Natural England Research Report NERR032

No Charge? Valuing the natural environment: Technical report

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No Charge? Valuing the natural environment: Technical report

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Project details

This report is the technical version of the No charge? Valuing the natural environment report (NE220) launched on 14th October 2009 - **www.naturalengland.org.uk/ourwork/securefuture/default.aspx**.

This report results from research commissioned by Natural England in order to explore and present evidence on the economic value of a healthy natural environment in England. The aim is to do so in a way that appeals to economists and non-economists alike. No new primary research was commissioned but what the report aims to do is build a strong argument in support of investing in ecological systems by combining economic, scientific and social evidence on the benefits of a healthy natural environment.

A summary of the findings covered by this report, as well as Natural England's views on this research, can be found within Natural England Research Information Note RIN032 – No Charge? Valuing the natural environment: Technical report.

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The views expressed in this report are solely those of the authors.

Summary

Key messages

1) A healthy natural environment is indispensible to current and future economic prosperity - it is a vital part of the infrastructure of a successful modern economy.
2) Conserving the natural environment is an efficient and effective way to deliver a wide range of benefits to society, but because many ecosystem services are not adequately reflected in our day-to-day decisions, they are all too often ignored.
3) The pace of environmental degradation is accelerating in many cases and this is jeopardising our ability to meet future challenges, such as coping with climate change and addressing concerns over food, water and energy security.
4) Investing in a healthy natural environment is essential and an ecosystems approach can help tackle future challenges in a way that enhances prosperity. Innovative ecological, as well as technological, solutions have a vital role to play.

Nature is a vital part of the infrastructure of a successful modern economy

As the world recovers from the worst financial crisis since the Great Depression and begins to emerge from recession, much attention is focussed on how to further revitalise the economy, ensure financial stability and create jobs.

But restoring economic stability today must not result in further degradation of our ecological systems. A healthy natural environment is critical to a sustained long-term recovery in England and to effectively tackle the challenges that lie ahead.

A healthy natural environment has enormous economic value and is a cost-effective way to deliver a wide range of benefits to society

We depend on nature much more than we realise and we cannot truly prosper without a healthy natural environment. In the extreme, nature makes economic progress possible. It underpins everything we consume. It provides raw materials for the production process. It heavily shapes the places in which we live and work. It also has huge untapped potential and offers opportunities for future discoveries that may prove to be critical turning points in the development of our economies and societies.

Illustrative examples of the economic value of nature include:

- The potential benefits of a UK network of Marine Conservation Zones could outweigh costs by a factor of between 7 to 40, with estimated benefits of between £7 billion and £19 billion.
- Floodplain restoration aimed at improving water quality has demonstrated benefit-cost ratios of up to 4:1.
- Many managed re-alignment projects deliver positive returns on investments of many millions of pounds.
- People who live within 500 m of accessible green space are 24 per cent more likely to meet recommended levels of physical activity. Reducing the sedentary population by just 1 per cent could reduce morbidity and mortality rates valued at £1.44 billion for the UK.
- We are losing between 2.8 and 5.8 million tonnes of CO_2 per year from the cultivation and drainage of lowland peat soils. The annual value of this loss is estimated at between £74 million and £150 million.
- Environmental Stewardship is estimated to deliver savings of 3.46 million tonnes of CO_2e per year. Without the scheme, greenhouse gas emissions from agriculture in England could be 11 per cent higher than present levels. If realised, the value of these emission

reductions could be an estimated £1.25 billion (range £600 million - £1.8 billion) over the current programme period (2007-2013).

We are failing to take account of the value of nature in day-to-day decisions

Human activities in a relatively short space of time have created an unprecedented disturbance in nature. England is no exception. Over the 20th century, biodiversity loss has occurred on a scale unseen in history.

Many ecosystem services are not traded in markets. Therefore, our economic activity tends to be skewed towards services that are. Over time this has led to the conversion of much of our natural environment in England to produce greater marketable commodities (such as food, fibre and fuel) at the expense of less marketable services (such as wildlife, water quality, flood risk management, climate regulation).

When a broader range of ecosystem services are valued and considered in decision-making, the benefits of investing in a healthy natural environment can outweigh the costs, many times over in some cases. There are many examples and case studies which strongly demonstrate this.

Clear understanding of the link between changes in ecosystems and economic performance (growth in Gross Domestic Product) is also a critical immediate need. A narrow focus on short-term economic growth perpetuates the belief that environmental investments harm competitiveness. Choosing between a healthy natural environment and economic growth is a false choice. The evidence suggests that addressing the degradation of our ecosystems is a highly effective pro-growth strategy in the long-term.

21st century problems require new 21st century solutions

Restoring economic stability and creating jobs can and must be achieved in ways that also enhance ecological stability. This will help to prepare us for the challenges that lie ahead.

Climate change, population growth and food, water and energy shortages are formidable issues on their own, but combined, they could grow into the *perfect storm* with each deepening the severity of the others.

A new ecosystems approach could help us overcome these challenges with our prosperity intact. A strategy of integrating new technological and ecological solutions has much potential. The evidence suggests, however, that we currently overlook many cost-effective ecological solutions to problems such as flood and coastal defence, local climate regulation and water quality.

Next steps

While there is no silver bullet to these challenges, there are a number of mutually reinforcing steps and interventions that could be progressed:

1) Deepening our understanding of the economic value of nature and natural capital and using an ecosystem services approach to better inform decision-making processes.
2) Strengthening public investments in the natural environment to deliver greater efficiency and improved outcomes.
3) Developing new mechanisms and institutions that enable more ecosystem services to become part of the formal economy, thereby stimulating innovation, enterprise and investment in their provision.

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1 Introduction

'Our 'natural capital' can be a much-needed source of growth in a time of recession, a provider of new and decent jobs in a time of increasing unemployment, and a solution to persistent poverty, a vast human problem which we cannot ignore'.

TEEB (2009)

1.1 As the world recovers from the worst financial crisis since the Great Depression and begins to emerge from recession, much attention is focussed on how to revitalise the economy, ensure financial stability and create jobs.

1.2 A return to 'growth' is critical. But restoring economic stability today must not come at the expense of our ecological systems. In ways overlooked in the past, these systems will influence how long any recovery can be sustained.

1.3 An innovative response to the recession can potentially turn the current crisis into an opportunity. A return to 'business-as-usual' will do little to prepare us for the imminent challenges we face, namely climate change and food, water and energy security. Instead, the 21st century must ensure we deliver economic growth in ways that can be sustained and reinforced by our ecological systems.

1.4 This report aims to make the case for a more integrated approach to future development, one that embraces ecological, as well as technological, solutions to some of the big challenges we face. In doing so, it emphasises four key messages:

1) A healthy natural environment is indispensible to current and future economic prosperity - it is a vital part of the infrastructure of a successful modern economy.
2) Conserving the natural environment is an efficient and effective way to deliver a wide range of benefits to society, but because many ecosystem services are not adequately reflected in our day-to-day decisions, they are all too often ignored.
3) The pace of environmental degradation is accelerating in many cases and this is jeopardising our ability to meet future challenges, such as coping with climate change and addressing concerns over food, water and energy security.
4) Investing in a healthy natural environment is essential and an ecosystems approach can help deepen our understanding of the value of nature and help tackle future challenges in a way that enhances prosperity.

