal boundaries rarely overlap exactly, the need for consideration of these spatial issues will be a common issue, although in practice it may be quite hard to take this into account.

- 5.5 In a policy appraisal context, there are several issues related to the spatial scale of analysis. Firstly, as highlighted above, the spatial scale for analysis implied by the policy options will not necessarily match that required to understand the impacts on ecosystems and their services. Moreover, the spatial scale will also need to take account of that related to the affected population, whose values may be affected through changes in ecosystem services. To apply appropriate values, there is a need to understand whether each ecosystem service is impacting at a local, regional, national or global level. The population affected by the service will be influenced by the uniqueness of the service provided. For example, a rare species in England may have significant non-use values attached to it across a wide population, whereas for a less unique species, values may be held only by a local population. A pragmatic approach should be taken in scoping out the appropriate spatial scales for analysis in the preliminary stages of the analysis.

Temporal issues in analysis

- 5.6 Similar to the spatial issues discussed above, impacts on ecosystems and their services may have impacts that could extend well beyond a standard time period taken for the policy appraisal. Ecosystem responses can take considerable time to develop, which should be taken into account in valuing changes in ecosystem services. This will also mean the scientific information needs to demonstrate how these changes will develop over time to link into an economic assessment.
- 5.7 It is therefore important to account for any temporal distribution of costs and benefits. This is normally done by discounting, using an appropriate discount rate, which converts all costs and benefits to 'present values' so that they can be compared. The Treasury guidelines³⁷ recommend using different (declining) discount rates over the longer term. The reason for this is that uncertainty increases as we look further into the future. The choice of discount rate can make a very significant difference in terms of the final outcomes of any cost-benefit analysis. The appropriate discount rate to use when evaluating policies in the UK are those laid down in the Treasury guidance. The timeframes over which costs and benefits are considered should depend on the duration over which the costs and benefits will be realised.

Environmental limits and thresholds

- 5.8 The services that ecosystems provide depend not only on the scale and function of the ecosystem but also, crucially, on its quality. As the state of an ecosystem deteriorates, the services it provides are likely to diminish. Sometimes, this may be a gradual process, but in other circumstances a threshold may be reached. Beyond this threshold, an irreversible change to the ecosystem may occur (e.g. total collapse), resulting in permanent loss of services. Box 5.1 provides a further discussion of the key concepts.
- 5.9 One example of such non-linear change is provided by the collapse of the Newfoundland cod fishery. After decades of increased fish landings and declining fish stocks, the fishery then collapsed abruptly in 1992. Even after a 10-year moratorium, fish stocks had not recovered and it is thought this is because of permanent changes to the ecosystem that occurred when the fishery collapsed.

³⁷ <http://greenbook.treasury.gov.uk/>

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- 5.10 Irreversible impacts are not easily accounted for in the standard procedures for economic appraisal. As the quality/quantity of a service or stock of a habitat e.g. a wetland, declines, we would expect to see this reflected in increased marginal values to take account of this scarcity. However, an economic valuation study will typically have estimated values for only a marginal change in a service or habitat at a few points along the demand curve. Applying these marginal values therefore may well not be appropriate to particular policy contexts. Transparency of assumptions and undertaking sensitivity and scenario analysis will help to inform the analysis of the significance of these issues. They do, however, remain difficult areas.

Box 5.1: What are environmental limits and thresholds?

A scoping study³⁸ for Defra on environmental limits provided insights on understanding environmental limits and thresholds. An **environmental threshold** exists when a natural resource system exhibits rapid change or even sudden collapse. Water quality in lakes that are impacted on by nutrient inputs and marine fisheries suffering from over-fishing can exhibit environmental thresholds that mark the boundary between alternative stable states. Evidence suggests that when thresholds are crossed, it may be difficult to restore systems to their former condition. It is also the case that we often do not know where thresholds lie until they are crossed. However, although some natural resource systems can exhibit this type of response, it is uncertain how common this is. In contrast, **environmental limits** are relevant to all natural resource systems whether they show a threshold response or not, being defined as 'the point or range of conditions beyond which the benefits derived from a natural resource system are judged unacceptable or insufficient'. The report also goes on to say that while this definition may be based on the biophysical properties of a natural resource system, its identification also relies on the way people value the outputs from it.

- 5.11 Previous chapters highlighted the distinction between final and intermediate services in the valuation of ecosystem services; valuation should focus on the final services to prevent double-counting of benefits. However, it may still be very important to keep track of intermediate services as an input to this final service. An example of this is water quality where water quality is a function of wetlands. The final service (water quality) may not change much with initial changes in wetland habitat until some threshold is reached, at which point further losses may have a significant impact. These point to the need for monitoring of intermediate services in producing these final services.

Dealing with cumulative effects

- 5.12 A related challenge to environmental limits is how to deal with cumulative effects, an issue of particular importance, for example, in the context of development decisions. If there is a large amount of a natural resource available, there may be societal benefits from developing a part of the area and losing some of the natural resource. Such decisions at the margin can be made repeatedly and independently of each other. If these decisions are made in an unco-ordinated way, the total value of the resource may be lost because of the cumulative effect of the individual decisions. This can happen when so much of the resource is lost that its services are no longer sustainable, or because of a loss of connectivity between different parts of the resource. Where possible, it is helpful to analyse the effect of such decisions in the context of the total resource provided by the ecosystem, so that such cumulative effects are considered. This approach is similar to the principles embodied in SEA. Box 5.2 links the discussion of cumulative impacts to valuation with some illustrative examples.

38 Haines-Young R; Potschin M and Cheshire D (2006): *Defining and Identifying Environmental Limits for Sustainable Development. A Scoping Study*. Report to Defra: <http://www.defra.gov.uk/wildlife-countryside/natres/nr0102.htm>

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Box 5.2: Cumulative impacts – examples

Here, we have three hypothetical examples that illustrate the importance of taking account of the cumulative impact of decisions:

- In many cases, the more of a resource that is used, the more valuable each remaining unit becomes (Example 1)
- Sometimes the value of a resource is greater than the sum of its parts and using part of the resource can diminish the value of each remaining unit (Example 2)
- Thresholds can cause the value of a resource to fall sharply once a certain amount has been used (Example 3).

