Ecosystem services assessment: How to do one in practice

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Contents

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About this document: This document was developed based on learning by the authors from conducting a range of pioneering ecosystem services assessments. It has been widely used in draft form not only as a learning resource but also to conduct 'live' ecosystem service assessments.

The Institution of Environmental Sciences is publishing this document to make it accessible to those who may wish to make use of it as a learning resource or for practical guidance in undertaking an ecosystem services assessment, thus adding to the growing body of case studies upon which it is based or which it has already informed.

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About the Institution of Environmental Sciences (IES): The IES is a visionary organisation leading debate, dissemination and promotion of environmental science and sustainability. We promote an evidence-based approach to decision and policy making.

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Executive summary

This document provides guidance on how to make an ecosystem services assessment. It explains what ecosystem services are, why an ecosystem services assessment needs to be made, and how it can add impact to your work. It addresses assessment of likely ecosystem service outcomes across a range of contexts, including:

- development or management initiatives where there is a pre-determined approach, or set of potential approaches; or
- where novel options for place or scheme development are being explored; or
- assessment of the ecosystem service outcomes of schemes or projects already completed.

This guide is intended to take you through the principal steps in preparing for and undertaking an ecosystem services assessment. It is generic and flexible in nature, recognising that there are many types of development or management schemes ranging from localised habitat enhancements or planning determinations through to large-scale industrial or flood risk projects.

The guide provides generic information about the value of and the steps entailed in undertaking an ecosystem services assessment, drawing upon learning from a series of published ecosystem services case studies and providing references to further guidance and sources of information.

Guide is structured as follows:

1. *Introduction to this ecosystem services assessment guide* providing background information on what an Ecosystem Approach can do for you, the purpose of the guide, and how to apply it to the scheme you wish to assess.
2. *Defining your study area and identifying key stakeholders*, which provides information on how to identify the boundary of the area under consideration, the main ecosystems, prioritisation of ecosystem services for further study, and key stakeholders to engage in consultation.
3. *Determining preferred options informed by an Ecosystem Approach*, which addresses developing options for desired management change and initial consideration of options to influence or pay for the required management changes.
4. *Assessing changes in ecosystem services* (actual changes for completed schemes or likely changes for options assessment), including whether to value in economic terms or not and, if so, how this is achieved.
5. *Results of ecosystem service assessment of your scheme.*
6. *Identifying options for bringing about change*, including consideration of measures that may bring about desired enhancement or protection of ecosystems that may potentially include 'paying for ecosystem services' (PES) methods.
7. *Decision-making and learning points*, including identifying research gaps and learning beyond the scheme.
8. *Annex 1: Overview of ecosystem services*, including methods for their assessment.
9. *Annex 2: Ecosystem services case studies*, from which further lessons may be drawn about practical ecosystem service assessments that have already been conducted.
10. *Annex 3: Detailed results of ecosystem services assessment of your scheme*, providing a set of tables in which to record your results and currently including some illustrative valuation methods used in already-published ecosystem service assessments.
11. *Annex 4: Template ecosystem services assessment* report including additional guidance and sample text.

Our intention is that this guide can be used directly as a skeleton for conducting your own ecosystem services assessment, as guide structure reflects that we have found to be most effective for reporting on scheme assessments.

This guide has been drafted consistently with key messages from HM Government's 2011 Natural Environment White Paper The Natural Choice (HM Government, 2011) providing references to additional sources of information and guidance where helpful.

It is intended that this guide will be periodically updated to reflect new knowledge and experience.

1. Introduction

The HM Government (2011) White Paper *The Natural Choice highlights that "Nature is sometimes taken for granted and undervalued" and that "This is why we must properly value the economic and social benefits of a healthy natural environment while continuing to recognise nature's intrinsic value"* (**see Box 1.1**).

The body of the Natural Environment White Paper expands upon these central driving principles and how they will be put into effect, culminating in 92 Government commitments. These principles and commitments cumulatively form part of government policy, embedding the Ecosystem Approach into the mainstream, including of the formulation and implementation of national policy.

It is therefore necessary to be able to assess the breadth of implications for ecosystem services of policies, land use and other practices, development options and other activities.

Box 1.1: Key principles from the Executive Summary of the HM Government (2011) Natural Environment White Paper, The Natural Choice

1. "Nature is sometimes taken for granted and undervalued. But people cannot flourish without the benefits and services our natural environment provides. Nature is a complex, interconnected system. A healthy, properly functioning natural environment is the foundation of sustained economic growth, prospering communities and personal wellbeing."

2. "This is why we must properly value the economic and social benefits of a healthy natural environment while continuing to recognise nature's intrinsic value. The Government wants this to be the first generation to leave the natural environment of England in a better state than it inherited. To achieve so much means taking action across sectors rather than treating environmental concerns in isolation. It requires us all to put the value of nature at the heart of our decision-making – in Government, local communities and businesses. In this way we will improve the quality and increase the value of the natural environment across England."

3. "We will mainstream the value of nature across our society by:

- facilitating greater local action to protect and improve nature;
- creating a green economy, in which economic growth and the health of our natural resources sustain each other, and markets, business and Government better reflect the value of nature;
- strengthening the connections between people and nature to the benefit of both; and
- showing leadership in the European Union and internationally, to protect and enhance natural assets globally."

1.1 What are ecosystem services?

The natural environment provides a wide range of benefits to people. These include, for example, production of clean water and many raw materials used in economic activities, regulation of climate and flooding, soil formation and crop pollination, and cultural benefits such as aesthetic value and recreational opportunities. These multiple benefits that people derive from ecosystems are known as 'ecosystem services'. The Millennium Ecosystem Assessment (2005) updated a diversity of prior ecosystem service classifications schemes into a harmonised classification, outlined in **Annex 1**. Examples of some of the many beneficial ecosystem services provided by upland areas are described in **Figure 1**.

Ecosystem services underpin our health, economy and quality of life, albeit that many have been overlooked. For this reason, ecosystem services will increasingly frame the way that we assess the impacts and implications of how we interact with the natural environment, and they will also shape the ways in which we manage both the environment and human activities impinging upon it. The concept of ecosystem services is now beginning to be widely understood and applied. **Annex 1** provides further description and a reference to key sources for those wishing to know more.

The term 'Ecosystem Approach' has a broader scope (described in **Annex 1**), defined by the Convention on Biological Diversity as "...a strategy for the integrated management of land, water and living resources". Ecosystem services are an element of the wider Ecosystem Approach, which sets them in a wider geographical and socio-economic context.

1.2 What can an ecosystem services assessment do for me?

In order to fulfil government intent articulated in the third key principle of the Executive Summary of *The Natural Choice*, relating to the 'mainstreaming' of the value of nature across society (**see Box 1.1**), it is necessary to find means to put the value of the natural environment at the heart of decision-making. This will provide evidence to identify management options that optimise public benefit across the breadth of ecosystem services, avoid potentially significant costs and risks arising from overlooking implications for some services, or expose transparently the social and economic costs implicit in any trade-offs. This wider scrutiny of implications across the whole spectrum of ecosystem services is implicitly required by commitments under *The Natural Choice*, relating to all policy areas including public health, economic recovery, sustainable business, education, culture, climate change and sustainable transport.

A practical example of how an ecosystem services assessment can support policy and implementation decisions is in optimising cross-service benefits and hence cumulative societal value in the

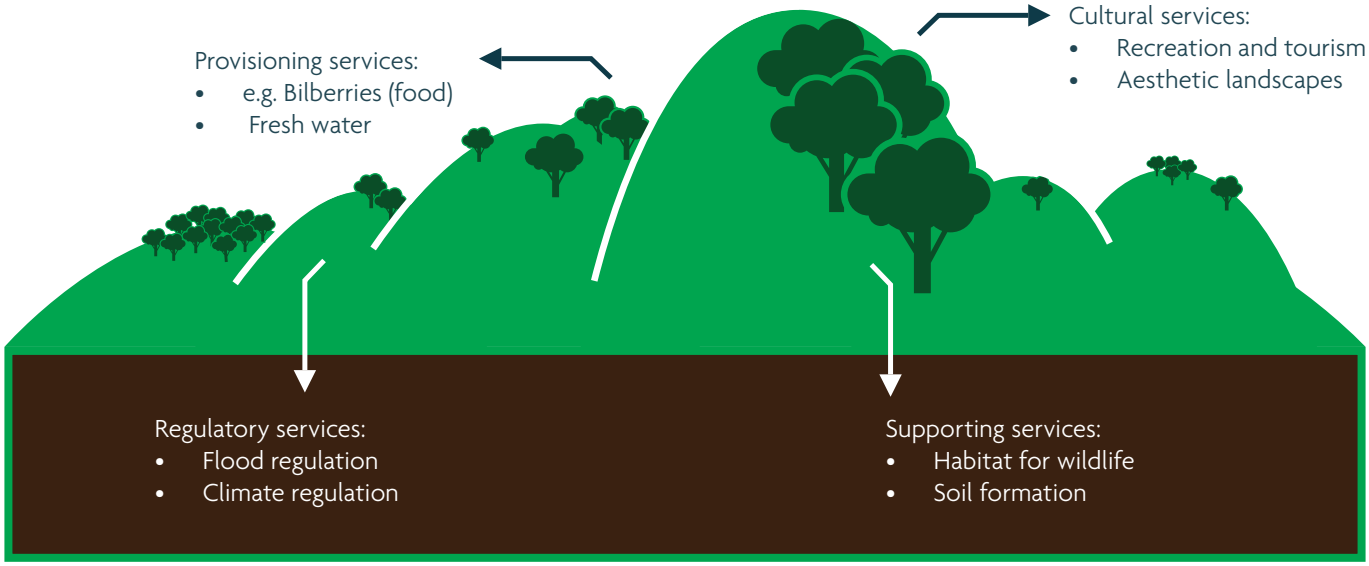


Figure 1: Example of ecosystem services provided by upland areas.

application of urban 'green infrastructure'. There is considerable consensus already in the literature about the desirability and potential for achieving multiple, cross-disciplinary benefits, including those accruing to ecosystems (Tzoulas *et al.*, 2007; Everard and Moggridge, 2012). The value of the environment for health outcomes is also recognised in the UK Index of Deprivation, which is based on environmental as well as social and economic conditions of communities (Office of the Deputy Prime Minister, 2004), emphasising the role of decisions affecting the environment for the wellbeing of all in society. Furthermore, taking full account of ecosystems and their services can increase the long-term resilience of business decisions, policies and actions. It is, indeed, part of good practice in assessing the general environmental impact of policy options, consistent with HM Treasury (2013) 'Green Book' which guides appraisal and evaluation in central government.

Taking an Ecosystem Approach provides improved assurance of sound stewardship and risk management, facilitating the processes of securing planning permission or loans for project work. It also takes better account of societal choice, accounting for the benefits accruing to all sectors of society from the services provided by nature.

