England’s Terrestrial Ecosystem Services and the Rationale for an Ecosystem Approach

Full Technical Report to Defra
(Project Code NR0107)

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Notes:
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\(^1\) See project homepage for more details: [www.ecosystemservices.org.uk](http://www.ecosystemservices.org.uk)

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Executive Summary

Background

1. The publication of the Millennium Ecosystem Assessment (MA)\(^3\) has stimulated widespread, international debate about the importance of the links between ecosystems and human well-being. The MA found that at global scales, 60% of the ecosystem services on which people depend were being damaged through human action or mismanagement. As a result there is now considerable interest in finding out what is happening at regional and national scales.

2. This study considered whether it is possible to make an assessment of the state and trends in England’s major terrestrial and freshwater ecosystem services on the basis of the evidence that is currently available. The task is a particularly challenging one because the methods used to make such an assessment are still developing. We also have to be sure how such assessments can be designed to provide information that is useful to decision makers.

3. The need to refine assessment methods and ensure that they can be used effectively in decision making required us to consider the merits of the Ecosystem Approach (EsA) that has been promoted through the Convention for Biological Diversity (CBD). It is an internationally accepted framework designed to help decision makers take full account of ecological systems and their associated biodiversity. It has also been proposed as a useful framework for thinking about ecosystem services. Since Defra currently consider the as potentially helping deliver their current vision for the natural environment, as part of this study, we have gone on to examine critically the rationale for using it in the English context.

Objectives of this study

4. The objectives set for this study were to:
   - establish and agree what an Ecosystem Approach involves and how it can be used to make an assessment of the outputs of ecosystem services at national, regional and local scales; and,
   - understand how the principles of the Ecosystem Approach and the assessment of ecosystem services can be used in decision making at national, regional and local scales.

5. In order to achieve these objectives we have:
   - considered different methodologies for the classification of England’s terrestrial ecosystems, and how they can be developed to measure the capacity of ecosystems to deliver the services described in the Millennium Ecosystem Assessment;
   - reviewed the existing data and evidence on the state and trends of the terrestrial natural environment in England; and,
   - used these methodologies to provide an initial analysis of the state of England’s ecosystems.

The Ecosystem Approach

6. We have suggested that the EsA is an appropriate framework to use for assessing ecosystem services. The EsA is a valuable system for considering what constitutes an ecosystem service and how such service may be valued, and it promotes the inclusive, cross-sectoral decision making needed for effective management of natural resources. It also stimulates debate about what are the right spatial and temporal scales for securing the supply of ecosystem services both currently and in the future.

7. Our review showed that while the principles underpinning the EsA are consistent with and support the current UK Strategy for Sustainable Development, Defra’s current vision did not show clearly enough how it could be used operationally. We have

\(^3\) MA (2003) and Report Series (MA, 2005), see also homepage: [http://www.millenniumassessment.org/](http://www.millenniumassessment.org/)
suggested that one way to promote an EsA is by encouraging people to think about the state and trends of ecosystem services and to use this information for developing effective policy and management responses.

**Assessment methodologies**

8. The study considered three distinct, but complementary perspectives on the problem of making an assessment of England’s terrestrial and freshwater ecosystem services. The work examined their strengths and weaknesses, and the extent to which they could be used given the data currently available.

9. The first perspective used the framework of the Biodiversity Action Plan Broad and Priority Habitats as the basis of the assessment, and looked at the different services that were associated with them. A matrix of associations was constructed using expert judgement and materials derived from an extensive literature review. The ‘habitats perspective’ was useful in identifying the distinctive roles that habitats made to service provision and their multifunctional characteristics. However, by evaluating the services on a habitat by habitat basis it was difficult to build up a clear picture about what was happening to the supply of services overall.

10. The second methodology considered, looked at the problem of assessment from a ‘service perspective’. The services identified by the MA, and habitats, as such, were only considered if they were appropriate for understanding the ecological processes that gave rise to them. This perspective was found to be effective in making an assessment of some services at the national scale, i.e. for England, given the evidence currently available. However, in terms of its contribution to a decision making context, the approach tended to obscure the linkages between services. The multi-functional characteristics of ecosystems could not so easily be identified by adopting this perspective.

11. The final methodology for assessing ecosystem services explored a ‘place-based perspective’. Since decision making is often explicitly concerned with specific geographical areas, methods that encourage people to think about the relationships between all the services in an area, and how they are changing are valuable. These methods could be used to support the kind of cross-sectoral partnerships and integrated management approaches needed to achieve the goals of sustainable development. It was suggested that a place-based focus is therefore an ideal way of helping people to apply the principles that underpin the Ecosystem Approach.

**The state and trends of England’s terrestrial ecosystem services**

12. The analysis of services by habitat suggested that there was relatively good information available for many of the Broad and Priority Habitats. This allowed us to make an assessment of changes in stock and ecological condition to be made (Figure 1). Out of the 19 Broad Habitats (not including urban) considered:

- There was evidence that nine may be experiencing changes that could impact on service provision, particularly in the area of genetic resources; the evidence was strongest for Acid Grassland, Bog, and Calcareous Grassland.
- One, Broadleaved, Mixed and Yew, showed evidence of change that was possibly enhancing services, particularly the cultural ones linked to recreation and landscape.

13. The major limitation of the analysis was that on the basis of current scientific knowledge, the link between ecological condition and the service output characteristics of different habitats is unclear. **Further work is needed to develop new condition measures for our Biodiversity Action Plan (BAP) habitats that help people understand their importance for ecosystem services and subsequently, for quality of life and human well-being.**
Figure 1: Overview of changes in stock and condition of Broad Habitats in England

- This table assigns Broad Habitats by changes in stock and condition over the period 1990-1998 using the results of CS2000, although the placement also took account of other information from SSSI monitoring and the 2005 BAP Targets Review where appropriate.
- The inclusion of evidence other than CS2000 led to the placement of Broad Habitats being subject to some qualification; these are indicated by arrows. The arrows should be read as indicating that the assessment is “...likely to be here or in the neighbouring cell”, the position of which is indicated.

14. The analysis of services considered a selection of the themes covered by the MA (Table 1). Out of the eight services examined:
   - There was evidence of declining or impaired service output for five of them. The areas of concern were related to the regulation of water quantity and quality, pollination, and the provisioning of genetic resources, and possibly climate regulation.
   - The recreational service is probably enhancing, and there may be potential for deriving additional benefits from ecosystems in the area of assimilation and purification.

15. The major limitation of the analysis was that on the basis of current knowledge, it was not possible to make an assessment of the aesthetic service because there is little agreement as to how the landscape resource should be conceptualised. **Further work is needed to develop better methods for analysis and assessment in the area of cultural services.**

16. It was also noted that the output of some services, particularly those linked to the highly artificial, ‘social ecosystems’ associated with agriculture gave rise to benefits and liabilities. **Further work is needed to bring the assessment of ecosystem services within an environmental accounting framework.**

17. The place-based approach was not used to assess the state and trends of ecosystem services given the brief for this study which a focused on issues at national scales. Nevertheless, our review suggested that a spatially explicit approach to the assessment of ecosystem services would be beneficial. It would, for example, support the kinds of decision making that are now required as a result of implementation of the Water Framework Directive, and new approaches to regional
Table 1: Preliminary assessment for selected services* associated with England’s terrestrial ecosystems.

<table>
<thead>
<tr>
<th>Service group</th>
<th>Service theme</th>
<th>Assessment</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural</td>
<td>Recreation</td>
<td>▲</td>
<td>Recreational provision has improved as a result of forest policy and extension of access rights.</td>
</tr>
<tr>
<td></td>
<td>Aesthetic</td>
<td>?</td>
<td>Unknown, the conceptual frameworks used to assess the aesthetic contribution of landscape service is presently limited.</td>
</tr>
<tr>
<td>Provisioning</td>
<td>Food and fibre</td>
<td>▣</td>
<td>While the integrity of provisioning services seems stable, the impact of activities associated with the exploitation of this service has major impacts on other ecosystems.</td>
</tr>
<tr>
<td></td>
<td>Genetic</td>
<td>▼</td>
<td>Probably declining.</td>
</tr>
<tr>
<td>Regulating</td>
<td>Water quantity</td>
<td>▼</td>
<td>Probably declining but more slowly than in the past. Land cover change is an important driver.</td>
</tr>
<tr>
<td></td>
<td>(flow regulation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water quality</td>
<td>▼</td>
<td>Probably declining but more slowly than in the past; diffuse pollution is a major driver.</td>
</tr>
<tr>
<td></td>
<td>Pollination</td>
<td>▼</td>
<td>Probably declining possibly as the result of loss of food plants</td>
</tr>
<tr>
<td></td>
<td>Climate</td>
<td>? ▼</td>
<td>Although opportunities for increased carbon sequestration, the past loss or damage to blanket peat deposits and losses in soil organic carbon suggests that the service has been impaired.</td>
</tr>
<tr>
<td></td>
<td>Assimilation and purification</td>
<td>P ▲</td>
<td>There is the potential to increase the use of this service especially for the assimilation of organic materials.</td>
</tr>
</tbody>
</table>

* Supporting services were not included to avoid the problem of ‘double counting’; the assessment made here takes account of changes in any underlying ecological structures, processes or functions. Given the time and resources available for this study, only a subset of the services from the MA were considered. Selection was made on the basis of ease of access to information.

Key to symbols: ▲ service probably showing a positive trend; ▼ service probably showing a declining trend; ▣ service provision probably stable;? some uncertainty associated with the assessment; P there is potential to expand this service.

and sub-regional spatial planning. A place-based perspective on ecosystem services may be an effective way of making the Ecosystem Approach operational. The range of spatial mapping data currently available is probably sufficient for an initial assessment at regional scales. However, for the future, better systems for linking information on habitat, land cover, management and monitoring are probably needed.

**Recommendations**

18. Our review of the case for Defra promoting an Ecosystems Approach suggests that in the context of securing the supply of ecosystem services, it is a valuable approach to decision making. Its holistic character means that it can help address the many of the cross-cutting issues affecting ecosystem services that, historically, have often been ignored or left unresolved. **We suggest that to take the EsA forward, Defra should review the consistency of its activities (and potentially those of other Government Departments) with the principles of the EsA.** Such a review would help make the case that, at the operational level, current approaches to decision making were limited, and that these deficiencies could be overcome by application of the concepts and methods embodied in the Ecosystem Approach.

19. The assessments of ecosystem services made here are necessarily provisional, and the robustness of the analysis should be tested by more broadly-based consultation. We therefore suggest:

- That a more detailed assessment is considered at the level of the Government Office Regions linked closely to the process of regional and sub-regional spatial planning. Such work could form a component for a national assessment of ecosystem services in England, following the model of the global Millennium Ecosystem Assessment.
- That the work is supported by the development of a common set of guidelines and data resources to ensure a flexible but unified approach across the different assessment units. This calls for cross-sectoral partnership working.
- That the promotion of such an initiative should form part of Defra’s future strategy for ensuring that the principles underpinning the Ecosystem Approach are understood and used more widely in decision making across government policy sectors at every level.
- That such an initiative should also be seen as part of a potential UK and European assessment of ecosystem services.
Part 1: Introduction - Ecosystems, Policy and Ecosystem Services

1.1 Contexts

The idea that human well-being is dependent on the integrity of environmental systems is not a new one. Perhaps only in developed societies, where most people are no longer working directly with the resources provided by the land, sea and air, do we need to be reminded of the importance of the benefits that nature provides.

This report considers two important ideas currently being discussed in the research and policy literatures that may help people manage and use ecological resources sustainably. The first is the ‘Ecosystem Approach’, which is an evolving framework of ideas, designed to help decision makers take full account of ecological systems and their associated biodiversity. The second is the concept of ‘ecosystem services’, an idea that is currently being widely promoted to emphasise the benefits that ecological systems provide for people, and the importance that systems based on biological diversity have in maintaining human existence and the quality of people’s lives. The purpose of this work is to understand better the relevance of the Ecosystem Approach to policy making in England, and to examine how we might use it to manage and understand better the benefits that our major terrestrial ecosystems generate.

The publication of the Millennium Ecosystem Assessment (MA, 2005) stimulated much of the current, widespread, international scientific debate about the importance of ecosystem services to human well-being. It was undertaken as the result of the call in 2000, by the UN Secretary-General Kofi Annan, to “assess the consequences of ecosystem change for human well-being and the scientific basis for action needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being” (MA, 2005). The work began in 2001, and involved over 1,360 international experts. It resulted in a series of publications in 2005, that described “state-of-the-art” scientific appraisals of the condition and trends in the world’s ecosystems and the services they provide (such as clean water, food, forest products, flood control, and natural resources) and the options available to restore, conserve or enhance the sustainable use of ecosystems.

The results of the MA have now been taken up by the wider policy community across the globe, who have been particularly concerned about the implications of these ideas for the way decisions affecting natural resource systems are made. In his oral evidence to the UK House of Commons Environmental Audit Committee in 2007, for example, the then Minister, Barry Gardiner MP, said that he believes the Government's obligation now is “to try and see how we can use [the MA] to inform policy making and to inform decision making…within DEFRA”. He went on to add that current work was “…developing tools that will help other Government departments make better policy decisions on the back of … [the] ecosystem services approach…”.

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4 It should be noted that the literature contains a number of variations in terminology designed to emphasise different aspects of the idea. For example, one may find reference to an ‘ecosystem-based approach’, a term used mainly to promote holistic thinking in the design of specific management strategies for natural resource systems. Defra, in recent publications (e.g. Defra, 2006, 2007a), refer to an ‘Ecosystem Approach’, using the plural to emphasise that no prescriptive methodology is implied. In this report we employ the more widely used ‘Ecosystem Approach’, as described in the CBD, which emphasises the higher-level or more strategic issues surrounding decision making. However, we accept that the concept may need to be adapted in the context of specific applications – but there seems little merit in multiplying the terminology in perhaps, what is an already confusing field.

5 Note that for convenience the term ‘ecosystem services’ is used to denote the longer ‘ecosystem goods and services’. Ecosystem services are conceptually considered to include the output of goods.

6 In this report when referring to terrestrial ecosystems we include freshwater or aquatic systems – marine systems (including coastal, offshore) are outside the scope of this project.
The importance of the Ecosystem Approach (EsA)\(^7\), and ideas about ecosystem services, have already been acknowledged by Defra, who have used them as a starting point for their current work to draft a ‘new vision’ for natural resource management in England\(^8\). The outputs from the present study will therefore help refine this vision, by starting to identify some of the evidence needed to carry thinking forward into enhanced policy-making and delivery. It is intended that the outputs will also help shape Defra’s research programme on Natural Resource Protection\(^9\), which aims to explore more fully how the Ecosystem Approach can add a new dimension to decision making – not just within Defra but across Government as a whole. The need to ‘live within environmental limits’ is a major theme and guiding principle of the UK Sustainable Development Strategy (HM Government, 2005).

1.2 Objectives

Defra’s vision aims to create a diverse, healthy and resilient natural environment, which accommodates both an understanding of society’s needs and insights about the limits constraining the operation of environmental systems (Defra, 2006). In order to examine further the implications of the Ecosystem Approach as part of the brief for this study, we were asked to review the key ideas embodied by the concept and in particular to examine how they can help resolve the sustainability issues affecting England’s major terrestrial ecosystems. Thus the specific objectives for this study were to:

1. Establish and agree what an Ecosystem Approach involves and how it can be used to make an assessment of the outputs of ecosystem services at national, regional and local scales; and,
2. Understand how the principles of the Ecosystem Approach and the assessment of ecosystem services can be used in decision making at national, regional and local scales.

Achieving the first objective involved reviewing how current thinking about environmental limits and values links into the Ecosystem Approach, and how such information could be used for assessing the current state and trends in the output of ecosystem services. In meeting the second objective this study had to consider the adequacy of the current evidence-base and the types of decision-support tools that would be necessary for implementing the approach, in relation to current policy and decision-making frameworks. As a result this study will enable Defra, its agencies and others, to look critically at the case for adopting an Ecosystem Approach in policy development, by examining what knowledge and institutional barriers might exist in relation to its potential take-up.

1.3 Structure of the Report

Parts 2 and 3 of this Report have been designed to achieve a better understanding of the Ecosystem Approach and ecosystem services. In Part 2 we discuss what the Ecosystem Approach involves and what kind of case could be made by Defra for adopting it as the basis for implementing its vision. Part 3 builds on this material and considers how it can be used conceptually as a framework for assessing the supply of ecosystem services.

Both objectives make reference to decision making at local, regional and national scales. Although discussion of scale issues is included in Parts 2 and 3, they are considered largely from a theoretical perspective. In order to ground our analysis on empirical

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\(^7\) As the EA is already used as an abbreviation for other idioms such as “Environmental Assessment” but also for the “Environment Agency” the authors have decided to use EsA as the abbreviation for Ecosystem Approach in accordance with IUCN Commission on Ecosystem Management (personal communication, email Pat Hawes, secretariat IUCN-CEM, 14 December 2007).

\(^8\) The completion of the project pre-dated the 2007 publication of Defra’s Action Plan, which was developed from this draft vision document. Although our work was developed specifically in response to the earlier material, many of the issues carry over.

evidence, and identify how these scale issues translate into the English policy context. Parts 4 and 5 of the report review information on ecosystem services currently available for our national Biodiversity Action Plan (BAP) Broad and Priority Habitats, and for services at national scales. These sections help in identifying what is currently known about the state and trends in ecosystem services, what knowledge gaps exist, and what kinds of challenge we face in making decisions about using these resources more sustainably. In Part 6, we consider how a place-based perspective might help to making such an assessment. Part 7 summarises the outcomes of the study and the conclusions that can be drawn about how the principles of the Ecosystem Approach can be used in decision making at national, regional and local scales.

This study complements a series of parallel projects funded under Defra’s Phase II Programme (see Defra homepage for details):

<table>
<thead>
<tr>
<th>Project No</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR0106</td>
<td>Inventory study on natural environment data 2</td>
</tr>
<tr>
<td>NR0107</td>
<td>England’s terrestrial ecosystem services and the rationale for an ecosystem-based approach</td>
</tr>
<tr>
<td>NR0108</td>
<td>An assessment of the economic value of England’s terrestrial ecosystem services</td>
</tr>
<tr>
<td>NR0109</td>
<td>Guiding development in the Kent Thamside development area</td>
</tr>
<tr>
<td>NR0110</td>
<td>The selection of the M6-Heysham link road route, Lancashire</td>
</tr>
<tr>
<td>NR0111</td>
<td>Management of the Parrett Catchment Somerset</td>
</tr>
<tr>
<td>NR0112</td>
<td>Management of the Otmoor protected area (Oxfordshire)</td>
</tr>
</tbody>
</table>

Phase I of the natural environment programme consisted of the following projects:

<table>
<thead>
<tr>
<th>Project No</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR0101</td>
<td>Inventory and assessment of existing resources</td>
</tr>
<tr>
<td>NR0102</td>
<td>Defining and identifying environmental limits</td>
</tr>
<tr>
<td>NR0103</td>
<td>Collating and evaluating research on the value of the environment</td>
</tr>
<tr>
<td>NR0104</td>
<td>Identification and characterisation of pressures on natural resources, including the effects of cumulative pressures</td>
</tr>
<tr>
<td>NR0105</td>
<td>Characterising the Policy Framework</td>
</tr>
<tr>
<td>NR0115</td>
<td>Public understanding of the concepts and language around ecosystem services and the natural environment</td>
</tr>
<tr>
<td>SD0314</td>
<td>Future trends - work on horizon-scanning to identify future trends and pressures that will affect the natural environment and the policy framework</td>
</tr>
</tbody>
</table>
Part 2: Developing an Ecosystem Approach

2.1 Introduction

If a case is to be made for promoting an Ecosystem Approach (EsA) as the basis for decision making, then we must be clear about what it involves, and how its key elements map onto current priorities and responsibilities. In this part of our Report we therefore review the principles underpinning the EsA and some of the implications that follow. The material presented in Part 2 thus sets out the general arguments for adopting the EsA as a means for delivering Defra’s vision for the environment. It also provides a foundation for Part 3, where its application is considered in the context of current thinking about the supply and consumption of ecosystem services.

2.2 Framing the EsA

2.2.1 What does the EsA involve?

The Ecosystem Approach emerged as a topic of discussion in the late 1980s and early 1990s amongst the research and policy communities concerned with the management of biodiversity and natural resources (Hartje et al., 2003). It was argued that a new focus was required to achieve robust and sustainable management and policy outcomes. An Ecosystem Approach, it was suggested, would deliver more integrated policy and management at a landscape-scale and be more firmly directed towards the needs of people.

Much of the recent interest in the EsA can, however, be traced to the influence of the Convention for Biological Diversity (CBD), which in 1995 adopted it as the ‘primary framework’ for action (IUCN, 2004). Under the convention, the approach is the basis for considering all the goods and services provided to people by biodiversity and ecosystems (Secretariat of the Convention for Biological Diversity, 2000).

According to the CBD, the EsA

“….places human needs at the centre of biodiversity management. It aims to manage the ecosystem, based on the multiple functions that ecosystems perform and the multiple uses that are made of these functions. The ecosystem approach does not aim for short-term economic gains, but aims to optimize the use of an ecosystem without damaging it.”

As such it also embodies a core set of management principles11 (Table 2.1). The principles seek, for example, to promote an integrated approach to management that operates across both natural and social systems, and between different ecosystems. An understanding of the way in which natural and social systems are coupled is seen as particularly important because, it is argued, management decisions have to be seen in their economic and social context, i.e. people are an integral part of ecosystems. The principles proposed by the CBD cover the conservation and sustainable use of resources, and the sharing of benefits derived from natural resources throughout society. This concept also resonates with ideas about ‘environmental justice’, which is a key component of creating more sustainable communities (SDRN, 2007).

While decisions about policy and management are essentially a matter of societal choice, the principles proposed by the CBD also recognise that decisions have to be grounded on a scientific understanding of biophysical limits that constrain ecological processes and the spatial and temporal scales at which they operate. From the more scientific perspective, the EsA recognises the inherently dynamic nature of ecosystems and the uncertainties

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10 http://www.iucn.org/themes/CEM/ourwork/ecapproach/index.html
11 For more extensive documentation see https://www.biodiv.org/programmes/cross-cutting/ecosystem/sourcebook/advanced-guide.shtml?approach
Table 2.1: The Principles of the Ecosystem Approach


1. The objectives of management of land, water and living resources are a matter of societal choice.
2. Management should be decentralised to the lowest appropriate level.
3. Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.
4. Recognising potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should:
   a. Reduce those market distortions that adversely affect biological diversity;
   b. Align incentives to promote biodiversity conservation and sustainable use; and
   c. Internalise costs and benefits in the given ecosystem to the extent feasible.
5. Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the Ecosystem Approach.
6. Ecosystems must be managed within the limits of their functioning.
7. The Ecosystem Approach should be undertaken at the appropriate spatial and temporal scales.
8. Recognising the varying temporal scales and lag-effects that characterise ecosystem processes, objectives for ecosystem management should be set for the long term.
9. Management must recognise that change is inevitable.
10. The Ecosystem Approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.
11. The Ecosystem Approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.
12. The Ecosystem Approach should involve all relevant sectors of society and scientific disciplines.

Note: These are the principles set down in the 1998, 'Malawi workshop'

involved in any attempt to manage them. Thus the principles seek to promote a holistic, adaptive and flexible approach to natural resource management. One of the merits of the Ecosystem Approach, as is it claimed, is that it helps focus decision makers on longer-term, more sustainable perspectives rather than on shorter-term fixes that may ultimately fail to deliver lasting, cost-effective socio-economic and environmental benefits.

An overview of the wide range of work that has been encouraged by the Ecosystem Approach can be gained through the case study database currently available from the CBD\(^2\) and IUCN\(^3\) websites.

\(2.2.2\) Implementing the EsA

The ‘principles’ that the CBD sees as making up the Ecosystem Approach are, of course, not unique to the Convention. Indeed, just as the Convention sought to capture and represent a range of concerns around the sustainable use of ecosystems that were being voiced at the time of its drafting, others have subsequently interpreted, extended and emphasised the ideas in a number of different ways. While some have proposed that the EsA principles need to be revised and clarified to make them more useful operationally (e.g. Korn, 2006; Müller, 2006), the key point that emerges from recent debates is that there is probably no final definition of the concept, and that its meaning is likely to develop

\(^2\) [https://www.biodiv.org/programmes/cross-cutting/ecosystem/sourcebook/search.shtml](https://www.biodiv.org/programmes/cross-cutting/ecosystem/sourcebook/search.shtml)
\(^3\) [http://www.iucn.org/themes/CEM/ourwork/ecapproach/index.html](http://www.iucn.org/themes/CEM/ourwork/ecapproach/index.html)
as it is applied and shortcomings detected. Indeed, as a number of commentators have observed, (Maltby, 2000; Smith and Maltby, 2003; Hartje et al., 2003), the fluidity of the EsA concept is a virtue, because the principles that underpin it are not equally applicable in all circumstances. Solutions have therefore to be tailored to meet the requirements of the problem in hand. Despite its critics, the EsA continues to provide a strong conceptual basis for policy and management decisions.

We suggest that the broad definition of the Ecosystem Approach suggested by Smith and Maltby (2003) remains a useful starting point for discussion. It is:

“...a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way.” (Smith and Maltby, 2003, p.103).

The ideas contained in this definition are consistent with the recent formulation of the concept by Defra, which has set out a number of initial objectives that it hopes to see realised by its application (Defra, 2006 and 2007a). This definition is also consistent with the way the approach is being used by Defra’s partners, such as JNCC14 and Natural England (Laffoley et al., 2004). **We conclude therefore, that it is appropriate to accept the case for the EsA in general terms, and focus more on how its key ideas can be refined and re-expressed in the context of current needs and decision making processes.**

The main benefits that Defra sees as being delivered through an Ecosystem Approach have been summarised in their draft vision for the natural environment (Defra, 2006) and finalised Action Plan (Defra, 2007a) (Table 2.2). If a case is to be made for adopting the EsA, then one would need to show that: (a) these aspirations are those which are most relevant in terms of the issues currently affecting natural resource systems in England; and, (b) they are more easily achieved by using this framework for decision making, rather than some other. It is also clear that even if a case could be made in these terms, this would not, by itself, ensure success. There are also likely to be significant barriers to overcome in communicating the key ideas to decision makers both within Defra and elsewhere, and of ensuring that wider institutional structures, and their roles and remits adapt in ways that enable the approach to be truly effective.

<table>
<thead>
<tr>
<th>Table 2.2: Benefits seen by Defra of adopting an Ecosystem Approach to policy (after Defra, 2007, p.11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• more effective delivery of our environmental outcomes</td>
</tr>
<tr>
<td>• better-informed decisions that take full account of environmental impacts, helping us to achieve sustainable development</td>
</tr>
<tr>
<td>• better prioritisation and more efficient use of our resources</td>
</tr>
<tr>
<td>• more effective communications and greater awareness of the value of natural environment and ecosystem services</td>
</tr>
</tbody>
</table>

### 2.2.3 Delivering ‘joined up’ policy

Although successive Governments have acknowledged the importance of the natural environment and the benefits it provides to people, it has been recognised that in terms of delivering the objectives of sustainable development, a more ‘joined-up’ approach to making decisions is required. For example, in the consultations that led up to the publication of the 2005 Sustainable Development Strategy (HM Government, 2005),

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14 [http://www.jncc.gov.uk/page-1576](http://www.jncc.gov.uk/page-1576)
natural resource protection and environmental enhancement was identified as one of the five priority areas for action. To achieve this it was argued that we needed:

“...a better understanding of environmental limits, environmental enhancement and recovery where the environment is most degraded to ensure a decent environment for everyone, and a more integrated policy framework.” (HM Government, 2005, p. 18).