1.5 There is already a growing body of supporting evidence thanks to the efforts of the Stern Review on the Economics of Climate Change, UN Millennium Ecosystem Assessment (MA), United Nations Environment Programme (UNEP), The Economics of Ecosystems and Biodiversity (TEEB) project as well as the work of Defra.

1.6 This report is focussed mainly on England. It hopefully provides an accessible overview of the relationship between nature, the economy and society while capturing the significant complexities that are inherent to this topic.

1.7 The report is structured as follows:

- **Section 2**: presents a framework, developed by the Millennium Ecosystem Assessment, for thinking about the benefits human-kind receives from nature.
- **Section 3**: presents a short review of recent environmental trends and reviews some of the reasons why we are failing to fully account for the value of nature in our everyday decisions.
- **Section 4**: reviews some of the big future challenges we face and argues that if we are to successfully overcome them, new approaches and new solutions need to be developed. It

makes the case for the development and implementation of an integrated ecosystems approach.

- **Section 5**: discusses a range of potential solutions and possible next steps - focussing in particular on how the value of nature might be better captured and brought into the formal economy.

1.8 Accompanying the main report are four ‘evidence sections’. These form a critical part of the overall narrative, providing a range of case studies and more detailed examples to illustrate the report’s main conclusions.

- **Section 6**: reviews the evidence base on what the Millennium Ecosystem Assessment calls ‘regulating services’ or what might be termed our immediate life support services.
- **Section 7**: looks in more detail at nature’s contribution to our health and how improved health outcomes can flow from engaging with nature.
- **Section 8**: reviews the relationship between biodiversity and the provision of ecosystem services.
- **Section 9**: provides a brief overview of some critical provisioning services - specifically those from farming, forestry and fisheries.

2 The benefits of a healthy natural environment

2.1 This report is fundamentally about the benefits of nature to people. There are many strong ethical reasons why nature should be conserved, but equally important is the fact, it is in our best interests to do so. We cannot truly prosper without a healthy natural environment. It is integral to our health, well-being and happiness.

2.2 In the extreme, nature makes economic progress possible. It underpins everything human-kind collectively consumes. It provides raw materials (inputs) for the production process, for example, timber, fuels, water and critically food. It heavily shapes the places in which we live and work. It also has huge untapped potential and presents opportunities for future discoveries that may prove to be critical turning points in the development of our economies and societies, for example, genetic resources and biotechnologies.

2.3 Over recent decades there have been many attempts to understand and articulate our relationship with, and dependence, on nature. The Millennium Ecosystem Assessment (MA) (2005) popularised the concept of *ecosystem services*, seeking to describe the full suite of benefits nature provides. Simply defined, ***ecosystem services are the services provided by nature that benefit people*** (Defra 2007). The MA groups these services into four broad categories as follows (see Figure 1):

- Provisioning services - the products obtained from ecosystems such as food, fibre, fuel, natural medicines and pharmaceuticals, and genetic resources.
- Cultural services - the non-material benefits that people obtain through things like recreation and learning, spiritual enrichment and cognitive development.
- Regulating services - the benefits people obtain from the regulation of ecosystem processes, such as air quality maintenance and climate regulation (for example land cover can affect local temperature and precipitation).
- Supporting services - services necessary for the production of all other ecosystem services and provide the basic infrastructure for life on Earth (see Case study 1).

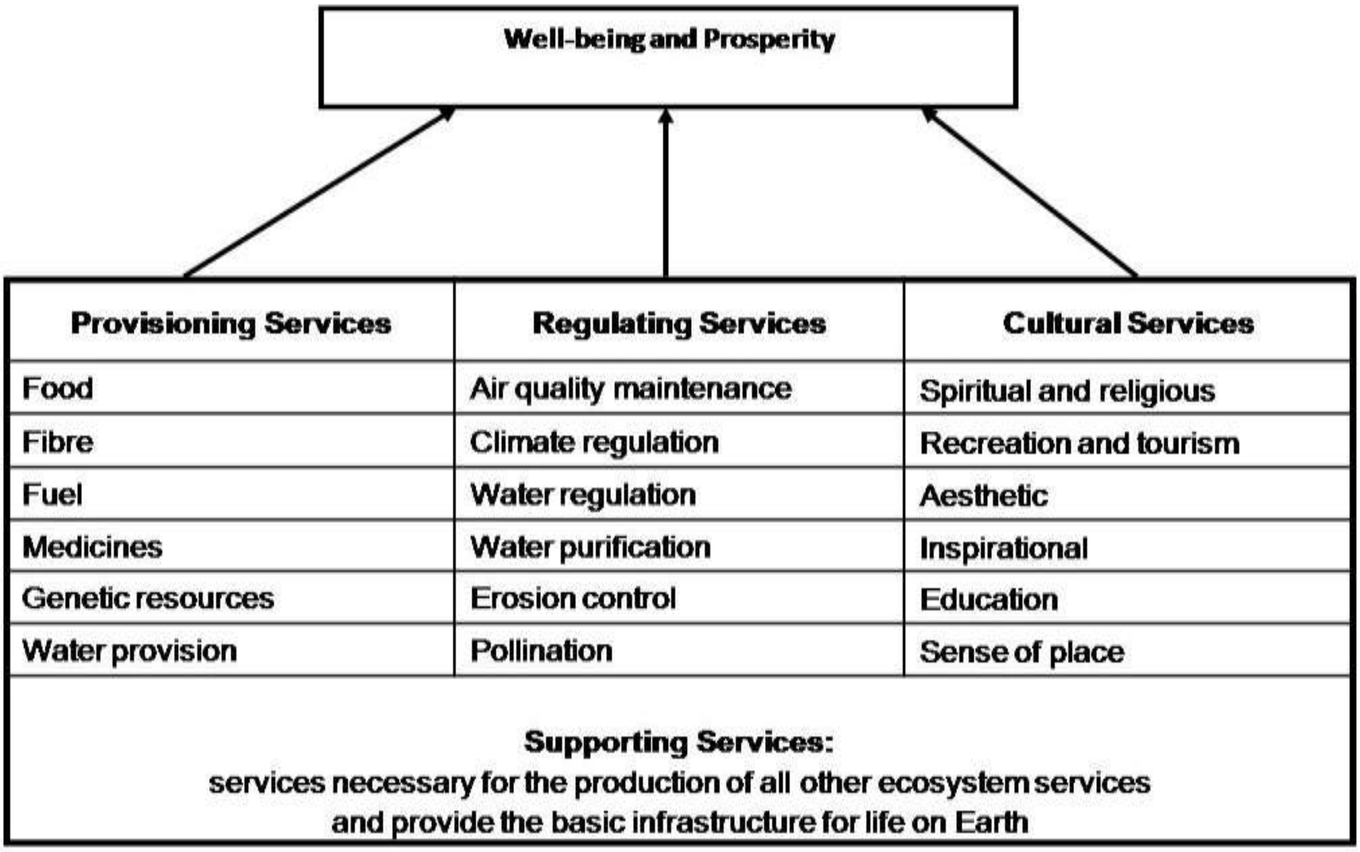


Figure 1 The ecosystem services framework - linking nature and human well-being

Case study 1 Supporting services - the deep ecology of human well-being

Supporting services are a set of processes that operate at the most fundamental level in the functioning of ecosystems. They ultimately control the level of all ecosystem services provided by the natural environment. These processes include:

- **Photosynthesis** - the light fuelled capture of chemical energy on which we depend for food. It also oxygenates the atmosphere and regulates carbon dioxide levels.
- **Decomposition** - the breakdown of naturally occurring or manmade organic compounds, including many waste products.
- **Nutrient capture and recycling** - prevents polluting nutrient build-up and maintains levels of fertility.
- **Soil formation** - the slow chemical and biological processes that create soil or restore soil fertility.
- **Evapo-transpiration** - water loss from plants which equilibrates temperatures and drives the water cycle and so availability of rainfall.

Available evidence suggests that the rate and resilience of many of these processes are dependent upon levels of biodiversity (see Evidence section 8 for a more detailed discussion).

3 Why are we failing to take account of the value of nature?

3.1 There is overwhelming evidence to suggest that we have failed to take proper account of the value of nature and its contribution to our prosperity.

'During the 20th century the world population grew by a factor of 4 to more than 6 billion; industrial output increased by a multiple of 40 and the use of energy by 16; methane producing cattle populations grew in pace with the human population; fish catch increased by a multiple of 35; and carbon and sulphur dioxide emissions by a factor of 10'.

Dasgupta (2007)

3.2 Over the last century, technological innovations have added greatly to our lives. Artificial fertilisers and other farming technologies have provided plentiful and affordable supplies of food and the internal combustion engine has advanced trade and enabled the personal freedom to travel. Such innovations have changed and often improved our lives in ways that were previously unimaginable.

'...nearly two thirds of the services provided by nature to humankind are found to be in decline worldwide. In effect, the benefits reaped from our engineering of the planet have been achieved by running down natural capital assets'.

Statement from the Millennium Ecosystem Assessment Board

3.3 Yet these innovations have resulted in serious side effects for the environment, not least because many are reliant upon burning fossil fuels. The level of carbon dioxide in the atmosphere is the highest it has been for 650,000 years (**www.ipcc.ch**) and is expected to increase significantly over the next century if business-as-usual continues. The world's ecosystems are being degraded at an accelerating pace. Species extinction is occurring at a rate many times higher than the 'normal' background rate (Thomas and others 2004). It is no exaggeration to state that human activities, in a relatively short space of time, have created an unprecedented disturbance in nature (Dasgupta 2007). A detailed account of past and current trends in England is presented in Natural England's State of the Natural Environment Report (see Case study 2). In addition, the National Ecosystem Assessment (due to report in 2011) will provide a comprehensive assessment of the state of ecosystems and ecosystem services in the UK.

3.4 These trends are important and they matter for economic reasons:

- Braat and others (2008) estimates that the cost of global biodiversity decline under a business-as-usual scenario could be as much €14 trillion by 2050 (or roughly equivalent to 7 per cent of global gross domestic product).
- The Stern Report on the Economics of Climate Change (2006) argues that a business-as-usual scenario for green house gas emissions could result in costs equivalent to between 5-20 per cent of GDP by 2050, whereas stabilising green house gas concentrations in the atmosphere, at an acceptable level (500-550 ppm CO_2e), could cost as little as 1 per cent of GDP.

3.5 If a healthy natural environment matters so much (or conversely an unhealthy natural environment costs so much), why are we failing to fully value its contribution to our economy and prosperity?

Case study 2 State of the natural environment in England

During the 20th century a loss of biodiversity occurred in England on a scale not seen in history. Although there are signs of some of these downward trends slowing and some increases, the picture remains one of decline for many habitats and species.

In terms of habitats only 3 per cent of the species-rich grassland present in the early 1930s has survived; a 2005-6 survey of lowland heathland sites found none outside of Sites of Special Scientific Interest (SSSI) were in favourable condition; and it is estimated 1 per cent of saltmarsh habitat is lost each year in southern and eastern England.

Although some positive species trends have been observed in recent years, for example with otters and some habitat generalist butterflies, there were major declines in the second half of the 20th century in the three best monitored groups - birds, butterflies and flowering plants. Such declines have been particularly marked in certain groups. Farmland bird population levels are now less half those of 1970, and, 2006 populations of habitat specialist butterflies were at 37 per cent of their 1976 population levels. Only six of 25 British bumblebee species remain widespread.