1.3 When might an ecosystem services assessment be helpful, and what form should it take?

Undertaking an ecosystem services assessment will always add value to decisions. An awareness of potential implications across the range of ecosystem services contributes to averting unintended negative consequences and potentially to optimising net benefits arising from decision-making. However, determining the level of detail required in an assessment will vary with context.

Ecosystem services assessments are useful risk assessment tools for all sectors of society, forming a subset of implementation of the wider Ecosystem Approach. They can be applied to determine and communicate the broader ramifications of decisions, policies and planned schemes, to consider options for the future use or management of habitats ('places'), to broaden the scope of impact assessments, to address the robustness of business plans, and to communicate with and better engage local communities.

1.4 The purpose of this guide

This practical guide integrates learning from a range of published ecosystem services case studies and applies it in logical steps to help practitioners make their own ecosystem services assessments. This guide has been in widespread use during its long development, each application of the guidance providing feedback that has improved its robustness and operational relevance.

Consequently, the way that the guide is structured directly mirrors the format of a series of published reports on practical ecosystem services case studies. Most of the case studies listed in **Annex 2** have either informed the development of this guide, or else were directly shaped by application of this evolving guide. Lessons emerging from the application of ecosystem services assessment from most of these case studies are reviewed by Everard (2012) and listed in **Box 1.2**. The authors' intention is to expand **Annex 2** as more assessments are published.

Box 1.2: Lessons emerging from ecosystem services assessments (adapted from Everard, 2012)

1. System-level consideration may lead to different outcomes than those that arise from a local spatial, temporal and/or disciplinary focus
2. Ecosystem restoration maximises value across all ecosystem services by focusing on natural processes from which services derive
3. A systems approach recognises all stakeholders in decision-making, as all ecosystem services represent the interests and value systems of different sectors of society
4. Because they are defined as benefits to people, the language of ecosystem services can help better communicate/engage with people in socially-meaningful terms
5. By considering the role that localised schemes can play in the production and flow of ecosystem services, scheme design can be enhanced to contribute to sustainability outcomes over broader spatial scales
6. Markets may have a key role to play as a means to bring into the mainstream of decision-making some of the values of ecosystem services that may have previously been overlooked
7. To 'mainstream' the Ecosystem Approach, addressing multiple outcomes and implications for different people, it is necessary to incorporate an ecosystem services perspective into pragmatic tools (including comprehensible guidance) supporting day-to-day decision-making and operational processes

For those then wanting to produce their own ecosystem services assessment, a template report based on this flow of guidance, including useful ways to present results, is included at **Annex 4**.

You may simply follow the flow of ideas in this guide if no such report is required.

1.5 How to use this guide

Ecosystem services assessment may be required in a wide diversity of applications. This guide can not hope to provide a 'one size fits all' solution. However, the flow of sections and concepts in this guide can be adapted to meet the needs of different potential users and contexts. The flow of sections in this guide is shown in **Figure 1.2**

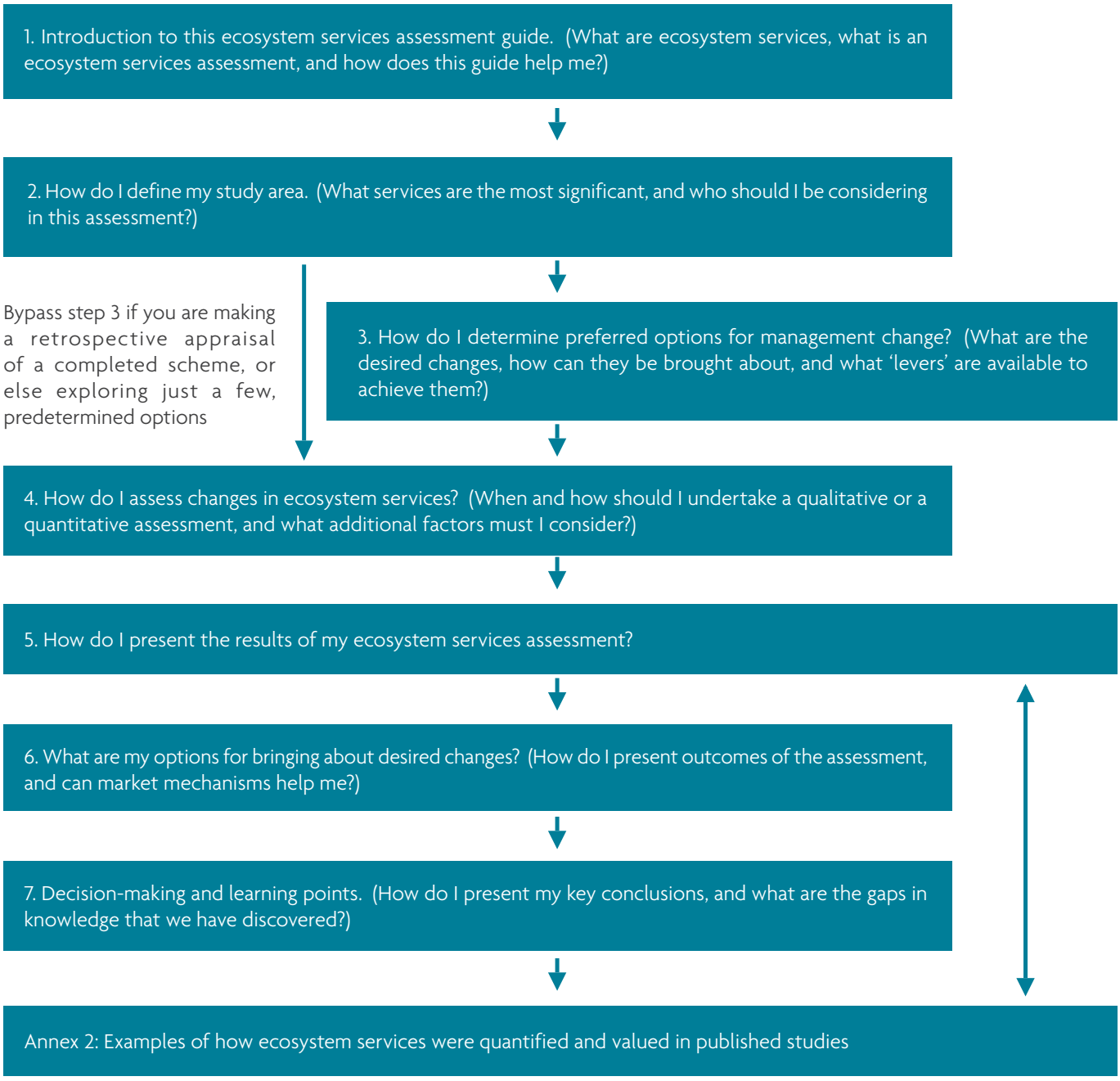


Figure 1.2 The flow of sections in this guide

There are four Annexes supporting this conceptual flow including (**Annex 4**) a template that you may use as the basis for your own bespoke assessment.

1.6 Where do I go for further guidance?

Further guidance on applying an ecosystem services assessment, and for specific steps in the process, can be found in **Table 1.1:**

Table: 1.1: Further guidance on applying ecosystem services.

Policy-level guidance	• HM Government (2011) White Paper The Natural Choice • Convention on Biological Diversity. (www.cbd.int.)
Overview of ecosystem services	• Defra. (2010a). What nature can do for you: a practical introduction to making the most of natural services, assets and resources in policy and decision making.
Guides for business	• World Business Council for Sustainable Development. (2011). Guide to Corporate Ecosystem Valuation: A framework for improving corporate decision-making. (www.wbcsd.org.) • The Economics of Ecosystems and Biodiversity. (2011). TEEB for Business. Earthscan, London. (www.teebweb.org/ForBusiness/tabid/1021/Default.aspx.) • Everard, M. (2009). The Business of Biodiversity. WIT Press, Ashurst.
Participatory and Deliberative Techniques	• Participatory and deliberative techniques to embed an ecosystems approach into decision making. Defra Project Code NR0124. (http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=16395&FromSearch=Y&Publisher=1&SearchText=nr0124&SortString=ProjectCode&SortOrder=Asc&Paging=10, accessed 10th September 2013.)
Valuation (addressed in more detail later in this guide)	• Defra. (2007a). An introductory guide to valuing ecosystem services. Department for Environment, Food and Rural Affairs, London. (www.defra.gov.uk/wildlife-countryside/pdf/natural-environ/eco-valuing.pdf.)
Payments for ecosystem services (PES)	• Smith, S., Rowcroft, P., Everard, M., Couldrick, L., Reed, M., Rogers, H., Quick, T., Eves, C. and White, C. (2013). Payments for Ecosystem Services: A Best Practice Guide. Defra, London. (www.gov.uk/government/publications/payments-for-ecosystem-services-pes-best-practice-guide, accessed 10th September 2013.)

2. Defining your study area and whom to engage

This section addresses things to think about, and issues that may arise, in defining the area that will be the subject of your ecosystem services assessment.

The kind of area that you might choose to study may include:

- Assessing the ecosystem service outcomes for a completed scheme, which will have impacts at a range of scales. Practical examples of ecosystem services assessments of completed schemes include studies of the River Glaven sea trout restoration (Everard, 2010) or the upper Bristol Avon buffer zone (Everard and Jevons, 2010);
- An area for which development options are being considered, such as in the East of England case studies by Glaves *et al*. (2009);
- A study into different options for a particular management goal, such as the Wareham coastal defence study included as an annex in the Defra (2007a) *An introductory guide to valuing ecosystem services*; or
- Location and design of housing or other development schemes, including development of mitigation or offsetting measures to address unintended harm, in order to protect important ecosystem services (for example as implicit in urban 'green infrastructure' or to address 'biodiversity offsetting').

In all cases, you should outline the main characteristics of the location and the options being considered for its development. This can be achieved by following the sequence of guidance as set out below.

2 .1 Identify the boundary of the area under consideration

The objectives and drivers of a project are a key consideration in deciding the boundaries of the area you need to consider. Whilst this step may be obvious for some projects, it may be less clear for others. Some iteration of boundaries may be required as the project progresses. Nevertheless, defining a working boundary at the outset is necessary to enable the following steps. Often, the area of your study will be defined by an existing project scope, such as:

- A catchment, as in the River Glaven sea trout restoration study (Everard, 2010) or the Tamar 2000 study (Everard, 2009);
- A specific development, such as studies of the upper Bristol Avon buffer zone (Everard and Jevons, 2010) or likely outcomes from the proposed Pancheshwar Dam (Everard and Kataria, 2010); or
- A unit of landscape, as was the case for the set of five East of England case studies (Glaves *et al.,* 2009).

However, the ecosystem services assessment will also need to address cross-boundary issues. This includes services 'produced' in the study area from which others beyond it may benefit or suffer (such as upland land use influencing people subject to flood risk downstream) and conversely services (such as flood or air quality regulation or the recruitment of fish stocks) from which people benefit within your study area but which are largely or wholly 'produced' outside of it.

2.2 Identify the main ecosystems and ecosystem services present, including those 'produced' or 'consumed' elsewhere

This step entails a mapping process which initially can be done quickly, though refinement may be ongoing as the project progresses. Identifying the broad habitat types and their location is a helpful step in understanding the assets or natural capital in the project area. Ecosystem services flow from these assets.