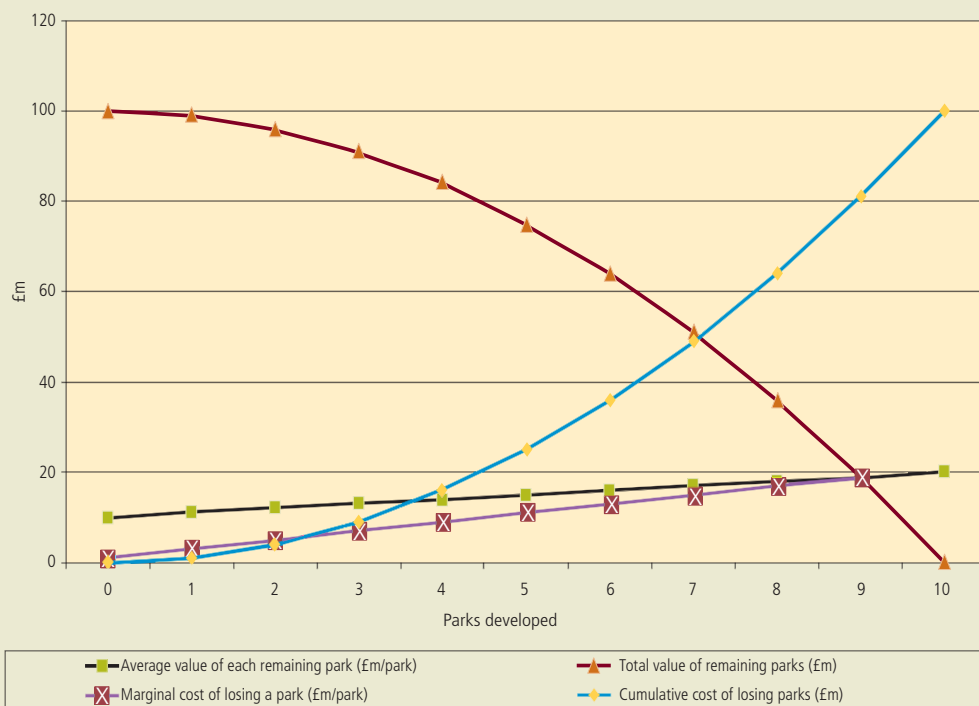
In each of these cases, the marginal cost to society of using the resource changes according to the cumulative impact of previous and simultaneous use of the resource. Mistaking the average unit value of a resource for the marginal value will result in the wrong decision being made.

Example 1: Deciding to develop housing on inner city parks

Say a city has 10 similar parks. A policy-maker is deciding whether or not to grant planning permission to build houses on some of the parks. An ecosystem services valuation study is undertaken and estimates that the value of the ecosystem services (mainly from recreation) from each park is £10 million.

However, although the average value is £10 million, as each park is built on, more city residents will make use of the remaining parks, thus increasing their value. In the hypothetical example presented in **Figure 1**, the value of the parks increase linearly with scarcity – when one park is built upon, the remaining parks are all worth £11 million, when the second park is built on the remaining parks are worth £12 million and so on. In this way, the marginal cost of losing a park to development rises slowly and only reaches the figures found by the valuation study after four parks have been developed.

Figure 1: Deciding to develop housing on inner-city parks

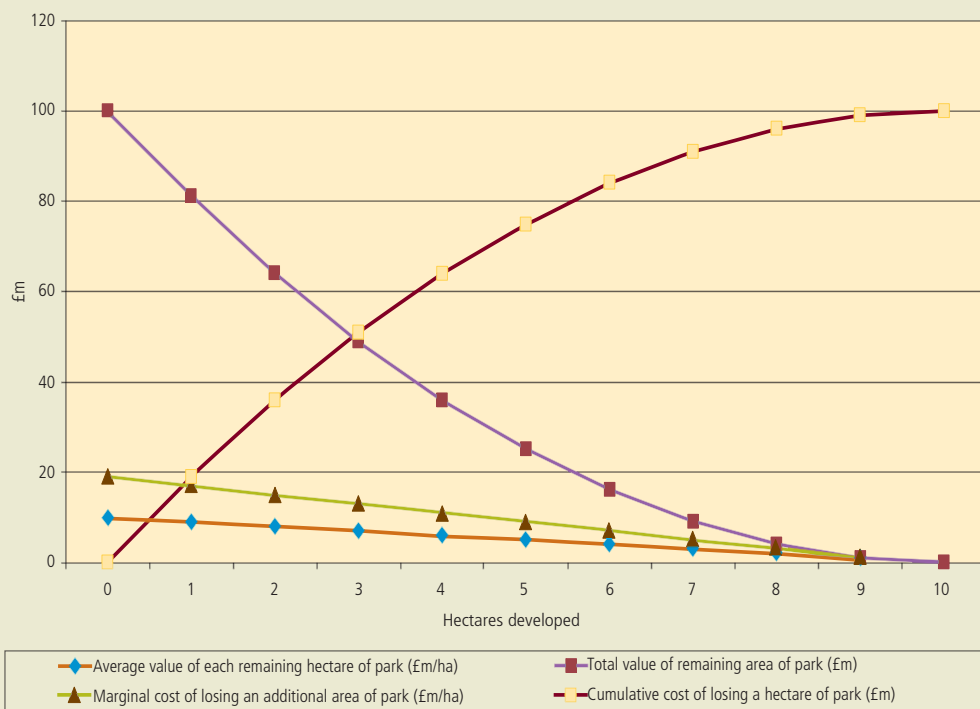


Example 2: Gradually reducing the size of an inner city park³⁹

Say a policy-maker is investigating whether it would be beneficial to develop housing on the margins of a 10 hectare city park. An ecosystem services valuation finds that the average value of each hectare of the park is £10 million.

However, although each hectare is valued at £10 million developing on one part of the park has an adverse effect on the remaining area, as one of the main things people prize about the park is the feeling of being far away from the noise and pollution of the city. Developing part of the park will thus reduce the quality of the remaining area of parkland. In the hypothetical example presented in **Figure 2**, the marginal cost of developing on a hectare of the park is not £10 million, but £19 million (£10 million plus £1 million off the value of each remaining hectare), and as each unit of the park is developed, the marginal value of each remaining hectare falls further. Thus the first development decision makes it much more likely that more development decisions will follow.

Figure 2: Gradually reducing the size of an inner city park



Example 3: A habitat for a rare species of bird

Say a policy-maker is deciding whether or not to develop on an area of brownfield land that includes an important wetland habitat. An ecosystem services valuation is undertaken and finds that each hectare of the 10 hectare site is worth £10 million, with the ecosystem services from a rare bird species making up the bulk of the value.

However, the wetland needs to be a certain size in order to support the bird habitat. Once development reduces the wetland to below this size, the birds can no longer use the wetland and the value of the remaining area falls sharply. In the hypothetical example presented in **Figure 3**, the marginal cost of developing a hectare is £10 million, until after 5 hectares have been developed, when the threshold is reached. The marginal cost of developing the sixth hectare is equal to just below the remaining value of the site. Once the sixth hectare has been developed, the remaining hectares are almost worthless.

³⁹ Example 2 is an interpretation of a paper presented by Dieter Helm, *Reviewing Land Use Policy*, to Defra seminar on land use, February 2007.

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Figure 3: Marginal, average, total and cumulative curves



5.13 Similarly, taking account of the cumulative impacts on ecosystem services at a programme level may lead to a different cost-benefit relationship than consideration of each project on its own. An example of where a comprehensive ecosystem services approach can provide a different result from conventional 'case by case' appraisal is of 'managed realignment' in flood management, particularly on the east coast of England, the area with the highest flood risk in the country.⁴⁰ Managed realignment involves the deliberate breaching of engineered flood defences to allow the creation of extended inter-tidal marshes, relying on these to store flood waters. The resulting wetlands are also habitats for birds and other species, and create a biogeochemical store for nutrient pollution and heavy metal contaminants. Implementing this strategy in the Humber Estuary would recreate vast areas of previously destroyed salt marsh at various points in the estuary. While individual managed realignment proposals do not pass the cost-benefit test, consideration of the totality of potential schemes does.