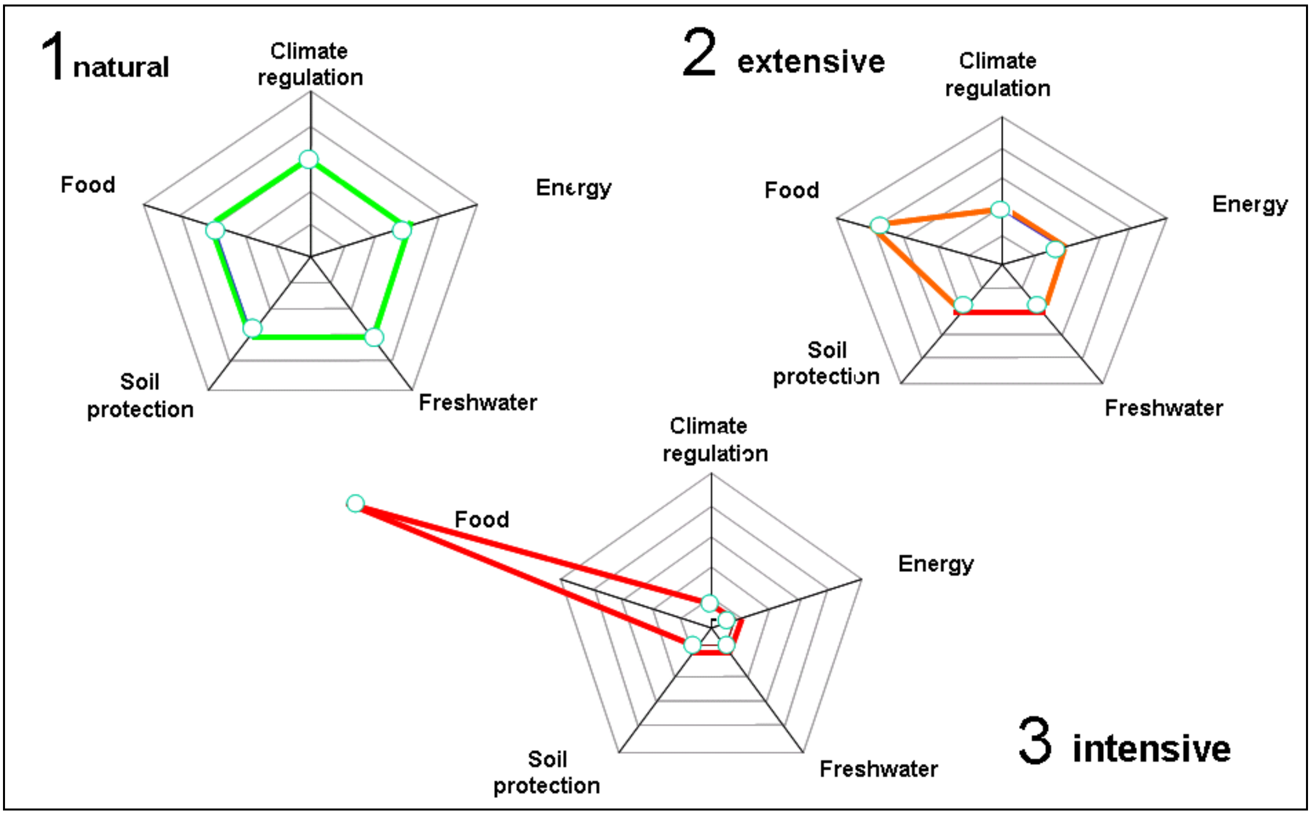
Source: Natural England 2008

3.6 A major reason is that many ecosystem services are not bought and sold in markets and consequently they do not have readily observable prices. This makes it very difficult for their value (their scarcity) to be routinely considered in the same way as goods and services that are traded in markets.

3.7 For example, we know roughly the value of bread, clothes or cars, because they have observable prices, but this is not true for many ecosystem services like flood protection, pollination, climate regulation. Many of these services are not ‘used up’ or consumed in the same way as commodities like wheat and they tend to benefit many people at once. In other words they tend to be ‘public goods’, which makes it difficult for providers of these ecosystem services to profit directly from investment in their provision. As a result, not enough do.

3.8 A good example of this in England is wildlife protection. The right land management practices are critical for the survival of many species. However, there is little incentive for land managers to manage land favourably because, by and large, the market does not reward them for doing so. This provides a rationale for government programmes like the Rural Development Programme for England and Environmental Stewardship schemes that seek to reward land managers for protecting wildlife and ensuring society is able to benefit from this (see section 5 for more details).

3.9 Many ecosystems are not traded in markets. However, the majority of economic activity tends to be skewed towards those services that are. Over time, this has encouraged the conversion of much of our natural environment in England to produce greater marketable commodities (for example, timber or other commodities) at the expense of less marketable ecosystem services such as wildlife. Using the Millennium Ecosystem Assessment terminology, more and more provisioning services are being produced at the expense of many regulating and some cultural services. A stylised illustration is presented in Figure 2.



Source: redrawn from Braat and others 2008

Figure 2 The consequences for ecosystem service levels of maximising food production

3.10 Figure 2 illustrates the potential trade-off between different ecosystem services. The service levels provided by a natural ecosystem tend towards some kind of balance, fitting the capability of the particular ecosystem. In the third diagram, representing an intensive food production system, the other services - provisioning (energy, freshwater), regulating (climate) and supporting services (soil protection) - have been reduced to very low actual and potential levels.

3.11 There is overwhelming evidence to suggest that although many ecosystem services are not routinely factored into the production and consumption decisions we make every day, they still have significant economic value (eftec 2009). A range of techniques enable insights into these values (see Defra (2007) An Introductory Guide to Valuing Ecosystem Services[1]).

3.12 Using these valuation techniques a recent Impact Assessment for the Marine and Coastal Access Bill found that the potential benefits of a UK network of marine conservation zones could outweigh costs by between 7 and 40 times (Defra 2009), yielding benefits of between £7 and £19 billion over a 20 year period. Floodplains are another case in point. Studies have found that restoration projects can deliver significant water quality benefits and that the gains can outweigh costs by a factor of 2.5 - 4 in some cases (Meyerhoff and Dehnhardt 2004). The avoided green house gas emissions from good land management also has significant economic value. According to research by Defra (2007a), Environmental Stewardship is estimated to deliver savings of 3.46 million tonnes of CO_2e per year. Without the scheme, greenhouse gas emissions from agriculture in England could be 11 per cent higher than present levels. If realised, the value of these emission reductions could be an estimated £1.25 billion (range £600 million - £1.8 billion) over the current programme period (2007- 2013). Further examples are presented in Case studies 3 and 4 as well as in the Evidence sections at the end of this report.

[1] http://www.defra.gov.uk/environment/policy/natural-environ/documents/eco-valuing.pdf

3.13 Though the evidence base on the costs and benefits of environmental programmes has grown significantly over recent decades, considerable work is needed to further refine valuation techniques and ensure greater use is made of them. General conclusions from the literature suggest an ongoing tendency for the costs of environmental programmes to be overestimated while the benefits tend to be presented as conservative estimates, either covering only a limited range of ecosystem services or erring on the side of caution (eftec 2009).

Case study 3 The social and environmental benefits of forests in Great Britain

As well as providing marketable timber, forests provide numerous benefits including: recreational use, landscape amenity, biodiversity benefits, carbon sequestration and flood risk mitigation. An economic analysis of the social and economic benefits of Britain's forests valued a range of services as follows:

Table 1 The social and environmental benefits of forests in Great Britain

Benefit	Annual £ millions
Recreation	393
Landscape	150
Biodiversity	386
Carbon fixation and sequestration	94
Total*	**1023**

*This total includes the contribution of forestry and woodlands to improving air quality

Compared to the overall value of woodlands, the marketable value of timber is quite small. Studies from around the country suggest that in many cases the marketable value of timber is only 10 per cent of the total value. The problem is that it is currently difficult for owners of woodlands, who have to pay for management, to receive income for the provision of certain ecosystem services, for example carbon sequestration, landscape and biodiversity.

Source: Willis and others 2003, Forestry Commission

Case study 4 Environmental accounts for agriculture

In addition to marketed outputs (such as crops, meat and milk), the agricultural sector produces a range of positive and negative environmental impacts. Valued in economic terms, the costs and benefits are significant as the table below illustrates.

Table 2 Environmental account for agriculture

Benefits	**£ millions**
Landscape	607
Biodiversity	1091
Other benefits (for example, waste sink)	36
Total benefits	***1735***
Costs	
Water quality	-102
Water pollution incidents	-0.4
Abstraction	-41
Drinking water clean-up costs	-130
Flooding	-244
Waste	-8.5
Soil erosion	-11
Total annual costs	***-539***
Green house gases	-1190
Air Quality	-634
Total cost of GHG and air quality (present value terms)	***-1824***

Source: Defra (2009b)

3.14 Understanding and making better use of evidence on the costs and benefits of a wider range of ecosystem services is essential for better outcomes and decision-making. But increased knowledge on how nature and a healthy natural environment contributes to, and supports, the economy directly and indirectly is also of critical importance.