The encouragement that the EsA gives to ‘whole-systems’ thinking is therefore something that makes it highly relevant to present policy needs. However, the problem we face evaluating Defra’s current Action Plan, and the extent to which it will lead to the approach becoming embedded in decision making, is that there is something of a gap between the benefits summarised in Table 2.2 and the ‘principles’ that constitute the EsA. The benefits identified are in fact mostly of an operational character, in that they are only likely to be recognised as ‘successful outcomes’ by Defra and some of its closer, partner organisations. They will probably not be seen or understood as benefits by the wider policy community or the public.

The problem of communication has recently been highlighted in a study for Defra on the ‘Public understanding of the concepts and language around ecosystem services and the natural environment’ (Defra, 2007)\(^\text{15}\). It pinpoints a key dilemma facing Defra: namely, that while seeking to demonstrate that its approach to policy development and appraisal are consistent with accepted scientific norms, it is hard not to use the technical language in which these paradigms are usually expressed, even though that language might not be understandable by, or acceptable to, the very decision-makers that need to be convinced.

One way of avoiding this dilemma is not to argue for an Ecosystems Approach explicitly, but rather to suggest how current approaches are, or could become, more consistent with the important ideas that lie behind it. If the EsA principles are be expressed as a more easily understood set of generic ideas, as now been done in the current Action Plan, then the task is to find ways of embedding these ideas in existing procedures, or using them to shape the evolution of future decision making structures and processes.

In an attempt to present a stronger public case for the EsA, we suggest that it would be useful to extend the discussion contained in Defra’s current Action Plan, for example, more clearly linking the EsA’s underlying principles to the current UK Sustainable Development Strategy (HM Government, 2005). These have a much wider interest and acceptance, in that they have been agreed across UK Government and the devolved administrations. While the principles are described in the vision document, there is no direct ‘read-across’ between them and what are seen to be the benefits of the EsA. Similarly, given the importance of the Public Service Agreement (PSA) Targets it would also be useful to show how progress might better be achieved or more appropriate targets identified through the EsA.

Table 2.3 has been constructed as a way of aligning the key ideas of the EsA with Defra’s strategic concerns in relation to Sustainable Development (SD) and PSA Targets. The table cross-references the issues covered by the Sustainable Development Strategy with both the EsA principles themselves (Table 2.1) and the more detailed ‘operational guidance’ published by the CBD\(^\text{16}\) (Appendix A).

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\(^\text{15}\) The key findings are:
- It is best to avoid terms such as ‘ecosystems’, ‘biodiversity’ or ‘green infrastructure’;
- Respondents expressed little belief or concern that the environment was under serious threat within the UK;
- Respondents connected most strongly to the natural environment via aspects that enhance the quality of people’s life; and
- Costs implications of environmental damage for individuals increased interest significantly.

\(^\text{16}\) [http://www.cbd.int/ecosystem/operational.shtml](http://www.cbd.int/ecosystem/operational.shtml)
Table 2.3: The relationship between the EsA-principles and EsA-guidance (after CBD, 2000), the UK Sustainable Development Strategy (HM Government, 2005) and Defra's current Public Service Agreement (PSA) Targets 17

<table>
<thead>
<tr>
<th>Sustainable Development Strategy Principles</th>
<th>Resonance with Defra’s PSA Targets (See Footnote)</th>
<th>Benefits arising from using an EsA in the context of Defra’s vision for ‘a diverse, healthy and resilient natural environment, which provides the basis for survival, wellbeing and prosperity now and in the future’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living within environmental limits</td>
<td>Sustainable use of water that balances water quality, environment, supply and demand. Land and soils managed sustainably Reversing the long-term decline in the number of farmland birds (considered a useful proxy indicator of ecosystem health) Favourable conservation status for Sites of Special Scientific Interest Reducing greenhouse gas emissions Improving air quality and ensuring that harmful levels of pollutants are not exceeded.</td>
<td>EsA Principles: The need to be aware of the limits associated with natural resource systems is one of the key CBD principles, and so ‘EsA thinking’ is already strongly reflected in policy concerns at national level. In terms of articulating Defra’s vision further, the link between the concept of a resilient and healthy ecosystem and notions of living within limits needs to be made, together with an understanding of what implications might arise if limits are not ‘respected’.</td>
</tr>
<tr>
<td>Respecting the limits of the planet’s environment, resources and biodiversity – to improve our environment and ensure that the natural resources needed for life are unimpaired and remain so for future generations.</td>
<td></td>
<td>EsA Guidance: In terms of the practical need to understand the relationships and processes within ecological systems, however, the evidence base relating to environmental limits is probably incomplete, and so currently decision makers may find it difficult to identify limits or to use them as decision making criteria. If Defra’s operational objectives are to be achieved, then information about potential limits, how they can be identified in different contexts, and how situations involving multiple limits can be dealt with should be developed. An understanding of limits is an essential part of designing any effective system of indicators, including the PSA measures listed here, since they help frame decisions about appropriate policy targets.</td>
</tr>
<tr>
<td>Ensuring a strong, healthy and just society</td>
<td>Clean, healthy, safe, productive and biologically diverse ocean and seas Enhancing opportunity in rural England Eliminate fuel poverty Improving air quality Bovine Spongiform Encephalopathy Bovine Tuberculosis</td>
<td>EsA Principles: The EsA recognises that the management of natural resources is a matter of ‘societal choice’ and that a balance must be struck between conservation and wise use of resources. The EsA also argues for an inclusive approach to decision making. In terms of articulating Defra’s vision further, however, the link between well-being and the integrity of natural systems needs to be made clear, and the role of the environment in promoting sustainable communities in different geographical contexts must be articulated.</td>
</tr>
<tr>
<td>Meeting the diverse needs of all people in existing and future communities, promoting personal well-being, social cohesion and inclusion, and creating equal opportunity for all.</td>
<td></td>
<td>EsA Guidance: At the operational level the EsA guidance emphasises the need for ‘benefit sharing’ which by implication (in terms of the EsA principles) includes non-market benefits of ecosystem services. Operation guidance is required to explain how social and ecological values can be considered alongside economic ones, and to show how they can be taken into account in decision making. Participatory processes to ensure the widest possible stakeholder involvement would clearly underpin activities in this area, particularly where issues of trade-offs between different types of benefit are involved; the role of community-based environmental initiatives in promoting social cohesion and capacity building should be emphasised, and its contribution to the PSA target for rural opportunity clarified, e.g. a role for the EsA in helping rural communities to become more sustainable.</td>
</tr>
</tbody>
</table>

17 The Operational guidance for the EsA (after CBD, 2007) and its implication for this study (NR0107) can be found in Appendix A.
Table 2.3, cont.:

<table>
<thead>
<tr>
<th>Sustainable Development Strategy Principles</th>
<th>Resonance with PSA Targets (See Footnote)</th>
<th>Benefits arising from using an EsA in the context of Defra’s vision for ‘a diverse, healthy and resilient natural environment, which provides the basis for survival, wellbeing and prosperity now and in the future’</th>
</tr>
</thead>
</table>
| Achieving a sustainable economy             | • People to enjoy, understand and care for the natural environment  
Building a strong, stable and sustainable economy which provides prosperity and opportunities for all, and in which environmental and social costs fall on those who impose them (polluter pays), and efficient resource use is incentivised. | **EsA Principles:** The EsA recognises that ecosystems generally have to be managed in an economic context, and that a balance between conservation and use of biological resources needs to be achieved. In terms of Defra’s vision for a healthy natural environment, economic benefits arising from the sustainable management of natural resources needs to be made clear and the costs of protection and restoration of natural systems needs to be taken into account in cost-benefit analyses. |
| Promoting good governance                   | • Land and soils managed sustainably  
Actively promoting effective, participative systems of governance in all levels of society – engaging people’s creativity, energy, and diversity.  
Biodiversity valued, safeguarded and enhanced  
People to enjoy, understand and care for the natural environment | **EsA Principles:** The promotion of ‘good governance’ is one of the main goals of the EsA. While initially this was aimed at promoting the better management of biodiversity, the emphasis on ecosystem services and benefit sharing means that the implications go much wider. Within the EsA principles, good governance is covered by the principles that deal with the way people are brought into decision making processes, but also by ensuring that decision making is at an appropriate spatial and temporal scale given the nature of the natural resource systems that are being considered. **EsA Guidance:** The EsA guidance suggests that good governance involves decentralisation and devolution of powers so that people and communities are genuinely empowered to take decisions about those aspects of the environment that affect well-being. However, multi-level decision making has implications for Central Government, in that its co-ordinating role becomes vital; it must provide clear strategic direction, facilitate and encourage the development of the evidence base on which decisions are made, provide resources, regulate, and offer arbitration and ultimately adjudication, where conflicts are unresolved at more local levels. The mediation of international commitments and agreements with national concerns and priorities is also an important consideration. |

/cont.
Table 2.3, cont.:  

<table>
<thead>
<tr>
<th>Sustainable Development Strategy Principles</th>
<th>Resonance with PSA Targets (See Footnote)</th>
<th>Benefits arising from using an EsA, in the context of Defra’s vision for ‘a diverse, healthy and resilient natural environment, which provides the basis for survival, wellbeing and prosperity now and in the future’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using sound science responsibly</td>
<td>+ Scrapie</td>
<td>EsA Principles: The importance of science- or evidence-based decision making is a key principle within the EsA, and is already subscribed to both by Defra and the UK Government more generally. By adopting the EsA, organisations must ensure that their research strategy is clearly aligned with the threats facing natural resource systems and the associated aspects of human well-being. The maintenance of public confidence in the information used to make decisions is essential; this can be difficult to achieve in the context of the many uncertainties that surround the dynamics of coupled social-ecological systems. The EsA principles dealing with the use of different types of knowledge in decision making, and the inclusion of all relevant groups in decision making are seen as key to ensuring public understanding and consent.</td>
</tr>
<tr>
<td></td>
<td>+ Bovine Spongiform Encephalopathy</td>
<td>EsA Guidance: The importance of adaptive management is a key element of the EsA guidance. It is argued that, given the complexities of the systems and the uncertainties associated with them, ecosystem management must be seen as a learning process; decision makers must adapt methodologies and practices to take account of the way systems respond to interventions and any new, external drivers of change. At the operational level, therefore, the EsA requires sound and appropriate monitoring systems, and the ability of people and institutions to review and respond to changing circumstances. Effective use of the precautionary principle in decision making requires information about the costs and risks associated with different strategies. The PSA targets relating to animal diseases illustrate recent initiatives to ground policy and management on the best science; horizon-scanning and foresight techniques are needed to ensure that the full range of environmental contingencies are considered.</td>
</tr>
<tr>
<td></td>
<td>+ Bovine Tuberculosis</td>
<td></td>
</tr>
</tbody>
</table>

Note: The PSA Targets referred to are those agreed prior to the 2007 Comprehensive Spending Review, in which an additional cross-government PSA was agreed, namely ‘To secure a diverse, healthy and resilient natural environment which provides the basis for everyone’s well-being health, prosperity now and in the future; and where the value of the services provided by the natural environment are reflected in decision making’ (Defra, 2007, p.6). The pre-2007 PSA targets are shown in italics, while the specific objectives associated with the new PSA target in the 2007 Defra ‘Action Plan’ are shown in non-italics.
The conclusion that emerges from this exercise summarised in Table 2.3 is that if we take
the five broad areas covered by the SD 'guiding principles', then all of them are consistent
with the ideas that make up the Ecosystem Approach. Indeed, the issues that arise in the
read-across between the SD elements and the EsA are not at the conceptual level, but
rather in terms of what is needed for guidance and delivery. **The questions need to be
answered relate to how at the operational level both the SD and EsA principles
can be implemented.** The same case could be made if the SD guidelines were replaced
with Defra’s current strategic priorities (Defra, 2007b), but we have used the former
because of their more general relevance.

If this conclusion is accepted then the message that Defra needs to convey in
promoting its vision is that the proposed approach is consistent with currently
accepted, international ‘best practice’ (i.e. the Ecosystem Approach), and then to
describe it in terms that will best shape the actions of others.

The language and terminology of the Ecosystem Approach is, in a sense, unnecessary in
terms of presenting a vision. The arguments about the way Defra’s approach is consistent
with the EsA are perhaps for internal consumption, or to be had with specialist or
interested parties. It is unlikely that Defra will encourage others to take up the EsA as it
stands and to use it in their thinking. However it is possible that, by working through the
ways Defra interacts with partners across its ‘delivery landscape’ (c.f. Defra, 2002) future
decision making can be made more consistent with the ideas contained in the EsA.

### 2.2.4 Embedding the EsA

Given the encouragement to ‘tailor’ the EsA to meet local needs, in the work leading up to
this Report we concluded that Defra should consider developing its vision using a
language and terminology that is appropriate to the audiences being targeted. On the
basis of the analysis presented in Table 2.3, it was clear that Defra’s broad strategic
objectives could easily be re-cast in terms of the EsA, but that there was scope for them
to be more focused in the way they are presented. We argued that the EsA principles
could be regrouped and restated more simply in terms that better reflect Defra’s needs.  

Although Defra’s recently published Action Plan (Defra, 2007a) presents the EsA
principles in a more generic way, the summary-nature of this document meant that the
rationale for doing so could not be set out in detail. We therefore present here what we
consider to the case for adopting such the ‘tailored’ approach to be.

On the basis of our review, we concluded that accepting the EsA amounts to no more
than seeking:

> Inclusive, cross-sectoral decision making at appropriate spatial
> and temporal scales so that proper account is taken of the value
> of environmental systems for the well-being of people.

This formulation of the EsA, we suggest, combines the four key themes included in the
EsA which are particularly relevant to Defra’s current priorities. The detailed rationale that
underpins it is as follows:

1. **Inclusive Decision Making**

The management of environmental resources is a matter of **societal choice**, and so we
need to ensure that the views and understandings of different people and organisations
are taken into account (Potschin & Haines-Young, 2006). These views include the values
and priorities people have in relation to the management of environmental resources, and
their knowledge about the systems being managed. The involvement of different groups

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18 See also attempts to cluster EsA principles: [www.iucn.org/themes/CEM/ourwork/ecapproach/index.html](http://www.iucn.org/themes/CEM/ourwork/ecapproach/index.html)
will help ensure that the costs and benefits of decisions are shared appropriately, and that in the long term management of ecosystems is likely to be more sustainable.

This idea seeks to combine the CBD principles, 1, 11, and 12, which emphasise the need to use participatory approaches in the design of environmental policy and management strategies. While consensus is desirable, choices between options often need to be made. This general idea highlights the belief that these approaches will ensure more equitable treatment of different sectors of society and, by their involvement, support more sustainable decisions and strategies in the long-term by involving people.

2. Proper Accounting for the Environment

The management of our environment needs to be set in and integrated with wider social and economic contexts. Thus we need to be sure that the costs and benefits associated with protecting it or using the resources it provides are fully taken into account, so that they can be considered alongside other societal issues within appropriate timeframes (see 3 below).

This statement encompasses principles 4 and 10, which deal with the need to balance conservation and use of biological resources and the proper valuation of them in decision making. Implicitly it also covers principles 5 and 6, which emphasise the need to maintain ecological systems and their services within their ‘limits of functioning’.

3. Appropriate geographical and time perspectives

Due to the complex ways environmental, social and economic systems interact, decision making about environmental resources will need to take place at a number of different levels and geographical scales. However, for management to be effective, those responsible for making decisions must work at a spatial and temporal scale that will allow them to use knowledge about environmental limits to act effectively to sustain the resource or to mitigate or modify the pressures that are acting upon it.

This statement takes in principles 2, 6 and 7, which focus on the need to match the scales of decision making to the scale of the problem or resource being managed. This idea has major implications in terms of potentially decoupling decision-making from political time-frames. Decentralisation may also be appropriate, but it has to be undertaken on the basis of an awareness that hierarchical sets of partnerships and relationships exist. The levels above that where decisions are made, have to provide resources and strategic information to facilitate action. Good communications with those below the level at which decisions are made is essential, in terms of gaining the consent and co-operation necessary to ensure successful delivery of a policy.

4. Joined-up policies

The complex ways that environmental systems are linked to each other and to other social and economic systems means that the broad implications of decision making needs to be considered by all sectors of society. Thus we need to ensure that in the design and appraisal of policy, or the evaluation of management decisions or development plans, the implications of proposals are considered in an integrated way so that the integrity of environmental systems is not undermined and change is managed sustainably.

This takes into account principles 3, 8 and 9 that recognise the crosscutting nature of decision making and impacts, and the possibility of cumulative effects. While change is inevitable, it may be possible to manage it in ways that not only sustain but also enhance and expand the integrity of ecological systems, and the output of services and benefits associated with them.
2.3 Developing the Rationale for an EsA

The first part of the brief for this study was to consider the rationale for the Ecosystem Approach (EsA). Our review of what the approach involves and how it resonates with Defra’s objectives in relation to sustainable development, suggests that it is wholly consistent with current policy concerns. Adopting the EsA can be justified simply on the grounds that it represents internationally recognised ‘best practice’. In our restatement of the EsA Principles from a ‘Defra perspective’, we have shown its key aspects and how the framework can be tailored to meet current needs. In presenting the case for the EsA there is nothing to be gained by discussing whether it should be referred to as an Ecosystem, Ecosystems, or Ecosystems-Based Approach. It is the way the ideas are applied that counts most.

From the outset we argued that the case for adopting an Ecosystem Approach cannot be made in terms of ‘principles’ alone. Operational matters also have to be considered. At the practical level we still need to examine the extent to which current practice falls short of what might be expected or identify how it could be improved by using some set of guidance based on the EsA.

If the EsA is accepted as a way of working, then it potentially provides a framework for reviewing and auditing current initiatives and programmes. As reference to the CBD case study database illustrates, the principles and associated operational guidelines can be used quite effectively for evaluation at the project, programme or policy levels, and then used to generate lessons that might help shape future actions. A review of the consistency of all Defra’s activities and areas of concern with EsA principles is, therefore, one potential next step that could be recommended on the basis of this study. Such a review would provide the evidence necessary to make the case that at the operational level, deficiencies were apparent, and that these could be overcome by application of the concepts and methods embodied in the Ecosystem Approach. The review might then be extended to environmental issues linked to the work of other Government departments.\(^\text{19}\).

For example a key area for review would be the extent to which the current suite of indicators used to monitor progress towards sustainable development and other important policy goals are consistent with a ‘whole-systems’, cross sectoral approach. The extent to which such indicators are grounded on understandings of the limits of ecosystem function, and the ways such knowledge is used to set appropriate targets could also be considered\(^\text{20}\). The next step would then be to explore whether the specific policy initiatives that these indicators were designed to measure were themselves sufficiently integrated to ensure consistency across Defra’s delivery landscape.

Clearly such a wide ranging review of indicators and policy is outside the scope of the current project. However, as a first step towards evaluating the contribution that the EsA might make at an operational level, we focused specifically on the issue of ecosystem services. The sustainable management of ecosystem services is a key area highlighted in Defra’s current Action Plan. The importance of ecosystem services is also specifically acknowledged in the EsA (being the subject, for example, of Principle 5; see Table 2.1).

To explore the case for the EsA further, in the remaining parts of this Report we will explore what current evidence exists about the state and trends of the services associated with England’s major terrestrial ecosystems. In particular we will examine the extent to which the ways that the current policies or management frameworks are

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\(^{19}\) Defra’s current Action Plan (Defra, 2007a) now sets out actions to ‘mainstream’ the EsA at national level which could be used to monitor success, and these could be a starting point for such a review.

\(^{20}\) Defra has commissioned a project on “Reviewing targets and indicators for the ecosystem approach” (project code NR0119). For aims, objectives and contractor consult Defra homepage: [http://www.defra.gov.uk/wildlife-countryside/natres/research.htm](http://www.defra.gov.uk/wildlife-countryside/natres/research.htm).
consistent with the thinking embodied in the EsA, or what more might be done to ensure that better strategies for sustaining these services can be devised. Part 3 sets out the conceptual framework, and Parts 4 and 5 then consider the evidence empirically.

**Box 2.1: Key messages from Part 2**

- The Ecosystem Approach (EsA) provides a strong conceptual basis for making policy and management decisions. It may best be considered as an evolution of other approaches from the specific position of ecosystems. It is largely consistent with – and could be a more explicit part of – the broader approach offered by the sustainable development agenda.

- As an integrative and holistic framework, the EsA provides an attractive and relatively consistent conceptual approach to addressing cross-cutting issues and externalities that, historically, have often been ignored. Much of its value is as a conceptual tool that allows for (and places at its centre) real environmental value that has traditionally been ignored in economic valuations.

- The EsA is best promoted by tailoring its key ideas to current strategic needs and priorities, and by finding ways of using the principles to shape the actions of decision makers in other Government departments or in Society more generally.

- The EsA principles can be used as a way of auditing current and future policy initiatives, and the extent to which they are consistent with ‘whole-systems’ thinking.
Part 3: Understanding Ecosystem Services

3.1 Introduction

In Part 2 it was suggested that a case for an Ecosystem Approach (EsA) could be made on grounds that it represented internationally recognised ‘best practice’ and that it underpinned Defra’s current strategic needs. The operational issues that might follow from adopting the approach are, however, complex and wide ranging. In this part of our Report we consider what they might involve in the context of assessing the state and trends of ecosystem services, and their consequences for human well-being. Clearly, if the EsA is found to be essential in helping decision-makers think about ecosystem services and link issues across the environmental, social and economic domains, then the case for proposing it as an overarching philosophy would be much stronger. In this section of the Report we therefore examine current thinking about ecosystem services, and specifically how the EsA might help in managing them sustainably.

3.2 What is an Ecosystem Service?

3.2.1 The Millennium Ecosystem Assessment (MA) and Ecosystem Service Typologies

While the concept of an ecosystem good or product is relatively straightforward to understand, representing something tangible like a material resource, such as a food or fibre product, the idea of an ecosystem service is more complex. According to the Millennium Ecosystem Assessment (MA, 2003, Ch 2, p.53) ecosystem services are the benefits people obtain from ecosystems. The MA definition of a service draws on earlier definitions that suggest:

1. Ecosystem services are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life. They maintain biodiversity and the production of ecosystem goods, such as seafood, forage, timber, biomass fuels, natural fiber, and many pharmaceuticals, industrial products, and their precursors (Daily, 1997, p.3); and,

2. Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions (Costanza et al., 1997, p.253).

<table>
<thead>
<tr>
<th>Provisioning Services</th>
<th>Regulating Services</th>
<th>Cultural Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Products obtained from ecosystems</td>
<td>Benefits obtained from regulation of ecosystem processes</td>
<td>Nonmaterial benefits obtained from ecosystems</td>
</tr>
<tr>
<td>Food</td>
<td>Climate regulation</td>
<td>Spiritual and religious</td>
</tr>
<tr>
<td>Fresh Water</td>
<td>Disease regulation</td>
<td>Recreation and ecotourism</td>
</tr>
<tr>
<td>Fuelwood</td>
<td>Water regulation</td>
<td>Aesthetic</td>
</tr>
<tr>
<td>Fiber</td>
<td>Water purification</td>
<td>Inspirational</td>
</tr>
<tr>
<td>Biochemicals</td>
<td>Pollination</td>
<td>Educational</td>
</tr>
<tr>
<td>Genetic resources</td>
<td></td>
<td>Sense of place</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supporting Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service necessary for the production of all other ecosystem services</td>
</tr>
<tr>
<td>Soil Formation</td>
</tr>
</tbody>
</table>

Note this is not a comprehensive list of services; those listed are indicative only.
On the basis of this definition the MA provided a simple typology of services (Figure 3.1) that has since been widely taken-up in the international research and policy literatures. The MA’s four broad categories of service are defined as:

- **Provisioning services** - which are represented by the output of products such as food, fresh water, fuel, fibre, biochemicals and genetic resources;
- **Regulating services** - which cover the mediating role that ecological systems have in affecting climate, the incidence of disease, water quality and quantity, and pollination processes;
- **Cultural services** - which include the non-material benefits ecological systems can provide in terms of their spiritual or religious significance, recreation and tourism, aesthetics, educational and scientific value and cultural significance; and,
- **Supporting services** - which are the processes that underpin all the other services, such as soil formation, nutrient cycling and primary production.

Although the MA typology has served well in terms of stimulating discussion, it has some limitations for those interested in operationalising the concepts. Four problems are evident:

1. The list of services is by no means complete. Other more extensive and detailed categorisations have been provided (e.g. Bastian and Schreiber, 1999; de Groot, 1992; de Groot et al., 2002)
2. There are the logical inconsistencies within the scheme: food and fresh water are placed under provisioning services, but clean air is not. Also, while ‘educational’ and ‘ecotourism’ feature, there is no mention of other job opportunities that arise from services.
3. As pointed out by the authors of the MA, categories may overlap and some services underpin others, but they nevertheless sit next to each other in the table, such as climate regulation and food, or climate regulation and disease regulation. And
4. If we follow the MA definition that ‘services are the benefits people obtain’ then should we only focus on the things that are **directly** obtained or should we also include the more indirect things on which these outputs depend? The placement of supporting services is problematic because they may lead to ‘double counting’ in valuation studies.

As Banzhaf and Boyd (2005), and Boyd and Banzhaf (2005, 2006) have noted, the literature is in fact extremely ambiguous about how to distinguish between ecosystem functions (the mechanisms by which services are generated) and the services themselves, and what this means for the way we might value the benefits that people eventually enjoy from these services. This situation prevails despite the many attempts to provide systematic typologies of ecosystem functions, goods and services (de Groot, 1992; Daily, 1997; de Groot et al., 2002; MA, 2005).\(^{21}\)

Banzhaf and Boyd (2005) conclude that the typologies of ecosystem services such as that of the MA (2005) are unhelpful because they represent as services what are more properly considered on the one hand as functions and on the other as benefits. It is certainly the case that in the MA there is ambiguity between the definition of services as ‘benefits people obtain’ and the representation of the link between services and human well-being in the widely published diagram reproduced in Figure 3.2. This clearly seems to make the distinction between some set of outputs derived from ecological systems (i.e. services) and something that is consumed or enjoyed by people. Banzhaf and Boyd (2005) argue that it is particularly important to identify clearly what a service as opposed to a benefit is, because only then are we likely to be able to develop measures of ecosystem services that are consistent with approaches used for their valuation.