You can use the checklist of ecosystem services (using the Millennium Ecosystem Assessment categorisation) in **Annex 1** to understand the range and approximate extent of ecosystem services provided by your study area.

This will enable you to identify some of the principal services provided, and from where they are 'produced'. As noted previously, some of these services may cross the boundary of the project area or provide services to people outside the study area. These all need to be recorded. This may not be a straightforward task, but it does help you think about the 'baseline' condition of the site which will be important for the subsequent determination of marginal changes under different development options. In practice, this step may also be iterative as it can be refined as further information is provided by stakeholders as the project progresses.

An assessment of the relative importance of the services provided can be helpful in any project, serving to ensure that unintended negative outcomes are not overlooked and that opportunities to maximise synergy across ecosystem service outcomes are realised. There are a number of ways of doing this:

- Using the Defra (2007) weighting system, outlined in the following section, to ascribe the relative significance of ecosystem services;
- Using the approach undertaken in the East of England case studies (Glaves *et al*., 2009) which assessed four criteria: magnitude, sensitivity and vulnerability, replacability of

ecosystem services, and cumulative impact; or

- Discussing with stakeholders which services are of particular significance (perhaps using the Defra (2007a) weighting system as a means to record this).

An example of outcomes from this stage is illustrated in **Table 2.1** below, taken from the East of England case studies (Glaves *et al*., 2009, Valuing Ecosystems Services in East of England Volume 2 Case Studies, Table 6.2, page 13). Natural England's baseline documents for the three upland ecosystem services pilots are another example (e.g. Natural England, 2012, Delivering Nature's Services: the ecosystem services pilots).

Table 2.1. Mapping of significant ecosystem services provided by key habitat units at Marston Vale (source Glaves et al., 2009)

	Main Ecosystem Types							
Types of Service	**Woodland**	**Farmland**	**Grasslands**	**Freshwater wetlands**	**Riverine**	**Parks and Gardens**	**Urban Green Space**	**Brownfield Sites**
Provisioning services								
Food		Wheat, barley, rape, linseed, beans	Some grazing					
Fibre and Fuel	Firewood Timber – currently small but growing	Fuel crops Stubble as biofuel						
Biodiversity /Genetic resources	Conservation of local genetic resources. Community Tree Trust - collection of seed, nurture & plant (commercial potential)	Conservation of local genetic resources	Conservation of local genetic resources Biodiversity of farms – 30% stewardship Declining farm species	Conservation of local genetic resources Important metapopulations of protected great crested newts	Conservation of local genetic resources	Conservation of local genetic resources	Conservation of local genetic resources	Conservation of local genetic resources
Biochemicals, natural medicines,								
Ornamental	Some very small scale traditional markets							
Fresh water		Aquifer on green sand ridge	Aquifer on green sand ridge	Maintenance of water table	Maintenance of water table	Aquifer on green sand ridge		Disused Clay & Gravel Pits – see freshwater
Saline water		Biofuels						New nature conservation sites
Others	Coppice – small but increasing Woodland burials?							

2.3 Identify the key stakeholders for consultation

Ecosystem services relate to the multiple benefits provided to people by ecosystems, covering broader groups of stakeholders and their associated (often non-monetary) value systems than have traditionally been addressed in consultation. Furthermore, ecosystem services can only be ascribed economic value to the extent of the benefits enjoyed by people. For these reasons, engagement with people is a key part of ecosystem service assessment.

There is an increasing legal, political and moral imperative to engage stakeholders in decision-making. This can vary across a well-recognised 'ladder of engagement' (Arnstein, 1969) from (low level) 'consultation' on a few favoured options right through to full public participation from the problem identification stage and onwards to problem framing, options identification and appraisal, implementation and adaptive management throughout life.

Engagement is a big topic beyond the scope of this short guide. However, you should be clear about the level of engagement you require, the processes to ensure that it is effective, and the potential to influence the process. You will need to identify and use suitable tools to ensure this. Ecosystem services are, of course, in part an engagement tool, helping connect diverse stakeholders via the ways in which they actually use or otherwise connect to ecosystem processes, and making clear the likely interactions between different users and uses. The Defra (2011a) research report *Participation and an ecosystems approach to decision making* is a useful source for pursuing stakeholder engagement around ecosystem services.

There are some key stakeholders to consider when developing any project. These include the people who currently manage the land, water or sea to provide the services, those who benefit from the services the area provides, and also those with decision-making responsibilities over the area. It is important to be aware that some beneficiaries may be a long way from the source of the services. By being clear about who the providers and beneficiaries are, you can also be clear about the consequences of decisions for these people and seek to address issues or trade-offs at an early stage.

The need, or at least the perceived need, for stakeholder engagement will vary on a case-by-case basis. You should adapt methods to your needs. By completing this stage, you will have identified the area under consideration, principal ecosystem services provided by it and the people affected.

3. Identifying preferred options for management of change

This step in the ecosystem services assessment process addresses working with stakeholders to identify preferred options from ecosystem management.

Note: If you are simply assessing the ecosystem service impacts of different pre-determined options to manage a site (such as options to achieve a particular flood defence outcome), or else undertaking an assessment of ecosystem service impacts of a completed scheme (such as studies of the Tamar 2000 and Alkborough Flats schemes published by Everard, 2009), you may bypass this section and move straight onto Assessing changes in ecosystem services **(Section 4)**.

3.1 What are the desired changes?

In many projects, there is an intention to change management of an area or 'place' in some way. This might be because there is an objective to change a service provided by the area, for example a desire to improve water quality in the river or else amenity access or nature conservation value. Alternatively, there may be a desire to change the suite of services provided by the area, for example a local authority may wish to improve multiple benefits for the community from an area.

Different stakeholders will hold a diversity of views about desirable objectives, and there is also likely to be more than one way of achieving them. Options or scenarios can be worked up in association with the stakeholders and project partners, and tested for the consequences of the changes. The questions that need to be considered are:

- What are the services changes we want to make?
- What options are there for management interventions that may achieve them?
- What are the consequences to services provision and their beneficiaries of these different options?

You should therefore consider all potential winners and losers of change in ecosystem management, and be open to alternative options or modifications that may avoid losses or at least be informed and transparent about where trade-offs may occur. You also need to aware of opportunities to realise co-benefits additional to the key objectives.

This process has to be undertaken on a stakeholder basis, working with different interests affected by ecosystem services arising from the site towards a desired future state. You will have identified key services and stakeholders in the previous stage of this assessment process.

You should use the full ecosystem service framework to determine desired services, and to avoid unintended or unforeseen conflicts with provision of other services.

3.2 What management will provide the desired change ecosystem services?

Understanding the ecosystems and services within the project area will enable an assessment of the potential for service change within the project area. Some ecosystem services can only be generated from specific places under specific circumstances (for example improved water quality or flood alleviation). Other changes could be in number of places, such as improved recreational opportunities or carbon sequestration.

Understanding the potential of the area helps in the design of management changes. Often, local information can help considerably in understanding what it is possible to do and where. Also, stakeholder-provided knowledge better informs decision-makers about desired outcomes, as well as reflecting improvements that can be brought about by behavioural change and the means to encourage it (such as improved agricultural land use practices or better zoning of intrusive recreational activities). It is important to understand the link between changed activity and changes in services.

3.3 Initial consideration of options to influence or pay for the required management changes

At this stage, you may start to think about the 'levers' of change. What are the inducements or incentives that may bring about change? This could include education, payments, enforcement or a wide range of other means to affect changes. We will consider these in more detail later in this process.

4. Assessing changes in ecosystem services

By this stage in the assessment, you will have identified the study site and its associated services and key stakeholders. You will also have identified the management or development options that you want to assess.

This next step entails quantifying, and potentially valuing, the marginal changes likely to arise from management or development options relative to a 'baseline' condition.

4.1 What is distinctive about an ecosystem services assessment?

An ecosystems perspective ensures that the full range of ecosystem services is recognised in assessment, not just a selected few of particular interest. The reason for this is that failing to retain an overview of interactions with the full system risks maximising some focal benefits at unaccounted cost to other ecosystem services and their beneficiaries.

This consideration of the distribution of outcomes also ramifies across longer timescales and broader spatial scales. The HM Government (2011) White Paper *The Natural Choice* is explicit about this point noting that "*Past action has often taken place on too small a scale*" (key principle 5 from the Executive Summary). Furthermore, the 12 Principles of the Ecosystem Approach explicitly address consideration of the effects of activities on adjacent ecosystems (Principle 3), taking account of 'appropriate spatial and temporal scales' (Principle 7) and setting objectives for ecosystem management for the long term (Principle 8).

4.2 Marginal change

An important concept in taking forwards ecosystem service assessment is the distinction between 'absolute' valuation and assessment of 'marginal' changes.

Absolute assessments seek to quantify the total amount of a service produced. This was most famously executed in the assessment by Costanza *et al*. (1997), which used conservative means to deduce that the total value (replacement cost) of global ecosystem services to humanity was in the order of $33 trillion. Costanza *et al*. were at pains to point out in their abstract that there were many uncertainties in this assessment, and that some aspects of it were logically meaningless (for example humanity could not survive if key services were lost). However, the Costanza *et al*. paper, which noted that this value was similar to global GDP, was highly influential in raising the profile of the importance of ecosystems and their services in the global political arena. More recent attempts to develop an assessment of the value of ecosystems to society, including by The Economics of Ecosystems and Biodiversity (TEEB, 2010, www.teebweb.org) and the UK National Ecosystem Assessment (the UK NEA, 2011, http://uknea.unep-wcmc.org), have also proved how conceptually ambiguous and difficult to deduce absolute values can be.

Of more value in day-to-day decision-making are assessments of 'marginal' changes. Marginal change recognises the difference between a 'baseline' state and a 'post-intervention' state. Marginal assessments of observed or anticipated changes in ecosystem services are more robust as the large number of assumptions and uncertainties used in any such study are applied to both the 'baseline' and 'outcome' states which, to a certain extent, cancels them out during comparison.

4.3 What sort of changes are we looking at?

You may wish to assess different kinds of outcomes. For example, you may seek to assess marginal changes (intended or unintended) arising from a completed project (which you may see referred to as an ex post study). Alternatively, you may have an option, or set of options, for which you want to assess the outcomes across the suite of ecosystem services (also known as an ex ante study). Or you may be generating options for development or management of a site with its key stakeholders, and need an

Table 4.1 Example from ecosystem services assessments

Published ecosystem services assessment	Assessment of completed scheme or future options?	Example of assumptions applied to both 'baseline' and 'post-intervention' states
River Tamar (Everard, 2009a)	A completed scheme implemented by the Westcountry Rivers Trust in 2000	As one example of a service assessment, current versus improved water quality linked to implications for treatment costs
River Glaven (Everard, 2010)	A completed scheme, though plans to bypass a remaining major obstruction on the river was assessed as a future option	As one example of a service assessment, the degree of public engagement and community-building (brought about in delivering catchment restoration)
Proposed Pancheshwar Dam (Everard and Kataria, 2010)	Assessment of likely outcomes from a proposed scheme to dam a major Asian river	Estimate of people affected directly and indirectly in catchment, including determination of major winners and losers

assessment method to quickly determine the likely consequences arising from these options for all ecosystem services and their beneficiaries (also ex ante assessments). **Table 4.1** notes examples of each type of case study, highlighting the basis for marginal comparison of 'baseline' and 'post-intervention' states.