Impacts not easily valued – neglected benefits?

5.14 One of the potential benefits of a focus on ecosystem services is that it provides a more systematic approach to defining the services that ecosystems provide and should encourage progress on quantification and valuation of these effects, especially through the increased use of benefits transfer. It needs to be recognised, however, that this is a longer-term aim, and even in the future it is likely that certain ecosystem services will be impossible to value. **These still need to be incorporated into the appraisal system as far as possible, in quantitative or qualitative terms. Even where ecosystem impacts are presented in monetary terms, it is important to present the underlying scientific evidence as a key part of the overall analysis.**

⁴⁰ Presentation by Professor Kerry Turner at Defra Valuation Seminar, Economic Valuation of the Environment: Policy Applications, October 2006: <http://statistics.defra.gov.uk/esg/evri/evri/Additional%20Information%20and%20Forthcoming%20events.htm>

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- 5.15 Furthermore, it may be that the TEV of changes in ecosystem services is less than the total systems value. Reasons for this include the fact that ecosystems may provide insurance value. The available evidence suggests that increased biodiversity (for example, at the species level) adds insurance value to ecosystems by improving their resilience, resistance, predictability and stability, as well as helping buffer ecosystems, in the face of exogenous changes. This may be especially important in an environment experiencing relatively rapid climate change.
- 5.16 Moreover, in order for ecosystems to deliver services, some minimum scale of organisation and operation is necessary before services can be provided. This infrastructure has value insofar as it needs to exist in order for services to be provided but may not be easily picked up in the valuation of ecosystem services.

Dealing with uncertainty

- 5.17 There is considerable uncertainty surrounding both the functioning and valuation of ecosystems. Even among specialist scientific communities, there is a lack of understanding about certain aspects, for example, what services are provided by different ecosystems, how these may change over time and how changes to ecosystems may affect the quantity and quality of the services they provide. This is further complicated by the fact that ecosystems may not respond to change in a linear fashion; there may be thresholds beyond which an ecosystem responds in a previously unknown manner.
- 5.18 Under such circumstances, consideration needs to be given to the uncertain future losses that might be associated with potential change. One method of doing this is to conduct a sensitivity analysis by identifying areas of uncertainty and testing how sensitive the evaluation outcomes are to changes in values or assumptions used in valuing ecosystem services. The Treasury Green Book⁴¹ provides more detailed guidance on this and other methods available for testing the key factors that underlie the evaluated outcomes.
- 5.19 In addition, these uncertainties would suggest that there will be a need for decision-making to consider precautionary approaches to ecosystem management.
- 5.20 Chapter 4 highlighted the importance of quasi-option value – the value of information secured by delaying a decision, where outcomes are uncertain and where there is opportunity to learn by delay. In the context of uncertainty and irreversibility, it may pay to delay making a decision to commit resources.

41 <http://greenbook.treasury.gov.uk/>

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Scientific challenges

- 5.21 It is important to recognise the scientific challenges of understanding how ecosystems function and the delivery of ecosystem services that have impacts on human wellbeing. Key scientific challenges include:
- the definition of an ecosystem and its boundaries. There may be a case for thinking in terms of a functional definition, focusing on the services provided rather than the physical ecosystem
 - the development of better environmental understanding and predictive models, particularly in relation to:
 - reliable prediction of biological, physical and chemical impacts on ecosystems and the services they provide
 - understanding of cumulative effects, feedbacks and compensatory behaviour of systems
 - dealing with slow effects and lags in the development of impacts
 - effective valuation of genetic material

Key opportunities

- 5.22 The challenges discussed above, highlight the range of complexities that need to be taken into account. However, as this Guide has shown throughout, the use of ecosystem services as a framework for valuation presents good opportunities to incorporate a wider range of environmental impacts in policy appraisal work in the future.
- 5.23 Evidence on the valuation of ecosystem services can be of use in the decision-making process in different ways. Valuation evidence can be important in an assessment of the overall costs and benefits of a policy proposal. Examining the distribution of ecosystem services values – among stakeholder groups, sectors and geographical areas – also presents an opportunity for providing important information in the decision-making process. It can be useful as information in its own right and for establishing finance/incentive systems e.g. payments for ecosystem services.
- 5.24 Recent research work⁴² is focusing on the practical application of the concept of ecosystem services in order to develop more systematic approaches to the valuation of ecosystem services for use in policy. This is a reason for presenting this as an Introductory Guide and considering the need for more detailed appraisal guidance in the future that can take account of these developments.
- 5.25 This does not mean that the valuation of ecosystem services cannot be taken forward now – and indeed the priority is that it should be. The case study presented in Chapter 6 demonstrates how valuation can be useful in a policy and project appraisal context. However, it is recognised that it will be a long-term challenge for policy appraisal to fully take into account all the impacts on ecosystems and their services.

⁴² Fisher B, Turner R, Costanza R, and Morling P, (forthcoming) *A Systems Approach to Definitions and Principles for Ecosystem Services*. Ecological Economics. In addition, a current Defra project, *An Assessment of the Economic Value of England's Terrestrial Ecosystem Services* is looking to take account of the current research work and developing methodologies in this area: <http://www.defra.gov.uk/wildlife-countryside/natres/research.htm>

Wareham Managed Realignment Case Study⁴³

Summary

This chapter presents a case study which looks at the appraisal of a Flood and Coastal Erosion Risk Management (FCERM) scheme, with a focus on the impact of including estimates of the economic value of changes in ecosystem services under the scheme options considered.

The case study is considered with reference to the impact pathway approach outlined in Chapter 3, and illustrates how such an approach can work in practice. It demonstrates how the ecosystem services valuation framework can be material and useful, despite imperfect information, both in terms of selecting or ruling out certain options and in directing attention towards the most important data gaps and uncertainties that may have a bearing on the results of appraisals. Previous work underpinning this case study suggests that key stakeholders in the area of FCERM are broadly supportive of moves towards greater inclusion of economic value estimates in appraisals. The potential is recognised for valuation to provide useful input to the main phases of FCERM, including policy-making, strategic planning, option formulation, option appraisal, and scheme prioritisation.

This case study shows the uncertainty surrounding the absolute value of the ecosystem services resulting from uncertainty concerning both the physical changes in ecosystem services and the appropriate monetary values to apply to these. However, the work also demonstrates that the 'perfect' ecosystem service valuation may not be necessary for many appraisal purposes. Practical appraisals need to compare the relative magnitude of changes in the provision of ecosystem services across different options, and this can be possible even with limited availability and precision of scientific and economic information. In most cases, it should be possible to present a robust assessment, with suitable sensitivity analysis, highlighting the main uncertainties and exploring their implications. The methodology should lay a clear audit trail, in which assumptions and calculations are clearly set down, and can be altered easily by any stakeholder wishing to conduct their own sensitivity analysis. Even where the assessment is inconclusive in terms of option choice, it will provide information on the key areas in which further information or research is needed in order to resolve the uncertainty.