3.15 Gross Domestic Product (GDP) is the standard measure of economic activity. It measures the value of all the goods and services produced in the economy over a particular time period. GDP, therefore, captures those ecosystem services that are traded in markets as discussed above. So for example, agriculture, forestry, fishing and hunting all feature in national accounts though their share of GDP has declined significantly over previous decades (see Evidence section 9). Recent figures show that, in total, these sectors account for around 1 per cent of GDP (**www.ons.gov.uk**).

3.16 GDP also picks up the value of a range of ecosystem services in a more indirect way because they impact on things that are traded in markets. For example, well managed, fertile and healthy soils will tend to boost crop yields and agricultural output, and unique and well managed landscapes tend to attract more visitors, potentially boosting economic activity in the tourism sector (see Case study 5). Even general improvements in environmental conditions, such as air quality (which is greatly improved in areas with trees and woodlands), are likely to affect the output of the economy through improvements in the health of the workforce (see Evidence sections at the end of the report).

Case study 5 The contribution of the natural environment to leisure and recreation activities in England

Natural environments are a preferred destination for many in pursuit of recreation and leisure activities. The popularity of England's National Parks is testament to this. For example, the New Forest National Park receives 13 million annual day visits with cycling, horse riding, and walking being among the most popular activities (Sharp and others 2008).

Leisure and recreation visits to the countryside generate economic activity and help support local economies. The 2005 England Leisure Visits Survey recorded:

- a total of 763.4 million rural leisure visits in England;
- an average expenditure of £13.99 per visit per person; and
- an estimated total expenditure on rural leisure visits of £10.6 billion (Natural England, 2006).

Other studies have estimated the total annual expenditure linked with walking trips alone to be approximately £6.14 billion, supporting between 180,500 - 245,500 full-time equivalent jobs (Christie and Mathews 2003).

The 2008 UK Tourism Survey (Visit Britain 2009) measured visits involving more than one night undertaken by residents of the UK. It estimated:

- 17.21 million tourism trips (18 per cent of all trips) to the countryside/villages;
- 17.84 million trips to the seaside (18 per cent of all trips); and
- a total spend on countryside trips was £2,776 million and on seaside trips £3,652 million.

Case study 6 Geology's contribution to the Isle of Wight economy

Webber and others 2006 undertook economic impact analysis on the Isle of Wight to determine the size of the local economic impacts that geodiversity brings to the Island. This found 39 per cent of tourists surveyed had visited the area specifically for this reason. Those surveyed were estimated to have spent on average £73.86 per person per trip. In total, tourism on the Isle of Wight was estimated to be worth around £352 million for the tourism year 2004/2005. Through a process of aggregation, the study estimated that geology-based tourism accounted for approximately £11 million of this value. Applying income and employment multiplier coefficients, the study concluded that geology-based tourism generated between £2.6 million and £4.9 million in local income and supported between 324 - 441 full time equivalent local jobs in that year.

Source: Webber and others 2003

3.17 The reverse is also true and there are examples of where poor management can result in both weak environmental performance and weak economic performance. Fisheries management illustrates this. In this instance GDP figures tend to reflect the following:

- Lower output / value of landings (often significantly lower than could be achieved under better management arrangements);

- Knock-on impacts (reflected in reduced output) on other sectors competing for the use of the same or related resources - in this case sectors like angling, diving and other tourism and recreation activities; and
- The cost of public subsidies to the sector, such as investments in fleet capacity and fishing effort.

A study on Eastern-Atlantic Blue-fin Tuna found that a more **optimal management regime for the fishery could boost landings from US$ 1billion to US$ 3 billion** (in net present value terms).

OECD (2008)

3.18 These are just illustrative examples. The links between nature and the economy are many and often very complex. For the most part, they tend to be diffuse, indirect and take time to show up, making them difficult to measure easily and reliably. This can lead to perverse conclusions in some cases, where poor and costly environmental conditions show up positively in GDP over the short-term. For example, inappropriate land management can lead to drinking water contamination and investment in expensive water treatment facilities. The costs of the water treatment works would be reflected in GDP but actions to improve land management, a potentially more cost-effective option in some cases, would not.

3.19 In addition, there are cases where a particular economic activity is unsustainable (it ultimately erodes the natural resource on which it depends and therefore cannot physically be sustained) but this is not taken into account. Some fisheries, despite being renewable resources, serve as examples (see Section 4), as do some farming practices, such as the cultivation of peat soils.

3.20 There have been many attempts to 'adjust' national economic accounts to better reflect changes in environmental and social conditions. Examples include the United Nations Development Programme (UNDP) *Human Development index* (HDI) and the World Bank's *Genuine Savings* approach. Natural England is currently working with the East-Midland Development Agency (EMDA) to further develop the *Regional Index of Sustainable Economic Well-being* which is used to help measure progress in the region. Like other initiatives, the index seeks to incorporate a range of environmental and social changes alongside changes in regional economic output with a view to providing a more balanced measure of progress.

3.21 Despite the wealth of alternative and complementary indicators of progress, we are still some way off having a robust single integrated indicator of the sort needed to inform policy development and delivery that might sit alongside GDP.

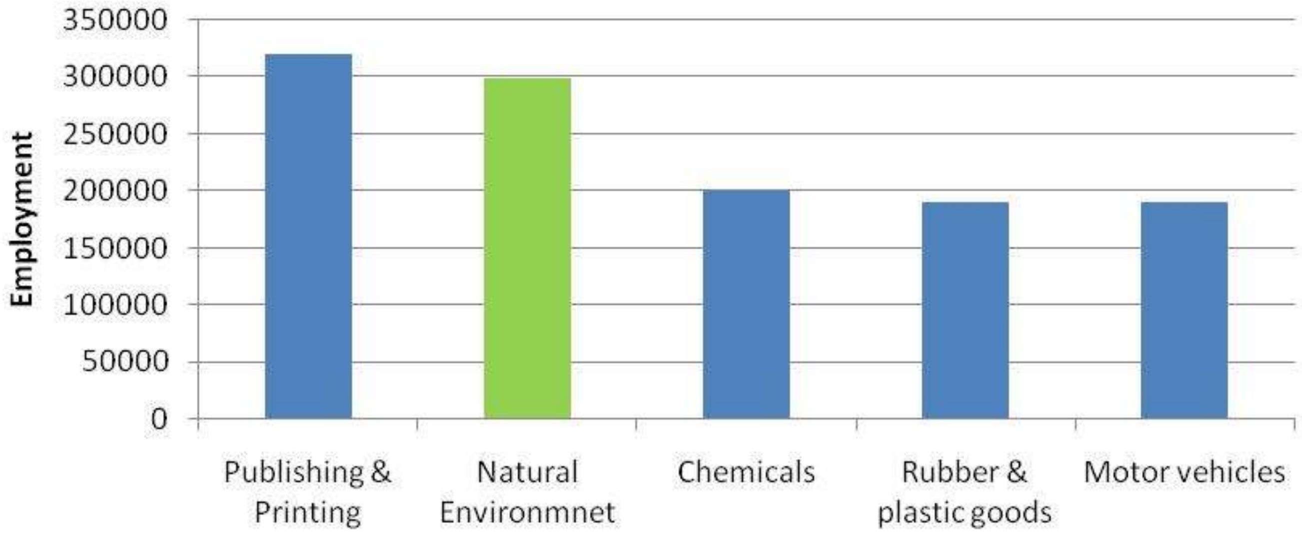
Case study 7 Measuring progress - GDP and beyond