\(^{21}\) The EC funded project Rubicode ([www.rubicode.net](http://www.rubicode.net)) has developed a glossary to tackle this issue, which includes definitions of the above plus many other relevant terms.
3.2.2 Ecosystem Service Cascades
Despite its influence, the ‘service typology’ of the MA, though useful, clearly demands elaboration and refinement. Thus, we suggest Figure 3.3 as a way of capturing the logic that underlies the ‘services paradigm’, and as a framework for distinguishing more clearly between structures, processes, functions, services and benefits in any particular study, so that others can see how analyses are being constructed.

22 The present study (NR0107) “only” deals with the first three steps (including services; the valuation part is dealt within another project commissioned by Defra (NR0108), see p.6 of this report for overview.
Figure 3.3 makes a distinction between what can be regarded as ecological structures and functions and the eventual services and benefits that they provide to people. The key point that needs to be emphasised is that a particular function (potential, utility) that a given ecological structure or process might have, depends on whether people actually place a value on that particular output (i.e. regard the service as producing some ‘benefit’). Thus, woodlands or the presence of other habitats such as wetlands in a catchment, may have the capacity (function) of slowing the passage of surface water, thereby modifying the intensity of flooding. Whether this function is regarded as a service depends upon whether ‘flood control’ is considered as a benefit or not. People or society will value this function differently in different places at different times. Therefore in defining what the ‘significant’ functions of an ecosystem are and what constitutes an ‘ecosystem service’, an understanding of spatial context (geographical location), societal choices and values (both monetary and non-monetary) is as important as knowledge about the structure and dynamics of ecological systems themselves. The figure also suggests that the view that Society takes of the sufficiency of service output from the system, may partly affect the view taken of the pressures upon the system and what policy responses are required.

Although the terminology and the way the elements shown in Figure 3.3 are grouped may differ between commentators, the same idea of a cascade from structures, processes and functions through services and benefits underlies many of the accounts found in the literature (for example, see Figure 3.4). It is also consistent with notions of ‘intermediate’; and ‘final’ goods used for input-output analysis in national economic accounting studies.

**Figure 3.4: Contrasting representations of ‘intermediate’ and ‘final’ quantities in the ecosystem services paradigm** (after Raffaelli et al., 2007; for references see last chapter of this report)

We conclude that the list of services presented in the MA are regarded more as a set of ‘service themes’, and that the way they are refined and expanded will depend on the circumstances of any particular study.

Our review of the current literature suggests that the importance of the ‘ecosystem-services paradigm’ is not that it emphasises the benefits that the environment has for human well-being – this message is hardly new. Rather, the significance of the idea is that it focuses attention on the need to investigate the systematic links between the
different environmental, social and economic elements that ultimately give rise to some benefit for people in a given situation. The research challenge is to describe and understand for a particular situation or problem, the nature of the ‘production line’ that is represented by the ecosystem service cascade or ‘supply chain’ illustrated in Figure 3.3.

The move away from discussions of the adequacy of general ‘service typologies’ to an investigation of how specific benefits or sets of benefits are generated is an important step, because it will ensure that the complexities of real world situations are confronted. For example, Banzhaf and Boyd (2005, p.12), have argued that part of the difficulty of generally defining what an ecosystem service is lies in the fact that they ‘are contingent on particular human activities or wants’. The problem they flag up can be illustrated by reference to Figure 3.5, which concerns the different roles that ‘water quality’ can have in the analysis of ecosystem services and societal benefits.

| Figure 3.5: The identification of benefits, services and functions in the context of recreational angling and the provision of drinking water (after Banzhaf and Boyd, 2005) |
|---|---|---|
| **BENEFIT** | **SERVICES** | **INTERMEDIATE COMPONENTS** |
| Recreational Angling | The water body | The water body’s quality |
| | The bass population | |
| | The riparian forest | |
| Drinking Water | The water body’s quality | Wetlands, natural riparian land cover |

Clearly the quality of the water body plays an important role in the ecosystem service ‘supply chain’ that gives rise to benefits we might recognise as ‘recreational angling’ and ‘the provision of drinking water’. However, only in the case of drinking is the water directly consumed, and so only here is ‘the water body’s quality’ to be regarded as a service. Wetlands and natural riparian land cover are important assets that help deliver that service, but they are not services in themselves. By contrast for recreational angling, the water body’s quality is no longer the service. Here the things being used directly are the fish population (bass) and elements of the environment such as the presence of the surrounding vegetation through their influence of the angling experience. The value of the water body’s quality is taken account of in the service represented by the fish stock. Thus in this situation the quality of the water body is an asset (i.e. is at the functional level) not a service.

The observation that ecosystem services appear to be ‘contingent’ or determined by human activities and needs, has considerable implications for this study because it suggests that it is unlikely that we can devise a generic checklist of services that ecosystems or regions might support, as many commentators have done. Rather the task seems to be one of treating the MA typology of services more as a menu of service-benefit themes, and using the framework of the cascade to examine how particular systems operate.

3.3 Ecosystem Service Units

A problem that arises when using the Ecosystem Approach, or when attempting to make an assessment of ecosystem services, is that it is often difficult to decide what an ecosystem actually is (see also Jax, 2007). While many regard the flexibility of defining ecosystems as a virtue, because the concept can be applied on any scale, it must be acknowledged that such latitude poses a considerable operational difficulty. The problem
can be seen in a particularly acute way when we think about ecosystem services. How do we go about defining the units over which ecosystem services are to be assessed?

The discussion of ‘service-benefit cascades’ (Figure 3.3) suggests that decisions about what constitutes an ecosystem are clearly not solely determined by the way in which ecological structures and functions are thought to be linked up, but also by what features of the system (e.g. outputs, characteristics, or processes etc.) particular people or groups (scientists, managers, policy makers, publics) think are significant. Thus a first key decision to make in any analysis of ecosystem services is whether to approach things from the ‘supply’ or ‘demand’ side – since we cannot assume that the two necessarily match up.

For example, in the context of ‘recreation’, we could look at the capacities of individual habitat parcels to provide recreational opportunities, or moving up a level, all the habitats in a defined area to do so. Such an analysis focuses on the functional characteristics of the habitats and their ability to supply services and benefits. By contrast, we could consider things from the perspective of the consumer – the people who ‘consume’ recreational services. In this case we would need to define the service unit in terms of the way people distribute themselves over space, what particular habitats or places they use and in what combinations and proportions. Demand might be a function of proximity or travel times, and the other cultural characteristics of the area as well as specific capacities associated with individual habitat patches.

The problem of defining service units becomes even more difficult when services are consumed or enjoyed far away from where they are generated (say in the case flood protection and the location of woodlands in the upper catchment), or where demands are not well expressed or identified by ‘consumers’, or easily attached to the characteristics of specific locations (e.g. in the case of clean air).

There is probably no best way of defining what an ecosystem service unit is, since it depends on the specific question being asked. Nevertheless, it is important to note that depending on the approach taken, different conclusions may arise. A mismatch between institutional structures or jurisdictions and the relevant ‘process-response’ unit that delivers a particular set of ecosystem services is often a major cause of management or policy failure (Brunckhorst et al., 2006; Heal et al., 2001). Since decision making is often ‘place-based’ it is important to try to ensure that the geographical scope of the policy or management problem is drawn appropriately, as the EsA principles emphasise, even though these units may cut across the boundaries of the ecosystems that give rise to a particular service and the needs of the people who depend on it. The difficulties of achieving this aim are discussed in Part 6.

The methodological issues surrounding the definition of ecosystem service units are actively being discussed in the research literature. For example, the concept of Service Providing Units (SPU)23 proposed by Luck et al. (2003) has attracted considerable recent attention24 as a framework for identifying quantitative links between components of ecosystems and service provision. Brainard et al. (2001) and others have looked at modelling demand, in the context of understanding how particular services might be valued. However, there is at present little agreement about what the relevant assessment units are for ecosystem services as a whole. As a result we have chosen to take a pragmatic approach as the basis for this study – and mainly to use the habitat level as a framework for thinking about the problem.

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23 SPU as defined in Rubicode is “the characteristic of biodiversity required to deliver a given ecosystem service at the level needed by service beneficiaries” (www.rubidoce.net)
24 www.rubicode.net/
3.4 Linking Ecosystem Services and the EsA

From the material presented here it is apparent that if the assessment and management of ecosystem services is a priority, then setting these activities within a more general Ecosystem Approach is probably essential. Indeed it could be argued that encouraging people to think about ecosystem services might be the best way of leading them to apply ‘EsA thinking’, particularly in the context of developing sustainable development strategies. The propositions made in the EsA, about appropriate or desirable ‘decision making styles’ and ‘whole-systems’ perspectives, seem to follow once the link between ecological services and human well-being is accepted (see Müller and Burkhard, 2007, e.g. Fig.2). Thus the EsA and the ‘ecosystem-services’ paradigm are mutually supportive sets of ideas – and in making the case for one – it is difficult not to make the case for the other.

In the UK, the Biodiversity Action Plan (BAP) Broad and Priority Habitats represent a convenient and pragmatic unit for exploring how an assessment for ecosystem services might be made. They have been used to identify many of the conservation issues facing ecological systems at national scales. They are also a useful framework to consider because they are the basis of a broad range of policies and management initiatives aimed at sustaining many of our most important ecological assets. By focusing upon them we may ask, with particular reference to the EsA:

1. Are the BAP habitats a suitable unit of assessment for ecosystem services, do they allow us to think about services in an integrated way at appropriate geographical and temporal scales?

2. Are the management and policy issues that arise in terms of sustaining the output of the services associated with them being dealt with appropriately, or what more would the EsA offer in terms of say more inclusive approaches to decision making?

3. How robust is the evidence that underpins any assessment, and what kinds of information might be needed, particularly in terms of links between ecosystems?

4. What are the limitations of taking a habitats perspective in terms of making an assessment of the outputs of ecosystem services at national, regional and local scales, would such an approach allow the real value of the environment to be understood?

These questions will be considered in the next part of this Report.
Box 3.1: Key messages from Part 3

- The Millennium Ecosystem Assessment (MA) and other initiatives have been useful in moving the debate forward in terms of understanding the link between ecological systems and human well-being.
- However, frameworks used to define ecosystem services tend to conflate processes and outputs, functions and services, making it difficult to operationalise. The MA service typology is best regarded as a set of themes that must be refined and expanded in the context of any particular study, and further work is needed to examine how this can best be done in different situations.
- The difficulty of defining the bounds of ecosystems makes it hard to define units for assessing ecosystem services. Further work is needed on the definition of ecosystem service units.
- In defining what the ‘significant’ functions of an ecosystem are and what constitutes an ‘ecosystem service’, an understanding of spatial context (geographical location), societal choices and values is as important as knowledge about the structure and dynamics of ecological systems themselves.
- Encouraging people to think about ecosystem services might be the best way of leading them to apply ‘EsA thinking’, particularly in the context of developing sustainable development strategies.
- In the English context, an assessment of services from a Biodiversity Action Plan habitats perspective may be a useful starting point for thinking about ecosystem services, because they have been used to collate a large body of information about the pressures upon ecological systems at national scales, and as the basis of national policy. The information produced by such an assessment will help to identify what kinds of contribution the EsA might make at the operational level.
Part 4: Ecosystem Services - Taking a Habitats Perspective

4.1 Introduction

In this Part of our Report, we review current data availability for making an assessment of the services associated with England’s major terrestrial ecosystems. As the discussion in Part 3 highlighted, there are a number of ways in which an ecosystem might be defined. As an initial, exploratory step, our investigation began by considering what might be achieved if we took a ‘habitats perspective’. It was felt that consideration of services by habitat unit would be valuable, given the place which habitat units have in current environmental policy. Since the ‘Broad’ and ‘Priority Habitats’ of the UK Biodiversity Action Plan (see Jackson, 2000) provide a strong and accepted framework for conservation policy and management at national, regional and local levels, it seemed worthwhile to consider the extent to which they might also help understand ecosystem services.

In the UK we are particularly well-placed to explore the merits of a ‘habitats perspective’ to the assessment of ecosystem services, because of the wide acceptance by different organisations of the Biodiversity Action Plan (BAP). A clear advantage of using these habitats as a framework for representing the output of ecosystem services, is that as distinct ecological units they could be seen in terms of the ‘bundles’ of services that they can deliver. As a result, the importance that they have as elements of ‘natural capital’ can be more properly assessed, and any trade-offs in the output of ecosystem services that arise through current or future management choices can be better understood. In short, people already make decisions about Broad and Priority Habitats, and if thinking can be extended to take in issues relating to the maintenance of ecosystem services, then this might be one way of initially testing and eventually promoting the principles underpinning the Ecosystem Approach (EsA).

4.2 Constructing the Evidence Base

4.2.1 Habitat-Service Associations

The BAP system of Broad and Priority Habitats is hierarchical with the former representing the widespread types of habitat that cover the land surface of the UK; altogether 28 Broad Habitats are recognised (if we include Urban), 20 of which are terrestrial and freshwater or aquatic (Table 4.1). Since they are general in character, they contain a good deal of internal ecological differentiation. The Priority Habitats pick out some of this important variation. They nest within the Broad Habitats and denote sub-types that are significant in conservation terms. The term ‘priority’ comes from the fact that they are the parts of the Broad Habitats that are the target of current conservation concern.

Broad Habitats have summary statements associated with them, which give an overview of the current issues affecting them and policies that are relevant to their general management. For the Priority Habitats, however, detailed ‘Action Plans’ documenting the specific management actions and area targets for stock and condition needed to conserve their value are available. For our work we have made a review of these materials, and the documentation arising out of the revision of the original set of BAP targets Priority Habitats made in 2005/6.

Our review of the published materials relating to the BAP Habitats suggested that both in terms of the overall case made for the importance of each Priority Habitat, and in the justifications made for the setting of the new targets for stock and

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25 See for example, [http://www.ukbap.org.uk/](http://www.ukbap.org.uk/) and [http://www.jncc.gov.uk/page-2433#download](http://www.jncc.gov.uk/page-2433#download)
Table 4.1: The Biodiversity Action Plan Broad Habitats

<table>
<thead>
<tr>
<th>Terrestrial and freshwater Broad Habitats</th>
<th>Marine and Coastal Broad Habitats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arable and horticulture</td>
<td>Continental shelf slope</td>
</tr>
<tr>
<td>Acid grasslands</td>
<td>Inshore sublittoral rock</td>
</tr>
<tr>
<td>Calcareous grassland</td>
<td>Inshore sublittoral sediment</td>
</tr>
<tr>
<td>Improved grassland</td>
<td>Littoral rock</td>
</tr>
<tr>
<td>Neutral grassland</td>
<td>Littoral sediment</td>
</tr>
<tr>
<td>Boundary and linear features</td>
<td>Oceanic seas</td>
</tr>
<tr>
<td>Broadleaved, mixed and yew woodland</td>
<td>Offshore shelf rock</td>
</tr>
<tr>
<td>Coniferous woodland</td>
<td>Offshore shelf sediment</td>
</tr>
<tr>
<td>Bogs</td>
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<tr>
<td>Bracken</td>
<td></td>
</tr>
<tr>
<td>Dwarf shrub heath</td>
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<tr>
<td>Fen, marsh and swamp</td>
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<tr>
<td>Inland rock</td>
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<tr>
<td>Montane habitats</td>
<td></td>
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<tr>
<td>Urban</td>
<td></td>
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<tr>
<td>Built up areas and gardens</td>
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<tr>
<td>Rivers and streams</td>
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<tr>
<td>Standing open water and canals</td>
<td></td>
</tr>
<tr>
<td>Supralittoral rock</td>
<td></td>
</tr>
<tr>
<td>Supralittoral sediment</td>
<td></td>
</tr>
</tbody>
</table>

Note: According to the project brief only the terrestrial and freshwater Broad Habitats are considered in this study. For information about how the Broad Habitats are defined and how the Priority Habitats are nested within them see Jackson (2000).

condition, the arguments largely involved conservation-related issues. The value that these habitats had for ecosystem services was only covered implicitly.

Since evidence about the association of ecosystem services and the Broad and Priority Habitats was lacking, we devised a questionnaire that was sent to the lead-name cited in the documentation relating to the target revision for each Priority Habitat. We asked respondents to consider the wider benefits that these habitats might provide and what might be achieved by the revision of the target in terms of securing or enhancing the output of ecosystem services. The ecosystem service typology of the MA was used to prompt those surveyed about the potential services or benefits that might be associated with each habitat. Respondents were also asked if the service-benefit identified was associated only with the Priority Habitat or could be attributed to the wider, Broad Habitat. Altogether 33 people completed the questionnaire, and information on 16 Priority Habitats and information on 15 Broad Habitats was collected by this means.

The coverage and completeness of the information gained through the questionnaire was cross-checked in two ways. First, by a literature review made by the project team, using the Broad and Priority Habitat names as the key search terms and any case studies suggested by our contacts; second via a series of expert workshops. Four workshops consisting of between 4-7 experts from ADAS and other institutions were organised, so that the Broad and Priority Habitats could be considered in related groups (uplands, lowlands, woodlands, and rivers, standing waters and soils). In addition, in an attempt to explore the issues surrounding the woodland Broad Habitat in greater detail, an additional workshop with external experts was organised.

The questionnaire responses, literature review and the workshop discussions produced a database containing 640 'habitat-service' records. Table 4.2 summarises the associations of service-themes and broad habitats identified (Appendix B provides a complete record).
Table 4.2: Association between ecosystem services and the BAP Broad Habitats in England, and the potential pressures upon them.

<table>
<thead>
<tr>
<th>Service-themes</th>
<th>Broad Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aesthetics</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of services</td>
<td>18</td>
</tr>
</tbody>
</table>

### Pressures

|              | Agricultural intensification (crop regime, grazeland) | Atmospheric pollution/dissolve pollution/critical load exceedance | Climate change | Exclosure of woodland, coppicing/planting | Effluent, pollution, freshwater | Erosion | \textit{Eutrophication} pollution (soil + water) | \textit{Flood control} | \textit{Habitat loss} (heath, fens, marshes, peat, water) | \textit{Human disturbance} (agricultural) | \textit{Inappropriate grazing regimes (overgrazing/undergrazing)} | \textit{Infrastructure/Mineral extraction} | \textit{Invasive species (competition, disease, predation)} | \textit{Lack of dead wood} | \textit{Land drainage} (agri, non-agri, infrastructure) | \textit{Flood defence} | \textit{Management (of inappropriate, incl. land abandonment)} | \textit{Natural hazards} | \textit{Natural succession} | \textit{Replanting woodland} with inappropriate tree species | \textit{Urban development} | \textit{Water abstraction} (ground, surface) | \textit{Woodland forestry planting} |
|---------------|------------------------------------------------------|---------------------------------------------------------------|----------------|-------------------------------------------|---------------------------------|---------|------------------------------------------------|-----------------------|------------------------------------------------------|-------------------------------------|----------------------------------------------------------|---------------------------------|------------------------------------------------------------|-----------------------|------------------------------------------------------------|-----------------------------|------------------------------------------------------------|----------------------------------------------------------|------------------------------------------------------------|
|               | 2                                                    | 3                                                             |                |                                           |                                 |         | 3                                              | 3                     | 3                                                      | 2                                    | 3                                                      | 2                               | 2                                                         | 2                     | 3                                                         | 3                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                      | 2                                                         |
|               | 2                                                    | 3                                                             |                |                                           |                                 |         | 3                                              | 3                     | 3                                                      | 2                                    | 3                                                      | 2                               | 2                                                         | 2                     | 3                                                         | 3                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                         |
|               | 2                                                    | 3                                                             |                |                                           |                                 |         | 3                                              | 3                     | 3                                                      | 2                                    | 3                                                      | 2                               | 2                                                         | 2                     | 3                                                         | 3                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                         |
|               | 2                                                    | 3                                                             |                |                                           |                                 |         | 3                                              | 3                     | 3                                                      | 2                                    | 3                                                      | 2                               | 2                                                         | 2                     | 3                                                         | 3                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                         |
|               | 2                                                    | 3                                                             |                |                                           |                                 |         | 3                                              | 3                     | 3                                                      | 2                                    | 3                                                      | 2                               | 2                                                         | 2                     | 3                                                         | 3                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                         |
|               | 2                                                    | 3                                                             |                |                                           |                                 |         | 3                                              | 3                     | 3                                                      | 2                                    | 3                                                      | 2                               | 2                                                         | 2                     | 3                                                         | 3                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                         |
|               | 2                                                    | 3                                                             |                |                                           |                                 |         | 3                                              | 3                     | 3                                                      | 2                                    | 3                                                      | 2                               | 2                                                         | 2                     | 3                                                         | 3                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                         |
|               | 2                                                    | 3                                                             |                |                                           |                                 |         | 3                                              | 3                     | 3                                                      | 2                                    | 3                                                      | 2                               | 2                                                         | 2                     | 3                                                         | 3                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                         |
|               | 2                                                    | 3                                                             |                |                                           |                                 |         | 3                                              | 3                     | 3                                                      | 2                                    | 3                                                      | 2                               | 2                                                         | 2                     | 3                                                         | 3                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                         |
|               | 2                                                    | 3                                                             |                |                                           |                                 |         | 3                                              | 3                     | 3                                                      | 2                                    | 3                                                      | 2                               | 2                                                         | 2                     | 3                                                         | 3                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                         |
|               | 2                                                    | 3                                                             |                |                                           |                                 |         | 3                                              | 3                     | 3                                                      | 2                                    | 3                                                      | 2                               | 2                                                         | 2                     | 3                                                         | 3                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                      | 2                                                         | 2                                                         |

**Notes:** The cross tabulation is based on questionnaire survey results, literature review and expert workshop assessments. The services are separated and colour-coded into Cultural (C), Production (P), Regulating (R) and Supporting (S) groups, and association is indicated by the appropriate colour tone; the cross-hatched cells are those identified in the workshops as probably the most important for each Broad Habitat. Service marked with an F? indicate where some of those consulted argued that the themes represent ecological functions rather than services – but we have retained the MA typology as the basis of this Table. The pressures were identified from the source shown by colour coding, although similar types of pressure were grouped. The Table indicates specific pressure subtypes using letter codes defined in the row title for each pressure. A more detailed breakdown of the pressures for Priority Habitats is given in Appendix D.
Before the results shown in Table 4.2 are discussed in detail a number of general points must be made about the evidence collected:

- Most of the respondents and workshop participants thought that the service themes they identified when prompted about Priority Habitats also applied to the Broad Habitat. Thus we have grouped the service themes by Broad Habitat in Table 4.2, to provide as comprehensive a view as possible. Where there are particular aspects of the Priority Habitat that need emphasising, we will deal with them in the detailed discussion of results.

- The questionnaire responses and workshops showed that people were able to identify potential service-benefit themes associated with a given habitat unit. However, coverage was often uneven. For example, in the questionnaire, only two respondents identified a supporting service as important. In the workshops, it was felt that supporting services, like nutrient cycling, primary productivity and soil formation were relevant in most, if not all habitats. Thus results shown in Table 4.2 show the three supporting services to be fairly ubiquitous across the set of Broad Habitats. Sediment supply emerged as a potential supporting service in the context of supralittoral sediments. Since by definition, the supporting services are not 'final products', the key task in any subsequent analysis is to show how they underpin the other regulating, production and cultural services.

- ‘Biodiversity’ was identified as a benefit by the questionnaire respondents and the workshop participants, but sometimes they could not easily assign it to any of the four service groups (production, regulation, cultural or supporting). In fact, the difficulty of placing biodiversity is also evident in the MA typology, which sees it as encompassing all the services (see Figure 3.2). Since biological activity is inherent in all the so-called services, it is difficult to think of it as a separate service. Most of the difficulty can be resolved by being more specific about what aspect of ‘biodiversity’ is being considered. Thus if it is the role that living organisms play in recreation, through say bird-watching, then the service ‘observing wild-life’ would be a cultural category. Alternatively if ‘biodiversity’ is being considered in terms of importance as a genetic resource, then the service would be classed as provisioning. ‘Biodiversity’ does not therefore appear as a separate category in Table 4.2.

- Given the nature of the questions asked in the survey and workshops those consulted naturally focused on the benefits that the habitats could potentially provide. However, it became clear, particularly in the workshop discussions, that there were often ‘liabilities’ associated with some habitats that also needed to be considered. For example, in relation to questions about ‘disease regulation’, it was noted that some habitats, could be a reservoir of infections, such as Lyme Disease. Although they partly ‘regulated’ the level of disease in the sense of controlling the level of infection, they did not do so in a positive or mitigating sense – which is the way this type of service is described in terms of MA and other service typologies. It was concluded that in the longer term, a much better framework was needed to take account of both the benefits and liabilities that ecosystems might have in relation to human well-being.

4.2.2 Habitat Status, Trends and Pressures in Services

The brief for this study asked us to consider not only the services associated with England’s major terrestrial ecosystems, but also what evidence exists that can provide an insight into their status and trends. The Broad and Priority Habitats framework is particularly valuable in this context because it has been used extensively as a focus for monitoring and assessment activities in the UK.

At the outset it should be noted, however, that while the Broad and Priority Habitats have been used for monitoring, the assessments made have not explicitly concerned
ecosystem services. Rather they have focused on changes in stock and condition, or conservation status, of the habitats themselves, and the factors impacting upon them. Since the mechanisms linking the habitats to services are at present unclear, the extent to which these monitoring data can be used to infer trends in the services themselves is an issue that must be explored critically.

Information about the status and trends of the Broad and Priority Habitats has been summarised in Tables 4.2 and 4.3. The lower half of Table 4.2 provides an overview of the information about the pressures impacting on each habitat unit that were identified from a review of the BAP Broad and Priority Habitats statements and action plans. This has been supplemented by material from information found on the Forestry Commission and Woodland Trust websites, feedback from the questionnaire and workshop consultees, and a review of the reasons leading to unfavourable conservation status of SSSI, obtained from the site monitoring undertaken by Natural England.

Table 4.3 is based on evidence from Countryside Survey 2000, the SSSI condition monitoring data published by Natural England, the status and trends assessment included in the 2005 review of BAP Targets, and the change indicator for each Broad Habitat published in the New Plant Atlas of GB (Preston et al., 2002). In the table, the Broad Habitats are located according to the evidence we have about them in relation to changes in stock and condition. The evidence underpinning the Table is provided in Appendix C.

**Table 4.3: Overview of changes in stock and condition of Broad Habitats in England**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Stock</th>
<th>Stable</th>
<th>Increasing</th>
<th>Unknown stock trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Declining</td>
<td></td>
<td></td>
<td>Rivers and streams</td>
<td>Broadleaved woodland</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Boundary and linear? ▲</td>
<td>Fen, marsh swamp? ▼</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coniferous woodland</td>
<td>Built up areas and gardens</td>
<td>Inland rock</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acid grassland</td>
<td>Improved grassland</td>
<td>Suprallittoral rock</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Calcareous grassland? ▲</td>
<td>Neutral grassland? ▼?</td>
<td>Suprallittoral sediment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Arable and horticulture? ▲</td>
<td>Standing waters and canals? ▼</td>
<td>Montane</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dwarf shrub heath? ▲</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decaying</td>
<td></td>
<td>Urban</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- This table assigns Broad Habitats by changes in stock and condition over the period 1990-1998 using the results of CS2000, although the placement also took account of other information from SSSI monitoring and the 2005 BAP Targets Review where appropriate.
- The inclusion of evidence other than CS2000 led to the placement of Broad habitats being subject to some qualification; these are indicated by arrows. The arrows should be read as indicating that the assessment is “…likely to be here or in the neighbouring cell”.