Background – policy context and rationale for case study

- 6.1 The case study area lies at the western end of Poole Harbour around the town of Wareham, including the tidal reaches of the rivers Frome and Piddle, as far upstream as the A351 Wareham bypass.
- 6.2 The policy context is the Environment Agency's (EA) responsibility for maintaining approximately 20 km of tidal flood banks within the area. These were built about 50 years ago, are currently in very poor condition and are subject to reactive maintenance only. The existing standard of tidal flood defence is low. Ongoing deterioration in defences, coupled with sea-level rise and possibly increased fluvial flows, mean there is a significant risk in the near future of failure by overtopping or breaching. Thus, the current situation is not sustainable and there is a need to decide on a course of action for flood defences in the area.

⁴³ This case study was prepared for Defra by etec in September 2007. Full details of the case study can be found in the separate document attached, *Policy Appraisal and the Environment: An Introduction to the Valuation of Ecosystem Services – Wareham Managed Realignment Case Study*. We would like to thank the Environment Agency for their support in providing this case study material and to etec for undertaking the report.

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- 6.3 At the same time, rising sea levels and coastal squeeze elsewhere in the estuary are leading to losses in inter-tidal habitats, in particular saltmarsh. Under the Habitats Regulations there is a requirement to provide compensatory habitat for these losses. There is potential to create such habitat in the case-study area through a policy of managed realignment (MR). This could make a significant contribution to UK Biodiversity Action Plan (BAP) targets for reedbed, brackish lagoon, mudflat and saltmarsh, as well as offsetting the loss of saltmarsh that is occurring elsewhere in Poole Harbour.
- 6.4 In addition to the value of habitat creation, a number of other ecosystem services could be influenced by the decision, including provisioning services (fisheries), regulating services (nutrient cycling, carbon storage) and cultural services (recreation, archaeology).
- 6.5 Any EA proposal for changes to the current regime will require a project appraisal. There are several possible environmental / ecosystem service impacts that will need to be taken into consideration. There is therefore wide scope for use of an ecosystem services framework and economic valuation techniques as part of the appraisal process. This makes Wareham an ideal case study for the present work.
- 6.6 The main policy options are:
- 'Do nothing'.
 - 'Do minimum'. This is a continuation of existing maintenance, delaying (but not avoiding) defence failure.
 - 'Improve'. Improve existing defences to maintain appropriate standards of defence in the face of sea-level rise.
 - 'Managed realignment (preliminary vision)'. MR could be undertaken to different degrees, and would be staged.
 - 'Managed realignment (unconstrained)'. All tidal banks would be removed, though secondary defences would be provided for a small number of selected key habitats that cannot readily be recreated elsewhere.
- 6.7 In the initial policy appraisal, there was no attempt to apply economic values to any environmental impacts. The conclusion of the study was essentially that the Managed Realignment scenario looked very promising as a flood defence solution and as a means of creating habitat for compensation purposes, and that further work should be carried out towards fuller understanding of the implications of this and other scenarios. The contribution of the present case study is therefore the attempt to augment the physical/ecological analysis by applying economic values to ecosystem service changes under the different scenarios. Full details of the costs and benefits under each scenario, including the values of changes in ecosystem services are presented in the Wareham case-study document.

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Impact pathway approach

6.8 Evidence from the case study is drawn upon below to broadly illustrate the impact pathway approach outlined in Chapter 3.⁴⁴

Step 1: Establish the environmental baseline

6.9 Initial policy appraisal featured a quite detailed physical analysis, and some ecological analysis, of the various impacts of different options, which included certain environmental impacts. There was analysis of the flood damage costs and the impacts on freshwater, terrestrial and inter-tidal habitats arising under the 'do nothing' scenario. This scenario would allow defences to deteriorate and eventually fail.

Step 2: Identify and provide qualitative assessment of the potential impacts on ecosystem services

6.10 The specific ecosystem service impacts that are important for the case study can be considered using the MA framework and terminology:

supporting services

- nutrient cycling: nutrient storage in sediment (or could be considered as a regulating service – water purification)
- soil formation, primary production – both likely to be impacted on. While valuation is difficult, it may be captured in general 'environmental quality' aspects of benefits transfer

provisioning services

- ecosystem goods: agricultural changes – loss of (mostly low productivity) grazing land; fisheries changes – potential loss/increase in nursery function
- fresh-water: unlikely to be affected
- biochemicals/genetics: possible effects are not clear

regulating services

- climate regulation: carbon storage in sediment
- erosion regulation: in principle covered by the scope of the appraisal (patterns of habitat formation, defence maintenance, flood risk)
- other regulating services: no information to quantify these directly (but arguably they are captured in general 'environmental quality' aspects of the benefits transfer)

cultural services

- recreation and tourism: fishing; navigation; birdwatching; shooting; walking; local business impacts
- aesthetic: no information to quantify these impacts directly; in any case, to include them would risk double-counting, because a large part of these impacts will be through 'recreation and tourism' estimates and they may be reflected in the general habitat value used in benefits transfer
- educational: potential for educational services in the MR options, both in terms of learning about MR and in direct interpretation and educational use of habitats, but there is no information on these

⁴⁴ Note that chapter 3 provides generic guidance on taking an ecosystem services framework for valuation. The actual case study makes use of more detailed guidance developed specifically for flood and coastal erosion risk management: *Flood and Coastal Risk Management: Economic Valuation of Environmental Effects, Handbook for the Environment Agency, 2007*.

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- Cultural heritage: possible risk to archaeology. While details are not available, the options largely involve making areas wetter, which is likely to aid preservation of the archaeology (though also making it much harder to access in future).

6.11 A qualitative assessment of the potential impacts of the various policy options are considered in Table 6.1.

6.12 This is a broad-brush framework within which the full range of potential impacts can be considered, with varying degrees of uncertainty about absolute size and importance of impacts. The role of the framework is partly to structure systematic discussion and consideration of different possible service impacts.

Table 6.1: Qualitative assessment of ecosystem services impacts

Option	Do nothing	Do minimum	Improve	MR vision	MR unconstrained
Supporting services					
Soil formation	+	+	0	+	+
Primary production	+	+	-	+	+
Nutrient cycling	+	+	-	++	++
Provisioning services					
Ecosystem goods	+fish/-agri	+fish/-agri	-fish	+fish/-agri	+fish/-agri
Fresh water	0	0	0	0	0
Biochemicals/genetics	?	?	?	?	?
Regulating services					
Air-quality regulation	0	0	0	0	0
Climate regulation	+	+	-	+	+
Water regulation	+	+	-	+	+
Water purification	+	+	-	+	+
Pest regulation	?	?	?	?	?
Disease regulation	?	?	?	?	?
Pollination	+	+	-	+	+
Erosion regulation	+	+	--	++	++
Cultural services					
Recreation and tourism	-	-	0	++/-	++/-
Aesthetic	+/-	+/-	+	+	+
Educational	0	0	0	+	+
Cultural heritage	--	--	0	-	-

Source: eftc (2007), Wareham Managed Realignment Case Study.