Over-reliance on GDP as a proxy indicator for overall societal development and progress has been raised again as an issue in a recent Communication by the European Commission (EC 2009a). In response, the Commission has stated it will:

- Develop a comprehensive environmental index which captures harm to or pressure on the environment in the European Union. In addition, they are exploring a comprehensive indicator of environment quality.
- Continue to develop indicators of quality of life and well-being.
- Aim to provide 'near real-time' information for decision-making.
- Provide more accurate reporting on distribution and inequalities.
- Develop a Sustainable Development Scoreboard and step up efforts to identify thresholds for environmental sustainability.
- Extend national accounts to better include environmental and social issues - specifically integrated environmental-economic accounting which requires monetary valuation of changes in environmental assets.

Case study 8 Employment linked to the conservation and enhancement of the natural environment in England

- Direct employment in nature and landscape conservation in England is estimated to support some 8,600 full-time equivalent jobs.
- By including activities that are closely linked to the management of the natural environment in the agriculture, food, forestry, fisheries and tourism sectors, employment in England is estimated at around 300,000.
- Aggregation of the regional environment-economy studies suggests that the overall scale of the environmental-economy, including activities in urban areas, may number around 1 million jobs, and typically accounts for between 3-6 per cent of regional GDP.



Source: ECONOMICS AND FUNDING GROUP SIG. 2007

Figure 3 Comparison of employment in different sectors of the economy, England 2004

4 Facing the future - the need for an ecosystems approach

'Growth in human populations and prosperity [has so far translated] into increased conversion of natural ecosystems to agricultural, industrial or residential use, but also into increased demand for ecosystem inputs, such as fresh water, fibre, and soil fertility, as well as increased pressure on the capacity of natural systems to assimilate our waste... ***In short, we are asking more and more from natural ecosystems even as we reduce their capacity to meet our needs****'.*

Source: Pagiola and others (2004)

4.1 Despite the arguments set out in the previous sections, the debate about environmental policies still tends to be underpinned by a strong fear of the 'harm' that efforts to improve the natural environment can do to competitiveness and the economy. This is perpetuating the notion of an inherent trade-off between nature on the one hand and future economic growth and prosperity on the other; the former often seen as a luxury; the latter as a necessity (Dasgupta 2007).

4.2 This is a false choice. In the current economic climate, restoring growth, financial stability and creating jobs are critical short-term goals, but this can be achieved in such as way as to prepare us for the future challenges that lie ahead. Environmental degradation has the potential to undermine long-term prosperity (HM Treasury 2007) and as Stern (2006) argues, tackling climate change is actually a highly effective pro-growth strategy.

4.3 Based on current and expected future trends, there are strong grounds to argue that over the next few decades, we could face what Professor John Beddington, the Government's Chief Scientific Advisor, has called the 'perfect storm' of climate change, population growth, and food, water and energy shortages. These issues are, in themselves, significant enough but potentially coming together and feeding off one another means the scale of the challenge may grow exponentially.

4.4 The United Nations estimates that global population will reach 8 billion before 2030. Over the same time period, the demand for food is expected to increase by an estimated 50 per cent, demand for water by 30 per cent and the demand for energy by 50 per cent. Such demands will have to be met whilst mitigating and adapting to climate change at the same time (see **www.foresight.gov.uk**).

4.5 To overcome these challenges and to emerge with our prosperity intact, a new approach is needed. Alongside a new wave of innovation in science and technology, investment in a healthy natural environment is a critical part of the solution.

4.6 As one of the most densely populated countries anywhere in the world, space, water and other resources are already at a premium in England. The need to manage our land and water to serve multiple purposes will grow more acute over the coming years. Until recently the approach to most environmental problems in England has been to seek technological solutions. For example, the response to coastal flooding has been to build sea walls, water treatment works have been relied upon to purify water, pesticides are widely used to control the insect pests of crop plants.

Case study 9 Ecological limits and thresholds

Degradation of an ecosystem will often result in a gradual reduction in the level of ecosystem service provision. Setting limits on the use of ecosystems is, therefore, important to ensure degradation does not exceed acceptable levels. However, there also occur in nature ecosystem thresholds beyond which small amounts of additional over exploitation or degradation cause dramatic adverse changes in the ecosystem (Haines-Young and others 2006). Unlike limits, which are socially, economically and politically determined, threshold effects are determined by scientific factors.

One of the most frequently encountered examples of a threshold effect is seen in freshwaters where a gradual increase in nutrients results in very minor changes. However, beyond a certain point, small additional amounts of nutrients cause algal blooms which make the water unattractively turbid (Scheffer and others 1992), potentially leading to fish death and risks to human health (Smith & Schindler 2009).

A further example is that of cod fisheries in Newfoundland, Canada where a prolonged period of over fishing resulted in the fishery being closed by the Canadian Government in 1992 as the fish stock had collapsed. This has caused profound long-term change to the functioning of the ecosystem, which has so far prevented recovery of the cod stocks (Frank and others 2005). This was the largest industrial closure in Canadian history. In the first year of fisheries closure it resulted in costs of US$1billion to the Canadian government in income support payments, along with the loss of 18,000 fishing jobs alone, in a remote area with few other prospects for economic development (Ruitenbeek 1996).

Such ecological thresholds would appear to be relatively uncommon in nature. However, as systems degrade the probability of over-stepping such thresholds increases. Ecological scientists are currently unable to predict with certainty where such ecological thresholds occur although there is some evidence they are more common in species-poor systems (Lawton 1999; Frank and others 2005).

An exception concerns coral reefs - one of the most biologically diverse ecosystems in the world. As TEEB 2009 argues, the scientific evidence suggests that higher ocean temperatures and acidification is threatening the viability of these ecosystems globally. Stabilising the level of CO_2 in the atmosphere at 500ppm (a very ambitious target) is unlikely to be enough to avoid extinction.

The existence of ecological thresholds increases the need for a precautionary approach to environmental management.

4.7 Technological solutions tend to be focused on solving single problems in isolation and there can be costly unintended consequences. For example, building sea walls can result in increased flood risk elsewhere on top of the loss of inter-tidal habitat that supports wildlife, stores carbon and detoxifies pollutants, and pesticide use often results in the development of chemically resistant strains of pest species, while potentially killing off natural pest enemies and pollinating insects.