4.4 Proportionality

The depth of detail required for each type of assessment (including both quantification and, if necessary, valuation), and hence the robustness of the assessment, may differ depending on the kinds of decisions it is intended to support. It is important that the effort undertaken in making an ecosystem services assessment is proportional to the problem you are addressing.

Three important things to remember in quantification are that: (1) there is no single 'right way'; (2) defensible evidence is used to quantify likely impacts including inherent uncertainties; and that (3) ALL ecosystem services must be considered (as addressed above).

You are advised to take a risk-based approach. For example:

- if risks are low (i.e. you are making a rapid assessment with stakeholders of options for scheme development generated in a workshop) then all you may require is an overview of the likely range and magnitude of impacts upon ecosystem services. Alternatively,
- if risks are high (to justify an expensive decision or where there is contention or a high degree of uncertainty) then you may require a more detailed evaluation of both quantification of impacts across ecosystem services, and the values that may be associated with them.

4.5 Where do I find the information that I need to make an ecosystem services assessment?

Accepting the principles above that (1) there is no single 'right way' but (2) evidence needs to be defensible when (3) assessing all ecosystem services, there is clearly no single formula for ecosystem services assessment in every situation. In practice, time and budget availability mean that you have to draw upon often currently-available information from which you make transparent but defensible assumptions, unless scheme magnitude and contention necessitates bespoke studies. This means that you will have to be creative, but always openly state your base data, assumptions and methods that others may challenge. Remember, in most cases, you are not looking to derive an objectively 'exact' value, but merely to illustrate the magnitude of likely impact (positive or negative and/or large or small) for each ecosystem service to ensure that it are not overlooked in decision-making processes.

Information sources to assess implications for ecosystem services can therefore be diverse. For example, in a number of case studies informing this guide, an indicative value for the supporting service of 'habitat for wildlife' was extrapolated from costs averted by schemes for bespoke biodiversity management evaluated in terms of the costs of digger hire (without identifying exactly what the digger would have done). As another example, the proposed Pancheshwar Dam study (Everard and Kataria, 2010) drew upon a wide range of sources of information including, for example:

- Official reports and documentation;
- Scientific literature;
- Newspaper and technical reports;
- Interviews with a range of stakeholders from local village residents to shop owners, engineers, farmers, tour operators, etc; and
- Websites and forums that served to capture a range of opinions.

A range of published case studies (**see Annex 2**) include the methods used for quantifying the magnitude of change in ecosystem services. You may derive methods directly from some of these studies where appropriate, but they will also give you hints of how to deduce the magnitude of likely outcomes.

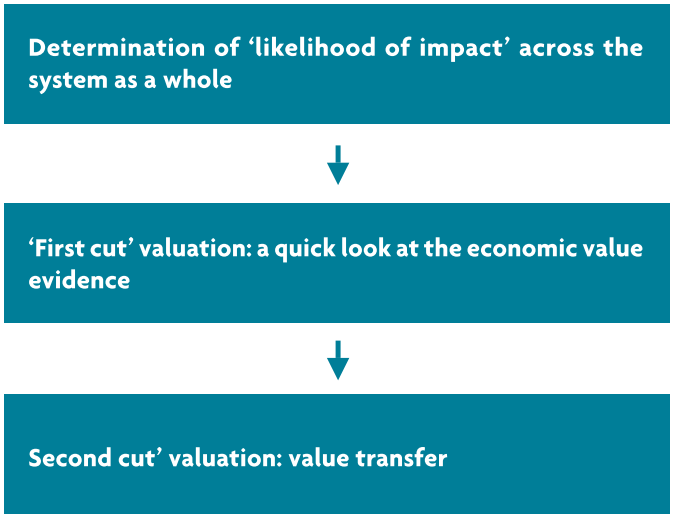
4.6 To value or not to value ecosystem services?

Economic valuation may not always be essential. Indeed, for many purposes, it may be prohibitively time-consuming and expensive. However, it is important in all cases to assess impacts across the whole of the system of services, and not (for reasons already outlined) make potentially erroneous prejudgements about which services are the 'most important'.

The driving principle here is one of proportionality, ranging from the relatively trivial and quick assessment to a full-blown economic study for contentious, contested, major or highly uncertain development proposals or investments. Also, for stakeholder dialogue purposes, you may want to start with a generic, systems-level overview to familiarise your participants, later drilling down into more detail if the process demands it. This will be highly case-specific, so you should work out the most pragmatic approach to address the particular problems you are trying to address. This should lead you to consider the following hierarchy of approaches shown in **Figure 4.1**

4.6.1 Determination of 'likelihood of impact'

This will take the form of a screening of likely impacts across the full set of ecosystem services. This ensures that system-wide impacts are taken into account in your assessment, including the perspectives of multiple stakeholders. To facilitate a systems-level scan of likely significance, Defra (2007a) published a simple



'likelihood of impact' scoring system through which stakeholder groups, or in their absence groups of experts, can consider likely impacts of schemes or options. This scoring system is reproduced at **Table 4.2**.

Table 4.2 Defra (2007a) 'likelihood of impact' scoring system

Score	Assessment of likely impact
++	Potential significant positive effect
+	Potential positive effect
0	Negligible effect
-	Potential negative effect
--	Potential significant negative effect
?	Gaps in evidence / contention

Applied using the full suite of ecosystem services (it is suggested that the Millennium Ecosystem Assessment classification, reproduced in **Annex 1**, is used), involving multiple experts and ideally different stakeholders, this provides a 'read out' of the likely magnitude and positive/negative tendency of impacts. This then informs a risk-based approach to decision-making. In some instances, this 'likelihood of impact' scoring may prove sufficient for decision-making or other assessment purposes (such as in the Wareham Harbour case study included as an Annex in the Defra 2007a guide as well as in the proposed Pancheshwar Dam study). In other instances, it may serve as a first system-scale filter helping prioritise services warranting the allocation of limited resources on the basis of significance for service impacts arising from of knowledge gaps.

4.6.2 First cut valuation

Where economic valuation is found to be necessary, you first ensure that you are addressing impacts across all ecosystem services (and not a partial set of them due to biases described previously). Once we understand impacts across the system then limited resources can, if necessary, be deployed to explore the most significant negative or positive impacts or the most prominent unknowns or areas of contention. However, different circumstances may necessitate 'first cut' or more detailed levels of economic valuation. An eftec Handbook (2010) provides guidance on these different levels of assessment, how they may be applied and how to conduct economic assessments. For the 'first cut', eftec suggests:

> "...this provides a series of default values for use in option development. The intention is to provide an indication of the magnitude of economic value evidence related to typical environmental effects associated with FCERM scheme options. This is particularly appropriate for preliminary assessments of an initial 'long list' of FCERM options ensuring that an explicit account is made of the environmental costs and benefits. Depending on the requirements of the decision-making context, the evidence generated by the first cut may be sufficient in a preliminary assessment. It is less likely to be sufficient in a main options assessment where more detailed analysis should be undertaken."

4.6.3 Second cut valuation

Where more detailed monetisation is required, a range of techniques can be applied. The eftec (2010) Handbook describes the 'second cut' valuation as, In practice, the case

> "...a full scale value transfer analysis in the specific context of FCERM schemes with the express intention of inputting to CBA. This level of analysis requires more information and practitioner effort than the first cut. The level of effort should of course be appropriate to the needs of the overall decision-making context as highlighted above."

studies upon which this guide is based used a wide range of valuation techniques, many of which are cited as illustrative examples in **Annex 2**. Prime amongst these are 'value transfer' techniques, which draw upon existing valuating studies and

transfer the values to the current study with appropriate and stated assumptions appropriate to context. The ecosystem services case studies listed in **Annex 2** may contain values that could be transferred into your study with appropriate caution. The National Ecosystem Assessment (www.uknea.unep-wcmc.org), including the Synthesis of the key findings report published in 2011, contains further potentially transferable values or methods for value deduction. You may also find further values in additional pre-existing studies, from the peer-reviewed literature, value transfer databases, of other sources. New techniques are also emerging under research programmes including NERC's Valuing Nature Network (www.valuing-nature.net). Furthermore, Defra published An introductory guide to valuing ecosystem services (Defra, 2007a) outlining a range of methods suitable for valuing ecosystem services.

'Transferred values' must always be used with considerable caution, with values modified by circumstances. Most of the case studies listed previously depend upon transferred values, and also serve as a key resource for values to transfer to additional studies. Transferred values may also be drawn from various references and standard databases (for example, EVRITM; Woodward and Wui, 2001).

Some values may elude valuation, for example where value systems are simply not comparable (so-called 'incommensurabilities' such as balancing spiritual values with commodity prices). However, it is important to associate some value with services that are believed to be significant, as otherwise there is a high risk of them been assumed valueless in decision-making. You should be explicit that you are seeking only to ascribe a relative importance here (negative or positive and either large or small as compared to other valued services) to guide decision-making.

There is no single 'right' technique, the governing principles being that: (1) methods are used transparently with justification of the assumptions and values upon which they are based; and that (2) the simplest approach appropriate to context (the principle of parsimony) should guide your choice of methods such that you are not creating either an unnecessary workload and expense, nor a spurious sense of accuracy in valuation derivation from general assumptions.

4.6.4 Bespoke valuation

As highlighted above, for contentious, complex, major or contested schemes, bespoke valuation studies may need to be carried out. These bespoke studies are very costly and time-consuming, requiring specialist support, so are not addressed in any more detail in this guide. However, the principle of looking at the whole system, not prejudging which services as 'important' and which by implication are then overlooked, remains essential to support sound, equitable and best-value decision-making.

4.7 Further notes on valuation of ecosystem services

Since ecosystem services relate to the benefits that people derive from ecosystems, they are inherently (although often with some practical difficulty) amenable to economic valuation. Environmental economics provide a common and transferable basis for assessing the different categories of benefits and dis-benefits associated with changes in ecosystem services consequent from interventions in socio-environmental systems. This growing mechanism to support inclusive environmental decision-making signals many opportunities for further research, including filling knowledge gaps exposed by current ecosystem service evaluations many of which have been highlighted within this report.