The Table was built up as follows:

- The results of Countryside Survey 2000 for England (Norton et al., 2003) were used to make the initial assessment of changes in stock and condition. If we assume that the condition measures in CS2000 can be used to give some insight into the capacity of habitats to deliver ecosystem services, then these data are perhaps the most complete that we presently have and so can be used as a starting point in any analysis. These data cover the period 1990-1998.

- The condition assessment in CS2000 is based on the analysis of change in permanent vegetation plots located in each of the CS sample squares across GB. Changes in vegetation composition between 1990 and 1998 were used to construct a suite of indicators describing, for example, changes in species richness, the relative dominance of competitive species, stress-tolerators and ruderals, and the extent to which composition reflects differences in pH, light conditions, fertility and moisture availability (see Appendix E). The decision about whether condition was stable, declining or increasing was made according to which indicator was most relevant in the context of the ecology of each habitat but it was cross-checked using a number of other sources:
  - The New Plant Atlas indicator change in plant species composition at Broad Habitat level was used to gauge longer term trends in condition between 1930-1969 (the first period) and in 1987-99 (the second survey period); the indicator records the changes in abundance of plants characteristic of each Broad Habitat.
  - If a significant proportion of the stock of a Broad Habitat was included in the SSSI network, then the condition assessment was used as an additional piece of evidence relating to recent change. The Broad Habitat link was made using the 'Main Habitat' field.
  - If the area of a Priority Habitat covers a significant part of the stock of a given Broad Habitat, then the trend reported in the BAP Targets Review was also considered.
  - Finally, if other indicators relevant to the Broad Habitat were available (e.g. for Farmland and Woodland Birds), then these were also taken into account.

- The Urban Broad Habitat is placed alongside Built-up and Garden in Table 4.3. CS2000 does not cover urban areas and so no stock and condition data are available. There are also no SSISIs for which the Main Habitat is urban. On the basis of sources such as CLG’s Land Use Change Statistics, we may assume that the stock of Urban is increasing in England; their condition is however, unknown.

- Stock estimates for the sublittoral rock and sediment and inland rock Broad Habitats are unavailable.

### 4.3 Ecosystem Services and England’s Broad and Priority Habitats

#### 4.3.1 Habitat-Service Associations

The survey and review of services by habitats suggests that there were marked differences between the habitats in terms of the number of service-themes that were identified as being associated with them (Table 4.2). Broadleaved, Mixed and Yew, Dwarf Shrub Heath, Neutral Grassland, Rivers and Streams and Supra-littoral sediment had the most, with over 20 themes identified, while Bracken, Inland Rock and Supra-littoral Rock had the least, with fewer than 10. It is widely recognised that most, if not all ecosystems are ‘multifunctional’ in that the structures and processes within them are capable of

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generating a range of different services (i.e. the systems can be regarded as multi-product or ‘multi-benefit’) (e.g. de Groot, 2006; Mander et al., 2007). The survey and review suggest that this is indeed the case when we view services from a habitats perspective.

Table 4.2 also suggests that while many of the immediate pressures upon the Broad Habitats are wide-ranging, and impact on more than one type, some habitats stand out as being affected by a larger number of pressures than others. Broadleaved and Mixed Woodlands, Bog, Dwarf Shrub Heath, and Fen, Marsh and Swamp are potentially those habitats where the effects of cumulative pressures may be particularly significant.

The analysis shown in Table 4.2 has a number of limitations, however. A particular problem is that the service themes derived from the MA typology are so general that it is difficult not to associate all habitats with all service categories. Within the cultural and provisioning groups, for example, the service themes were identified across many of the Broad Habitats, although there did seem to be more differentiation between habitats in terms of the regulating services. The ubiquitous nature of the supporting services was noted above. The attempt to identify the ‘most important’ services through the workshops did, however, suggest that some clearer differences could be seen between the habitats, but the extent to which Table 4.2 gives a true picture of the individual habitat-service associations or the degree of multi-functionality across the BAP Broad Habitats is unclear.

A second limitation with Table 4.2 is that it gives no indication of the liabilities associated with habitats, only the potential benefits that they might generate. The problem of the association of disease vectors with certain types of habitat (e.g. Lyme disease with Bracken) was noted above. Other examples, of where habitats had both liabilities and benefits associated with them were Arable and Horticultural and Improved Grassland Broad Habitats, which generated impacts on other ecosystems through, for example, diffuse pollution27.

A final limitation of Table 4.2 is that the evidence for the pressures upon the Broad Habitats has been brought together from a diverse range of sources. Since there is no commonly agreed terminology or categorisation of pressures it was difficult to make such an assessment consistent. It cannot be assumed that all the pressures identified are equally significant, or that they all act simultaneously across the geographical extent of a given habitat. It was also apparent that many of the pressures cited may have been more significant in the recent past than at present (e.g. agricultural conversion and boundary removal).

Our review of the evidence available for the individual habitat-service associations and the pressures upon them suggests that it is uneven and incomplete. While some literature sources, for example, simply asserted that a service was important in the context of a given habitat, others provided more detailed accounts of the underpinning ecological mechanisms so that we could be certain that a link existed. In terms of overcoming the knowledge gaps that exist, therefore, we suggest that a more systematic and detailed investigation of the links between habitat characteristics, pressures and service output is needed. Such an analysis would also lead to a better understanding of the ‘multi-functional profile’ of each habitat, which would need to take account of both the potential that the habitat has for supporting a particular service, and some understanding of the relative contribution it makes to the overall output of that service. However, our review also suggests that a simple focus on services would tend to overlook the liabilities or environmental costs that might be associated with certain types of habitat so that the information generated by such an exercise is not sufficient to inform fully societal choice or ensure that a proper account of the value of ecosystems is made. A more integrated cost benefit approach to the assessment of ecosystem services may be necessary

27 This issue is considered further in Part 5.
in a country such as England, where the systems depend on a high level of management inputs.

4.3.2 Implications of Changes in Habitat Stock for Ecosystem Services

As Table 4.3 shows, evidence suggests that the stock of two Broad Habitats, namely Broadleaved and Mixed Woodlands, and Fen, Marsh and Swamp have increased since 1990, while that of Acid Grasslands, Calcareous Grasslands and Coniferous Woodlands has declined. It should be noted, however, that some trends have a high level of uncertainty associated with them, given the difficulty in monitoring the stock of the rarer Broad Habitats, such as Calcereous Grassland. Our review of the stock estimates for a number of Broad and Priority Habitats, including those which we have identified as ‘stable’ in Table 4.3, suggests that much of the basic information needed to make an assessment of state and trends is deficient or conflicting. For example, the estimated area of Bog given by CS2000 is lower than the stock recorded as being within the SSSI network, and much less than that estimated in the 2005 BAP Review.

The analysis of the pressures upon each Broad Habitat shown in Table 4.2 suggest that the main causes of change are related to urban expansion, woodland planting, habitat replacement in the farmed landscape and natural succession brought about by changes in land management.

If we accept that the assessment of recent changes in the stock of Broad habitats shown in Table 4.3 is the best available, then we may ask what implications follow for the services associated with them. The picture is unfortunately complex, not least because we cannot assume that there is a simple linear association between service output and habitat extent, or that all services associated with a habitat operate in the same way.

Our literature review suggests that there is very little empirical evidence available that would enable any quantitative estimates to be made of the way the output of a service might change with change in habitat area. Although for some services (such as carbon storage) we may assume this to be linear, for others, such as biodiversity (i.e. the genetic service) there often appears to be a non-linear relationship between species number and area. Species number tends to increase with the log of habitat area, suggesting that above some limit, changes in area might have a negligible impact on species number (see for example, Lomolino, 2000). Moreover, changes in area may take time to affect the level of service output. This is particularly so in the case of new woodlands, for example, where the services relating to landscape, shelter and biodiversity may only be realised when the stands mature.

Despite gaps in the evidence base relating to the link between habitat stock and service output, as a first approximation it could, nevertheless, be argued that, ignoring any intervening effects of changes in habitat condition. At the individual habitat level the services associated with those habitats that are show as increasing in Table 4.3 are being enhanced or at least sustained. While those services associated with the habitats that are stable or declining are at best maintained or possibly reducing.

If we are to use such data as that shown in Table 4.3 to make a judgement about the possible implications of these changes for services, three key points emerge from our review:

- Some changes in stock are the deliberate result of public policy, and are not necessarily ‘undesirable’. For example, the expansion of Broadleaved and Mixed Woodlands has in many areas been undertaken at the expense of Coniferous Woodlands or one of the intensively managed agricultural Broad habitats, given the

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28 For full analysis of individual Broad Habitats see Appendix D of this report.
policy decision to promote and re-establish native woodlands in England. The BAP Broad and Priority Habitats already have a number of societal values built in.

- Some trends appear to partially offset each other in terms of the overall output of services. The case of Acid Grasslands, which shows a 15% reduction in stock for England between 1990 and 1998, is particularly interesting. The evidence from CS2000 suggests that the losses in stock of Acid Grasslands have mainly been to Improved Grassland, and to a smaller extent Bracken, Bog and Fen, Marsh and Swamp. While these changes might have considerable implications in terms of the genetic resources associated with each habitat, it is not clear that the overall level of, for example, the landscape and recreational service would be changed, or how services associated with water regulation might be modified.

- A number of the BAP targets set in the 2005 Review involved significant increases in the stock of certain Priority Habitats (e.g. Lowland Calcarioue Grassland, Lowland Dry Acid Grasslands, Lowland Heath, Lowland Dry Acid Grassland, and Native Broadleaved Woodlands). The review materials are unclear, however, about wider benefits such expansion would have – other than securing the conservation value of these habitats.

Thus it seems clear that while distinct habitat-service associations might be identified, changes in habitat stock cannot necessarily be used as a simple indicator of changes in a given service. Nor does current evidence allow us to predict what the consequences of changes in the extent of a given habitat might have. **Since changes in stock generally involve the exchange of land area with other types of habitat, the overall implications of change probably have to be looked at in a wider context, or from a whole-systems perspective lending support to the notion that in the context of managing ecosystem services, an Ecosystem Approach will be beneficial.**

### 4.3.3 Implications of Changes in Habitat Condition for Ecosystem Services

The evidence summarised in Table 4.3 suggests that while the overall ecological condition of the Broadleaved and Mixed Woodlands, and Rivers and Streams appeared to be improving, that of Acid and Calcarioue Grasslands, Dwarf Shrub Heath, Arable and Horticulture and Bog appeared to be declining. As in the case of the analysis of implications for changes in stock levels, however, tracing the consequences of these trends for the output of ecosystem services is complex.

**Part of the problem we face in understanding the implications of changes in habitat condition for service output is that most of the measures of condition relate to some aspect of conservation status or biodiversity, and cannot easily be used to assess what this might mean for the output of other services.** Moreover, we cannot assume that changes in condition would affect all the services associated with a given habitat equally. The extent of the evidence available is variable, and much more is known about some habitats than others.

For example, in the case of Acid Grasslands, the results of CS2000 suggest that this Broad Habitat also showed significant changes in vegetation condition, with small but significant increases in the fertility scores of permanent plots and increases in the presence of more competitive species normally associated with more fertile conditions, both measures implying some loss of ecological integrity. Similarly only 75% of the area of SSSIs for which Acid Grassland was recorded as the main habitat type were assessed as being in favourable condition or favourable recovering. However, while the consequences for the genetic resources associated with the Broad Habitat are clear, namely that they might be at risk, the consequences for the landscape, recreational and other regulating functions associated with the habitat are uncertain.

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29 For full analysis of individual Broad Habitats see Appendix D of this report.
By contrast, in the case of the Bog Broad Habitat, a better understanding of the link between habitat condition and service output is available. It is widely accepted, for example, that the loss of functioning Bog ecosystems in England has resulted in considerable reduction in the potential ecosystem services that they can provide. An insight into the scale of loss, and the benefits that might be obtained from their restoration, can be gained by the restoration work currently being undertaken by United Utilities and RSPB in North West England (see case study by Anderson in Kettunen and ten Brink, 2006).

United Utilities own about 57,000ha in the North West, primarily to protect the quantity and quality of water entering reservoirs. Much of the land is also used for agricultural purposes, and historically overgrazing, drainage, reseeding of grasses and fertiliser applications have led to the conversion of bog to other habitats or loss of ecological integrity. As a result there has been a decline in the quantity of water available, and its quality, due to oxidised peat entering drainage systems, thereby discolouring the water. Erosion and oxidation of peat also results in the release of carbon sequestered by the ecosystem (plus methane and nitrous oxide). The restoration work, involving the blocking of drains and reseeding habitats, has been designed to secure the biodiversity value of the Bog habitat in the North West. It also aims to produce major economic benefits in relation to water supply. Andersen (in Kettunen and ten Brink, 2006) reports that the measures to improve water quality will lead to annual savings of between £1.2M to £2.6M, based on the costs of “end of pipe” water treatment that would otherwise be incurred.

The example of the Bog Broad Habitat illustrates how it would be valuable to expand the notions of ecological condition, and particularly conservation status to identify what changes in condition mean for the output of at least the most important services associated with each habitat, and what the wider gains might be of restoring sites from unfavourable to favourable condition. As in the case of the arguments for increases in the stock of the Priority Habitats, the management case for the BAP targets dealing with conservation status would be considerably strengthened if it could be shown what additional benefits would be gained by enhancing or securing the output of ecosystem services.

In terms of achieving the sustainable management of these habitats, the measures of changes in condition should also more explicitly take account of the limits of ecosystem function, so that a better assessment could be made of the significance of the pressures acting upon them. As the summary in Table 4.2 shows, not only do most of the pressures identified appear to act through their impact on condition rather than stock, but many of them affect more than one habitat. The most wide-ranging pressures identified in Table 4.2 include, for example, the effects of atmospheric pollution, eutrophication, overgrazing and inappropriate management. Such patterns suggest that even at the individual habitat level, measures to secure the output of ecosystem services in the face of such pressures would need to be framed on a more general, whole-systems basis if their effects are to be properly managed.

4.4 The Habitats Perspective – An Assessment

Table 4.4 summarises the information gathered on the status and trends of the Broad Habitats and possible implications for the services associated with them.

At the end of Part 3 we posed a number of questions about using the BAP Habitats as a framework for assessing the state and trends of ecosystem services in England. On the basis of the material presented here it is clear that the framework is one in which a significant body of evidence can be brought together and can give insights into:
the possible association between habitats and different types of service;

the ecological state and trends of these habitats as putative ‘service providing units’; and,

the pressures that have in the past, are currently, or might in the future, impact upon these habitats, so that a picture of longer-term trajectories can be built up.

In terms of the overall picture that emerges, as a preliminary assessment it could be argued that at national scales at the individual habitat level, the services associated with the Acid Grassland, Arable and Horticulture, Bog, Calcareous Grasslands, Coniferous Woodlands, Dwarf Shrub Heath, Montane and Standing Waters and Canals and possibly Fen, Marsh Swamp, show evidence of decline, whereas those associated with Broadleaved and Mixed Woodlands, Rivers and Streams are possibly stable or increasing. At this stage, however, we cannot draw any firm conclusions about the overall significance of these changes for individual services, or even what importance to attach to them at the individual habitat level.

The results of the analysis suggests that while the focus on habitat service associations is useful in terms of understanding the mechanisms that generate different types of service, it is probably limited as a way of promoting an Ecosystem Approach to policy and management. On the one hand, it would probably be difficult to address or mitigate the pressures on services by working at the individual habitat level, because they are generally of a more wide-ranging character. On the other, the relationships between habitats, and in particular the different values we place on the services associated with them, need to be considered if an overall assessment of changes in stock and condition are to be made. While the Broad and Priority Habitats may be a useful framework in which to pursue the conservation of biodiversity, other areas of public policy are more concerned with balancing the benefits and liabilities associated with different kinds of habitat against each other. These cross-habitat assessments cannot easily be made if we restrict ourselves to thinking about services only at the individual habitat level. In an attempt to find ways of overcoming these problems, we turn now to a review of what a more ‘service-orientated’ perspective might offer.

Box 4.1: Key messages from Part 4

- The BAP Broad and Priority Habitats provide a convenient framework in which to think about the mechanisms that generate ecosystem services and the pressures that may impact upon them.

- The BAP work also provides a framework in which a large body of information on the state and trends of these potential 'ecosystem service units' can be assessed.

- However, further research is needed to understand how changes in the extent and condition of these habitats affect the output of services potentially associated with them. The evidence available mostly relates to their conservation value, rather than the other cultural, provisioning and regulating services that can be linked to them. The conservation case for the BAP habitats would be considerably strengthened if the implications of changes in stock and condition for ecosystem services could more clearly be set out.

- Further work is also needed to document the liabilities (dis-benefits) associated with particular habitats so that more balanced ecosystem assessments can be made.

- Although the study of services by habitats may be useful in terms of understanding how ecological structures and processes ultimately give rise to particular benefits, a 'habitats perspective' on services is limited in terms of promoting an Ecosystem Approach to management and policy. A more integrated view of services is needed if an overall assessment of the impact of habitat change on service output is to be made, or the impacts of pressures on these services are to be mitigated.
Table 4.4: Summary of changes in stock and condition by broad habitat, impact on services and knowledge gaps

<table>
<thead>
<tr>
<th>Broad Habitat</th>
<th>Assessment</th>
<th>Sensitivities and long term trends</th>
<th>Potential impact on services</th>
<th>Comments on evidence base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid Grassland</td>
<td>▼</td>
<td>• Sensitive to pressures related to land management and diffuse pollution</td>
<td>• Possible loss of genetic services</td>
<td>• More information needed on relationship between ecological condition and the output of cultural, and regulating services</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Medium vulnerability to climate change esp. for Lowland Dry Acid Grassland</td>
<td>• Importance of impact on cultural and regulating services associated with Broad Habitat unknown since habitats replacing Acid Grassland may have similar service associations</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Small increase in area of Lowland Dry Acid Grassland Priority Habitat planned under 2005 BAP Review</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arable &amp; Horticulture</td>
<td>=</td>
<td>• Sensitive to changes in market conditions and regulatory environments</td>
<td>• Potential impact on genetic services associated with Broad Habitat which are not used directly in provisioning activities</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Probably can adapt to changing climate conditions assuming appropriate management and policy interventions</td>
<td>• Impacts of emissions on other habitats potentially significant – externalities need better accounting frameworks</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Marked increase in area of Cereal Field Margins planned under 2005 BAP Review</td>
<td></td>
<td>• More information needed on output of non-market services associated with this Broad Habitat, especially extent of landscape and amenity and species protection</td>
</tr>
<tr>
<td></td>
<td>▼?</td>
<td></td>
<td></td>
<td>• More information needed on quantifying the service benefits associated with targets for expansion of extent of field margins</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• More information needed on extent to which agricultural system can generate additional benefits through assimilation of organic wastes etc.</td>
</tr>
<tr>
<td>Bogs</td>
<td>=</td>
<td>• Sensitive to pressures related to land management (esp. drainage) and diffuse pollution</td>
<td>• Marked impact on regulation services for water quantity and quality</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▼</td>
<td>• Lowland raised bogs have high potential vulnerability to climate change scenarios</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Substantial increase in area of Broad Habitat in favourable condition planned under 2005 BAP Review</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Better information needed on extent of Broad Habitat and variations in condition</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Better inventory information needed to document different categories of bog and its potential for restoring different ecosystem services</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• A better understanding is needed about the way the overall functionality of the ecosystem is reflected in the current criteria used to assess conservation status</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• More research on extent to which restoration methods will restore or secure ecosystem services associated with Broad Habitat</td>
</tr>
</tbody>
</table>

Key ▼ = declining; ▼? Possibly declining; = Stable; ?= Possibly stable; ▲ = Increasing; ▲? Possibly increasing; !=Unknown; Climate change assessment from Hosseil et al. (2000)
<table>
<thead>
<tr>
<th>Broad Habitat</th>
<th>Assessment</th>
<th>Sensitivities and long term trends</th>
<th>Potential impact on services</th>
<th>Comments on evidence base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boundary &amp; linear features</td>
<td>≈? ▲</td>
<td>• Sensitive to changes in land management and especially agri-environmental support • Vulnerability to climate change uncertain • Substantial increase in extent and proportion of Broad Habitat in favourable condition planned under 2005 BAP Review</td>
<td>• Past changes have impacted on ability to deliver genetic and landscape resources</td>
<td>• Better inventory information on stock and condition is needed at local scales, together with information on hedgerow trees • More research is needed into the wider service characteristics of hedgerows, in terms of regulatory functions</td>
</tr>
<tr>
<td>Bracken</td>
<td>≈</td>
<td>• Sensitive to changes in land management, • Low vulnerability to climate change</td>
<td>• Services associated with this habitat are currently not highly valued, although Broad Habitat does have some significance for BAP species, and for landscape • Liabilities associated with habitat often emphasised more than benefits</td>
<td>• Better information is needed to understand the costs and benefits associated with control of bracken in different types of location, especially in terms of nutrient and carbon fluxes</td>
</tr>
<tr>
<td>Broadleaved, Mixed &amp; Yew</td>
<td>▲ ▲</td>
<td>• Sensitive to changes in land management and support through planting and management grants • Probably can adapt to changing climate conditions assuming appropriate management and policy interventions, although effects are likely to vary geographically • Substantial increase in extent and proportion of Broad Habitat in favourable condition planned under 2005 BAP Review</td>
<td>• Non-market benefits associated with this habitat appear to have expanded significantly, and are probably valued more highly • Services associated with some Priority Habitats (Traditional Orchards, and Wood Pasture) may be at risk</td>
<td>• Better inventory information on changes in stock, condition and management status is needed, both for important woodland habitats recognised by the BAP framework, and in terms of woodlands generally (e.g. NIWT) • Publicly available information on woodland stock and condition should be linked to information on the location and purposes of woodland grant scheme agreements, and locations and circumstances where felling licences are granted</td>
</tr>
</tbody>
</table>

Key ▼ = declining; ▼? Possibly declining; ≈ Stable; ≈? Possibly stable; ▲ = Increasing; ▲? Possibly increasing; ! = Unknown; Climate change assessment from Hosell et al. (2000)
<table>
<thead>
<tr>
<th>Broad Habitat</th>
<th>Assessment</th>
<th>Sensitivities and long term trends</th>
<th>Potential impact on services</th>
<th>Comments on evidence base</th>
</tr>
</thead>
</table>
| Calcareous Grassland | ▼ ?≈      | • Sensitive to changes in land management in areas marginal for farming, and impact of diffuse pollution  
  • Probably at medium to high risk under climate change scenarios  
  • Substantial increase in extent and proportion of Broad Habitat in favourable condition planned under 2005 BAP Review | • Possible loss of genetic services, and aesthetic properties of landscape where scrub invasion has occurred  
  • Habitat possibly important for pollinators and for water quality/quantity regulation                                                                 | • Better stock and change data needed; CS2000 estimates are unreliable  
  • Impacts of restoration measures on services other than those related to conservation value need to be investigated                                                                                           |
| Coniferous woodland  | ▼         | • Sensitive to changes in forest and conservation policy, which currently aims to replace stock with native tree species  
  • Sensitive to change in market conditions  
  • Potentially at medium to high risk under climate change scenarios                                                                                                                                  | • Services associated with this habitat are currently not highly valued                                                                                       | • Further information is needed about the effectiveness of restoring coniferous woodland to other habitat types and the costs and benefits involved – other than those associated with the conservation case  
  • The potential benefits of maintaining some old-growth coniferous stands should be investigated                                                                                               |
| Dwarf Shrub Heath    | ≈          | • Sensitive to changes in land management and development pressure in lowland situations.  
  • Possibly at medium levels of vulnerability in terms of climate change  
  • Substantial increase in extent and proportion of Broad Habitat in favourable condition planned under 2005 BAP Review                                                                 | • Past losses have depleted the provisioning (genetic), cultural (landscape) and regulating services associated with this habitat                                      | • Significant knowledge gaps exist in terms of assessing the extent and condition of the Dwarf Shrub Heath resource outside of SSSIs, and therefore of monitoring progress on the BAP Targets  
  • The extent to which the functioning of heathlands can be restored is also uncertain                                                                                                            |

Key ▼ = declining; ▼ ? Possibly declining; ≈ Stable; ?≈ Possibly stable; ▲ = Increasing; ▲ ? Possibly increasing; ! = Unknown; Climate change assessment from Hosell et al. (2000)
### Table 4.4, cont.:

<table>
<thead>
<tr>
<th>Broad Habitat</th>
<th>Assessment</th>
<th>Sensitivities and long term trends</th>
<th>Potential impact on services</th>
<th>Comments on evidence base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fen, Marsh &amp; Swamp</td>
<td>▲</td>
<td>≈? ▼</td>
<td>• Past losses have depleted the provisioning (genetic), cultural (landscape) and regulating services associated with this habitat for water quantity and quality</td>
<td>• Improved systems are needed for monitoring the extent and condition of both wetlands, and upland communities</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• The expansion of Fen, Marsh Swamp may have mainly been due to the increased area of rush dominated pastures and so may have had limited positive impact on the services expected to be associated with this habitat (esp. those related to the wetland types of priority habitat)</td>
<td>• There is considerable interest in the restoration of wetlands at the landscape scale. More research is needed to understand the extent to which wetland restoration can restore the full range of ecosystem services, and to understand how conservation status maps onto underpinning ecological functions</td>
</tr>
<tr>
<td>Improved Grassland</td>
<td>≈</td>
<td>≈</td>
<td>• Potential impact on genetic services associated with Broad Habitat which are not used directly in provisioning activities</td>
<td>• More information needed on output of non-market services associated with this Broad Habitat, especially extent of landscape and amenity, species protection and water storage</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Impacts of emissions on other habitats potentially significant – externalities need better accounting frameworks</td>
<td>• Better systems needed for the surveillance and monitoring of grazing marshes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Further work is needed to develop indices of quality that take all the component interests of grazing marshes into account, including invertebrates, birds, aquatic macrophytes, wet grassland and fen plant species</td>
<td></td>
</tr>
</tbody>
</table>

Key ▼ = declining; ▼ ? Possibly declining; ≈ Stable; ≈? Possibly stable; ▲ = Increasing; ▲ ? Possibly increasing; ! = Unknown; Climate change assessment from Hessell et al. (2000)
Table 4.4, cont.:

<table>
<thead>
<tr>
<th>Broad Habitat</th>
<th>Assessment</th>
<th>Sensitivities and long term trends</th>
<th>Potential impact on services</th>
<th>Comments on evidence base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inland Rock</td>
<td>!</td>
<td>= Unknown</td>
<td>● The service characteristics of this Broad Habitat are uncertain – although they clearly play a role in both landscape and recreational services</td>
<td>● Further work is needed to identify the service associations of this Broad Habitat</td>
</tr>
<tr>
<td>Montane Habitats</td>
<td>!</td>
<td>▼ Unknown</td>
<td>● The service characteristics of this Broad Habitat are uncertain – although they clearly play a role in both landscape and recreational services</td>
<td>● Further work is needed to identify the service associations of this Broad Habitat</td>
</tr>
<tr>
<td>Neutral Grassland</td>
<td>▲</td>
<td>≈?▼ Sensitive to changes in land management and level of agri-environmental support and diffuse atmospheric pollution  ● Lowland Meadow Priority Habitat possibly at medium risk in relation to climate change  ● Substantial increase in extent and proportion of Broad Habitat in favourable condition planned under 2005 BAP Review</td>
<td>● Increases in stock possibly beneficial impact on services associated with this habitat, although lower intensity of agricultural inputs to pastures systems is generally beneficial  ● Expansion of Lowland Meadow Priority Habitat have possibly benefited genetic provisioning services</td>
<td>● Further work is needed to support the conservation studies on scarce animal and plant taxa associated with unimproved neutral grasslands, and to understand the assess the effect of atmospheric nutrient deposition and climate change on community composition, and commission research as appropriate  ● Better surveillance and monitoring programmes are needed to support action plan targets</td>
</tr>
</tbody>
</table>

Key ▼ = declining; ▼ ? Possibly declining; ≈ Stable; ?= Possibly stable; ▲ =Increasing; ▲ ? Possibly increasing; ! =Unknown; Climate change assessment from Hosell et al. (2000)
<table>
<thead>
<tr>
<th>Broad Habitat</th>
<th>Assessment Stock</th>
<th>Sensitivities and long term trends</th>
<th>Potential impact on services</th>
<th>Comments on evidence base</th>
</tr>
</thead>
</table>
| Rivers & Streams       | =                 | • Sensitive to changes in land management and diffuse agricultural pollution  
                       |                   | • Sensitive to water regulation strategies in surrounding catchments, and water abstraction levels  
                       |                   | • Chalk Rivers possibly at high risk in relation to climate change | • General improvement in water quality throughout England, although resource remains vulnerable to agricultural runoff  
                       |                   | • Water (flow) regulation service impaired in some areas by engineering – more sustainable management strategies are being promoted | • In the light of the Water Framework Directive, a better understanding of catchment hydrology, nutrient budgets and loads, and the costs and benefits occurred in relation to delivering the services associated with this Broad Habitat is needed  
                       |                   |                                   | • More research is needed into the limits of tolerable eutrophication and the costs and benefits of different mitigation strategies in different locations, and in particular the effects of eutrophication on recreation and tourism and on the lives of those living and working by affected water courses  
                       |                   |                                   | • Better information is needed on the extent of ecological and social damage brought about by poor water quality and flow regulation, and on the costs of in-water preventative and remedial measures |
| Standing open water & canals | =                   | • Sensitive to changes in land management and diffuse agricultural pollution.  
                       | =? ▼                | • Sensitive to water regulation strategies in surrounding catchments, and water abstraction levels  
                       |                   | • Vulnerability of Mesotrophic Lakes to climate change is probably medium, but is lower for Eutrophic Lakes. Vulnerability of Aquifer Fed Waterbodies is uncertain | • General improvement in water quality throughout England, although resource remains vulnerable to agricultural runoff | • In the light of the Water Framework Directive, a better understanding of catchment hydrology, nutrient budgets and loads, and the costs and benefits occurred in relation to delivering the services associated with this Broad Habitat is needed  
                       |                   |                                   | • More research is needed into the limits of tolerable eutrophication and the costs and benefits of different mitigation strategies in different locations, and in particular the effects of eutrophication on recreation and tourism and on the lives of those living and working by affected water courses  
                       |                   |                                   | • Better information is needed on the stock and condition of the Eutrophic and Mesotrophic Priority Habitats |

Key ▼= declining; ▼? Possibly declining; = Stable; =? Possibly stable; ▲=Increasing, ▲?= Possibly increasing; !=Unknown; Climate change assessment from Hossell et al. (2000)
Table 4.4, cont.:

<table>
<thead>
<tr>
<th>Broad Habitat</th>
<th>Assessment</th>
<th>Sensitivities and long term trends</th>
<th>Potential impact on services</th>
<th>Comments on evidence base</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stock</td>
<td>Condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supralittoral rock</td>
<td>!</td>
<td>≈</td>
<td>Limited evidence available</td>
<td>• Better monitoring and surveillance data are needed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Further work needed to identify how integrated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>coastal management plans, water quality objectives,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>and pollution control and avoidance measures can</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>be integrated to enhance the services associated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>with this Broad Habitat</td>
</tr>
<tr>
<td>Supralittoral sediment</td>
<td>!</td>
<td>≈</td>
<td>Limited evidence available</td>
<td>• Better monitoring and surveillance data are needed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Further work needed to identify how integrated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>coastal management plans, water quality objectives,</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>and pollution control and avoidance measures can</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>be integrated to enhance the services associated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>with this Broad Habitat</td>
</tr>
<tr>
<td>Urban (including build up areas and gardens)</td>
<td>▲</td>
<td>!</td>
<td>N/A</td>
<td>• More research is needed into how better urban</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>design could enhance or expand the provision of</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>non-market environmental services to people, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>minimise the impacts of urban living on surrounding</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>habitats</td>
</tr>
</tbody>
</table>

Key ▼ = declining; ▼? Possibly declining; ≈ Stable; ?= Possibly stable; ▲=Increasing; ▲? Possibly increasing; !=Unknown; Climate change assessment from Hosell et al. (2000)
Part 5: Taking a Service Perspective

5.1 Introduction

To what extent is it possible to take the matrix of habitats and services shown in Table 4.1, and make an analysis of each service on the basis of the individual habitats that potentially contribute to it? The simple answer is that given the current state of knowledge it is difficult. Three issues need to be considered:

First, we would have to assume that the identification of services and their relative importance shown in Table 4.1 for each habitat was comprehensive and that it really did identify those habitats contributing to a given service. Unfortunately, the matrix was put together on the basis of ‘best available information’, and only gives a picture of the link suggested by different commentators. The lack of an association between a habitat and a service may simply mean that there is currently no literature on it, or that those consulted did not feel it was important compared to the other habitat-service associations identified.

Second, even if the matrix of associations between services and habitats shown in Table 4.1 was complete, then we would still need some way of weighting the contribution each habitat to overall service output. To some extent this weighting would have to reflect the extent or quantity of each habitat unit, as well as its capacity to provide that service. As Part 4 suggested, there is little information on the relative importance of different habitats for a given service.

Finally, faced with the task of making an assessment of the state and trends of a service, it may not be appropriate to view it as some aggregation of contributions made by these habitat units at all. The ecological mechanisms that underpin some services (e.g. flood protection) may operate across habitats or depend more on their combinations and patterns, than on the state and dynamics of individual habitats.

As a result it seems unlikely that we can presently use a framework like Table 4.1 to make a direct assessment of the service themes on an all England basis, even knowing what to do about the state and trends of individual habitats. In order to identify what can be achieved, this section of the Report will review each of the service themes in turn and examine what analytical opportunities exist, and how potential barriers might be overcome. In view of the number of service themes identified in Part 4 it is impossible to review them all, however. Thus we focus only on those where we feel progress could be made, or where particular analytical issues arise. Those selected are listed in Table 5.1, together with a summary of the assessment that we have made. The aim of the review presented here is to consider the merits of an explicitly service-orientated perspective. Although we draw upon a range of public attitude and valuation studies, our intention is not so much to provide a critique of the monetary estimates per se, but to examine critically how it conceptualises ecosystem services and whether the models provide an adequate basis for future assessment.

30 Note: the brief of the present study (NR0107) does not include the valuation aspect of services, this part is dealt within another project commissioned by Defra (NR0108), see p.6 of this report for overview.
Table 5.1: Preliminary assessment of trends for selected service themes associated with England’s terrestrial ecosystems.

<table>
<thead>
<tr>
<th>Service group</th>
<th>Service theme</th>
<th>Assessment</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural</td>
<td>Recreation</td>
<td>▲</td>
<td>Recreational provision has improved as a result of forest policy and extension of access rights.</td>
</tr>
<tr>
<td></td>
<td>Aesthetic</td>
<td>?</td>
<td>Unknown, the conceptual frameworks used to assess the aesthetic contribution of landscape service is presently limited.</td>
</tr>
<tr>
<td>Provisioning</td>
<td>Food and fibre</td>
<td>➔ ◄</td>
<td>While the integrity of provisioning services seems stable, the impact of activities associated with the exploitation of this service has major impacts on other ecosystems. Probably declining.</td>
</tr>
<tr>
<td></td>
<td>Genetic</td>
<td>▼</td>
<td></td>
</tr>
<tr>
<td>Regulating</td>
<td>Water quantity</td>
<td>▼</td>
<td>Probably declining but more slowly than in the past. Land cover change is an important driver.</td>
</tr>
<tr>
<td></td>
<td>(flow regulation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water quality</td>
<td>▼</td>
<td>Probably declining but more slowly than in the past; diffuse pollution is a major driver.</td>
</tr>
<tr>
<td></td>
<td>Pollination</td>
<td>▼</td>
<td>Probably declining possibly as the result of loss of food plants</td>
</tr>
<tr>
<td></td>
<td>Climate</td>
<td>?▼</td>
<td>Although opportunities for increased carbon sequestration, the past loss or damage to blanket peat deposits and losses in soil organic carbon suggests that the service have been impaired.</td>
</tr>
<tr>
<td></td>
<td>Assimilation and</td>
<td>P▲</td>
<td>There is the potential to increase the use of this service especially for the assimilation of organic materials.</td>
</tr>
<tr>
<td></td>
<td>purification</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Supporting services were not formally included in the assessment to avoid the problem of ‘double counting’: the assessment made here takes account of changes in any underlying ecological structures, processes or functions.

Key to symbols: ▲ service probably showing a positive trend; ▼ service probably showing a declining trend; ➔ ◄ service provision probably stable; ? some uncertainty associated with the assessment; P there is potential to expand this service.

5.2 Cultural Services

The analysis of cultural services is challenging because unlike regulating and supporting the assessment of the understanding of ecological processes and functions, and the way people use them. This is particularly so in the case of recreation, where the characteristics that may affect the capacity or suitability of a site or habitat for a particular activity can only be identified by knowing what people require. Similar problems arise when we think about aesthetic, cultural and spiritual services. We focus our discussion of these issues on the two cultural services that were cited most frequently in our survey, namely recreation and aesthetics (landscape).

5.2.1 Recreation

At national scales some information about the relative contribution that different types of locality might make to recreational activities can be obtained from sources such as UK Day Visits Surveys of 1994, 1996, 1998 and the GB Day Visits Survey for 2002/3 and the England day Visits Survey of 2005. Unfortunately the types of locality considered are highly generalised, and not easily linked to the BAP Framework, so that any relative ranking of habitat types cannot be made; moreover, since survey methodologies have changed31, it is not always possible to track trends for all types of visit type over time.

In 1998 in the UK it was estimated that there were about 1.1 billion day trips were made in England, of which 321 million were made to woodlands. This figure was about 17% more than the number in 1994. These levels of use were more than double those for canals and rivers. Walking was the most popular activity, but picnicking, cycling, horse riding, bird watching and orienteering are also very popular. The 2002/3 and 2005 Surveys also found woodlands to be more popular than water bodies. However, the differences in methodologies between these and the earlier surveys, means that it is not possible to

compare visitor numbers directly. The 2005 Survey suggested that of the 3.6 billion day
trips taken in England, 170 million were to woodlands, 65 million to water without boats,
and 85 million to water with boats. Total visitor numbers declined between the 2002/3 and
2005 Surveys by around 33%, although the relative popularity of woodlands compared to
the other types remained about the same. Unfortunately, the woodland and water
categories are the only sub-destination recognised as part of a much larger ‘countryside’
destinations type, and so further differentiation by habitat is not possible.\(^{32}\)

Although the reasons for the decline in day visits between 2002/3 and 2005 are unclear, it
is more likely to be due to changes in demand than supply. It is interesting to note that in
terms of changes in ecological status, woodlands stand out as one of the habitats that
have increased both quantitatively and qualitatively, and the general condition of water
bodies (Rivers and Streams, and Standing Water and Canals) also appears to be stable
or increasing. The changes to access arrangements initiated by the Countryside and
Rights of Way Act (CROW) 2000, are also likely to have increased the recreational
capacity of the countryside. **As a result we have suggested that the trend in
recreational service at national scales has probably been one of improvement.** In
future national studies it would be useful to explore in more detail both the reasons for
changes in patterns of use and gain a better insight into the way other habitats within
‘countryside’ are used.

Recreation is an example of a service theme where, if we start from a habitats
perspective, we are quickly led to consider additional attributes, over and above
ecological status, as a way of modelling potential functionality. The study of Brainard et al.
(2001), for example, illustrates the importance of understanding general site
characteristics more fully. These workers looked at 33 forest sites across England, and
found demand for woodland recreation could be modelled using a number of ‘site traits’,
including car park capacity, signage, and general woodland cover close to and in the
general area.

Clearly the particular site characteristics that are relevant will depend on the particular
recreational activity being considered: the requirements of dog walkers are very different
to anglers. Nevertheless, if we take a general recreational activity such as walking, then
with the types of digital map data now available, such OS X-Point, the proximity of sites or
habitat patches to a range of features (e.g. car parks, view points, historic features) that
might, depending on the type of activity being considered, affect their recreational
potential can now be assessed. Moreover, sites can also now routinely be assigned
attributes related to access and tranquility. Access data are available from a number of
sources. As part of the CQC Project\(^{33}\), a dataset was created estimating the length of the
different types of public rights of way in each 1km x 1km cell of the OS National Grid. The
dataset differentiates between footpaths, bridleways, byways open to all traffic (BOAT),
routes used as a public path (RUPP), and an aggregated category covering all other
types, and potentially can be used to either rate particular parcels according to their
access characteristics, or zone whole areas according to the density of access routes
(Figure 5.1). As a result of the CROW Act areas of ‘open countryside’ have now been
mapped, and such data can be used to rate habitat parcels according to different access
criteria.

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\(^{32}\) Although it is possible to identify visits to National Parks and Access Land.

\(^{33}\) “Countryside Quality Counts” [www.cqc.org.uk](http://www.cqc.org.uk)
The rating of sites or habitat patches in terms of their tranquillity is also possible as a result of the national Tranquillity Mapping initiative (MacFarlane et al. 2004). The map gives an aggregated tranquillity score for each 1km x 1km OS grid square in England, which like the access data, can be used to score different localities (Figure 5.2).

Figures 5.1 and 5.2 illustrate how digital map data can be used to build an understanding of the variations in site characteristics that affect ‘recreational capacity’ particularly at local and possibly regional scales. Such mapping exercises clearly provide a foundation on which benefit transfer functions might be built, once valuation studies have been undertaken. They also provide a spatial framework in which we can better understand the way recreational uses relate to the ecological and geographical characteristics of an area. If we can identify the kinds of feature that make a given site more or less suitable for a particular recreational activity, then there is the potential for complementing studies such as those of Brainard et al. (2001) by mapping the ‘supply-side’ of ecosystem services
related to the recreation. **What seems clear, however, is that both aspects must be taken together, since only by understanding what it is that people value about particular types of site or habitat, can we begin to model site capacities to provide a given service.** Given the need to combine biophysical and human perspectives, recreation is also a service that may be best understood and managed using an Ecosystem Approach.

### 5.2.2 The Aesthetic Service

While the analysis of sites for their recreational potential seems tractable, the assessment of the other most widely cited theme in our survey, namely the aesthetic or landscape service, is more complex. Most of the difficulties arise because it is rather poorly conceptualised within the MA framework, particularly when we try to apply it at national or local scales.

Some of the difficulties can be seen by considering the study by Eftec & IEEP (2004) which sought to estimate the landscape and amenity value of agricultural landscapes, as part of a much broader environmental accounting study. Their work is of particular interest because it used the Broad Habitats framework and CS2000 data to calculate the value of landscape amenity services for the agricultural sector (Table 5.2a) and to use these values to calculate the overall costs and benefits of farming in the UK (Fisher, 2007; and O’Neill, 2007) (Table 5.2b).

<table>
<thead>
<tr>
<th>Broad Habitat Type</th>
<th>Feature (from ELF)</th>
<th>National Average WTP per ha per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved Grassland</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Arable and Horticultural</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Dwarf shrub heath</td>
<td>Hay Meadow</td>
<td>131</td>
</tr>
<tr>
<td>Neutral, acid and calcareous grassland</td>
<td>Rough Grazing</td>
<td>84</td>
</tr>
<tr>
<td>Woodland</td>
<td>Woodland</td>
<td>135</td>
</tr>
<tr>
<td></td>
<td>Arable Headlands</td>
<td>25</td>
</tr>
<tr>
<td>Linear features</td>
<td>Hedgerows</td>
<td>21</td>
</tr>
<tr>
<td>Fen, Marsh, Swamp and Bog</td>
<td>Wetland</td>
<td>92</td>
</tr>
</tbody>
</table>

**Table 5.2a: The matching of the ELF model to Broad Habitats for estimating national Willingness To Pay (WTP), undertaken by the Eftec & IEEP (2004) Study**

**Table 5.2b: Value of environmental benefits associated with agriculture in the UK (after Fisher, 2007)**

<table>
<thead>
<tr>
<th>Environmental benefit category</th>
<th>Source</th>
<th>£m per year in 2004 prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of landscape amenity services by the current provision of landscapes</td>
<td>Eftec 2004</td>
<td>498 (~126 for England)</td>
</tr>
<tr>
<td>Value of habitat protection services provided by current land use within the agriculture sector</td>
<td>Eftec 2004</td>
<td>229 (England only)</td>
</tr>
<tr>
<td>Value of species protection services provided by current land use within the agriculture sector</td>
<td>Eftec 2004</td>
<td>313</td>
</tr>
<tr>
<td>Carbon sink service</td>
<td>Hartridge and Pearce</td>
<td>415</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>1455</strong></td>
</tr>
<tr>
<td><strong>Total as % of Gross Value Added of Agriculture £5238m pa</strong></td>
<td></td>
<td><strong>28%</strong></td>
</tr>
</tbody>
</table>
The approach adopted in the Eftec study was based on matching the landscape features used in an earlier IERM & SAC (2001) project to BAP Broad Habitats (see Table 5.2a). The authors acknowledge that this exercise was approximate – but whether or not this was the case, the most significant factor affecting the final overall valuation was the fact that no monetary estimates were made for either Arable and Horticulture or Improved Grassland. Estimates of landscape and amenity services were solely based on the Willingness To Pay (WTP) values and current stock of Neutral Grassland, Bog, Dwarf Shrub Heath, Acid Grassland, Fen Marsh Swamp, and Calcareous Grassland. Even if the landscape value of the two were substantially lower than those to which monetary estimates were assigned, then this would have a significant impact on the final calculation because of the area that Arable and Horticulture and Improved Grassland cover (Table 5.2b). The six Broad Habitats included in the calculation of amenity services associated with landscape cover only about 10% of the land area of England.

The assumption that neither the Arable and Horticultural or Improved Grassland Broad Habitats contribute to landscape is one that could be questioned, given the review presented in Part 4. It cannot be argued that they are essentially artificial or human-made habitats and therefore should be discounted – because the ‘semi-natural’ habitats that were included are as much the result of management activity, albeit at a lower intensity. In his review of the conclusions from his study Fisher (2007) notes that methodologies for estimating both costs and benefits still need to be developed and refined. While these initial valuation studies cannot be criticised on grounds of the lack of availability of data, it is clear that a more integrated conceptual framework for valuation in landscape is needed. As the recent study by Swanwick et al. (2007), for example, confirms, a number of contrasting approaches to the valuation of landscape exist – and much more empirical work is required before the nature of the resource can be fully understood.

The study by Swanwick et al. (2007) compared whether to approach valuation of landscape in terms of its individual elements or to look at it in a more holistic or integrated way. They found that “…the estimation of landscape values is more sensitive to natural, cultural and social conditions of the original surveys than with other environmental goods”, and suggest that the use of “…previous studies for benefits transfer is not likely to be meaningful” (Swanwick et al., 2007, p.58). They recommend a whole-landscape approach, based on a simplified landscape typology that helps identify the important variations between different types of farmed landscape.

In terms of assessing the relative contribution of different habitats to the ‘cultural resource’, the understanding of the landscape or aesthetic service therefore remains particularly problematic. As a result we have suggested in Table 5.1 that it cannot at present be modelled. Compared to the analysis of recreational capacity, it is much more difficult to specify in advance the characteristics of habitats or areas that make them more or less significant in landscape terms, and we are more or less forced to use public values or preferences to weight contributions. It may also be the case that it is not useful to think of the landscape service as being associated with individual habitats at all, but rather to approach the problem at the level of the mosaic of habitats found in an area, and try to understand how the marginal values might change if their relative abundance and spatial patterns are transformed in some way34. This is the approach that has been adopted in the CQC project35 which has sought to make an integrated assessment of the contribution that landscape makes to countryside quality by the analysis of changes in landscape character (Haines-Young, 2007), although no explicit valuation was attempted. The approach is partial, in the sense that the analysis was based on the assessment of professional rather than public values, it indicates how landscape information could be

34 See also European Consortium for Landscape Economics (http://www.ceep-europe.org/index.php)
35 Countryside Quality Counts project (www.cqc.org.uk)
used alongside habitat data for developing and implementing local Biodiversity Action Plans as part of the ‘localism and sustainable communities’ agenda.

5.3 Provisioning Services

5.3.1 Food and Fibre

The fact that many habitats or agricultural cover types generate tangible goods for which there are identifiable markets means that an understanding of their relative importance for provisioning service is fairly straightforward. The ‘final quantities’ needed for the valuation are easy to specify, and the kinds of factors that might affect the productive capacity of systems can in principle be defined. In the case of agriculture, for example, an understanding of site characteristics such as soils, drainage, topography and aspect can be used to predict differences in yield, and thus variations in the quality and quantity of the underlying biophysical asset base on which farming partly depends. Moreover the marginal gains and losses associated with changes in these biophysical inputs can also, in principle, be assessed. A similar argument could be made in relation to the fibre production associated with forests.

Our review of provisioning services suggests that, at least for those for which formal markets exist, the most interesting aspect of the analysis is not so much the mechanisms generating the service per se, but an assessment of the external impacts or environmental costs that this production process has in other kinds of ecosystem service. The Arable and Horticultural and Improved Grassland Broad Habitats are clearly the most important contributors to the production of food and fibre. They are both highly modified, artificial ecological systems that require management interventions that can both generate significant benefits and lead to significant environmental costs. Thus the overall contribution that these habitats make to ‘well-being’ has to be weighed against a number of environmental liabilities that are associated with them.

The importance of calculating the external costs and benefits associated with provisioning services can be illustrated by returning to the recent work of Fisher (2007) and O’Neill (2007) on the external costs and benefits of agriculture in the UK, which attempted to update an initial study made by the Environment Agency in 2002, using the results of the 2004 Eftec Study and data from the 2004 Periodic Review of the Water Industry. These workers estimated that the external environmental costs of agriculture (i.e. in our terms, the environmental costs of supporting the provisioning services associated with the farmed landscape) are about £1bn - £3bn pa or about 20-55% of the industry contribution to GDP (Gross Value Added of Agriculture – at 2004 prices). This calculation is based on the costs imposed on society by the impact of agriculture on water and air quality, and the loss of soil through erosion (Table 5.3).

By contrast, they suggest that the environmental benefits of agriculture are about £1.5bn pa or 28% of agriculture’s Gross Value Added (Table 5.2b). As we have seen the estimation of these benefits was based on the amenity and landscape services, and

<table>
<thead>
<tr>
<th>Environmental pollution or impact category</th>
<th>Agriculture’s cost £m per year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Soil</td>
<td>120</td>
</tr>
<tr>
<td>Water</td>
<td>318</td>
</tr>
<tr>
<td>Air</td>
<td>583</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1021</strong></td>
</tr>
<tr>
<td>Total as % of Gross Value Added at basic prices £5238m in</td>
<td><strong>19%</strong></td>
</tr>
</tbody>
</table>

Note: 2004 prices
species and habitat protection provided indirectly by agriculture and carbon sequestration. Given the magnitude of costs identified, Fisher (2007) concludes that to reduce them in both the short and long term, measures to improve water quality are likely to be the most effective, alongside those directed at better soil management. Measures to reduce the environmental impacts of diffuse air pollution are potentially the most costly. Fisher (2007) concludes his assessment by reviewing existing agricultural and environmental policies and the extent to which they are likely to result in yield significant environmental gains.

This discussion of the external environmental costs and benefits associated with those ecological systems that play an important provisioning role in England, highlights an important area of analysis that is often overlooked in current discussions of ecosystem services, namely that a more balanced ecosystem accounting model is probably more useful in the context of the highly artificial ecosystems that we find in the UK. Since many of these external costs are judged on the basis of impacts on other habitats or biological systems, such an accounting model would have to look at services from an integrated or ‘whole-systems’ perspective. Such an accounting model might, in fact, be the most appropriate one to take the Ecosystem Approach forward in an operational sense. The development of an accounting framework is one that would be particularly beneficial in the context of exploring the implications of different ‘agricultural futures’ for both the nature of the provisioning services associated with agriculture themselves and the overall impact that farming systems have on other ecosystems. Although current climate change forecasts suggest that agricultural yields are likely to be maintained or increase in Northern Europe (IPCC, 2007), the pattern of agriculture in England and its environmental consequences will also be determined by the way global changes impact on world markets more generally.

In Table 5.1 we have provisionally assessed the provisioning services as stable, but highlighted that it is probably the relative costs of impacts on other ecosystem that is of most interest. Our review did not consider provisioning services related to the informal collection of food or other biological materials by people, which in a developed economy such as ours, may be more important culturally than directly for well-being.

The development of an accounting framework is one that would be particularly beneficial in the context of exploring the implications of different ‘agricultural futures’ for both the nature of the provisioning services associated with agriculture themselves and the overall impact that farming systems have on other ecosystems. Although current climate change forecasts suggest that agricultural yields are likely to be maintained or increase in Northern Europe (IPCC, 2007), the pattern of agriculture in England will also be determined by the way global changes impact on world markets more generally.

As Morris et al. (2005) have recently emphasised, in economic terms, a number of different agricultural futures are possible, each of which may have different implications for the environment. Alongside a base-line projection, they considered four contrasting economic scenarios for the period up to 2050, which they called ‘world markets’, ‘global sustainability’, ‘national enterprise’ and ‘local stewardship’. The scenarios differed on two axes, ‘globalisation and independence vs. regionalisation and autonomy’, and ‘consumer/individualism vs. conservation/community’. These researchers argued that land required for lowland intensive farming declines under their ‘business as usual’ scenario and those where the assumptions associated with the world markets or national enterprise scenarios dominate, while there is insufficient land to meet requirements under the global sustainability and local stewardship scenarios, especially if commodities such as energy crops are considered. As a result the balance of ecosystem services associated with them is likely to differ considerably. For example, the market-driven scenarios (‘world markets’ and ‘national enterprises’) all lead to a reduction in overall pressure on natural resources because of the release of land from intensive farming due to competition. As a result, the area of extensive, lower input agriculture may increase,
together with other uses such as nature conservation and woodland expansion. By contrast under scenarios emphasising greater regional autonomy – the extent of more intensive farming is more stable and the pressures it exerts on other ecological systems is maintained.