4.8 Alongside technological innovation, ecological innovation and solutions have an important role to play and the evidence suggests they can be cost-effective (TEEB 2009). For example, there are now 23 managed realignment schemes on the English coast (Morris and other 2008), where setting back sea walls and restoring inter-tidal habitats provides natural flood protection and a range of other ecosystem services (see Alkborough case study in the Evidence section).

4.9 The evidence suggests that such solutions can be very beneficial - delivering very favourable benefit-cost ratios over a relatively short period of time (25 years in some cases) (eftec 2009). Similarly, water contamination caused by upland degradation in the South Pennines is being addressed through improving land management (see Moors for the Future case study in the Evidence section).

4.10 It is unlikely that an ecosystem approach will entirely displace the need for innovative technological solutions. It will not, for example, remove the need for sewerage and drinking water treatment entirely. More often an integration of technological and ecological thinking will offer effective solutions, as with increasing use of *integrated pest management*, where maintaining levels of the natural enemies of pest species compliments the use of pesticides.

4.11 A further reason why an ecosystems approach can be highly effective is that ecosystems generally deliver a broad bundle of services and benefits, while technological solutions typically do not. For example urban green spaces, particularly if they contain some woody vegetation, can directly benefit humans by reducing summer temperatures, cleaning the air, reducing noise and providing space for active recreation, thereby facilitating improved health outcomes. At the same time they contribute to reducing storm flood risk, and can be used for education, support wildlife, store carbon and so on (see Figure 4).

4.12 Whilst an ecosystem approach can provide effective solutions, it does not generate a universal template for what to do. There can be hard choices. For example using flood plains to store flood water in summer can conflict with their use for agriculture and nature conservation interests. An effective ecosystems approach, therefore, relies upon informed local decision-making, and consultation with a wide range of local interests.

4.13 To conclude, if we are to succeed in meeting the challenges of the 21st century, we need a new 21st century approach that explicitly recognises that a healthy natural environment and future economic growth and prosperity go hand-in-hand. We need to deliver food and environmental security, more low-carbon energy generation and wildlife - ecosystems-based solutions can help us achieve this.

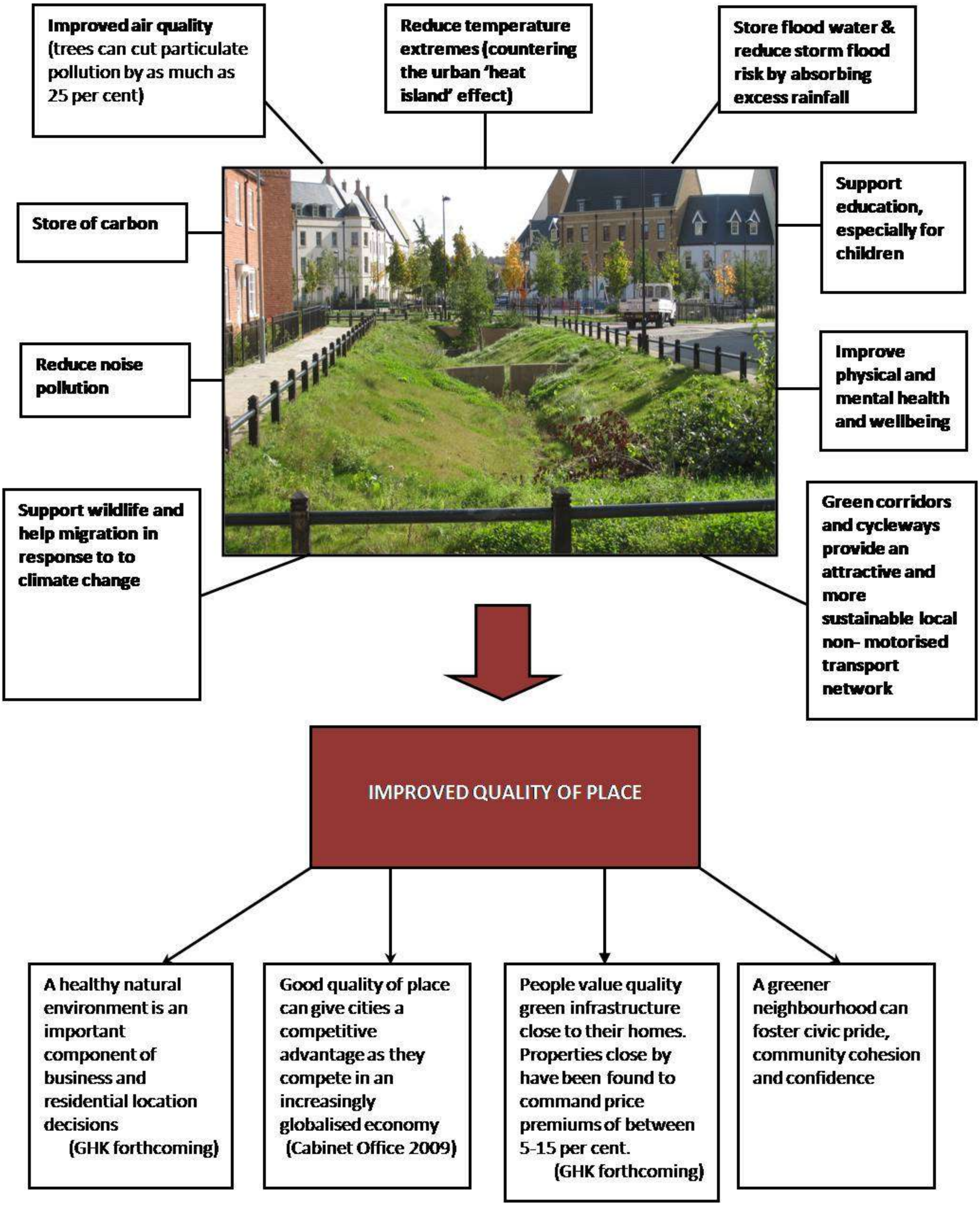


Figure 4 Turning urban areas into quality places using green infrastructure to deliver ecosystem services

Climate regulation through carbon storage

Upland peat soils are the largest carbon store in England – holding nearly 300 million tonnes. In good condition, peatlands can remove carbon from the atmosphere. But, soil erosion means we are losing many hundreds of thousands of tonnes of CO_2 every year. Exact figures are not yet available.

Water quality and reducing flood risk downstream

Peatlands, in good condition, store, filter and regulate water. Up to 70 per cent of UK water supply is sourced from upland rivers, lakes and reservoirs. Peatlands that are artificially drained, or intensively grazed and burnt, can add a brown stain to water resulting in costly treatment processes, and potentially increasing downstream flood risk.

Wildlife and recreation

Uplands are home to many rare and internationally important habitats and species – containing 53 per cent of our SSSIs. 75 per cent of the uplands is designated as National Park or Area of Outstanding Natural Beauty. The 70 million visitors to upland National Parks each year contribute to local economies through spend on accommodation and outdoor pursuits.