> "An ecosystems approach to valuation provides a framework for looking at **whole ecosystems** in decision making, and for **valuing the ecosystem services they provide**, to ensure that we can maintain a healthy and resilient natural environment now and for future generations".."
>
> Defra (2007a) [authors emphasis]

As addressed previously, there is a long-standing and broad consensus that appraisal of absolute economic values have no clear meaning, sensitive as they are to a broad spectrum of factors including what is omitted or included from assessment, explicit and implicit assumptions, valuation methods and the scale of evaluation (e.g. Costanza *et al*., 1997; Defra, 2007a). However, the determination of marginal values (also known as relative values) that compare a 'baseline' condition (which may in practice be an expected future state without your project being undertaken) to an 'post-intervention' state provide insights into the tendency (positive/negative/neutral) and scale (large/small) of changes, and are most helpful in informing analysis and decisions.

Some authors (for example Turner *et al*., 2008) argue that only 'final services', comprising those actually consumed by people, should be valued. This is to avoid 'double counting', for example by identifying the value of an 'intermediate' service (such as the regulatory service of water purification) in addition to the resulting value for a 'final' service (for example the provisioning service of fresh water). However, the authors of case studies used to support this guide take the view that valuation should be sought for all services, explicitly explaining how double-counting has been averted, as otherwise there is a significant risk of perpetuating economic valuation only of tradable outcomes of ecosystem services, thereby continuing exclusion of non-traded services in decision-making.

A range of techniques for monetary valuation are presented in **Annex 2** of the HM Treasury (2013) *'Green Book'*, augmented by a supplementary guide to the *'Green Book'* published by Defra under the Natural Value Programme.

The principle here has to be one of 'fit for purpose'. Whilst a purist economics perspective may suggest that detailed and potentially bespoke studies are required, this is rarely possible under operational budgetary and time pressures. Consequently, generalisations and assumptions have to be applied to ensure that an approximate value is deduced. **The default, if services are not valued, is that they are effectively treated as zero in decision-making and so the value of the service is entirely lost** Operational realities necessarily force the principle of parsimony, and this is fine if the assumptions you have used and their associated uncertainties are specified. **Debate about the legitimacy of assumptions, and proposals for improvements of them, can form an important part of stakeholder dialogue leading to management decisions.**

4.8 Determination of lifetime values

The UK government's *'Green Book'* (HM Treasury, 2013) is used as a reference for methods to assess the total economic value of the benefits and costs entailed. Lifetime value is ascertained by summing annual values over an indentified life (often 100 years for flood defence assets and considerable shorter for many other assets), to which a 'discount rate' is applied. A discount rate is a year-on-year reduction in annual value throughout asset life, reflecting that value may decline relative to the current value of capital. (There is a broad literature on whether positive discount rates, reducing value over time, are in fact appropriate when assessing ecosystems and their functions, but that debate is well beyond the scope of this Guide.)

The *Green Book* does not specify a uniform design life. For some long-lived assets such as forests and flood defence structures, a longer lifetime with an associated lower discount rate might be appropriate, whereas shorter lifetimes and higher discount rates might be strictly appropriate for assets such as fences. However, this is where a judgement has to be taken to balance the exactness (and resource requirement) of economic methods with the 'principle of parsimony' necessary to enable these methods to be used in operational practice.

There is no single 'right answer', but the approach taken in a number of the case studies informing this guide (such as the Tamar, Alkborough Flats, the River Glaven and the buffer zone on the upper Bristol Avon) was to use a uniform discount rate of 3.5% spread over 25 years, explaining that this is a generalisation with associated uncertainties. By contrast, recognising some longer-lived assets at the urban Mayesbrook Park study (including river channel modification, wetland creation, tree planting, flood defences and wider landscaping of parkland) lifetime benefits were assessed over 40 years (with *'Green Book'* discount rates of 3.5% for the first 30 years declining to 3% for years 31-40), which is still highly conservative given the maturation rate of forestry and the longevity of river and park assets. The formula under which Net Present Value is calculated (whether made using spreadsheets or else with the support of economists) is:

$$dt=1/(1+r)^t$$

in which r is the discount rate, t is the year at which discounted and dt is change in value for the discounted year.

This simplified approach to calculation, using a uniform asset life, has been adopted for three principal reasons:

1. Avoiding a spurious sense of accuracy. A more technically precise approach might include identifying different design lives and discount rates for each element of the infrastructure but, since most valuation is based on stacked assumptions and inferences about value transfer, there is in reality a great deal of subjectivity associated with all derived annual values;

2. The principle of parsimony. Too elaborate a methodology, particularly where not reflecting the uncertainties in derivation of underpinning annual values, may defy both understanding and operational application (a key intent of the methods outlined in this guide); and

3. Conservative values. You should not overstate values, erring on the side of conservative valuation to reveal a 'worst case' outcome. This may avert disruptive challenge later in the process.

In practice, the annual values of marginal change that you derive for each service will be highly uncertain, particularly where you are using a range of assumptions to approximate the magnitude of the services. (For example, application of a travel cost method and a volunteer daily rate estimate respectively to determine the relative magnitude of amenity and community-building services in the River Glaven sea trout restoration study: Everard, 2010). Uncertainties introduced by cumulative assumptions about marginal change in the value of each service are likely to be substantial compared to those introduced by assumptions when calculating lifetime benefits.

Remember, this is all about approximating the positive/

negative tendency and magnitude of likely marginal impacts for all ecosystem services to ensure that they are factored into decision-making, not about deriving 'exact' values. So, as a general principle, it is better to be approximately right about the general positive/negative tendency and relative magnitude of impacts across all services than it is to advocate methods that may either give a spurious sense of accuracy, or else which may be too cumbersome or expensive to apply in operational decision-making.

Once you have selected your methods, these should be stated along with their associated uncertainties. Annual values for all services should then be converted to lifetime values and summed. It may be helpful to do so by service, by service category (provisioning, regulatory, cultural and supporting), and as a cumulative lifetime total. Where it proves impossible to value certain services, the likelihood of value (for example using the Defra 2007 weighting system) should be recorded with the monetised totals. Comparison with scheme costs then allows calculation of lifetime benefit-to-cost ratios.

An important consideration here is that deduced economic values contain many uncertainties and should not therefore be misunderstood as decision-making mechanisms. **Rather, they provide evidence for decision-support, decisions also needing to take account of other forms of information which should be included alongside valuation.**

5. Results of ecosystem service assessment of your scheme

The ways that study outcomes are reported may differ according to project intent.

Scheme-based projects (specific interventions) are more likely to follow the format of **Section 5.1** Presentation of options under place-based considerations (exploration of options for development or changed management of a site) may more usefully follow **Section 5.2** Project details and required outcomes may further influence how these are presented.

5.1 Presentation of results for scheme-based projects

Table 5.1 will comprise a summary of results abstracted from the detailed assessment of the likely ecosystem service impacts, positive and negative, resulting from your scheme. The detailed analysis, documenting working assumptions, will be recorded in **Annex 3**.

You should then discount these annual values to produce a lifetime benefit, as described in the preceding section. The methods selected should be stated, and lifetime benefits summed across services to yield a **gross lifetime benefit.**

Once you have derived an indicative gross lifetime benefit, this value can then be divided by scheme costs to produce a **lifetime benefit-to-cost ratio**. It is best to round this and other figures in presenting results (though to use unrounded values for calculation) to avoid any spurious sense of accuracy.

Remember also that it may not have been possible to quantify all marginal changes to services, but that an estimate of the significance or likely magnitude of service change should be recorded along with summary values.

5.2 Presentation of results for place-based projects

For place-based reporting, you are likely to want to explain in more detail pertinent information you have deduced and the ecosystem service implications of different options for place-based management or development. Examples of this kind of summary can be found in the reports of the East of England case studies (Glaves *et al*., 2009, *Valuing Ecosystems Services in East of England Volume 2 Case Studies*) and the Natural England (2012) *Delivering Nature's Services: the ecosystem services pilots*.

This should help determine:

- Key areas for service provision;
- Who benefits currently, and who will be the key 'winners' and 'losers' across service categories;
- Desired service enhancements;
- Measures necessary to achieve this, including their costs; and
- Assessment of lifetime benefit-to-cost ratio, perhaps broken down amongst key interventions required in the place.

Table 5.1 Summary results from ecosystem services assessment of your scheme

Ecosystem service	Annual benefit assessed Research gap/note
Gross annual provisioning service benefits	Summarise key provisioning services, highlighting the total annual value (if deduced) and noting the most significant contributing services (or unknowns), either as approximate figures or ranges
Gross annual regulatory service benefits	Summarise key regulatory services, highlighting the total annual value (if deduced) and noting the most significant contributing services (or unknowns), either as approximate figures or ranges
Gross annual cultural service benefits	Summarise key cultural services, highlighting the total annual value (if deduced) and noting the most significant contributing services (or unknowns), either as approximate figures or ranges
Gross annual supporting service benefits	Summarise key supporting services, highlighting the total annual value (if deduced) and noting the most significant contributing services (or unknowns), either as approximate figures or ranges
Total ecosystem services across the four categories	Record total annual value (and significant unknowns and omissions), either as approximate figures or ranges

6. Identifying options for achieving desired ecosystem service outcomes

If you are simply assessing likely marginal ecosystem service impacts from a completed scheme or a defined option or set of options, this section may be less relevant to you. However, if you are taking a 'place-based' approach and have identified with stakeholders a desired set of changes in ecosystem service outcomes, identifying options to achieve them will be an important next step.

There are many potential options for achieving this, including for example awareness, collaboration between agencies and other bodies, regulatory enforcement and potentially also markets between service 'providers' and service users (or 'buyers'). The UK National Ecosystem Assessment Follow-on programme (NEAFO: http://uknea.unep-wcmc.org/NEWFollowonPhase/tabid/123/Default.aspx) identifies a range of 'response options', an illustrative subset of which are: development and use of scientific knowledge; education and knowledge exchange; market-based schemes; technology; spatial planning; designated or protected areas; partnerships; common law; and voluntary standards.

All of these approaches are valid and may be useful, and you may have considered some of them already in looking ahead to how your objectives can be achieved. Discussing all of them in depth is clearly beyond the scope of this assessment guide, though all relate in one way or another to recognising the value of ecosystem services, which may include economic as well as other values. It is important that, whether monetised or simply assessed in non-monetary terms, these benefits are communicated to support the decision-making process and those whom it affects.

No response option is of universal efficacy; in practice it will be necessary to consider all means to broker change to achieve desired ecosystem service outcomes. This is likely to comprise combinations of response options, predicated not on what has been used to date within different organisations but by consideration of what combination is optimal for the desired outcome. A subset of response options are considered in the following three subsections – flexible implementation of regulations, 'systemic solutions' technologies and payments for ecosystem services (PES) – as examples of how novel and merging approaches may contribute to desired changes in ecosystem service outcomes.

6.1 Flexible implementation of regulations

Evolving understanding about the systemic interconnections between all environmental media and the ways in which people exploit their services should ideally form the basis for a new generation of policy instruments and response options. Some emerging legislation is, indeed, far more systemically framed including, for example, the EU Water Framework Directive the focal outcomes of which are achievement of good ecological status recognising its importance for system resilience and various dimensions of human wellbeing. But clearly we are starting from a far from clean sheet of paper, and have live with a wide range of legacy regulations, policies, incentives, etc.