Key: '+' likely positive effect, '-' likely negative effect, '0' likely no effect or insignificant, '?' uncertain effect

Step 3: Quantify the impacts on specific ecosystem services

6.13 Quantitative expressions of change were possible for certain categories of service in the case study. For example:

- Habitat calculations were made for terrestrial, agricultural, inter-tidal habitats and water, including fresh, saline lagoon and sub-tidal.
- Estimates of carbon and nutrient storage arising in inter-tidal habitats were calculated, although high levels of uncertainty were recognised.
- Fisheries, archaeological, recreational and navigational impacts are currently not known, although some qualitative information on these impacts was taken into account in considering the overall picture.

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Step 4: Assess the effects on human welfare

6.14 The changes in ecosystem services identified were assessed for the effects on human welfare. For example:

- Changes in habitats would result in changes in the ability of the ecosystem to store carbon, which in turn would impact on climate change.
- Changes in habitats would impact on recreational opportunities – including fishing, birdwatching, walking – and on educational opportunities and cultural heritage.
- Changes in provisioning services, such as an increase or decrease in the ecosystem nursery function, would potentially impact on both recreational and commercial fishing.

6.15 This step, in particular, needs to consider systematically the links between ecosystem services and human welfare, which will help in subsequent stages when values are applied. At this stage, consideration needs to be given to the population likely to be affected by any changes in ecosystem services. This could be on a local, national or international scale. This will determine the appropriate populations that values are applied to. Also, complexities and interrelationships between supporting, provisioning, regulating and cultural services suggest that seeking to place a value on each individual service may not be appropriate. Hence the approach to be considered is one that attempts to account for ecosystem services in combination, rather than in isolation.

Step 5: Value the changes in ecosystem services

6.16 This step involved applying economic values to the changes in ecosystem services identified and outlined above. In the absence of primary valuation studies being undertaken for the study site, evidence for the economic value of changes in ecosystem services under the various policy options was based on benefits transfer. Examples of the values of the changes in ecosystem services and how they were calculated include:

- The study valued the habitats in the study area by making use of three meta-analyses of wetland habitats. Using meta-analysis is generally considered to be more robust than the transfer of values from a single site. Table 6.2 summarises the values extracted for benefits transfer based on these studies.

Table 6.2: Unit value estimates for habitat gains and losses (£/hectare)

Type	Low	Mid.	High
<i>Woodward and Wui (2001) estimates</i>			
Inter-tidal 'general habitat' (W+W)	200	700	2,200
Inter-tidal 'bird watching' (W+W)	1,210	2,790	6,400
<i>Brander et al. (2006) estimates</i>			
Saltmarsh 50ha	-	990	-
Saltmarsh 250ha	-	830	-
Mudflat 50ha	-	1,680	-
Mudflat 250ha	-	1,410	-
Grazing marsh 50ha	-	390	-
Grazing marsh 250ha	-	260	-
Woodland 50ha	-	3,990	-
Woodland 250ha	-	2,670	-

Source: eftec (2007), Wareham Managed Realignment Case Study.

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- The transferred values for habitat gains and losses were taken to provide a general value estimate for the supporting, provisioning and regulating services.
- The value of carbon storage was based on the total area of the different types of habitats in the study area under the different policy options and the mid-range estimates of the social cost of carbon.
- The study identified separately the nutrient storage benefits in physical terms based on the type and quantity of habitat in the study area and used an approximate value based on a simple unit value transfer from three existing studies to estimate a range of values.
- Table 6.3 summarises the main values from the study, both in absolute values and in terms of the differences in value between the baseline and each of the policy options.

6.17 In terms of the main outcomes from the case study:

- The 'improve' option is very unlikely to be desirable. It had significantly lower ecosystem service value estimates than all other options, and would have the highest engineering and maintenance costs.
- 'Do nothing' displayed high ecosystem service benefits although these would be substantially offset by flood damage costs, various risks and the likely loss of recreation values.
- 'Do-minimum' was shown to have slightly lower ecosystem service benefits, but higher maintenance costs.
- The managed realignment options lie between the 'do-nothing' and the 'do-minimum' options, with the unconstrained option topping the list.

6.18 Many of these aspects are considered in standard appraisal, though usually not in quantitative terms, and rarely in monetary terms. One approach sometimes taken is to apply general habitat values, via benefits transfers, to specific habitat types. This fits reasonably well with the available evidence and with the application of simple value per hectare to agricultural land. As such, it avoids problems of double-counting that would arise if an attempt was made to value each ecosystem service separately.

6.19 It should be noted that many ecosystem services were not valued in this case study. These include the value of changes to recreational opportunities, the impact on navigation, fisheries, flood damage or freshwater habitats. In general, lack of scientific and economic information on the physical extent and value of these services limits inclusion in appraisals.

6.20 Extensive sensitivity analysis was undertaken as a key part of the analysis to test out how the results would change using low and high values for specific impacts as well as using simple switching analysis to test what values for the non-monetised impacts would be required to change the overall policy implications.

Table 6.3: Main valuation estimates with mid-estimate parameters

ABSOLUTE VALUE OF ECOSYSTEM SERVICES – Present value of benefits, PV(B), 100 YEARS, £m														
OPTION	HABITAT VALUES													
	TOTAL	PV(B) 100	Salt-marsh	Mud-flat	Reed bed	Fresh-water	Saline Water	Wood-land	Heath-land	Grazing Marsh	Grass-land	Sub-tidal	Carbon	Nitrogen
Present	18.01	18.01	0.69	5.68	1.66	0.00	2.04	1.39	5.49	0.26	0.00	0.47	0.20	0.12
Do nothing	21.75	21.75	1.41	9.36	4.29	0.00	1.36	1.12	2.29	0.25	0.00	0.99	0.43	0.26
Do minimum	20.77	20.77	1.32	9.52	2.65	0.00	1.36	1.12	3.14	0.27	0.00	0.83	0.36	0.21
Improve	17.51	17.51	0.69	5.56	1.36	0.00	2.04	1.39	5.49	0.23	0.00	0.44	0.19	0.11
MR vision	21.39	21.39	1.44	9.41	3.16	0.00	1.38	1.35	2.88	0.26	0.00	0.89	0.38	0.23
MR unconstrained	21.89	21.89	1.37	9.31	4.29	0.00	1.36	1.35	2.30	0.25	0.00	0.99	0.42	0.25
DIFFERENCE COMPARED WITH BASELINE: Do Nothing/Base, difference in Present value of benefits, PV(B), 100 YEARS, £M														
OPTION	HABITAT VALUES													
	TOTAL	PV(B) 100	Salt-marsh	Mud-flat	Reed bed	Fresh-water	Saline Water	Wood-land	Heath-land	Grazing Marsh	Grass-land	Sub-tidal	Carbon	Nitrogen
Do nothing	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Do minimum	-0.98	-0.98	-0.09	0.16	-1.64	0.00	0.00	0.00	0.65	0.02	0.00	-0.16	-0.07	-0.04
Improve	-4.24	-4.24	-0.71	-3.79	-2.93	0.00	0.60	0.27	3.20	-0.02	0.00	-0.55	-0.24	-0.14
MR vision	-0.36	-0.36	0.03	0.06	-1.13	0.00	0.02	0.24	0.59	0.01	0.00	-0.11	-0.05	-0.03
MR unconstrained	0.14	0.14	-0.04	-0.05	0.00	0.00	0.00	0.24	0.01	0.00	0.00	-0.01	0.00	0.00

Source: efttec (2007), Wareham Managed Realignment Case Study.