**Future policies in the provisioning sector, and the way we manage its impact on other ecological systems, will clearly have to take account of a number of competing concerns. In such debates a proper assessment of the impacts that different policy choices might have for natural resource systems, and a balanced evaluation of the costs and benefits of different options will be required. One way of taking the ecosystem approach forward, therefore, would be to further develop environmental accounting methods for the different land use sectors in England, such as agriculture and forestry, by explicitly including consideration of the ecosystem services and the inter-relations between them.**

### 5.3.2 Genetic Services

The provision of genetic resources is often emphasised in discussions about ecosystem services, since it captures many of the underpinning conservation arguments. As the review and survey described in Part 4 showed, most of the Broad Habitats were regarded as important for this service – even those which are not regarded as having a particularly high priority in the BAP process (e.g. Bracken and Coniferous Woodlands). **On the basis of the evidence underpinning recent BAP assessment the overall status of this service must probably be regarded as impaired (Table 5.1).**

The blanket assertion that all habitats are important for biodiversity is not particularly helpful in terms of understanding the relative contributions that different habitats make, or in understanding the significance of the impacts and pressures upon them. Even so, the alternative assertion that some habitats are more important than others needs to be underpinned by some understanding of the nature of the resource being considered. The type of problems we currently face in handling these two positions can be seen by returning to the recent efforts to calculate the external costs and benefits of agriculture and the way the ‘genetic services’ provided by the farmed landscape was assessed.

As noted above (see also Table 5.2b) the estimates for external benefits for agriculture included the species and habitat protection that the farmed landscape provided. It is interesting to note that just as the Arable and Horticultural and Improved Grassland Broad Habitats were assumed to have no value in landscape or amenity terms, they were also not included in the calculation of the benefits arising from species protection. Estimates for the latter were based on the biodiversity values assigned to the same set of semi-natural Broad Habitats that were used for the calculation of the amenity benefit. Moreover, these semi-natural Broad Habitats were only assumed to have a value if they were within the SSSI network and were in favourable condition.

Our critique of studies such as those of Fisher (2007) are not intended to undermine the results of these types of valuation exercise, which are constrained by the availability of data and the difficulties of integrating information from diverse sources. It is apparent, however, that if such work is to be refined, then we need a much better way of assigning relative importance scores to habitats to measure their genetic provisioning role, and of understanding how their condition may affect these relative values. Alternatively we have to find other ways of representing the status of the genetic resource. A number of approaches are possible.

At one level considerable progress has already been achieved through the use of indicators such as those for farmland and woodland birds (Defra, 2007c). Not only can such indicators be presented at both national and regional scales but evidence is becoming available that helps us understand the environmental limits or constraints that need to be considered when framing policy strategies designed to overcome the erosion of these genetic resources.
As Firbank (2005) has emphasised, the decline in biodiversity associated with the agricultural landscape during 20th Century was principally due to the loss of its fine-grained structure and the food sources for birds and small mammals. Following Shrubb (2003), Firbank (2005) notes that in England and Wales in 1960, stubbles covered about 30% of the area of arable crops. By the mid-1990s this had declined to below 5%. Gittings et al. (2005) have shown that if, through agri-environmental schemes, stubble areas can be increased from the current average of 3 ha per 1 km to 10 ha or more, then this should be sufficient to stem breeding bird population declines. In 2005 in England, CS agreements for stubble followed by spring or summer fallow, or a spring crop amounted to about 33,600ha or less than 1% of the Arable and Horticulture Broad Habitat.

A range of indicators for different groups of birds is now available for England. Alongside the indicators for farmland and woodland birds, there are metrics for coastal and seabirds, water and wetland birds, and town and garden birds. For the future it would be useful to extend the suite of indicators available to other species groups (especially mammals, and pollinators – see below) and where possible link them to defined habitat units that have clear policy relevance, even ones formed by aggregating the BAP Broad Habitats into more general units. It would also be useful, for example, to examine whether the indicator for change in the plant species characteristic of each Broad Habitat could be operationalised and updated in using Countryside Survey data, and whether the various other condition measures developed for each Broad Habitat could be aggregated into a single summary measure.

Several simple methods for weighting the importance of each Broad Habitat in terms of

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Links between species and habitats (GB)</th>
<th>Links between species and habitats (England)</th>
<th>No of BAP plans per unit area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid Grassland</td>
<td>14</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>Arable and Horticulture</td>
<td>22</td>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>Bogs</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Boundary and Linear Features</td>
<td>12</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Broadleaved, Mixed and Yew Woodland</td>
<td>159</td>
<td>134</td>
<td>17</td>
</tr>
<tr>
<td>Calcareous Grassland</td>
<td>46</td>
<td>40</td>
<td>143</td>
</tr>
<tr>
<td>Coniferous Woodland</td>
<td>19</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>Dwarf Shrub Heath</td>
<td>44</td>
<td>44</td>
<td>16</td>
</tr>
<tr>
<td>Fen, Marsh and Swamp</td>
<td>37</td>
<td>33</td>
<td>28</td>
</tr>
<tr>
<td>Improved Grassland</td>
<td>16</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>Inland Rock</td>
<td>30</td>
<td>21</td>
<td>210</td>
</tr>
<tr>
<td>Montane Habitats</td>
<td>4</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Neutral Grassland</td>
<td>8</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Rivers and Streams</td>
<td>11</td>
<td>10</td>
<td>36</td>
</tr>
<tr>
<td>Standing Open Water and Canals</td>
<td>33</td>
<td>32</td>
<td>46</td>
</tr>
<tr>
<td>Supralittoral Rock</td>
<td>16</td>
<td>15</td>
<td>136</td>
</tr>
<tr>
<td>Supralittoral Sediment</td>
<td>27</td>
<td>26</td>
<td>144</td>
</tr>
<tr>
<td>Unspecified habitats*</td>
<td>176</td>
<td>99</td>
<td>n/a</td>
</tr>
</tbody>
</table>
this importance as a genetic resource were examined during this study. For example, one approach considered was to develop weighting methods based on the number of native plant species associated with each Broad Habitat using the plot data from Countryside Survey or the New Plant Atlas, expressed on a unit area basis, or the number of BAP Species Action Plans being delivered through each Broad Habitat as being a proxy of its importance in terms of the genetic provisioning service (Table 5.4).

Taking these data alongside the changes in characteristic species recorded in the New Plant Atlas, suggests that the capacity of Acid and Calcareous Grasslands in supporting genetic resources is declining, since both have a relatively high number of Species Action Plans associated with them and they appear to be showing loss of stock and a loss of general plant species characteristic of these habitats. By contrast the Broadleaved Woodlands, and Fen, Marsh and Swamp stand out at increasing their capacity with respect to this service, since they have a high number of Action Plans associated with them and show marked increases in stock between 1990 and 1998; both are relatively stable in terms of the change in characteristic species associated with them according to the New Plant Atlas.

5.4 Regulating Services

The group of regulating services is the largest of the four identified within the MA typology. Our review and survey suggested that unlike the others there was perhaps the greatest differentiation between the habitats in terms of which were cited as important.

5.4.1 The regulation of water quantity and quality

The influence that different types of habitat have on the rate of water flow through the hydrological system is one that is widely cited in the literature on ecosystem services. In the UK, woodlands are, for example, generally thought to be less susceptible to run-off than other types of land cover such as pasture and agricultural crops (Armstrong et al., 1990), while the high densities of artificial surfaces associated with urban areas often lead to much higher rates of run-off.

O’Connell et al. (2004) have recently provided a review of the impact of changing rural land use on flood generation. Their work suggests that while it is important to understand the properties of individual cover types, it is the structure of the overall land cover mosaic and the land use practices associated with it that may be the most important predictor of flood response. Thus, in the post-war period they note that key landscape-scale changes leading to the higher contemporary rates of run-off have included the loss of hedgerows and the creation of larger fields and the installation of land drains connecting the hill top to the channel. A key influence has been the impact of changes in land management on soil structure. Modern cultivation practices have in many arable areas, caused more deeply compacted soils with the consequence that infiltration capacities are reduced and the chances of surface runoff therefore increased.

There have also been many human induced changes to the river networks that have increased the risk of flooding. In the post-war period, as a result of land drainage schemes and flood protection works for urban and rural floodplain areas, river channel form has been highly modified (O’Connell et al., 2004). ‘Engineering solutions’ have included straightening, re-sectioning, embanking, culverting and the construction of weirs and sluices. Coupled with the loss of vegetated riparian buffer zones that can provide space for water during high flow events, such channel changes have also contributed significantly to the frequency of flood events downstream.

In the light of such evidence from studies such as O’Connell et al. (2004) and others, it could be argued that in general terms, largely as a result of human intervention, the level of the ‘water regulation’ service provided by the natural and semi-natural habitats in England has probably declined (Table 5.1).
assessments need to be refined and qualified, however. Not only are the problems arising
out of past approaches to land and river management only to be found in certain areas or
catchments, but also the development of buildings and infrastructure has sometimes
taken place without the risks of inundation being fully taken into account.

The prospect of more frequent flood events as a result of current climate change
forecasts (IPCC, 2007) has given extra impetus to the search for new approaches to
managing water regulation. There has, for example, been a move towards the restoration
of ecosystem function by restoring channels and flood plains to a more natural state.
More broadly, the Government’s current strategy for flood and coastal risk management,
Making Space for Water, (Defra, 2005)\(^\text{36}\), recognises that if problems resulting from
changes in land use and land management are to be dealt with effectively, then a cross-
sectoral approach is needed.

It could be argued that in the area of water flow regulation, an ecosystem or whole-
systems approach designed to manage an important ecosystem service on a more
sustainable basis has already begun to emerge. Indeed this area might be one that
can be used to show how the principles of the EA can be applied at a more operational
level. The need to manage better flood risk provides an opportunity to show how by
focusing on the multi-functional characteristics of ecosystems, more cost effective
broadly-based strategies can be developed.

For example, in addition to its impacts on the dynamics of hydrological systems, changes
in land management have also impacted negatively on the regulation of water quality.
One of the other consequences of agricultural intensification in the post-war period has
been the steady eutrophication of surface and ground waters in England. A variety of
factors is thought to be responsible, including increased levels of fertiliser use, higher
frequency of ploughing, the shift from grass to arable crops, the loss of permanent
pasture in favour of temporary grass, and higher stocking density on the grassland that
remains (cf. Burt, 2001). As we saw in Part 4 of this Report the damage brought about by
inappropriate land management in the uplands of England has also undermined the
capacity of Bog to continue to deliver water of high quality.

In England, Nitrate Vulnerable Zones (NVZs) have been designated under the EC
Nitrates Directive. These cover all areas contributing nitrate pollution to surface and
ground waters and set in place a regulatory framework, designed to control the amount
of nitrate reaching surface and ground waters from sources such as fertilisers and organic
manures. At present NVZs cover 55% of England, but a recent review (ADAS, 2007a)
suggests that these should be extended to around 70%. The designation for surface
waters\(^\text{37}\) is based on the recognition of a limit expressing the maximum tolerable level of
pollution input, namely one where there is a more than 1 in 20 chance of water at a
measurement site exceeding 50 mg/l.

It has been reported that nitrate concentrations in surface waters in England have
stabilised in recent years, probably reflecting the fact that the level of fertiliser inputs have
decreased slowly, partly as a result of the NVZ regulations (ADAS, 2007a). However, given
the observation that nitrate concentrations still remain high in many areas, despite
the reductions achieved by the current NVZ Action Programme, and that the
extension of NVZ designation to other areas is necessary, it must be concluded that the regulation of water quality is a service which is presently still impaired
(Table 5.1).

Although the case of the NVZs illustrates that further work is needed to restore the
‘regulative’ capacity of the habitats associated with our farmed landscape, the progress
that has already been made in terms of improving water quality should not be overlooked.

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\(^{37}\) A similar approach is taken for ground waters
The most recent data suggest that in England 66% of rivers were of good chemical quality in 2006 compared to only 43% in 1990. Between 1990 and 2006 the percentage of rivers of good biological quality in England rose from 60% to 71%. Much of the progress that has been made, however, has probably been achieved by controlling point pollution sources. Diffuse pollution associated with agricultural activities is much more difficult to control.

As in the case of the problems associated with water flow regulation, we have seen in recent years the emergence of more integrated strategies for dealing with the problems of water quality, that are wholly consistent with the principles of the EA. In addition to efforts to introduce codes of good practice, supported by agri-environmental and cross-compliance measures, the recent Catchment Sensitive Farming (CSF) initiative has sought to create integrated approaches for dealing with a number of the problems facing land managers in river catchments across England.

The CSF Programme is a joint initiative between Defra, the Environment Agency and Natural England, which has prioritised 40 catchments as targets for action. Within these catchments a range of measures will be promoted to improve farm practices and reduce diffuse water pollution from agriculture, by bringing together farmers, farm advisers, conservation bodies, water companies, and other stakeholders. What is particularly interesting is that the strategies will not only attempt to deal with the management of nutrients, but also seek to promote good soil structure to maximise infiltration of rainfall and minimise run-off and erosion.

The importance of the CSF initiative and what lessons we may learn from it will be discussed further in Part 6 of this Report. At this stage it is sufficient to note that there significant challenges in the context of managing the regulative capacity of many of the land areas in England in the context of water quantity and quality. However, integrated, or whole-systems strategies, that are consistent EA principles and designed to address issues relating to a range of ecosystem services, already appear to be developing.

5.4.2 Pollination

There are a number of studies from Europe and America that have demonstrated that the loss of natural and semi-natural habitat, such as Calcareous Grassland, can impact upon agricultural crop production through reduced pollination services provided by native insects such as bees (Kremen et al., 2004). Pollinator diversity is essential for sustaining this highly valued service, which Costanza et al. (1997) estimated to be worth about $14 per ha per year.

Despite these concerns, little was known until recently about the patterns of change and what implication the loss of pollinators might have. However, an important addition to the literature has been made by Biesmeijer et al. (2006), who looked at the evidence available for the parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands. These workers compiled almost one million records for all native bees and hoverflies in both countries that could provide evidence of changes in abundance. Their analysis, which compared the period up to 1980 with that since, found that there was evidence of declines in bee abundance in Britain and the Netherlands, but that the pattern was more mixed for hoverflies, with declines being more dependent on location and species assemblage. In both countries those groups of pollinators with the narrowest habitat requirements were the ones to show the greatest declines. Moreover, in Britain, it was found that those plants which are most dependent on insect pollinators (obligatory out-crossing plants) were also declining, compared to other plant groups which depended on water and wind for pollination or were self-pollinating. Wind and water pollinated plants were found to be increasing while those that were self-pollinators were broadly stable.

http://www.defra.gov.uk/farm/environment/water/csf/index.htm
As Biesmeijer et al. (2006) note, while it is difficult to determine whether the decline in insect pollinated plants precedes the loss of pollinators or vice versa, taken together, they suggest that in Britain especially, we are seeing a causal connection between local extinctions of functionally linked plant and pollinator species (Table 5.1). Clearly work needs to be done to explore the implications of these results further, and particularly to understand the differences between Britain and the Netherlands, in terms of the ways the different insect and plant groups have changed over time, and the wider ecological and economic implications. We suggest that Defra should explore how a national ‘pollinator index’ might be created, to sit alongside those for our important bird groups, as a way of monitoring the level of risk to which the pollination services appears to be exposed.

5.4.3. Climate

An important aspect of the ‘climate regulation’ services that ecosystems can potentially provide that has been highlighted in recent discussions is the contribution they make as carbon stores. A number of commentators, for example, have considered what benefits might be gained by using changes in land use and land management as one element of a broader strategy to control carbon-budgets. Since in most terrestrial ecosystems, the amount of carbon in soil is usually greater than the amount in the living biomass, much of the focus has been on the ability of soil to sequester carbon under different conditions.

The discussions about the potential significance of carbon sequestration in soils have partly taken place against the backdrop of evidence that there has been a decline in the organic carbon content of soils in the UK. It has been estimated that since 1980 the average levels have declined on average by 15% in arable and rotational grass soils, 16% in soils under permanent managed grassland, and 23% in soils on agriculturally managed, semi-natural land. Such declines may have obvious implications for the productivity of soils and their vulnerability to the erosion hazard. Setting these issues aside, however, the ‘replacement’ of this carbon in soils may potentially make a contribution to the UK’s commitment to the reduction of CO₂ under the Kyoto Protocol. As a result of this loss of soil carbon, we have assessed this service as probably impaired in Table 5.1

Basing their analysis on a set of statistical relationships between change in soil carbon and various land management practices Smith et al. (2000a & b) considered what the best land use change scenarios were for carbon sequestration. They found that the best single mitigation option was the production of bioenergy crops, but even greater levels of sequestration could be achieved by a mix of strategies involving woodland regeneration, extensification, limited tillage and the application of straw and manure to soils. In this strategy, the bioenergy and woodland regeneration was assumed to take place on ‘surplus’ agricultural land (set at 10% of current 2000 levels), while the other treatments were applied to varying proportions of the existing arable land.

Although Smith et al. (2000a, b) concluded that such strategies could potentially make a significant contribution to the Kyoto carbon emissions target, it has recently been argued that the types of land use strategy considered need to be looked at in a more holistic way, since they also involve other changes that might also have implications for the design and evaluation of climate change mitigation strategies. Thus King et al. (2004) have recently reconsidered the potential carbon sequestration of agricultural soils in England, by looking at the wider energy savings and reductions of greenhouse gas emissions besides CO₂ that might be associated with the land management changes. They used a model-based approach that took account of changes in soil organic carbon, changes in the direct and indirect energy used on site, and changes in the emission from soils of other greenhouse gases such as N₂O. The estimates they presented were for a land use change scenario in which the wooded area of England was increased to the European average (15%), and in
which bioenergy crops covered about 11% of agricultural land, and permanent set-aside field margins amounted to 7.5% of the cultivated area.

King et al. (2004) found that the largest carbon sequestration and saving in energy came from an increase in the proportion of permanent woodland, followed by bioenergy crops, but that the scale of land use change envisaged was probably unrealistic under present conditions. More interestingly, changes in arable management were found to make a significant contribution to an abatement strategy if they involved greater use of permanent conservation field margins, increased returns of crop residues and reduced tillage systems but that the contribution that true soil sequestration made in the overall saving was minor. The main benefits were found to be due to reduced energy use, and lower N₂O emissions from reduced use of inorganic nitrogen fertiliser. The design of climate mitigation strategies that take account of the potential climate regulating services that different types of habitat or land use might provide clearly have to be looked at from a whole-systems perspective.

The need to develop a whole-systems approach is particularly important given the suggestion that expanding woodland cover might make a significant contribution to future climate mitigation strategies. As Post and Kwon (2000) have emphasised in the context of their work on the significance of land abandonment for global carbon budgets, while afforestation may achieve net uptake initially, eventually a new equilibrium is established, once the forests mature.

Forests are major stores of carbon but their role in future emission mitigation strategies also depends on their management and the uses of the products that we generate from them (Figure 5.3). Broadmeadow et al. (2003) have noted not only how the increasing use of wood products has already led to carbon sequestration, but also that over time, through progressive management systems the net effect can accumulate indefinitely. Thus forest industries almost certainly have an important role to play in shaping more sustainable patterns of both production and consumption, through carbon reserve management and carbon substitution management.

Broadmeadow et al. (2003) conclude that it is unlikely that additional planting in the UK could ever be sufficient to offset total emissions, but the ability of forests to sequester carbon could be part of future mitigation strategies. The economic analysis of Forestry Policy in England (CJC, 2003) has also concluded that there is presently no economic case (in the context of Kyoto) for the public procurement of additional carbon sinks through incentives for new planting. Only if the carbon-fixing benefits are considered long-

![Figure 5.3: Woodlands and their role as carbon sinks (Broadmeadow et al., 2003)](image)

(a) Estimated carbon stocks in wood products in primary and secondary use in the UK between 1965 and 2000; land fill not included. Note 90% of wood used in products was imported

(b) Simulated change in carbon stocks in a forest stand over 75 year management cycle. As the volume of wood products and bioenergy harvested through the management cycles increases, the magnitude of the carbon off-set accumulates. For details see Broadmeadow et al 2003)
term might the validity of this conclusion be questioned. They conclude: ‘There is likely to be a case in the future for intervention to support market creation in carbon sequestration. The FC should initially concentrate on this role rather than procurement of carbon fixing benefits through new planting’ (CJC, 2003, p.ii). However, as Kirschbaum (2003) has argued, the design of mitigation strategies is a complex issue and will depend on what we consider the most serious impacts to be, namely those relating to increasing temperatures or accumulating greenhouse gases. If we accept that decisions about future climate mitigation strategies are indeed a matter of societal choice, then the relevance of the EA as a framework for debate is clear.

5.4.4 Assimilation, purification and detoxification

The ‘waste processing’ capacity of ecosystems and their ability to ‘purify’ air or water is often emphasised as an important regulating service. Soils under grassland, crops or other kinds of vegetation can, for example, play a role in the remediation of wastes because of the naturally occurring microbial populations that are found within them, which can metabolise, transform, and assimilate waste constituents. Ultimately elements can be reincorporated into natural biogeochemical cycles. Coastal and riverine sediments may also perform an important assimilative or sink service. Covey and Laffoley (2002), for example, report that during the formation of mud-flats, both heavy metals and radionuclides can be removed from the water column and trapped within the sediment.

In making use of such an ecosystem service, a key issue is to understand the capacity of the system to deal with the potential inputs and, in particular, how this capacity varies over space and time. The nature of the problem can be illustrated by reference to potential strategies for land-based disposal of organic materials and the extent of available capacities, which are being considered as part of the current Defra funded ALLOWANCE Project (ADAS, 2007b).

Currently, 3-4 million tonnes of biosolids (treated sewage sludge) (Water UK, 2006), around 90 million tonnes of farm manures (Williams et al., 2000) and 4 million tonnes of industrial ‘wastes’ (Gendebien et al., 2001) are applied (on a fresh weight basis) annually to agricultural land in the UK. The volume of biosolids, which are a by-product of the wastewater treatment process, has grown since 1991 with the progressive implementation of the EU Urban Wastewater Treatment Directive, the increased levels of treatment needed to meet EU and UK regulatory and policy requirements, and the increased numbers of households and businesses connected to the sewerage network.

The application of organic materials to land is subject to a number of regulations which, for example, ensure that the application rates of specific heavy metals and their concentrations in soils are not exceeded. The regulations also ensure that the disease risks to stock and humans are minimised and that applications should match the requirements of crops. Indeed, the acceptance that the application of livestock effluent to land can have a valuable role as a fertiliser has meant that it falls outside classification as a waste, under the EU Waste Framework Directive. Biosolids provide useful quantities of nitrogen and phosphate, but only modest amounts of potash and magnesium because these elements are quite soluble and are washed out in the treated water. Other types of organic manures, biosolids also help to replenish soil organic matter.

Our review suggests that biosolids probably represent an important resource and that the assimilative capacity of soils is a significant potential service (Table 5.1). Although the evidence on the relative environmental footprints of biosolids vs. chemical fertilisers is incomplete, the information available suggests that the environmental footprint of biosolids is lower than chemical sources. Moreover, disposal of biosolids and similar organic materials through assimilation by soils is potentially the most cost-effective economic and environmental option, compared to the disposal by landfill or incineration.
Preliminary estimates from the ALOWANCE Project suggest that about 8-9 million ha of agricultural land in England and Wales is potentially available for the spreading of organic manures, of which 2–3 million ha is already used for farm-generated manures and excreta deposited during livestock grazing. In the case of biosolids, the available landbank is more limited due to restrictions linked to copping regimes, soil metal levels and pH. However, if we deduct the area already used for farm wastes, then preliminary estimates suggest that there is capacity of around 6 million ha available for spreading other organic materials such as biosolids, composts and paper crumble.

The exploitation of the assimilative capacity of agricultural land for the organic materials generated by Society is clearly a matter of public choice. However, it is clear that providing future strategies take account of the biophysical limits of ecosystem function and the risks associated with any new technologies, there are opportunities to develop new uses for the assimilative services that ecosystems can potentially provide. Although such decisions will have to be taken in the context of more general debates about appropriate patterns of sustainable consumption and production, they would benefit from the kind of ‘whole-systems’ thinking that the EA encourages. Consideration of the assimilation, purification and detoxification services provided by ecosystems in England suggests that the potential future benefits should, however, also be considered as part of any overall assessment of ecosystem services.

In the US Swinton et al. (2006) have emphasised that despite artificiality of agro-ecosystems they have great potential to expand the supply of ecosystem services compared to semi-natural systems. They argue that this is because much more is known about the biophysical relationships within them and we already have precedents for ways to intervene via markets or regulatory mechanisms exist. They also suggest that on grounds of past performance, agricultural systems have the capacity to respond to such external drivers. A similar argument probably exists for agricultural landscapes in England. The greater use of the assimilative capacity of soils may be one activity area in which this can occur.

**5.5 Supporting Services**

The supporting services, which include primary productivity and nutrient cycling, are problematic within the MA typology, in that they are regarded as underpinning the other service themes. Thus and by definition, they do not give rise to the ‘final quantities’ that we need to identify in any understanding of the way services contribute to human well-being. As a result it is difficult to disentangle them from the idea of ecosystem functions that somehow link these more fundamental processes to some output that is regarded as a service.

The need to make a distinction between ‘intermediate’ and ‘final’ services was highlighted in Part 3 of this Report. The distinction is important in that without it, valuation studies run the danger of ‘double counting’ the benefits that ecosystems potentially provide. This does not mean that these supporting services do not need to be considered as part of an overall Ecosystem Approach. The need to sustain underlying ecological or environmental processes is vital to any strategy for sustainable development.

Our review suggests, however, that it is probably premature to make any detailed analysis of how changes in these supporting services should be assessed for England’s terrestrial ecosystem. At this stage we suggest it is probably sufficient to approach the problem within the context of the other types of service, and look at the issue in one of two ways:

- First, by tracking back from the service of interest, through the ecosystem functions to the basic ecological processes on which they depend. In other words, make sure that where ever possible, the analysis of a service or set of services includes information in all the four boxes of the cascade model shown in Figure 3.3.
Second, by tracing the potential impacts of changes in global biophysical and socio-economic drivers, through the level of individual ecosystems, via the more local pressures that act upon them. This approach is evident within the MA process when various scenarios are considered. In the English context, considering the impacts of different climate or socio-economic futures on ecosystem processes could help to develop the EA.

Both approaches are consistent, however, with developing an assessment of ecosystem services within an EA framework.

5.6 The Service Perspective – An Assessment

The aim of Part 5 was to consider the extent to which it is possible to use the matrix of habitats and services shown in Table 4.2 and make an analysis of services. Our review suggests that while it is possible to examine the contribution that different types of habitat make within each service theme, there are few tools available that would allow us to rank or weight habitats for their importance for each service and so use the information we have about their status and trends to say something about the fate of the service as a whole. Nevertheless, while we have been forced to adopt a more piece-meal approach, it is clear that for a number of services a preliminary assessment can be made.