Dealing with this calls for flexible implementation of legacy regulations informed by emerging knowledge about ecosystem services. This is achievable through recognising the primary purpose of regulations, rather than slavish adherence to detailed sub-clauses in isolation. For example, the purpose of the Silage, Slurry and Agricultural Fuel Oils (SSAFO) 1991 regulation is to avert pollution of surface waters and groundwater, though the detail of the regulation itself addresses storage capacity and the thickness of impermeable layers. Narrow interpretation of the regulation can lock farming solutions into the suboptimal techniques they were drafted to over, whereas refocusing on the purpose of the regulation may enable implementation of novel approaches that are more effective (or at worst no less effective) in addressing the primary purpose of the regulation with better outcomes for ecosystems and the societal benefits and net public value that they support.

6.2 'Systemic solution' technologies

Under former management paradigms, technical environmental solutions were generally developed to address narrowly-framed outcomes. For example, increasingly intensive electromechanical wastewater treatment methods served to address more stringent effluent discharge standards but, at least until the end of the first decade of the twenty-first century, took little account of climate change implications stemming from increasing energy demands, issues raised by supply chains, waste arisings and vehicle movements associated with by chemical inputs, etc. A more systemic world view takes greater account of wider ramifications and net public value.

This has driven a quest for 'systemic solutions', which Everard and McInnes (2013) have defined as "*...low-input technologies using natural processes to optimise benefits across the spectrum of ecosystem services and their beneficiaries*". Systemic solutions contribute to sustainable development by averting unintended negative impacts and optimising benefits to all ecosystem service beneficiaries and by using natural processes rather than depending on substantial inputs with associated downstream issues, increasing net public benefit and economic value.

Examples of systemic solutions include integrated constructed wetlands (ICWs), designed explicitly as low-input systems optimising benefits across ecosystem service outcomes including as co-benefits whilst agricultural pollution, domestic wastewater, river restoration and other related changes challenges. Further examples addressed by Everard and McInnes (2013) include washlands and other 'softer' forms of flood risk management,

managed realignment of coastal defences and catchment-based approaches to water resource protection which not only represent cost-effective means to tackle focal challenges, but with also generate multiple addition co-benefits (enhancement of fisheries, aesthetic, biodiversity and ecotourism benefits, carbon sequestration and nutrient transformations, etc.) In an urban context, Everard and Moggridge (2012) identify progressive approaches to 'green infrastructure', SuDS (sustainable drainage systems), urban woodland, river restoration and related techniques as addressing multiple benefits through greater dependence on ecosystem processes rather than technical solutions addressing narrowly framed outcomes.

A novel approach to technological solutions, founded on considering the potential for achieving multiple service outcomes, may help identify win-win approaches.

6.3 Payments for ecosystem services (PES)

Market-based instruments comprise a diversity of economic techniques that may include recognising the value of ecosystem services as a means progressively to embed them into the mainstream of policy and practice. One emerging method for appropriating the value of ecosystem services is that of 'payment for ecosystem services' (PES), which will be addressed in a little more detail here as an example of a promising market-based instrument that is gaining considerable traction including promotion by the UK Department for Environment, Food and Rural Affairs (Defra).

PES entails the creation of a market wherein beneficiaries of ecosystem services pay those undertaking management (often land management) measures entailed in their protection or enhancement. Practical examples include markets in the UK, South Africa and elsewhere wherein payments by water users (often mediated by water service companies representing the collective interests of large numbers of customers) are recirculated as grants or subsidies for environmentally-sensitive farming which reduces pollutant loads, improves hydrology and so contributes to more reliable flows of water requiring less expenditure on 'downstream' treatment.

PES schemes have also been developed in Costa Rica and other countries for carbon sequestration (the ecosystem service of climate regulation) and for protection of biodiversity. The OECD (2010) estimates that some 300 PES or PES-like schemes were already operating around the world, and the rate of implementation has accelerated sharply since then.

Where you can find a willing 'buyer' of ecosystem services (which may be a private buyer such as a large-scale water user or a public buyer such as a wildlife trust of local authority), PES may provide a mechanism to fund and secure the desired change in ecosystem services.

For further guidance on PES, you can refer to *Payments for ecosystem services: A short introduction* (Defra, 2010b), *Barriers and Opportunities to the Use of Payments for Ecosystem Services* (Defra, 2011b) and *Payments for Ecosystem Services: A Best Practice Guide* (Smith et al., 2013).

6.4 Other response options

These are, of course, a subset of available response options. Information on other response options can be found in the UK NEAFO reports, which can serve as a basis for innovation of optimally effective means to achieve desired ecosystem service outcomes.

7. Acting on an assessment and learning from findings

This section addresses how your conclusions may address decision-making, and also the importance of capturing learning derived when conducting your study. These can span many learning points as well as areas identified as warranting further research.

7.1 Key outcomes of assessment of your scheme

Record the key findings of your study here. If relevant, compare them to other studies including: (1) other ecosystem service case studies; (2) studies of this scheme not addressing the full suite of ecosystem services; and (3) the wider literature.

Consider the balance of benefits/costs across ecosystem service categories (provisioning, regulatory, cultural, supporting) and the learning that may stem from that. For example, what would we have overlooked if we hadn't focused on implications for the full spectrum of ecosystem services?

Consider the return on investment, including the distributional impacts of who benefits (or loses) and who pays. Consider how different options could result in an improved balance of benefits across the full range of ecosystem services, and hence potentially deliver greater public value.

How does this analysis inform the final decision, and what lessons emerge about influencing the decision-making process to take greater account of wider systemic implications?

7.2 Capturing key learning points

Taking a learning approach is implicit in systems thinking, feeding the learning back into increasingly informed and systemic decision-making leading to increasing sustainable, optimal and better-value outcomes. Important learning questions include

How did the ecosystem services assessment help you in achieving better outcomes relative to traditional policy, regulatory, cost-benefit or other approaches? What were the key learning points and how can you embed them into the decision-making process in future?

If you are assessing different options for scheme delivery, what were the key strengths of different options? How could these be combined across options to achieve better outcomes, or is another approach preferable?

- How can the value of services substantially or completely overlooked in the past be better reflected in the decision-making process? These values will generally be 'softer' in nature than the 'hard' financial values that may be ascribed to many provisioning services, yet they may be no less important in terms of their contribution to human wellbeing (for example the public health or recreational opportunity implications of urban park restoration in an inner city). What are the principal 'missing markets' for services, and where might there be opportunities (for example through such as a PES schemes as addressed in Chapter 6) for more integrated thinking about how social and economic benefits can flow from protection and improvements of shared environmental resources that may have been radically undervalued and hence overlooked in the past.
- Having made your assessment of ecosystem service impacts, what opportunities are there for improving schemes (and associated operational guidance) in future?
- What lessons and deduced values arise from this case study that are transferable to other studies?

Annex 1. Ecosystem services and methods for their assessment

Ecosystem services describe the multiple beneficial 'services' derived by people from ecosystems. These services are many and substantial, underpinning basic human health and survival needs as well as supporting economic activities, the fulfilment of potential and enjoyment of life.

The Ecosystem Approach was defined by the Convention on Biological Diversity (CBD: www.cbd.int) as "*...a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way*". Ecosystem services are a core part of the 12 'complementary and interlinked' Principles framing the Ecosystem Approach, which collectively set a broader socio-economic and geographical context for their implementation.

The Ecosystem Approach represents a fundamental shift in the way we think about and manage the natural environment, introducing an holistic and integrated approach that is more people- and place-focused. A significant shift is recognising the natural world and its services as value-add resources, not as constraints on other forms of human development as they have often been perceived in the past. The ecosystem services framework expresses a diversity of value systems and human interests, and also recognises that management to realise any one benefit (for example food production) has inevitable repercussions for other benefits and their associated beneficiaries (which can include future generations).

HM Government's interest in developing the Big Society concept, with an emphasis on localism and on engaging communities in environmental decisions, is an additional reason why the Ecosystem Approach is finding resonance, providing a strong case for positive management of our shared natural environment for the benefit of all both now and for the future. Through the Ecosystem Approach, we can demonstrate the multiple values of nature and the benefits it provides for people. By so doing, it supports efforts to draw upon new insights, sectors, customers and broader stakeholder groups to inform decision-making processes and ensuing actions, integrating multiple objectives and value systems. It can also potentially lever in new funds from beneficiaries of enhanced or protected ecosystem services, such as water companies who may benefit from funding restoration of peatland or other key water capture and storage areas in catchments to secure clean drinking water. By expressing the value of the natural environment, we are better-placed to ensure that it is considered appropriately at all scales of decision-making.

Our historic trajectory of industrial development has largely overlooked or disregarded many of these ecosystem services, skewing environmental management and resource use to the maximisation of commercially-valued outputs (food, fibre, water yield, etc.) whilst degrading other ecosystem services which are not factored into thinking or traditional cost-benefit analyses (such as the yield of fresh water from landscapes, biodiversity or pollination). Current trends in ecosystem degradation necessitate greater recognition and improved stewardship of essential ecosystems if we are not to perpetuate this trajectory of systematically undermining human wellbeing.

Modern conceptions about ecosystem services represent the convergence of diverse strands of resource protection science and practice that have emerged since the 1980s. Recognition of the multiple values of ecosystems to human wellbeing can focus our minds on better means for their sustainable use, and the optimisation of public benefits from the ways we use them. By recognising and potentially quantifying impacts on this broad range of societal benefits, ecosystems are brought centrally into planning and other decision-making processes. Conversely, if they are not valued, they are effectively deemed worthless in decision-making processes, explaining much of the unintended but systematic historic decline in ecosystems of all types and scales across the world.

The UN Millennium Ecosystem Assessment (2005) harmonised these diverse strands of science into a consistent ecosystem services classification scheme, providing the basis for assessing the status of different habitat types and across bioregions, and ascertaining their capacity to support human wellbeing. The Millennium Ecosystem Assessment grouped ecosystem services into four main categories: provisioning services; regulatory services; cultural services; and supporting services.

- **Provisioning services** are those things that can be extracted from ecosystems to support human needs, and are more or less synonymous with a prior definition of ecosystem 'goods' including such tangible assets as fresh water, food (crops, fish, etc.), fibre and fuel.
- **Regulatory services** include those processes that regulate the natural environment such as the natural regulation of air quality, climate, water flows, erosion and pests.
- **Cultural services** include diverse aspects of aesthetic, spiritual, recreational and other cultural values.
- **Supporting services** do not necessarily have direct economic worth but include processes essential for the maintenance of the integrity, resilience and functioning of ecosystems (such as soil formation, photosynthesis and water recycling), and so the delivery of all other services.