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Discussion

- 6.21 The primary barrier to the use of economic valuation of ecosystem services in policy appraisal is the high level of uncertainty regarding both the physical data and the economic value estimates. Robustness must be considered in the context of 'fitness for purpose' and proportionate use of funds for appraisal and research purposes. While the 'perfect' ecosystem service valuation will remain elusive (and is, in fact, not necessary), with suitable sensitivity analysis and judicious use of data collection and research, it should be possible in most cases to present a relatively robust assessment, highlighting the key uncertainties and exploring their implications, and laying a clear audit trail in which assumptions and calculations are clearly set down and can be altered easily.
- 6.22 The second level of barrier is the complexity involved in applying benefits transfer, and the implications for those conducting appraisals. This can be helped by:
- clear guidance on the rationale for selecting relevant studies, transfer methods, reporting protocols
 - indicative values recommended for initial use in basic appraisals
 - perhaps a template spreadsheet or browser-based tool for completing ecosystem service benefit appraisals.
- 6.23 What are the biggest difficulties/uncertainties in incorporating ecosystem impacts in policy appraisal? The uncertainties and methodological issues underpin the barriers to a wider application of ecosystem service valuation in appraisal. These are the main problems, because the evidence on general reactions of stakeholders involved in this project appears to be broadly positive. The potential is recognised for valuation to provide useful input to policy-making, discussions, option formulation and prioritisation, and so on.
- 6.24 However, there are some caveats, and the most important of these is that the valuation has to be seen as 'robust'. Feedback suggests that the response of providing 'off the shelf' values, at least for initial appraisal purposes, would be a welcome, and perhaps a necessary step.
- 6.25 What changes to existing departmental/other guidance would need to be made to ensure that impacts on ecosystems could be taken into account in policy appraisal? In the sense that the framework for incorporating environmental values in appraisal already exists, not much needs to change. However, in practice, it is clear that in most cases environmental values are not fully incorporated into policy appraisal. Feedback suggests that appraisers and other stakeholders are willing to move forward with valuation, and the primary need is for support in carrying this out including:
- clear guidelines on the economic valuation of ecosystem services
 - a template for incorporating economic value evidence into the FCERM appraisal
 - a set of 'off the shelf' values, with guidance on appropriate use, would be welcome and perhaps necessary. Though this could imply less scope for expert judgement in the selection of transfer values appropriate to specific schemes, in practice such judgement may be in short supply and the use of standard values, at least at initial appraisal stages, would help with replicability, consistency and (perceived) robustness

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- if creating a set of 'off the shelf' values, serious consideration should be given to commissioning a meta-analysis specifically for the purpose of generating robust values for use in the UK context
- clear guidance on the conditions (in terms of main results and sensitivity analysis) under which further economic valuation guidance should be sought, either for a more tailored benefit transfer, or for original valuation study, depending on the importance and decision-relevance of the service(s) in question
- appropriate training and support to accompany new guidelines, templates and appraisal methods, which will be crucial for extending the use of economic value evidence in appraisal practice.

6.26 Where would the incorporation of impacts on ecosystem services into policy appraisal provide the greatest 'added value'? The case study indicates that ecosystem service valuation can play a part, but that broad-brush assessments may be sufficient; fine discrimination between subtly different options is not the primary concern. The sensitivity analysis is important here in determining which service values have the potential materially to affect appraisal outcomes and therefore to guide data collection and research efforts. The provision of pointers to materiality is one of the key aspects of 'added value'. The other main advantage is in providing evidence to support the expenditure of public funds on schemes that are necessary but which without the explicit inclusion of ecosystem service benefits may appear to have low cost-benefit ratios. The inclusion of ecosystem service benefits can help to demonstrate higher cost-benefit ratios, moving important schemes over funding hurdles and higher up priority lists. This can contribute to more effective distribution of public funding, and improved decision-making in the face of sea-level rise and biodiversity loss.

Chapter 7: Next Steps

- 7.1 This Guide is a first step in Defra's aim to better integrate impacts on the natural environment into decision-making. It is purposely 'introductory', recognising that further testing and development is needed to operationalise this approach in Defra policy appraisal and beyond.
- 7.2 The Introductory Guide has been published alongside the ***Securing a Healthy Natural Environment: An Action Plan for embedding an ecosystems approach***⁴⁵, which includes specific priorities for Defra and others in moving towards an ecosystems approach in policy-making and delivery. The action plan provides a clear overview of the principles and benefits of an ecosystems approach and sets out key steps to take the work forward. Ensuring that the value of ecosystem services is fully reflected in decision-making is one of the core principles outlined in the Action Plan.
- 7.3 Specific priorities for Defra and others in progressing the development of ecosystem services valuation include piloting the practical application of ecosystem services valuation in specific policy areas. If we can demonstrate that valuing ecosystem services is both practical and useful, in the longer term our aim would be to mainstream this approach in existing policy and project appraisal tools and guidance.
- 7.4 A number of Defra-funded research projects applying an ecosystem services framework to valuation are currently under way or are in the process of being commissioned. Box 7.1 highlights this current research. Further proposed pilots are outlined in the ecosystems approach Action Plan.
- 7.5 Other priorities in the valuation of ecosystem services relate to methodological challenges. A key focus of much current research in this area is on the practical application of the concept of ecosystem services in order to develop more systematic approaches to the valuation of ecosystem services for use in policy in the future.
- 7.6 A key priority is to review the need for further evidence to address gaps in the valuation evidence base. Improved understanding of the application of both economic valuation approaches and deliberative or participatory methods to valuing ecosystem services will be important. The use of benefits transfer is seen as a significant issue for the more practical use of environmental values in policy-making, but there is a need to consider how this can be taken forward in a systematic and appropriate way.
- 7.7 It is important to recognise the scientific challenges of understanding how ecosystems function and the delivery of ecosystem services that have impacts on human wellbeing. A greater focus on interdisciplinary working between natural scientists and economists will also be required to make this approach work in practice.