Out of the eight services examined there was evidence of declining or impaired service output for five of them (Table 5.1). The areas of concern were related to the regulation of water quantity and quality, pollination, and the provisioning of genetic resources, and possibly climate regulation. The major drivers of change appeared to be inappropriate land management or cross-sectoral impacts such as those arising from diffuse pollution. By contrast, the recreational service is probably been enhanced, largely as a result of changes in land management (particularly in relation to woodlands) and access arrangements. As noted in section 5.5.4, while there is some evidence of damage to the soil resource, there is possibly be considerable potential for deriving additional benefits from these ecosystems in the area of assimilation and purification, particularly for the treatment of organic wastes. No assessment could be made for the ‘aesthetic’ service associated with landscape because conceptual frameworks are limited.

The assessment presented the selected services is necessarily preliminary. On the one hand, we have considered only a subset of themes covered by the MA typology. On the other, the analysis probably glosses over many qualifications that need to be made about reliability and coverage of the evidence and the way it should be interpreted. In particular some consensus needs to be achieved in terms of the period to which the assessment should be made, and the work extended by looking at possible future trends via a set of agreed scenarios relevant to the English situation.

Clearly the robustness of the analysis made would benefit from a more broadly based consultation across the different topic areas. This kind of process lay outside the brief for this study, and could perhaps only be achieved if a full ‘MA style’ assessment was made at national level. In the context of the present work, the main interest in the analysis represented by Table 5.1 is not, we suggest, primarily the conclusions about the particular service trends, but rather the issues that arose in the attempt to make the assessment. These can be summarised as follows:

- Many of the services, especially the cultural ones, cannot be considered only from the biophysical perspective. The analysis of services such as recreation, for example, are contingent upon an understanding of peoples needs and preferences, and can only be undertaken if approached in an integrated way.
- The exploitation of many services, especially the provisioning capacity of ecosystems, has both costs and benefits for society. Thus any assessment of ecosystem services within an EA framework would have to look at the balance of
costs and benefits probably though some kind of ecosystem accounting framework.

- Of the selected themes, the group of regulating services are those which appear to be most affected by human activities. Some current initiatives to mitigate past damage and restore capacity, particularly in the area of managing water flow and quality, demonstrate the advantages of adopting an Ecosystem Approach, and could be used to identify best practice and operational guidelines.

- The assessment of services can be used to identify both where human action has adversely impacted on a service and where intervention might give rise to additional or new benefits, as in the case of the assimilation of organic wastes, where there is the possibility to exploit ecosystem processes more fully, providing risks are managed appropriately.

The service-based perspective is therefore one which can be used to frame an assessment of the benefits that ecosystems can provide.

Our review suggests that the main short-coming of the service-based perspective is that by taking each service in turn, the links or interactions between services might be overlooked. The approach, unlike the one built around habitats, might therefore not allow the multi-functional characteristics of ecosystems to be fully considered. In the final sections of this Report, we therefore investigate what strategies exist that might allow the insights provided by the two conceptual frameworks to be brought together, so that their strengths can be combined and used most effectively to support decision making.

Box 5.1: Key Messages from Part 5

- Although it is difficult to aggregate up from individual BAP Broad Habitats to make an assessment of the status and trends of ecosystem services, an understanding of habitat-service relationships was useful in developing assessment approaches.

- In some topic areas, especially those relating to the cultural services (e.g. aesthetics-landscape), further work is needed to develop a conceptual framework that would enable an assessment to be made.

- A more balanced assessment of provisioning services consistent with the EA could be made by adopting an environmental accounting framework, within which the costs and benefits of management activities and their impacts can be assessed, and the inter-ecosystem consequences of exploiting the service can be considered.

- Current initiatives to manage human impacts on a number of services, especially those relating to the regulation of water quality and quantity, demonstrate the merits of adopting an EA, and could be used to illustrate the kinds of integrated approach needed for the management of other types of service.

- In making an assessment of ecosystem services, the identification of future potential uses should be considered alongside an analysis of the extent to which current services have been impaired or damaged by human impact or environmental change.
Part 6: Taking a Place-Based Perspective

6.1 Introduction
Two contrasting but complementary approaches to the problem of making an assessment of ecosystem services have been reviewed. The ‘habitats perspective’ took as its starting point the idea that habitats could be used as service-providing units, and an analysis of changes in habitat stock and condition could give us insights into the state and trends of the ecosystem services associated with them. In Part 4 of this Report, such an approach was found to be useful in highlighting the multi-functional characteristics of different habitats, and some of the underlying ecological processes that gave rise to different types of service. The problem with the method was that it was difficult to aggregate up from habitats and make an assessment of each service as a whole. Thus an alternative methodology, which adopted a more explicit ‘service perspective’, was considered.

The service perspective was also found to be useful. Part 5 showed that it allowed the systems that gave rise to each service to be defined in a more flexible way, and enabled a more integrated understanding of the external pressures and drivers that impacted on service output to be developed than was possible by just considering habitats as service providing units. However, the service perspective also had its shortcomings. A problem with the approach was that since the systems generating the service were defined in rather specific ways, the cross-linkages between services and the issues that impinged upon them, were more difficult to discern. The multi-functional characteristics of ecosystems tended to be glossed over by pursuing a service perspective.

In this final, analytical part of our Report we therefore examine a third approach, which takes a ‘place-based perspective’ on the problem. A geographical or spatial approach seems to preserve strengths of each of the other perspectives and the opportunity to develop an integrated view of ecosystem services. Since people tend to make decisions about specific places, a spatial approach may be a useful way of making the principles underlying the EsA operational.

6.2 Context, Scale and Pattern
The primary motive for suggesting a place-based approach is that our review suggests that the assessment of ecosystem services is often context dependent. This can be demonstrated in a number of ways.

For example, a 1% increase in woodland stock in an area of low forest cover will have different implications for landscape compared to the same increase in a well-wooded location. Alternatively, particular combinations of habitats may enhance the output of a service over and above that which might be expected if we made an assessment on an individual habitat basis. Finally, particular groupings of habitats may mean that the output of a service is buffered, or is more resilient, to change. In the uplands of England, landscape quality may have been hardly affected by the loss of Acid Grasslands and the expansion of other types of semi-natural habitat, because all the habitats concerned have similar capacities to generate this particular service. The context or location in which change occurs therefore matters.

Understanding the geographical patterns associated with ecosystem services is also important because change is often uneven. A gain or loss in the output of a service, or a change in the threats or pressures that act on them, may be concentrated in certain places. Thus decision makers will have to make a judgement about the scale and significance of such patterns if they are to make a balanced assessment of the situation. These kinds of issue can be illustrated by looking at the assessment of surface water availability during summer in England (Figure 6.1). Current use levels appear to have
exceeded the ‘limit’ of what is acceptable in parts of southern England, if minimum ecological flows in rivers are to be maintained and the services associated these habitats sustained. Elsewhere the limits of ecosystem functioning are being approached.

Finally the need to adopt a place-based perspective arises because assessments made about the importance of changes in the output of an ecosystem service are also dependent upon the geographical scale at which people ask their questions. Issues that are significant locally may not be important nationally. Moreover, the services themselves might have different geographical ‘footprints’. This is frequently seen with many of the regulating services. While the capacities of ecosystems to regulate soil erosion and climate are both significant, the former is probably of most interest at regional and local scales. In the case of the erosion risk to peat areas in England, the causes of vegetation change and the consequences of vegetation loss are usually concentrated spatially, and so local assessments may be appropriate. By contrast, in the case of climate regulation, the significance of any release of the carbon stored in the peat has consequences far beyond the locality in which any damage to the resource occurs.

The Ecosystem Approach recognises that spatial context and scale matters; the principles set out the proposition that systems have to be viewed and managed at ‘appropriate’ geographical scales. However, while this is undoubtedly the case, the idea poses considerable operational difficulties. Most administrative or decision making frameworks have been drawn up according to other criteria, and their proponents could equally suggest that they are ‘appropriate’ given the social, economic and political systems that they are dealing with. Even if an Ecosystem Approach was accepted, it is difficult to imagine how decision making could be co-ordinated across a series of different biophysical frameworks, each of which might be appropriate for the service being considered, but which may bear little conceptual or physical relationship to each other.

Since the places people make decisions about are also a matter of ‘social choice’, it would be misguided to apply the EsA too strictly, and be prescriptive about what kinds of
spatial framework are to be preferred. In the review that follows we have therefore considered that types of spatial framework that could be useful for assessing the state and trends of ecosystem services, the data resources that underpin them, and how they could be used flexibly in decision making at national, regional and local scales.

6.3 The Spatial Data Resource
6.3.1 Mapping habitats and land cover
A pre-requisite for implementing a place-based approach to assessing ecosystem services is the availability of good map information. Despite the fact that England has some of the best and most comprehensive environmental data in the world, it is still difficult to answer some of the basic questions needed to build up a geography of ecosystem services. Habitat and land cover information, for example, have been gathered for many purposes and through a variety of different survey methods and classifications, and it is not always easy to integrate these data and build the kind of robust evidence base that decision makers require.

Elements of the Broad Habitat Classification, for example, have been used as mapping units for Land Cover Map 2000, and can be mapped against those which have been used for longer periods in the UK (Jackson, 2000), such as Phase 1 (NCC, 1990) and NVC (National Vegetation Classification, see Rodwell, 1991). However, it is important to note that the mapping of categories across different sources is not always straightforward, and generally involves introducing some levels of error, or at the very least uncertainty. For example, Land Cover Map 2000 has attempted to provide complete coverage of the Broad Habitats across the UK, but in practice is was limited to mapping only those that were found to be ‘widespread’. The version currently distributed with Countryside Information System (LCM2000 Blv7) amalgamates the four Broad Habitats: Montane, Dwarf Shrub Heath, Bog and Inland Rock, into a single ‘upland class’, and five others, Neutral Grassland, Calcareous Grassland, Acid Grassland, Bracken and Fen, Marsh & Swamp, into a ‘semi-natural’ class, because of the high level of confusion between these mapping units in the original image classification.

Alongside Land Cover Map 2000, the other easily accessible habitat data sources that could contribute to an EsA are the Natural England habitat inventories. These are based on work over two decades that has attempted to assemble strategic information for a range of habitats, such as their characteristics and location. In many cases the inventories have been constructed using survey information collected over a number of years and so trend information is generally lacking. The original information was also often collected for different purposes and so the quality of mapping varies and inventories are often incomplete. Although recently considerable effort has been made to update and improve and make them available in digital formats, they are stand-alone products and difficult to use alongside other sources of habitat mapping. The inventories are now available for most Priority Habitats (see Table 6.1), although there are few exceptions.

The site condition monitoring conducted by Natural England for SSSIs has also provided important spatial information on habitat distribution and in particular the condition of sites and trends over time. It is based upon the methods developed by Rowell (1993) and Reed & Rowell (1995) which relate monitoring to site objectives developed in the management plan. Under common standards monitoring each SSSI is sub-divided into site recording units to help reduce heterogeneity and to support the management planning and monitoring process. Each unit is visited at least once every five years and the condition of the recorded features recorded. Thus, although statistics are produced annually, perhaps only one fifth of the data are recorded in each year. This approach was
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<td>Mudflats</td>
</tr>
<tr>
<td>Coniferous woodland</td>
<td>Native Pine Woodlands</td>
<td>--</td>
</tr>
<tr>
<td>Broadleaves &amp; Yew woodland</td>
<td>Native Woodland - England</td>
<td>Lowland Beech and Yew Woodland</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lowland Mixed Deciduous Woodland</td>
</tr>
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<td></td>
<td></td>
<td>Upland Mixed Ashwoods</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upland Oakwoods</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Undetermined Woodland</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wet Woodland</td>
</tr>
<tr>
<td>Fen, Marsh &amp; Swamp</td>
<td>Purple Moor-Grass And Rush Pastures</td>
<td>Purple Moor Grass Rush Pastures</td>
</tr>
<tr>
<td>Fen, Marsh &amp; Swamp</td>
<td>Reedbeds</td>
<td>Reedbeds</td>
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<tr>
<td>Unassigned</td>
<td>Saline Lagoons</td>
<td>Saline Lagoons</td>
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<tr>
<td>Broadleaves &amp; Yew woodland</td>
<td>Upland Birchwoods</td>
<td>Will be included in other woodland categories</td>
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<td>Calcareous Grassland</td>
<td>Upland Calcareous Grassland</td>
<td>Upland Calcareous Grassland</td>
</tr>
<tr>
<td>Neutral Grassland</td>
<td>Upland Hay Meadows</td>
<td>Upland Hay Meadows</td>
</tr>
<tr>
<td>Dwarf Shrub &amp; heath</td>
<td>Upland Heathland</td>
<td>Upland Heathland</td>
</tr>
<tr>
<td>Built-up and Garden</td>
<td>Urban (none assigned)</td>
<td>-</td>
</tr>
</tbody>
</table>
designed to support and extend management planning and to provide a means to monitor and report on the effectiveness of management. Clearly it was not designed as a measure of the output of ecosystem services, although as we have argued condition monitoring can contribute useful information to such an assessment.

A comprehensive review of the adequacy of different spatial databases for assessing ecosystem services is outside the brief for this study. However, the experience gained through this review suggests that while the range of spatial information available allows particular aspects of ecosystem services to be explored, the data resource is fragmented and there is at present little incentive to bring the different elements together to construct an integrated data architecture.

For example, while the Natural England habitat inventories provide the most detailed coverage of the extent and distribution of Priority Habitats that is currently available, in their present state they do not provide much information on change in stock or habitat quality. Although they are widely used, it is unclear how representative, accurate or comprehensive they are. Moreover, since a proportion of the inventory sites lies outside the SSSI network, there is no requirement to monitor their condition, even in a modified or simplified way. Unfortunately the monitoring gap cannot be filled by an initiative like Countryside Survey, whose sample-based structure produces results at too coarse a thematic scale to give information at the Priority Habitat level.

Similar problems of integration exist when we consider using the different inventory data alongside more comprehensive mapping products such as Land Cover Map 2000. Information about the location of the inventory sites and SSSIs, like those of other habitat features, such as the woodland parcels mapped in the Forestry Commissions’ National Inventory of Woodlands and Trees, was not used to assist in the construction of LCM2000, nor do the parcels subsequently mapped in the LCM2000 product relate at all well to the boundaries found in the different inventories. Land Cover Map 2000 was produced at quite different scales of thematic and spatial resolution. The extent to which the planned update may overcome these problems remains to be seen.

The advent of digital mapping has done much to improve the range and quality of information available to users, but the data resources remain embedded in different institutional silos and their thematic structure and content reflects different operational and scientific concerns. If an Ecosystem Approach is ever to be made fully operational, then a much more integrated or flexible spatial data infrastructure is required than presently exists. Our assessment of the extent to which current data resources can be used to build a geography of different ecosystem services is that while they are adequate, there are considerable opportunities for improving the range and quality of data resources available to researchers and decision-makers.

6.3.2 Spatial Frameworks

Quite apart from the availability of good quality mapping, there is the issue of the kinds of spatial framework used to display and analyse these data so that geographical patterns can be better understood. A number of different types of spatial reporting units exist, ranging from those that define administrative areas (e.g. the hierarchical system of ‘NUTS’ regions used within the EU39) to those which have a biophysical basis, such as river catchments or environmental zones.

The problem of agreeing an appropriate spatial framework within which to make an assessment of ecosystem services depends on a number of factors. If we are more concerned with understanding the impacts of change in service output for human well-

39 Nomenclature of Territorial Units for Statistics -
being, then it may be more appropriate to look at patterns of supply in relation to the
distribution of people consuming or using the service. If, however, we are more concerned
with the ecological processes that generates a service, or the external pressures that
impact upon them, then a different approach may be needed.

Amongst the regulating services, the issues surrounding the assessment of water flow
and quality stand out as an area where there is a good understanding of the sorts of
spatial framework that are most appropriate for decision making. The concept of a river
catchment is one that especially lends itself to making an integrated place-based
assessment of ecosystem services.

In order to meet the requirements of the EU Water Framework Directive (WFD), the
Environment Agency has undertaken a process of basin characterisation at national
scales. The process has identified what the key issues and constraints are, in terms of
managing the relationships between people, land and water, and in particular has made
an economic assessment of water use. The characterisations have been undertaken at
the regional level, but have been built up from an understanding of the smaller
hydrological units within each area. Although the focus of the characterisation exercise is
on water resources, their management requires consideration of a number of cross-
sectoral issues that relate to other ecosystem services, and so it provides the kind of
spatial framework in which the principles underpinning the EsA might be taken forward.
As a result of the WFD, for each river basin district a river basin management plan has to
be prepared, implemented and reviewed on a six year cycle.

The characterisation of river basis at national scales has led on to more targeted
approaches that further implicitly demonstrate the merits of the EsA as a framework for
assessing and managing ecosystem services. As we saw in Part 5 of this Report, through
the Catchment Sensitive Farming Programme, 40 catchments have been identified as
priority areas for action, mainly on the basis of the need to address the problems of
diffuse agricultural pollution. Again, while the focus in on water quality, the scheme
illustrates how by looking at the multi-functional characteristics of drainage basins, a
range of linked environmental and socio-economic issues can be addressed. Although
the processes leading to the development of River Basin Management Plans, and
the CSF initiative have not explicitly been linked with discussions about the
benefits of the Ecosystem Approach or ecosystem services, at the operational level
they clearly provide material and experience that can stand as a test-case or a
demonstrator for many of the key concepts.

Unfortunately, while drainage basins capture many of the processes and issues that need
to be considered in the context of water regulation, they may not be so useful for other
services, such as those in the cultural group like recreation or landscape, or
understanding the ecological processes linked to the isolation and fragmentation of
habitats, that might be important in sustaining the genetic resources found in an area. In
these situations other types of spatial framework might be more appropriate.

In England, at national scales, the Joint Character Areas (JCAs) provide a spatial
framework in which a range of ecological, social and economic information can be
brought together to understand the implications of change in the countryside. They were
established in the 1990s by the Countryside Agency, English Nature and English
Heritage, when it was recognised that the geographical, ecological and historical
variations in landscape across the country could best described in terms of a set of
discrete ‘character areas’. Although this could clearly have been done at a range of
spatial scales, for the purposes of developing a national overview, the JCAs were thought
to represent units of an appropriate size that could be used to describe the differences in
ways that people could understand. The JCAs have subsequently been used in spatial
planning applications, where they have often been refined through more detailed and

local landscape characterisations, for developing advice to land managers as part of Environmental Stewardship, and as a framework for building indicators of countryside change (Haines-Young, 2007).

While the JCAs are not the only, or best, spatial framework for mapping ecosystem services, these or similar units could be used to make an inventory of services for different areas. They could be used to show how changes in land cover or land management within them might modify the output of services associated with each area. They could also be used to look at patterns of demand for particular services, in that some units quite clearly have a national importance, in terms of their cultural or heritage value. As projects such as CQC41 has demonstrated, while such units as JCAs are socially defined, they can nevertheless be used to monitor the implications of environmental change, because they provide an understanding of contexts and the values people apply in assessing the significance of change.

The suite of spatial mapping techniques now available means that flexible approaches to the definition of spatial frameworks can be adopted. For example, Natural England have partially developed a nested system of ‘landscape description units’, that might be developed to further examine how to map services or underlying functions at different spatial scales42. If structured appropriately, spatial databases can rapidly construct and transform different views of the same underlying data, so that we do not need to confine ourselves to using one spatial framework at the expense of all others. In building the type of integrated spatial data infrastructure that is needed to support an Ecosystem Approach, we suggest that a key requirement is that it should allow the hierarchical relationships between different types of spatial unit to be built. In this way, the place-based approach might be used for any spatial unit we care to define.

6.4 Making Decisions about Services

In the US context, Heal et al. (2001) have argued that ecosystem services might be best understood and protected by defining ‘ecosystem service districts’. They base their argument on the success of soil conservation and flood control districts, which have enabled a range of resources to be managed sustainably at local scales. While the formal designation of service districts may not be appropriate in England, by encouraging people to think about the services associated with the areas they are making decisions about might achieve similar results. The paper by Heal et al. (2001) is particularly interesting because it illustrates how, by focusing on the dynamics of the services associated with a particular place, the consequences of policy or management scenarios can be considered, by looking at the multiple benefits and trade-offs between different outputs (Figure 6.2). The analysis of trade-offs between ecosystem services is an essential part of the EsA, and better decision making tools are needed if the principles are to be implemented and cross-sectoral issues are to be considered appropriately.

As the hypothetical example provided by Heal et al. (2001) illustrates, the particular advantage of a place-based approach is that it seems to lead to consideration of a set of generic issues about ecosystem services that have to be resolved whether we are working at national, regional or local scales. These issues concern deciding what services are important where, what minimum levels of output are required, and how a balance between the outputs of different services can be struck in relation to the interests and needs of different stakeholder groups.

41Countryside Quality Counts, see www.cqc.org.uk
42 There is a national landscape typology at level 1, and a more detailed level 2 classification for parts of England.
management regimes considered in relation to analysis of trade-offs:

(A) convert entirely to pasture;
(B) maintain as mature forest with no harvesting;
(C) adopt sustainable forestry with native species;
(D) conduct unsustainable forestry; and
(E) conduct sustainable forestry with an exotic species

In the graph below the consequences of these management regimes are compared in terms of the different levels of output achieved across four ecosystem services. Service levels are assessed relative to each other, and are represented on an arbitrary scale.

In order to highlight the kinds of issue that need to be resolved generally, and to promote the EsA operationally so that people take account of the links between ecosystem services and human well-being, we suggest that the following questions should be used as a starting point for any assessment:

1. What are the ecosystem services associated with this place that matter to people’s well-being?
2. How are these services generated? Do they arise locally or are they generated outside the place or area being considered?
3. How important is each of these services, to which individuals or groups, and for what reasons? Do people outside the area also depend on these services?
4. How can the importance of these services be prioritised or valued? Do we expect to have enough of each of these services either here or elsewhere in the future? What, if anything, could replace or substitute for each of the benefits obtained from these services, either here or elsewhere?
5. What kinds of management or policy actions are needed to protect or enhance these services and in particular how might actions directed towards one service impact or enhance another?
We have based these questions on a set initially suggested by the *Quality of Life Capital Project*\(^\text{43}\). However, we have revised and extended them, to make the connection to ecosystem services explicit and the link to the Ecosystem Approach clear. If, as we argued in Part 2, the Ecosystem Approach is seen as promoting ‘**inclusive, cross-sectoral decision making at appropriate spatial and temporal scales so that a proper account is taken of the value of environmental systems for the well-being of people**’, then we suggest that by answering them the key themes that the approach seeks to promote can be pursued. The issue of inclusiveness is covered principally by question 3, while the notion of taking proper account of the value of services is covered mainly in 4. Questions 1 and 2 have been included to help people scope the assessment exercise, and to explore the extent to which it is at an appropriate spatial and temporal scale – or at least to identify what scale issues need to be considered. The importance of cross-sectoral links is covered in question 5.

We accept that the language in which these questions are set may need to be simplified, and that some support might be needed to help people answer them. Nevertheless, we suggest that such a place-based framework could be used to encourage people to work through the sorts of issues that need to be considered in relation to ecosystem services when confronted with tasks such as Environmental Impact Assessment (EIA) and Sustainability Impact Assessment (SIA), or when they come to draw up Local Area Agreements or more generally when they need to assess specific policy or management proposals. With all these tasks, there is probably no ‘best’ geographical scale for assessments and there will always be hierarchical relationships that have to be taken into account. However, we suggest that the questions cause people to look at these issues critically, and potentially identify how new and more effective decision making structures can be created. Thus there should be scope to include these sorts of questions within the evolving ‘neighbourhoods’ agenda under development by government and others as part of the new ‘localism’.

In Part 3 it was argued that one of the strengths of the EsA is that it encourages those concerned with policy or management to take a broader perspective by considering the implications of setting or pursuing multiple objectives. In the real world the application of the policy or management is often constrained by narrow organisational responsibilities and institutional structures that limit the capacity to work together. Perspectives are also often constrained by the shortness of political or institutional time-frames and the difficulties of resolving the local and global aspects of problems. **We suggest that the questions outlined above can be used both to help people explore the service characteristics of particular places, and put in place the whole-systems thinking that is needed to implement strategies for sustainable development.**

In terms of taking an assessment of ecosystem services associated with England’s major terrestrial ecosystems forward, we suggest that the spatial framework provided by the Government Office Regions is probably the one that is most appropriate. These geographical scales are more suited to the types of data resources that are currently available. More importantly, there are already institutional mechanisms in place within the Regions for looking at the implications of the UK Sustainable Development Strategy at local scales. With appropriate advice and guidance current approaches could be refined to cover issues linking ecosystem services and human well-being.

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Box 6.1: Key Messages from Part 6

- Although the ‘habitat’ and ‘service’ perspective are useful frameworks for assessing ecosystem services, decision making is generally focused on specific geographical areas. Thus a place-based approach to assessing and managing ecosystem services is also valuable.

- The range of spatial mapping data that is currently available is probably sufficient for an initial assessment to be made at regional scales. However, for the future, better systems for linking information on habitat, land cover, management and monitoring are probably required.

- A place-based perspective on ecosystem services may be an effective way of making the Ecosystem Approach operational. It can encourage people to think about cross-sectoral issues, the appropriate geographical scales for analysis, and the way the values and priorities of different stakeholder groups can be included in decision making.
Part 7: Conclusions and Recommendations

7.1 Introduction
The objectives set for this study were to:

1. establish and agree what an Ecosystem Approach involves and how it can be used to make an assessment of the outputs of ecosystem services at national, regional and local scales; and,

2. understand how the principles of the Ecosystem Approach and the assessment of ecosystem services can be used in decision making at national, regional and local scales.

In order to achieve these objectives we have:

a. considered different methodologies for the classification of England’s terrestrial ecosystems, and how they can be developed to measure the capacity of ecosystems to deliver the services described in the Millennium Ecosystem Assessment;

b. reviewed the existing data and evidence on the state and trends of the terrestrial natural environment in England; and,

c. used these methodologies to provide an initial analysis of the state of England’s ecosystems.

In this final Part of our Report we will provide an overview of the conclusions and recommendations that arise from this work. In particular, we have sought to identify where further work is needed to fill any gaps in the evidence base, and where a more holistic, ‘whole ecosystem’, approach could be beneficial for the management of ecosystems and the services associated with them.

7.2 The Ecosystem Approach
We found that the Ecosystem Approach (EsA) is an appropriate one to use for assessing ecosystem services. It is valuable because it promotes the kinds of inclusive, cross-sectoral decision making that is needed when we consider what constitutes an ecosystem service and how such services might be valued. It also stimulates debate about what the right spatial and temporal scales are for securing the supply of ecosystem services in the future.

Our review showed that while the principles underpinning the EsA are consistent with, and support the current UK Strategy for Sustainable Development, Defra’s draft vision did not show clearly how it could be used operationally. We have suggested one way to promote the EsA is to encourage people to think about the state and trends of ecosystem services and to use this information to develop effective policy and management responses.

We have recommended (Part 2, section 2.2.4) that, while all the principles that underpin the Ecosystem Approach described in the Convention for Biological Diversity are relevant, the way they are expressed in Defra’s current vision for the natural environment should be simplified. In particular they should be focused around the ways it can best deliver the goals of the UK Strategy for Sustainable Development.