The complete Millennium Ecosystem Assessment classification of ecosystem services is listed in **Table A1.1.**

Table A1.1 The Millennium Ecosystem Assessment classification of ecosystem services

Provisioning
Fresh water
Food (e.g. crops, fruit, fish, etc.)
Fibre and fuel (e.g. timber, wool, etc.)
Genetic resources (used for crop/stock breeding and biotechnology)
Biochemicals, natural medicines, pharmaceuticals
Ornamental resources (e.g. shells, flowers, etc.)
Regulatory services
Air quality regulation
Climate regulation (local temperature/precipitation, greenhouse gas sequestration, etc.)
Water regulation (timing and scale of run-off, flooding, etc.)
Natural hazard regulation (i.e. storm protection)
Pest regulation
Disease regulation
Erosion regulation
Water purification and waste treatment
Pollination
Cultural services
Cultural heritage
Recreation and tourism
Aesthetic value
Spiritual and religious value
Inspiration of art, folklore, architecture, etc.
Social relations (e.g. fishing, grazing or cropping communities)
Supporting services
Soil formation
Primary production
Nutrient cycling
Water recycling
Photosynthesis (production of atmospheric oxygen)
Provision of habitat

Note: The UK's National Ecosystem Assessment (NEA, http://uknea.unep-wcmc.org) uses a slightly modified classification of ecosystem services which, for example, categorises 'pollination' as a supporting services. This is highlighted here simply as a point of information to avert any future confusion; the placement of this service will not make any practical difference to the deduced importance or (if undertaken) quantification of the service.

Although neither perfect nor complete, the Millennium Ecosystem Assessment typology provides a broadly inter-comparable set of services across bioregions and ecosystem types. It also exposes the complexity and multiplicity of interactions between social and natural systems, the knowledge gaps about how all ecosystem services are 'produced', and the need for methods to monitor them.

Where appropriate, locally-important 'addendum services' can be added, including for example a provisioning of 'energy harvesting' (the proposed Pancheshwar Dam study), the regulatory services of 'salinity regulation' and 'fire regulation' (in South Africa as reported by Everard, 2009b), and the cultural service of 'education resources' (the Mayesbrook Park study: Everard *et al.*, 2011).

Annex 2: Ecosystem services case studies

A wider range of case studies have been published addressing various purposes. These are listing in **Table A2.1**

Table A2.1: Key attributes of selected ecosystem services case studies

Case study (principal source publication)	Relevant attributes of the scheme
Tamar 2000 (Everard, 2009a)	The 'Tamar 2000' project sought to stabilise farm incomes by improving agricultural practices and farm diversification in the predominantly rural River Tamar catchment (south west England). It did so by recommending farm interventions to protect or enhance the river ecosystem, including some farm business diversification.
Managed realignment at Alkborough Flats (Everard, 2009a)	A degraded flood bank at Alkborough Flats (on the Humber estuary, north east England), erected following the Second World War to 'reclaim' arable land had become uneconomic to renew. Managed realignment was undertaken, permitting tidal inundantion of more than 400 hectares of floodplain to form saltmarsh, mudflat, reedbed and other intertidal habitat. This fulfilled intertidal habitat mitigation obligations under the EU Habitats Directive and reduced flood risk elsewhere in the estuary.
Sea trout restoration on the River Glaven (Everard, 2010)	Restoration of habitat and improvement of access for sea trout recolonisation on the River Glaven (eastern England) brought together a range of statutory and voluntary organisations with common aspirations to rehabilitate the river ecosystem.
Buffer zone installation on the upper Bristol avon (Everard and Jevons, 2010)	Fishery interests instigated installation of fencing to exclude cattle from a field edge on the upper Bristol Avon (North Wiltshire, England). Regeneration of vegetation over the subsequent growing season was significant, improving aesthetics and also narrowing the river channel which reinstated low diversity and sinuosity, bed scour, sediment and other pollutant attenuation, and supported fish recruitment whilst providing habitat for other wildlife.
Mayes Brook restoration in Mayesbrook Park (Everard *et al.*, 2011)	The planned restoration of the Mayes Brook in Mayesbrook Park (East London) offers an opportunity to create an ecological and community focal point within a broader environmental regeneration project. Rehabilitation of a river reach within a currently barren park landscape also provides a chance to demonstrate synergistic approaches to flood storage and biodiversity enhancement.
Options for coastal defence development at Wareham (EFTEC, 2007; summary in Defra, 2007a)	Appraisal of options for tackling a degraded historic coastal flood defence bank at Wareham (Poole Harbour, southern England) explored likely outcomes and economic values associated with changes. Non-monetised weighting by stakeholders helped rule out certain options, directing attention towards the most important data gaps and uncertainties, and enabling identification of a preferred managed realignment option.
Defra, (2007a)	uncertainties, and enabling identification of a preferred managed realignment option.
Linked set of five ecosystem services assessments in the east of England (Glaves *et al.*, 2009)	A linked set of ecosystem service studies addressed the implications of development in five discrete locations in the East of England. It took a consistent approach of defining the opportunity, summarising habitat types on the site, auditing ecosystem services, applying the Defra (2007a) weighting scheme, monetisation of some of the most significant ecosystem services, and consideration of issues affecting them. This information was used to assess likely differences between 'do nothing' and 'preferred development' scenarios.
The proposed Pancheshwar Dam (Everard and Kataria, 2010)	The proposed Pancheshwar Dam is planned to be the world's second-tallest dam on the Kali River, defining the India/Nepal border in the Himalayas. Benefits including water and power supply were included in official documentation, but there was no formal acknowledgement of wider local and catchment-scale impacts. This assessment used an evolving draft of this guide, highlighting how important conclusions can result from semi-quantitative assessments, and particularly as they highlight distributional equity issues relating to appropriation of favoured services by the powerful.
Delivering Nature's Services: the ecosystem services pilots (Natural England, 2012)	A suite of three upland pilots that considered current and future management with partners, in terms of the ecosystem services provided. The projects are ongoing, with delivery plans being agreed and management action to bring about services changes being undertaken. It included economic valuation and participatory approaches to reaching consensus on future management.
Vieira da Silva (2012)	This MSc thesis implemented this guidance to assess likely outcomes of managed realignment at the Steart peninsula, on the mouth of the River Parrett in north Somerset. Multiple benefits were deduced, advancing benefit transfer methods. A more generally accessible publication (Vieira da Silva, Everard and Shore, in preparation) will shortly be published.

End of Annex 2

Annex 3: Detailed results of ecosystem services assessment of your scheme

Tables **A3.1** to **A3.4** below document the ecosystem services assessments of the annual benefits arising from your scheme respectively for provisioning, regulatory, cultural and supporting services, using methods explained in the body of this document.

Quantification and monetisation methods in the set of tables below are illustrative only, drawing upon the case studies introduced earlier in this guide. They cover different methods: transferred values, those derived from visitor numbers or from investment in conservation management averted, etc. These do not imply that each is the 'right' approach for that service, but serve to demonstrate that there are multiple approaches which can be applied and different approaches may to appropriate in different contexts. Bear in mind that there is a wealth of values to be transferred to published studies, peer-reviewed literature, 'grey literature' reports, surveys of population and impacts on health, tourism, etc. There may even be some studies related to your individual scheme.

The Defra (2007) *An introductory guide to valuing ecosystem services*, and other nationally-approved guidance such as practical guides produced by eftec (2010b and 2010c). Remember to ask economists in your team for support.

Table A3.1: Key attributes of selected ecosystem services case studies

Provisioning services and the methods and assumptions used for their evaluation [includes examples from other case studies]	
Fresh water	The Tamar study used projected cost savings on treatment of abstracted water resulting from river quality protection **Annual value = £xxx (rounded up, or range)**
Food (e.g. crops, fruit, fish, etc.)	The Alkborough Flats case study took account of the net marginal change associated with lost arable production replaced by rare breeds grazing outputs **Annual value = £xxx (rounded up, or range)**
Fibre and fuel (e.g. timber, wool, etc.)	Annual values for loss of straw production at Alkborough Flats was offset by projected returns on sale of rare breeds fleeces **Annual value = £xxx (rounded up, or range)**
Genetic resources (used for crop/stock breeding and biotechnology)	This service was considered not relevant in the Mayesbrook Park study **Annual value = £xxx (rounded up, or range)**
Biochemicals, natural medicines, pharmaceuticals	Loss of natural biochemicals through Inundation of mountainous habitat and its rare and diverse wildlife and genetic resources, replaced by a uniform reservoir, was considered in the Pancheshwar Dam study **Annual value = £xxx (rounded up, or range)**
Ornamental resources (e.g. shells, flowers, etc.)	Whereas this service is of local importance in many overseas contexts, none of the case studies identified it as significant beyond small informal use **Annual value = £xxx (rounded up, or range)**
Gross annual provisioning service benefits	**Summarise key provisioning services, highlighting the most total annual value (if deduced) and noting the most significant contributing services (or unknowns)**

Table A3.2: Assessment of marginal impact on regulatory services from your scheme

Regulatory services and the methods and assumptions used for their evaluation [includes examples from other case studies]	
Air quality regulation	The Mayesbrook Park case study used estimates of the impact of tree plantings and growth on problematic air quality determinands, allied with estimates of the costs of the health impact of man-made particulate air pollution experienced in the UK (derived from the Defra, 2007b, Air Quality Strategy for England, Scotland, Wales and Northern Ireland report) with conservative values based on the low Defra estimate and also from summary statistics for adjacent wards from the UK Census 2001 (http://neighbourhood.statistics.gov.uk/dissemination/). A high degree of uncertainty was noted, and for this reason the service was not quantified but it was noted that there was a 'likely significantly positive' contribution to air quality that should be fed (unquantified) into study interpretation. **Annual value = £xxx (if feasible) including 'likelihood of impact' if more relevant**
Climate regulation (local temperature/ precipitation, greenhouse gas sequestration, etc.)	The Mayesbrook Park study used a sum of a number of parameters affected by river improvements including: (1) projected tree growth multiplied by likely carbon sequestration derived from a review by SWIMMER (2007), sequestration in reedbeds and wetland habitat using peer-reviewed literature sources such as Kayranli et al. (2010), sequestration in floodplain soils using peer-reviewed literature sources such as Zehetner et al. (2009). This was augmented by estimates of the contribution of urban 'green spaces' to microclimate. It was recognised that it would be possible to assess the number of people living within a half-kilometre of the park's boundaries (based on UK Census 2001 summary statistics for wards adjacent to Mayesbrook Park derived from http://neighbourhood.statistics.gov.uk/dissemination/), and multiplied by studies on health/mortality impacts from heat waves (Haines et al., 2006; Kovats, 2008; World Health Organisation 2004). However, as for air quality at Mayesbrook Park, this benefit was assessed as a 'likely significantly positive' contribution that should be fed (unquantified) into study interpretation. Thus, at Mayesbrook Park, the overall assessment of climate change contained both monetised (carbon sequestration) and weighted but non-quantified (microclimate) elements. **Annual value = £xxx (rounded up, or range) including 'likelihood of impact' where relevant**
Water regulation (timing and scale of run-off, flooding, etc.	Since microclimate benefits from tree growth were already captured under 'air quality regulation', this benefit was not assessed separately in the Mayesbrook Park study so as to avoid double-counting. In other circumstances, such as sand dune systems or mangroves protecting land and property, this will have be a high-priority service to quantify separately. **Annual value = £xxx (rounded up, or range)**
Natural hazard regulation (i.e. storm protection)	Since microclimate benefits from tree growth were already captured under 'air quality regulation', this benefit was not assessed separately in the Mayesbrook Park study so as to avoid double-counting. In other circumstances, such as sand dune systems or mangroves protecting land and property, this will have be a high-priority service to quantify separately. **Annual value = £xxx (rounded up, or range)**
Pest regulation	This service may be valued, for example, by impacts on habitat for natural pest predators and the costs of replacement (spraying with chemicals, etc.) **Annual value = £xxx (rounded up, or range)**
Disease regulation	This service may be valued, for example, by impacts on habitat for both the vectors of disease but also of processes reducing disease transmission (such as reedbed attenuation of microbial pathogens). **Annual value = £xxx (rounded up, or range)**
Erosion regulation	Regulation of erosion in the Tamar study was quantified by extrapolating likely improvements to bank/wetland protection to the costs of dredging in the Tamar estuary. **Annual value = £xxx (rounded up, or range)**
Water purification and waste treatment	Where the provisioning service of 'fresh water' is separately quantified (Tamar, Bristol Avon, etc.) you will probably need to avoid quantifying this service to avoid double-counting; it is the service within the ecosystem that produces the god of fresh water. However, if there is some important waste assimilation service that is separate from extractive uses of water, you may want to assess the benefit by looking at the costs of treatment were the environment not to perform it. **Annual value = £xxx (rounded up, or range)**
Pollinationa	The service was not quantified on the Tamar as pollinating organisms were not perceived as limiting. However, the study did propose the quantification method of determining the cost of hiring in bee hives to compensate for lost pollination which is a major global problem for arable farming). **Annual value = £xxx (rounded up, or range)**
Gross annual regulatory service benefits	**Summarise key regulatory services, highlighting the most total annual value (if deduced) and noting the most significant contributing services (or unknowns)**