⁴⁵ <http://www.defra.gov.uk/wildlife-countryside/natres/eco-actionp.htm>

Box 7.1: Current Defra research on the valuation of ecosystem services

An assessment of the economic value of England's terrestrial ecosystem services

This research – to be completed early in 2008 – aims to provide evidence on the economic value of England's terrestrial ecosystem services to demonstrate the multi-functional values of ecosystems. Major outputs of this study will be an investigation of methodologies for combining and aggregating (both spatially and temporally) values based on different valuation techniques, and assessments of the suitability of existing studies for benefits transfer. Overall, the study should provide a useful assessment of the strength and gaps in the evidence base across England's ecosystem services.

Economic valuation of the UK BAP

Research is currently being commissioned by Defra to estimate the value of the changes in biodiversity and associated ecosystem services that will result from the delivery of the UK BAP by 2010. The main output of the research will be the development and application of an appropriate framework that enables a robust valuation of the total economic value of changes in biodiversity and associated ecosystem services. The research consists of three phases: an initial phase that assesses the ecological impact of the delivery of the UK BAP with respect to changes in biodiversity and ecosystem services; a second phase, which develops an appropriate framework for the valuation of these changes in a UK context; and a third phase, which applies the framework to the results of phase one and undertakes primary valuation work.

Marine Bill: costing the benefits of Marine Nature Conservation proposals

Research is currently under way to ascertain the economic value of the changes in ecosystem services resulting from the proposed implementation of a network of Marine Conservation Zones (MCZs). The ecosystem services provided by the marine environment are entirely dependent on the species and organisms that live in the sea. These are, in turn, reliant on the maintenance of good-quality habitats. Any unsustainable degradation of these species or habitats will lead to a reduction in the provision of the ecosystem services on which we rely. The proposed method of estimating the benefits of this proposal will be by constructing scenarios of a network of MCZs. The research will identify a selection of representative sites that can be aggregated to determine a total value for the network as a whole. The research will outline a suitable methodology and approach to enable the economic valuation of the changes in the ecosystem services in the case study sites.

Annex 1: Valuation Methods

Methods of eliciting economic values

Revealed Preference methods

Market prices. These can be used to capture the value of goods and services that are traded e.g. the market value of forest products. Even where market prices are available, however, they may need to be adjusted to take account of distortions such as subsidies. Market prices can act as proxies for direct and indirect use values but do not capture non-use values; the price will be a minimum expression of the willingness to pay.

Averting behaviour. This approach focuses on the price paid by individuals to mitigate against environmental impacts. For instance, the cost of water filtration may be used as a proxy for the value of water pollution damages; or costs of buying pollution masks to protect against urban air pollution (although this will only represent part of the damage value).

Production function approach. This focuses on the relationship that may exist between a particular ecosystem service and the production of a market good. Environmental goods and services are considered as inputs to the production process and their value is inferred by considering the changes in production process of market goods that result from an environmental change. This approach is capable of capturing indirect use value.

Hedonic pricing. This assumes that environmental characteristics (e.g. a pleasant view or the disamenity of a nearby landfill site), as well as other property features, are reflected in property prices. The value of the environmental component can therefore be captured by modelling the impact of all possible influencing factors on the price of the property. Hedonic pricing can measure direct and indirect use value.

Travel cost method. This is a survey-based technique that uses the costs incurred by individuals taking a trip to a recreation site (e.g. travel costs, entry fees, opportunity cost of time) as a proxy for the recreational value of that site. It captures use value; visitors to the site may hold non-use values, but these cannot be assessed using this valuation method.

Random utility models. This is an extension of the travel cost method and is used to test the effect of changing the quality or quantity of an environmental characteristic at a particular site. Again, only direct use value can be captured.

Stated Preference methods

Contingent valuation. This is a survey-style approach that constructs a hypothetical market via a questionnaire. Respondents answer questions regarding what they are willing to pay for a particular environmental change. Theoretically, contingent valuation can capture all elements of Total Economic Value, but in practice it may be very difficult to assess many different use and non-use values.

Choice modelling. This is a survey-style approach that focuses on the individual attributes of the ecosystem in question. For example, a lake may be described in terms of water quality, number of species etc. Participants are presented with different combinations of attributes and asked to choose their preferred combination or rank the alternative combinations. Each combination of attributes has a price associated with it and therefore the respondents reveal their WTP/WTA for each attribute. As with contingent valuation, choice modelling can capture all elements of TEV.

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Cost based approaches

These approaches consider the costs in relation to provision of environmental goods and services and only provide 'proxy' values. Examples of cost-based approaches are those that infer a value of a natural resource by how much it costs to replace or restore it after it has been damaged.

Opportunity cost. This method considers the value forgone in order to protect, enhance or create a particular environmental asset (e.g. opportunity cost of agricultural production lost if land is retained as forest).

Cost of alternatives/substitute goods. This approach considers the cost of providing a substitute good that has a similar function to the environmental good. For example, wetlands that provide flood protection may be valued on the basis of the cost of building man-made defences of equal effectiveness. Given that wetlands provide a range of ecosystem services, this costing would be a minimum estimate of the value of a wetland.

Replacement cost method (also known as shadow project costs). This technique looks at the cost of replacing or restoring a damaged asset to its original state and uses this cost as a measure of the benefit of restoration. The approach is widely used because it is often easy to find estimates of such costs.

Methods of eliciting non-economic values

Focus groups, In-depth groups. Focus groups aim to discover the positions of participants regarding, and/or explore how participants interact when discussing, a pre-defined issue or set of related issues. In-depth groups are similar in some respects, but they may meet on several occasions, and are much less closely facilitated, with the greater emphasis being on how the group creates discourse on the topic.

Citizens' Juries. Citizens' juries are designed to obtain carefully considered public opinion on a particular issue or set of social choices. A sample of citizens is given the opportunity to consider evidence from experts and other stakeholders and they then hold group discussion on the issue at hand.

Health-based valuation approaches. The approaches measure health-related outcomes in terms of the combined impact on the length and quality of life. For example, a quality-adjusted life year (QALY) combines two key dimensions of health outcomes: the degree of improvement/deterioration in health and the time interval over which this occurs, including any increase/decrease in the duration of life itself.

Q-methodology. This methodology aims to identify typical ways in which people think about environmental (or other) issues. While Q-methodology can potentially capture any kind of value, the process is not explicitly focused on 'quantifying' or distilling these values. Instead it is concerned with how individuals understand, think and feel about environmental problems and their possible solutions.

Delphi surveys, systematic reviews. The intention of Delphi surveys and systematic reviews is to produce summaries of expert opinion or scientific evidence relating to particular questions. However, they both represent very different ways of achieving this. Delphi relies largely on expert opinion, while systematic review attempts to maximise reliance on objective data. Delphi and systematic review are not methods of valuation but, rather, means of summarising knowledge (which may be an important stage of other valuation methods). Note that these approaches can be applied to valuation directly, that is as a survey or review conducted to ascertain what is known about values for a given type of good.

Further References

Guidance on environmental appraisal and valuation

Further information on the appraisal and valuation of environmental costs and benefits:
<http://www.defra.gov.uk/environment/economics/index.htm>

Pearce D, Atkinson G and Mourato S (2006), *Cost-Benefit Analysis and the Environment: Recent Developments*. OECD.