The challenge that now confronts Defra, in terms of promoting the principles that underpin the EsA, is to describe them to people in a non-technical way that encourages them to
use them as part of their decision making. One way this could be done is through assessing the links between ecosystem services and human well-being.

One potential next step is a review of the consistency of all Defra's activities and areas of concern using EsA principles. Such a review would provide the evidence necessary to make the case that at the operational level, deficiencies were apparent that could be overcome by application of the concepts and methods embodied in the Ecosystem Approach (section 2.3).

7.3 Assessment Methodologies and Evidence Gaps

7.3.1 Service Typologies

The task of making an assessment of England's major terrestrial ecosystem services is a challenging one because the methods used to make such an assessment are still developing. In developing them further there is also a requirement that they should be designed to provide information that is useful to a wide range of stakeholders and decision makers.

Part 3 of this report reviewed current scientific approaches to the problem of understanding and describing ecosystem services. We found that despite its influence the typology provided by the Millennium Ecosystem Assessment (MA) was problematic, in that many of the service categories were inconsistent, tended to overlap, and did not clearly distinguish between the capacity of ecosystems to deliver a service and the benefit that people might subsequently derive (Part 3, section 3.2.1). As a way forward we suggested that analyses should focus on the idea of 'ecosystem service cascades' (3.2.2) which document how biophysical structures and processes give rise to ecological functions that in turn provides a service that potentially can be quantified in terms of a benefit to people.

The cascade model seemed to resolve the problematic nature of the supporting services defined by the MA that potentially introduce problems of 'double counting' in valuation studies. It also helps make clear the ways that the identification of a service may be contingent on human values or preferences, and the ways in which notions of environmental limits can be used in making judgements about the limits of ecosystem functioning. It is proposed that the MA service typology is best viewed as a checklist of themes that should be refined, expanded and analysed through such a model.

7.3.2 Assessment Perspectives

A key problem that arises in the context of using the Ecosystem Approach, and in assessing ecosystem services, is to define what an ecosystem actually is in operational terms. In our review of the scientific literature we have considered what constitutes an ecosystem service unit, and concluded that currently there are some differences in opinion about how this can best be done.

In order to make progress, this Study considered three distinctive, but complementary perspectives on the problem of making an assessment of England's terrestrial ecosystem services. The work examined their strengths and weaknesses, and the extent to which they could be used given the data currently available.

(a) The 'habitats perspective'

The first perspective used the framework of the Biodiversity Action Plan Broad and Priority Habitats as the basis of the assessment, and looked at the different services that were associated with them. A matrix of associations was constructed using expert judgement and materials derived from an extensive literature review. The so-called
‘habitats perspective’ was useful in identifying the distinctive roles that habitats made to service provision and their multifunctional characteristics. However, by looking at services in a habitat by habitat basis it was difficult to build up a clear picture about what was happening to trends in the supply of services overall.

The habitats perspective was found to be particularly valuable because it had clear policy relevance by linking the assessment of ecosystem services to the Biodiversity Action Plan process. Despite the shortcomings of a habitat-based methodology for assessing services, we recommend that it is one that should be taken further because it would make the BAP conservation case even stronger. In order to take this forward we suggest:

- Those involved in the BAP process and the review of future targets should be encouraged to make the link between the habitats and species that they prioritise and important ecosystem services (section 4.2.1). Such an initiative would be particularly useful at Local BAP level, by involving decision-making bodies like Local Strategic Partnerships and related community groups, and establishing clearer links between the ecosystem services associated with each habitat and benefits local communities and businesses derive from them. This would help bring a place-based perspective, raise awareness, deepen understanding and encourage more cost-effective investment in nature conservation measures.

- Those involved in monitoring the status of BAP Broad and Priority Habitats should be encouraged to extend the range of condition measures employed to include measures that would trace the impacts of changes for the important ecosystem services associated with each habitat, and how these changes link to socio-economic drivers at different levels (section 4.3.3).

- That a more systematic and consistent typology of pressures impacting on habitats and potentially the services associated with them should be developed (4.3.1).

- The quality and coverage of stock and change data needs to be improved, and in particular the problems of inconsistency between different sources (e.g. Countryside Survey, SSSI and EN Habitat inventories, BAP Review Materials) should be resolved (section 6.3.1).

In reviewing the state and trends of the BAP Broad and Priority Habitats it was noted that many of them were vulnerable to changes in land management and that their dynamics were often linked to each other. Thus, a future BAP Targets Review might benefit by being undertaken in the holistic context of the Ecosystem Approach linking state and trends far more directly to socio-economic drivers.

(b) The ‘service perspective’

The second methodology considered in this Study, looked at the problem of assessment from a ‘service perspective’. It focused on the typology of services used in the MA, and habitats, as such, were only considered if they were appropriate for understanding the ecological processes that gave rise to them.

The perspective was found to be effective in making an assessment of some services at the national scale, given the evidence currently available. However, in terms of its contribution to a decision making context, the approach tended to obscure the linkages between services. The multi-functional characteristics of ecosystems could not so easily be identified by adopting this perspective.

Nevertheless, the service perspective was found to be particularly valuable because it clearly linked the notion of services to the problems and opportunities that confront people. Moreover, particularly for the regulation of water quality and quantity, there were clear examples of how the ideas that are implicit in the Ecosystem Approach could be used to mitigate the pressures on these resource systems, and enhance the future
benefits that they can provide, thus improving their sustainability. We recommend therefore that the focus on services is one that should be taken further, particularly in the context of River Basin Planning and management under the Water Framework Directive. In doing so the following issues should be noted:

- The major limitation of the analysis was that on the basis of current knowledge, it was not possible to make an assessment of the aesthetic service because there is little agreement as to how the landscape resource should be conceptualised. Further work is needed to develop better methods for analysis and assessment in the area of cultural services (Section 5.3.2).
- The output of some services, particularly those associated with the highly artificial, ‘social ecosystems’ associated with agriculture, gave rise to both benefits and liabilities (dis-benefits). Further work is needed to bring the assessment of ecosystem services within a robust environmental accounting framework (5.4.1).

(c) A ‘place-based’ perspective

The final methodology for assessing ecosystem services was one that adopted a ‘place-based perspective’. Since decision making is often explicitly concerned with specific geographical areas, methods that encouraged people to think about the relationships between all the important services that an area provides, and how they are changing would seem to be beneficial. Such an approach could also be used to encourage the kind of cross-sectoral partnerships and integrated management approaches needed to achieve the goals of sustainable development. It was suggested that a place-based focus was therefore an ideal way of helping people to apply the principles that underpin the Ecosystem Approach.

The constraint of thinking about ecosystem services in a specific geographical area seemed to overcome many of the problems that surround defining what an ecosystem is. While it may draw upon many of the same data sources used to support the other two perspectives considered, by focusing discussion on a specific area, a simple set of guidelines for analysis can be devised. We have suggested (section 6.4) a set of specific questions that could be used to frame the assessment of ecosystem services in a specific geographical locality that could be used by Defra to encourage people to take up the philosophy embedded in the Ecosystem Approach.

On the basis of the quality of the spatial data and other evidence considered in this Study, we suggest that the spatial framework provided by the Government Office Regions is probably the one that is most appropriate for taking the assessment of ecosystem services forward (section 6.4). While these regions do not represent biophysical units that provide services, they can be used frame a more detailed analysis within them either for specific landscapes or spatial units such as catchments can be investigated. The advantage of using such administrative regions is that the outcomes would be at the right spatial scales to feed into the strategic spatial planning process. This approach could be particularly important, given that the new Planning White Paper makes little reference regional Sustainable Development frameworks.

7.4 The state and trends of England’s terrestrial ecosystem services

The analysis of services by habitat (Part 4) suggested that there was relatively good information available for many of the Broad and Priority Habitats. This allowed an assessment of changes in stock and ecological condition to be made. It was found that out of the 19 Broad Habitats considered:
• There was evidence that nine may be experiencing changes that could impact on service provision, particularly in the area of genetic resources; the evidence was strongest for Acid Grassland, Bog, and Calcareous Grassland.

• One, Broadleaved, Mixed and Yew, showed evidence of change that was possibly enhancing services, particularly in for recreation and landscape.

The analysis of services on a case by case basis considered a selection of the themes covered by the MA. It was found that out of the eight looked at:

• There was evidence of declining or impaired service output for five of them. The areas of concern were related to the regulation of water quantity and quality, pollination, and the provisioning of genetic resources, and possibly climate regulation.

• The recreational service is probably enhancing, and there may be considerable potential for deriving additional benefits from ecosystems concerning assimilation and purification services.

These findings suggest that in terms of managing the pressures upon these resource systems, and of finding ways to enhance, protect and restore the benefits that they provide, an holistic, ‘whole ecosystem’ perspective, such as that promoted by the EsA is required in policy-making and delivery. It should be emphasised, however, that assessments made here are necessarily provisional, and the robustness of the analysis should be tested by more broadly-based consultation in keeping with EsA principles.

On the basis of these findings we therefore recommend that Defra should consider initiating:

• A more detailed place-based assessment of ecosystem services initially at the level of the Government Office Regions in England, and subsequently at more local scales.

• The development of a common set of guidelines and data resources to ensure a flexible but unified approach across the different assessment units is possible.

• A review of how, through the concept of making a place-based assessment of ecosystem services, the principles of the EsA can be incorporated in the current procedures used at regional scales to implement the UK Sustainable Development Strategy. Since the burden of delivery lies with Local Authorities, the review should pay particular attention to the ways in which a place-based approach can be translated from regional down to local scales. The EsA could be developed and promoted as one way in which this might be achieved.

Such an initiative should, we suggest, form part of Defra’s future strategy for ensuring that the principles underpinning the Ecosystem Approach are understood and used more widely in decision making. The work could also contribute to a potential UK and European assessment of ecosystem services.
Appendices
Appendix A: Operational guidance for the Ecosystem Approach\(^4^4\)
(after CBD, 2007)

<table>
<thead>
<tr>
<th>CBD Guidance</th>
<th>Implications for this study (NR0107) and application in practice</th>
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<tbody>
<tr>
<td>1. <strong>Focus on the relationships and processes within ecosystem.</strong></td>
<td>The many components of biodiversity control the stores and flows of energy, water and nutrients within ecosystems, and provide resistance to major perturbations. A much better knowledge of ecosystem functions and structure, and the roles of the components of biological diversity in ecosystems, is required, especially to understand: (i) ecosystem resilience and the effects of biodiversity loss (species and genetic levels) and habitat fragmentation; and (ii) underlying causes of biodiversity loss; and iii) determinants of local biological diversity in management decisions. Functional biodiversity in ecosystems provides many goods and services of economic and social importance. However, whilst accelerating efforts to gain new knowledge about functional biodiversity and ecosystem management is important, decisions about natural resource use are necessary even in the absence of such knowledge. Several specialists and stakeholders contacted in the course of this study strongly advised that <strong>focusing on the benefits to society would be a far more useful and meaningful approach</strong> for facilitating practical management by ecosystem managers (whether local communities or national policy makers) in the absence of total knowledge about ecosystem processes.</td>
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<td>2. <strong>Enhance benefit-sharing.</strong></td>
<td>Benefits that flow from biological processes within ecosystems provide the basis of human environmental security and sustainability. The ecosystem approach seeks to ensure that the benefits derived from these functions are fully maintained or restored through appropriate management. In particular, these functions should directly benefit those stakeholders responsible for their production and management. This requires, inter alia: capacity building, especially at the level of local communities managing biological diversity in ecosystems; the proper valuation of ecosystem goods and services; the removal of perverse incentives that devalue ecosystem goods and services; and, consistent with the provisions of the Convention on Biological Diversity, where appropriate, their replacement with local incentives for good management practices.</td>
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<td>3. <strong>Use adaptive management practices.</strong></td>
<td>Ecosystem processes and functions are complex and variable. Their level of uncertainty is increased by the interaction with social constructs, which need to be better understood. Therefore, ecosystem management must involve a learning process, which helps to adapt methodologies and local practices to the ways in which these systems are being managed and monitored. Implementation programmes should be designed to adjust to the unexpected, rather than to act on the basis of a belief in certainties. Ecosystem management needs to recognise the diversity of social and cultural factors affecting natural-resource use. Similarly, there is a need for flexibility in policy-making and implementation so that local knowledge and understanding is factored into national delivery processes. Long-term, inflexible decisions are likely to be inadequate or even destructive. Ecosystem management should be envisaged as a long-term, adaptive</td>
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</tbody>
</table>
process that builds on its results as it progresses. This "learning-by-doing" will also serve as an important source of information to gain knowledge of how best to monitor and use the results of management and evaluate whether established goals are being attained. In this respect, it would be desirable to establish or strengthen capacities of different policy sectors for sharing monitoring so that the results can be used more effectively.

<table>
<thead>
<tr>
<th>4. Carry out management actions at the scale appropriate for the issue being addressed, with decentralisation to lowest level, as appropriate.</th>
</tr>
</thead>
<tbody>
<tr>
<td>An ecosystem is a functioning unit that can operate at any scale, depending upon the problem or opportunity being addressed. This understanding should define the appropriate level for management decisions and actions. Often, this approach will imply decentralisation to the level of local communities. Effective decentralisation requires proper empowerment, which implies that the stakeholder both has the opportunity to assume responsibility and the capacity to carry out the appropriate action, and needs to be supported by enabling policy and legislative frameworks. Where common property resources are involved, the most appropriate scale for management decisions and actions would necessarily be large enough to encompass the effects of practices by all relevant stakeholders. Appropriate institutions would be required for such decision-making and, where necessary, for conflict resolution. Some problems and issues may require action at still higher levels, through, for example, transboundary cooperation, or even cooperation at global levels.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Ensure inter-sectoral cooperation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>As the primary framework of action to be taken under the Convention, the ecosystem approach should be fully taken into account in developing and reviewing national biodiversity strategies and action plans. There is also a need to integrate the ecosystem approach into the supply chains for agriculture, fisheries, forestry, tourism and other production and consumption systems that have an effect on biodiversity. Management of natural resources, according to the ecosystem approach, calls for increased inter-sectoral communication and co-operation at a range of levels (government ministries, management agencies, etc.). This might be promoted through, for example, the formation of inter-ministerial bodies within the Government or the creation of networks for sharing information and experience. And/or, alternatively, by embedding responsibility for cross-cutting issues within different departments. For example, the partnership working essential for effectively implementing the Water Framework Directive could also be useful for implementing the EsA.</td>
</tr>
</tbody>
</table>
Appendix B: Habitat-Service Database (Example)

Full database is available on an Excel spreadsheet (linked to digital version of this report. If you read a hard copy of this report, go to the project homepage to access excel file).

Example extract for Lowland Dry Acid Grassland Priority Habitat

<table>
<thead>
<tr>
<th>Provisioning services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
</tr>
<tr>
<td>Fibre</td>
</tr>
<tr>
<td>Genetic resources</td>
</tr>
<tr>
<td>Freshwater</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Regulating services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air quality regulation</td>
</tr>
<tr>
<td>Climate regulation</td>
</tr>
<tr>
<td>Water regulation</td>
</tr>
<tr>
<td>Erosion regulation</td>
</tr>
<tr>
<td>Waste management and water treatment</td>
</tr>
<tr>
<td>Disaster regulation</td>
</tr>
<tr>
<td>Pest regulation</td>
</tr>
<tr>
<td>Pollution</td>
</tr>
<tr>
<td>Natural hazard regulation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cultural services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spiritual and religious values</td>
</tr>
<tr>
<td>Aesthetic values</td>
</tr>
<tr>
<td>Recreation and outdoors</td>
</tr>
<tr>
<td>Heritage, archaeological remains</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supporting services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural cycling</td>
</tr>
<tr>
<td>Primary production</td>
</tr>
<tr>
<td>Soil formation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Keywords</th>
</tr>
</thead>
<tbody>
<tr>
<td>REFERENCES</td>
</tr>
</tbody>
</table>
| BODDLETT R.D., STREETER T.C. and BOL R. 2003 Soil microbes compete effectively with plants for organo-
  nitrogen inputs to temperate grasslands. Ecology, 84, 1227-1233. |
  environment, 120, 245-247. |
| LORIOT-NACHI A. and WINESTER M.L. (2000) Pollinators provide economic incentive to
  conserve natural land in agro-
  ecosystems. Agriculture, Ecosystems and Environment, 110, 245-250. |
  cycling and sequestration opportunities in temperate grasslands. Soil Use and Management, 20, 218-230. |

Personal Communication, 1st May 2007, NRO07 ADAS habitat workshop 1: Lowlands, University of Nottingham

Key:

Red text = services identified through expert questionnaire.
Blue text = services identified through ADAS expert workshops.
Black text = services identified through literature review.

Services highlighted in grey were identified by ADAS experts as the most important ones provided by a habitat.
Appendix C: Assessment of Changes in Stock and Condition by Broad Habitat
(Comments in cells are available in the digital version of this report, go to project homepage to access this information)
<table>
<thead>
<tr>
<th>Broad Habitat</th>
<th>Stock trend</th>
<th>SSSI indicator</th>
<th>Plant Atlas Indicator</th>
<th>BAP Indicator</th>
<th>Other Indicators</th>
<th>Overall Condition Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid Grassland</td>
<td>Declining</td>
<td>Declining slowly</td>
<td>Declining slowly</td>
<td>Declining slowly</td>
<td>Reduced but stable- farmland birds Emmissions - reducing slowly</td>
<td>Declining slowly</td>
</tr>
<tr>
<td>Arable &amp; Horticulture</td>
<td>Stable</td>
<td>Declining</td>
<td></td>
<td></td>
<td></td>
<td>Possibly slow decline</td>
</tr>
<tr>
<td>Bogs</td>
<td>Reduced stable</td>
<td>Declining slowly</td>
<td>Declining slowly</td>
<td></td>
<td></td>
<td>Declining slowly</td>
</tr>
<tr>
<td>Boundary and linear features</td>
<td>Reduced stable</td>
<td>Stable</td>
<td></td>
<td>Stable</td>
<td></td>
<td>Stable</td>
</tr>
<tr>
<td>Bracken</td>
<td>Stable</td>
<td>Stable</td>
<td></td>
<td></td>
<td></td>
<td>Possibly stable</td>
</tr>
<tr>
<td>Broadleaved, Mixed &amp; Yew</td>
<td>Increasing</td>
<td>Stable</td>
<td>Mostly increasing</td>
<td>Diminished but stable- woodland birds</td>
<td></td>
<td>Stable or increasing</td>
</tr>
<tr>
<td>Calcareous Grassland</td>
<td>Reduced stable</td>
<td>Stable</td>
<td>Declining</td>
<td>Declining slowly</td>
<td></td>
<td>Declining slowly</td>
</tr>
<tr>
<td>Coniferous woodland</td>
<td>Declining</td>
<td>Stable</td>
<td>??</td>
<td></td>
<td></td>
<td>Possibly stable</td>
</tr>
<tr>
<td>Dwarf Shrub Heath</td>
<td>Stable</td>
<td>Declining</td>
<td>Mostly stable</td>
<td></td>
<td></td>
<td>Declining slowly</td>
</tr>
<tr>
<td>Fen, Marsh &amp; Swamp</td>
<td>Increasing?</td>
<td>Declining?</td>
<td>Stable</td>
<td>??</td>
<td>Reduced but stable- farmland birds Emmissions - reducing slowly</td>
<td>Possibly stable</td>
</tr>
<tr>
<td>Improved Grassland</td>
<td>Stable</td>
<td>Stable</td>
<td>??</td>
<td></td>
<td></td>
<td>Possibly stable</td>
</tr>
<tr>
<td>Inland Rock</td>
<td>Stable??</td>
<td>Stable</td>
<td>??</td>
<td></td>
<td></td>
<td>Possibly slow decline</td>
</tr>
<tr>
<td>Montane Habitats</td>
<td>Stable??</td>
<td>Declining</td>
<td>??</td>
<td></td>
<td></td>
<td>Possibly or declining</td>
</tr>
<tr>
<td>Neutral Grassland</td>
<td>Stable??</td>
<td>Stable</td>
<td>??</td>
<td></td>
<td></td>
<td>Possibly or declining</td>
</tr>
<tr>
<td>Rivers &amp; Streams</td>
<td>Stable</td>
<td>Stable</td>
<td>??</td>
<td></td>
<td>CS2000 condition measures show decline for E&amp;W</td>
<td>Stable or increasing</td>
</tr>
<tr>
<td>Standing open water &amp; canals</td>
<td>Stable</td>
<td>Declining?</td>
<td>Stable</td>
<td>??</td>
<td>Waterways bird survey?</td>
<td>Stable or declining slowly</td>
</tr>
<tr>
<td>Supralittoral rock</td>
<td>Stable??</td>
<td>Stable</td>
<td>??</td>
<td></td>
<td></td>
<td>Possibly stable</td>
</tr>
<tr>
<td>Supralittoral sediments</td>
<td>Stable??</td>
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<td>??</td>
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<td>Possibly stable</td>
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<tr>
<td>Urban</td>
<td>Increasing</td>
<td>Stable</td>
<td>??</td>
<td></td>
<td></td>
<td>Possibly stable</td>
</tr>
</tbody>
</table>

This table was constructed using stock trend data for England derived from CS2000 and 2006 BAP targets review, where appropriate. CS 2007 data on changes in condition were supplemented with information on condition information was obtained from the other sources; the weight of these other sources depended on the proportion of the stock area covered in these assessments (i.e. SSSI condition data only used where it made up a significant proportion of the stock).
Appendix D: Pressures Identified in 2005 BAP Targets Review by Priority Habitat
<table>
<thead>
<tr>
<th>Priority Habitat</th>
<th>Acid Grassland</th>
<th>Forests &amp; Hedgebanks</th>
<th>Bogs</th>
<th>Breckland &amp; Upland Peat</th>
<th>Upland Deciduous Woodland</th>
<th>Boulewarnd Woodland &amp; Wet Woodland</th>
<th>Upland Oakwood</th>
<th>Calcareous Grassland</th>
<th>Upland Brown Woodland &amp; Heath</th>
<th>Fen, Marsh &amp; Swamp</th>
<th>Improved Grassland</th>
<th>Hard Rock</th>
<th>Moraine Habitats</th>
<th>River &amp; Stream</th>
<th>Standing Open Water &amp; Lakes</th>
<th>Tidal &amp; Estuarine Habitats</th>
<th>Coastal Vegetation</th>
<th>Coastal Saltmarsh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural expansion/Intensification (crop regime=c, grassland=g)</td>
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<tr>
<td>Climate change</td>
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<tr>
<td>Deforestation/coppicing/planting</td>
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<tr>
<td>Effluent, pollution/freshwater sediment/discharge of sewage, industrial/commercial, other agrochemicals</td>
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<td>Erosion</td>
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<tr>
<td>Eutrophication pollution (polls, weirs, etc)</td>
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<tr>
<td>Flood/irrigation/irrigation, flood defences</td>
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<tr>
<td>Habitat loss (heath/newt, field margins, trees, heath/wetland)</td>
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<tr>
<td>Human disturbance (eg tourism)</td>
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<tr>
<td>Inappropriate grazing regimes (overgrazing/undergrazing)</td>
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<tr>
<td>Invasive species (competition, disease, predation)</td>
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<tr>
<td>Loss of road/road</td>
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<tr>
<td>Lack of water pollution</td>
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<tr>
<td>Land drainage (for agriculture, infrastructure, flood defence)</td>
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<tr>
<td>Land-based pollution (eg run off)</td>
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<tr>
<td>Management (loss of inappropriate, highland abandonment)</td>
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<tr>
<td>Natural disasters</td>
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<td>Natural succession</td>
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<tr>
<td>Replanting woodland with inappropriate tree species</td>
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<tr>
<td>Urban development</td>
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<tr>
<td>Water extraction (grounding, suffosion)</td>
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<tr>
<td>Woodland/forest planting</td>
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</table>
**Appendix E: Indices of Ecological Condition (Haines-Young et al. 2000, p. 26)**

<table>
<thead>
<tr>
<th>Measures of vegetation condition used in CS2000</th>
<th>Explanatory notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Condition measure</strong></td>
<td><strong>Explanatory notes</strong></td>
</tr>
<tr>
<td>Species richness</td>
<td>Species richness per plot (counting only native and consistently identified species). This is a simple and easily understandable measure of plant diversity. However the interpretation is not always straightforward: It can depend on whether the species increasing or decreasing are considered desirable or not.</td>
</tr>
<tr>
<td>pH score</td>
<td>An indirect measure of change in soil pH. It reflects changes in the abundance of plants that are known to be associated with different levels of pH based on the Ellenberg value for soil reaction of each species.</td>
</tr>
<tr>
<td>Fertility score</td>
<td>An indirect measure of change in soil fertility. It reflects changes in the abundance of plants that are known to be associated with different levels of nutrient availability based on the Ellenberg value for fertility of each species.</td>
</tr>
<tr>
<td>Soil moisture score</td>
<td>An indirect measure of change in soil wetness. It reflects changes in the abundance of plant species that are known to be associated with degrees of wetness based on the Ellenberg value for soil moisture of each species.</td>
</tr>
<tr>
<td>Light score</td>
<td>An indirect measure of change in light availability at ground level. It reflects changes in the abundance of plants that either tolerate shade or cast shade (e.g. woodland plants) through to weeds found in open, often disturbed situations where there is much less shade. This association is based on the Ellenberg value for light of each species.</td>
</tr>
<tr>
<td>Competitor score</td>
<td>Plant strategy theory predicts that under conditions of high fertility and minimal disturbance, tall perennials well adapted to out-compete other plants for light will eventually dominate plant communities. The resulting vegetation may be species-poor. However woodlands are a good example of a vegetation type dominated by competitors that can be rich in biodiversity. The competitor score is the proportion of competitive species in each plot.</td>
</tr>
<tr>
<td>Stress-tolerator score</td>
<td>Stress-tolerant plants are typically well adapted to harsh environmental conditions such as extremes of temperature and shortages of nutrients or light. They are often slow growing and vulnerable to disturbance or increased fertility. This group includes some of the rarest plants in the British flora. The stress-tolerator score is the proportion of such species in each plot.</td>
</tr>
<tr>
<td>Ruderal score</td>
<td>Ruderals comprise all those plants often thought of as weeds. Their strategy is one of quick to arrive and quick to go again. They are adapted to take advantage of often short-lived opportunities for growth and reproduction provided by disturbance. As a result they are often small, fast-growing and produce lots of seed. The ruderal score is the proportion of such species in each plot.</td>
</tr>
<tr>
<td>Number of bird food plants</td>
<td>The number of plant species in each vegetation plot that are known to be important in the diet of a range of declining farmland birds.</td>
</tr>
<tr>
<td>Number of food plants for butterfly larvae</td>
<td>The number of plant species in each vegetation plot that are known to provide food for butterfly larvae (i.e. caterpillars). The list of plants includes those that provide food for common as well as scarce butterfly species.</td>
</tr>
</tbody>
</table>

References


Defra (2002): *Landscape review*. Final Report to the Department for Environment, Food and Rural Affairs and the Prime Minister’s Office of Public Services Reform