Table A3.3: Assessment of marginal impact on cultural services from your scheme

Cultural services and the methods and assumptions used for their evaluation [includes examples from other case studies]	
Cultural heritage	The significant cultural importance of the Pancheshwar site would be lost if the proposed dam were to be built, so this was therefore assessed as of high significance. **Annual value = £xxx (rounded up, or range)**
Recreation and tourism	The Mayesbrook Park study highlights that restoration would improve 'green space' facilities mainly for local people, increasing amenity and recreational opportunities, which were quantified by extrapolation from a park use survey (Shears, 2009) and based on observations on increased park usage at Ladywell Fields park following restoration of parkland and the River Ravensbourne (River Restoration Centre, 2008). This was multiplied by values transferred in for another urban waterside study (O'Gorman et al., 2009) relating to the value of waterways access. The Tamar study used more direct figures derived from projected increases in tourist facilities and opportunities, significantly including recreational angling. **Annual value = £xxx (rounded up, or range)**
Aesthetic value	Aesthetic improvements often support more directly quantifiable services such as 'recreation and tourism' so were not quantified separately in the case studies. **Annual value = £xxx (rounded up, or range)**
Spiritual and religious value	The proposed Pancheshwar Dam would inundate a number of temples and sangams (meetings of rivers) and inhibit access to moving waters for Kriya Karam (cremation) ceremonies, meaning that this impact would be highly significant. Though the Pancheshwar study was not monetised, and some of the values may indeed be 'incommensurabilities', it would be possible to address some aspects of lost value by calculating the additional travel and time costs of finding alternative temples and sites for Kriya Karam (cremation) ceremonies, and also building in values associated with the cohesion of local communities where these have a spiritual basis. **Annual value = £xxx (rounded up, or range)**
Inspiration of art, folklore, architecture, etc.	This service may be assessed as locally significant (such as in the Mayesbrook Park study), but generally evades reliable quantification. **Annual value = £xxx (rounded up, or range)**
Social relations (e.g. fishing, grazing or cropping communities)	The River Glaven sea trout restoration project served as a focal point for a number of statutory, local conservation, key estate and landowner, and other groups, enhancing local social capital around river integrity. In the absence of resources to conduct a full social audit, estimates of time expenditure were used as a surrogate for valuation. This included using volunteers estimates published in the River Restoration Centre (2006) 'Cinderella Chalk Streams' report and transferring in values from a review by O'Gorman et al. (2009). The quantified value was substantial, and the role of the project as a focus for community-building was identified as a very significant outcome from the project. **Annual value = £xxx (rounded up, or range)**
ADDENDUM: Education resources	This service was added as an addendum in the Mayesbrook Park study, recognising the value of restored river and park habitats to sporting and amenity opportunities with a diversity of educational benefit, amplified by close proximity to both a large secondary and a primary school. Value was derived on averted cost of school coach trips to access similar resources. **Annual value = £xxx (rounded up, or range)**
Gross annual cultural service benefits	**Summarise key cultural services, highlighting the most total annual value (if deduced) and noting the most significant contributing services (or unknowns)**

Table A3.4: Assessment of marginal impact on supporting services from your scheme

Supporting services and the methods and assumptions used for their evaluation **Note:** The Millennium Ecosystem Assessment classifies this category of ecosystem services as those entailed in the internal functioning and resilience of the ecosystems. As such, they are disastrous if lost yet often hard to quantify in operation. Many of our cultural practices have in fact depended on 'consumption' of these services, for example the way that industrial-scale farming 'mines' soil structure and fertility. [includes examples from other case studies]	
Soil formation	Although soil accretion will generally be enhanced by improved and diversified habitat, it was generally not valued so as to avoid potential double-counting with both the services of 'climate regulation' (carbon sequestration) and 'erosion regulation'. **Annual value = £xxx (rounded up, or range)**
Primary production	Primary production will also be enhanced by improved and diversified habitat. However, to avoid any potential double-counting with services such as provisioning uses of hay production, tree trimmings ('fibre and fuel'), this service is generally not quantified. **Annual value = £xxx (rounded up, or range)**
Nutrient cycling	A review by McInnes et al. (2008) of nitrogen and phosphorus cycling provides a basis for valuation of this service on the Tamar, Alkborough Flats, Mayesbrook Park and the upper Bristol Avon. **Annual value = £xxx (rounded up, or range)**
Water recycling	Habitat restoration/creation can be expected to enhance water recycling through processes such as floodplain storage, groundwater exchange and recycling of evaporation in more complex vegetation structure including trees. However, to avert double-counting with benefits valued under the 'water regulation' and also 'climate regulation' (microclimate) services, these are not quantified or monetised in these case studies. **Annual value = £xxx (rounded up, or range)**
Photosynthesis (production of atmospheric oxygen)	Loss of natural biochemicals through Inundation of mountainous habitat and its rare and diverse wildlife and genetic resources, replaced by a uniform reservoir, was considered in the Pancheshwar Dam study **Annual value = £xxx (rounded up, or range)**
Ornamental resources (e.g. shells, flowers, etc.)	Whereas this service is of local importance in many overseas contexts, none of the case studies identified it as significant beyond small informal use **Annual value = £xxx (rounded up, or range)**
Gross annual supporting service benefits	**Summarise key supporting services, highlighting the most total annual value (if deduced) and noting the most significant contributing services (or unknowns)**

End of Annex 3

Annex 4: Template ecosystem services assessment report

This Annex contains a sequence of headers, including some suggested/optional text, that can be used as a template for your own bespoke ecosystem services assessment.

General guidance is provided in this colour text. Black text, including that copied from other Annexes or the body of this report, may be adapted to meet the needs of your report.

Part 1. Introduction to your ecosystem services assessment
In this section, introduce the purpose of the assessment, outlining the project or place. If appropriate, you may wish to include an overview of ecosystem services. This can be adapted from the text in **Section 1** and **Annex 1**, modified for your audience.

Part 2. Details of your study
Outline in greater detail where, or what, is the focus of your assessment. This includes defining the study area, key ecosystem services and where they are produced/used, and which stakeholders should be involved. You may decide to adapt some text from **Section 2**.

Part 3. What outcomes are you trying to achieve and how
This section may not be required if you are only assessing the marginal impacts arising from a completed scheme, or you are assessing the likely outcomes of a pre-determined option (or set of options). However, where you are generating options for managing a particular place or scheme, you should articulate your desired ecosystem service improvements, the measures that may achieve this, and how they might be put in place.

Part 4. Assessment of changes in ecosystem services
This section of your report describes your methods used to assess marginal changes in ecosystem services, including whether and (if so) how quantified and/or monetised. It will cross-refer to the Annex containing details of your assessment.

Part 5. Results
This section reports the summary results of your assessment, cross-referencing the Annex containing details of your assessment.

Part 6. Options for delivering changes in ecosystem services
This section may be omitted if you are assessing an already-completed scheme, or for which an option (or set of options) has already been determined. However, where multiple options are being considered, or where mitigation or modifications may be applied to pre-determined options, this section considers how your identified options can be brought about including, if appropriate, the use of market instruments such as PES.

This relates to the implementation of any or a combination of 'response options' as outlined in **Section 6**. For example, if you are considering PES, you need to provide an overview of PES and how they apply to your proposals. In place-based schemes, it is likely to be important in determining how beneficiaries of enhanced ecosystem services may be connected through payment mechanisms with those undertaking different alternative management. In other instances, PES markets may not be important so you may omit this section from your project report. An introduction to the concept of PES may help you draw conclusions at the end of your study, for example where a particular benefit may be identified for which you believe a market could be established or for which you believe key beneficiaries should contribute.

You may like to adapt the following text to suit your audience: 'Paying for ecosystem services' (PES) schemes are being developed by creation of markets to connect 'sellers' of ecosystem services produced by improved management or restoration with 'buyers' benefiting from those services (as reviewed by Daily and Ellison, 2002, Jenkins et al., 2004, and Everard, 2009b). Wunder (2005 defined PES markets as PES is a form of market for ecosystem services in which "...a voluntary, conditional agreement between at least one 'seller' and one 'buyer' over a well defined environmental service—or a land use presumed to produce that service". Water supply in considered an important medium for such markets. For example safeguarding the quality of the Vittel springwater source in France (Perrot-Maître, 2006) and of the New York City public water supply (reviewed by Everard, 2009b) both of which are enacted through partnership with rural land users.

Part 7. Conclusion and recommendations
In this section, outline and substantiate your decisions, including how you reached them and who was involved. You may wish to record key learning points, including knowledge and methods gaps.

Annexes
You will need at least one Annex in which to record your methods and relevant assumptions, transferred values and calculations entailed in making your ecosystem services assessment. This may resemble the (illustrative) contents of **Annex 3**, or the Annexes of published ecosystem services reports outlined in **Annex 2**.

You may decided to add additional Annexes as appropriate, for example to record lists of stakeholders, outlines of key workshops and their conclusions, etc.

References
You should record the references that you use to support the processes, arguments, assumptions and values used in your study. Some of these may include those in the 'References' section of this guide, but you are likely to draw on wider literature.

End of Annex 4

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