Economic Valuation with Stated Preference Techniques: A manual. Report for the Department for Transport (2002): www.communities.gov.uk/documents/corporate/pdf/146871

Stagl S (2007), *Emerging Methods for Sustainability Valuation and Appraisal*. Report for the Sustainable Development Research Network. <http://www.sd-research.org.uk/post.php?p=129>

Eftec (1999), *Review of Technical Guidance on Environmental Appraisal*. Report for the Department of the Environment, Transport and the Regions:
www.defra.gov.uk/environment/economics/rtgea/index.htm

Natural environment and ecosystem services

Current Defra research work on the ecosystems approach and ecosystem services:
<http://www.defra.gov.uk/wildlife-countryside/natres/research.htm>

Further information on valuation of ecosystem services: <http://www.defra.gov.uk/wildlife-countryside/natres/eco-value.htm>

Eftec, Just Ecology and Turner R (2006), *England's Ecosystem Services: A preliminary assessment of three habitat types: broad leaved woodland, the inter-tidal zone and fresh water wetland*. English Nature Research Reports.

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<http://www.parliament.uk/documents/upload/postpn281.pdf>

Institute for European Environmental Policy (2006), *Value of Biodiversity: Documenting EU examples where biodiversity loss has led to the loss of ecosystem services*.

Eftec (2006), *Valuing our Natural Environment*. Report for Defra:
<http://www.defra.gov.uk/wildlife-countryside/natres/pdf/nr0103-full.pdf>

Economics and Funding SIG (2007), *Valuing the Benefits of Biodiversity*. England Biodiversity Strategy: <http://www.ukbap.org.uk/library/EconomicBenefitsOfBiodiversityJun07.pdf>

Van Beukering P, Brander L, Tompkins E. and McKenzie E (2007), *Valuing the Environment in Small Islands*. Joint Nature Conservation Committee: <http://www.jncc.gov.uk/page-4065>

Altruistic value. An example of non-use value. Altruism reflects a desire to secure an enhancement of the wellbeing of others.

Benefits transfer. The practice of estimating economic values for a service by taking evidence on the value of benefits from one context (the 'study site') and transferring it to another (the 'policy site').

Bequest value. An example of non-use value. It is the value individuals attach to the fact that the resource will be available for use by future generations.

Biodiversity. Biological diversity – or biodiversity. This is the term given to the variety of life on Earth.

Carbon sequestration. The uptake and storage of carbon. Trees and plants, for example, absorb carbon dioxide, release the oxygen and store the carbon.

Cost-benefit analysis. Analysis that quantifies in monetary terms as many of the costs and benefits of a proposal as is feasible, including items for which the market does not provide a satisfactory measure of economic value.

Cost-effectiveness analysis. Analysis that compares the costs of alternative ways of producing the same or similar outputs

Deliberative (or participatory) approaches. Approaches that tend to explore how opinions are formed or how individuals' preferences are expressed in units other than money.

Direct use value. Where individuals make actual or planned use of an ecosystem service.

Disamenity value. Welfare losses as a result of nuisance. The term is generally used to define a number of impacts such as noise, odour, litter, visual intrusion and associated perceived discomfort.

Discounting. A method used to convert future costs or benefits to present values using a discount rate.

Dose response. The quantitative relationship between a pollutant or environmental stressor and some ecosystem change or health-risk change.

Double-counting. An error that occurs when costs and benefits are counted twice.

Economic valuation. Assignment of monetary values to non-market goods and services.

Economic value. The monetary measure of the wellbeing associated with the change in the provision of some good.

Ecosystem. Defined at the most basic level as a natural unit of living things (animals, plants and micro-organisms) and their physical environment.

Ecosystem services. Services provided by the natural environment that benefit people.

Environmental Impact Assessment (EIA). Systematic listing and quantification, where possible, of the impacts of a policy or project on the environment.

Environmental limit. The point or range of conditions beyond which the benefits derived from a natural resource system are judged unacceptable or insufficient.

Environmental threshold. The point at which a natural resource exhibits rapid change or sudden collapse

Existence value. The value individuals derive from the knowledge that an ecosystem resource exists, even though they have no current or planned use for it.

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Habitat. Any place or type of place where an organism or community of organisms normally lives and thrives.

Impact pathway approach. A systematic approach to the assessment of the impact of policy change on an ecosystem and the services provided and its implications for human welfare.

Indirect use value. Where individuals benefit from ecosystem services supported by a resource, rather than by using it directly.

Intrinsic value. The worth of a good or service for its own sake.

Life-Cycle Analysis (LCA). A technique for measuring the environmental impacts of any product, process or activity according to each stage of its life cycle from the extraction of raw materials to final disposal.

Marginal value. The change in value resulting from one more unit of a good or service produced or consumed.

Market value. The price at which a commodity can be bought or sold, determined by the interaction of buyers and sellers in a market.

Meta-analysis. A statistical method of combining a number of valuation estimates that allows the analyst to systematically explore variation in existing value estimates across studies.

Multi-Criteria Analysis (MCA). Analysis of decisions in a context where there are multiple goals (objectives) that cannot be reduced to a single monetary measure.

Net benefit. The magnitude of benefits in excess of costs.

Non-use value. The value that is derived from the knowledge that the natural environment is maintained. This comprises bequest value, altruistic value and existence value.

Option value. The value that people place on having the option to use a resource in the future.

Pricing approaches. Approaches that use observed market prices either as a direct measure of economic value or as a proxy for the value.

Production function. The relationship that may exist between a particular ecosystem service and the production of a market good.

Quasi-option value. The value of information secured by delaying a decision, where outcomes are uncertain and where there is an opportunity to learn by delay.

Revealed Preference (RP). A valuation technique using actual data regarding individuals' preferences for a marketable good.

Risk Assessment. The process of analysing risks by studying the magnitude of loss and the probability of it occurring.

Sensitivity analysis. Analysis of the effects on an appraisal of varying the projected values of important variables

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Shadow price. The opportunity cost to society of participating in some form of economic activity. It is applied in circumstances where actual prices cannot be charged, or where prices do not reflect the true scarcity value of a good.

Social cost. The total cost associated with an activity, including both the cost to private individuals engaging in the activity and the cost to society.

Stated Preference (SP). A valuation technique using questionnaires to directly elicit individuals' preferences for non-market goods.

Strategic Environmental Assessment (SEA). Application of environmental assessment at the level of policies, plans and programmes.

Total Economic Value (TEV). The total gain in wellbeing from a policy. It comprises use and non-use values.

Use value. The value that is derived from using or having the potential to use a resource. This is the net sum of direct use values, indirect use values and option values.

Utility. A measure of the satisfaction that is gained from a good or service. It is synonymous with wellbeing.

Willingness to accept (WTA). The monetary measure of the value of forgoing an environmental gain or allowing a loss.

Willingness to pay (WTP). The monetary measure of the value of obtaining an environmental gain or avoiding a loss.

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