Provisioning services

The uplands are an important source of some foods, particularly lamb and beef. They support about 3 million sheep – 45 per cent of the total number of breeding ewes in the country. Uplands sheep produce around 5 million kilos of wool every year. Conifer plantations cover 6 per cent of the uplands - these are important areas for forestry.

Archaeology and the historic environment

Uplands retain a rich historic record of climatic and ecological and human development over time including:

- spectacular monuments, like Hadrian's Wall and the 4000 year old Castle Rigg stone circle.
- evidence of previous agricultural systems.
- old mineral workings and other upland industry.
- the pollen record preserved within peat soils.

Figure 5 Managing our uplands for multiple ecosystem services

Case study 10 The economic potential of nature - option value, insurance and irreversibility

In many cases, people value the option of using the natural environment in the future even though they may not current use it. For example, people may value a National Park and be willing to pay towards its conservation on the grounds that they value the option of being able to visit it at some point in the future despite having no specific intention to visit it now.

In the context of ecosystems and their services, **option value** describes the value placed on maintaining ecosystems and their component species and habitats for possible uses - many of which may not yet be known. Option value can therefore be thought of as a form of insurance against future uncertainties and is closely related to the concept of resilience as discussed in Case study 1 and Evidence section 8.

Another form of option value concerns the value of information secured by delaying a decision to convert an ecosystem from its natural state into something else where there is uncertainty about the impacts - particularly where the decision to convert is irreversible (once converted, the ecosystem / species is lost). This is particularly important in the context of ecosystems where there can be a major chance to learn through scientific progress. For example, option value in this context could capture the potential for new genetic information to be used to create new medicines and pharmaceutical products, or improved crop varieties. To put this into perspective, it is thought that up to 75 per cent of our medicines are based on compounds originally identified from natural sources which are then synthetically produced (Dobson 1995).

Due to the difficulty of quantification, a precautionary approach is important where it is thought option values may be significant and where a particular course of action is irreversible.

Source: Defra (2007), eftec (2006), OECD (2006), Dobson (1995)

5 Identifying solutions and next steps

5.1 While there is no silver bullet to the challenges we face, there are a number of mutually reinforcing steps and interventions that could be progressed. These can be grouped under three headings:

1) Deepening our understanding of the economic value of nature and natural capital and using an ecosystem services approach to better inform decision-making processes.
2) Strengthening public investments in the natural environment to deliver greater efficiency and improved outcomes.
3) Developing new mechanisms and institutions that enable more ecosystem services to become part of the formal economy, thereby stimulating innovation, enterprise and investment in their provision.

Deepening our understanding of the economic value of nature and our natural capital

5.2 In order to improve the efficiency and effectiveness of investments in the natural environment, there is a clear need to deepen our understanding and grow the evidence-base on the economic benefits and costs of environmental changes.

5.3 Developments in environmental economics have taken us a long way over recent decades and we now have tried and tested tools and techniques to quantify and attach financial value to a wide array of environmental impacts in different contexts. However, in many ways this is just the beginning and the challenge going forward is to embed the use of such techniques in decision-making processes where possible and appropriate. Advances in ecology and other natural sciences are also needed to deepen our understanding of how natural processes support the delivery of ecosystem services and how we might manage the natural environment most efficiently to deliver them.

Case study 11 Growing the evidence base on economic valuation

Natural England fully supports Defra's Ecosystems Approach Action Plan which, among other things, is developing a Benefits Transfer Strategy to facilitate greater use of economic valuation in different decision-making contexts. We are also working closely with Defra and other partners and stakeholders on a number of economic valuation projects due to conclude shortly, including:

1) 'Estimating the Non-market Benefits of Environmental Stewardship': a piece of research seeking to quantify and value in economic terms the benefits that will be delivered through England's Environmental Stewardship programme over the current operating period 2007-2013.
2) 'Economic Valuation of the Benefits of the UK Biodiversity Action Plan': a piece of research seeking to quantify and value the benefits of achieving the UK Biodiversity Action Plan targets.

5.4 It is important to recognise that while economic valuation is critical, it is unlikely to provide all the answers we need. There are limits to what can be meaningfully valued in economic terms. For example, it is not always possible to elicit monetary values for all ecosystem services in every situation. In addition, it is not always appropriate to attempt to place financial values on some cultural or spiritual values for which there is no substitute or, indeed, acceptable level of compensation for their loss (Turner and others 2003).

5.5 Secondly, as Turner (2006) argues, there is a 'primary' or 'infrastructure' value in nature that is dependent on the fact that some combination of ecological features or components are necessary to ensure systems 'work' and continue to function. As discussed in the following Evidence sections, nature provides 'essential life support' services for which no other man-made or human capital can substitute. Although we can and should attempt to value many of the services that flow from it, assigning monetary values to all critical natural capital itself is not meaningful in this sense.

5.6 Clearly we need our decision-making processes to include much deeper deliberations of value and the importance of nature to society, not only for today, but for future generations too.

Sustained and long-term investment in natural capital

5.7 As already mentioned, technology will be of critical importance in tackling many long-term environmental challenges. In addition, sustained long-term public investment in our ecological systems can play a vital role in helping meet future needs and is likely to remain a critical component of conservation policy. This is, in part, due to the public good characteristics of many ecosystem services, which makes complete commoditisation impossible and undesirable in some cases.

5.8 Public 'investment' can take a number of forms:

- Reducing current expenditure and subsidies that are impacting negatively on the natural environment.
- Boosting direct investment and spending on mechanisms such as agri-environment schemes whilst also improving their efficiency.
- Using other levers such as taxation to encourage investment and behaviour change.

5.9 One of the most cost-effective approaches would be to reform existing environmentally harmful subsidies and regulatory frameworks. Many countries across the world are still spending billions of pounds every year subsidising agricultural intensification, fisheries over-exploitation and high-carbon energy developments. For example, OECD figures suggest that energy subsidies in OECD countries alone amount to approximately US$ 80 billion per year, whilst in 20 non-OECD countries the total is closer to US$ 220 billion. Reforming these subsidies alone would reduce greenhouse gas emissions by an estimated 6 per cent and add 0.1 per cent to global GDP (Barbier 2009).

5.10 The situation is similar in agriculture where (mainly) OECD countries spend billions of pounds a year on production-related subsidies. Though there has been genuine reform over recent years in the EU with the move towards decoupled payments under the Common Agricultural Policy (CAP), subsidies and other interventions continue to distort agricultural markets considerably.

5.11 For example, approximately three quarters of the annual £2 billion payments to farmers and land managers in England are in the form of general income support through the Single Payment Scheme. These payments deliver little more than basic compliance with environmental regulations and, as such, do not deliver good value for money.

5.12 The remaining quarter of the CAP funding is devoted to rural development and over 80 per cent of this is spent on agri-environment schemes through the Rural Development Programme for England. These schemes deliver a range of defined environmental goods and services including climate change adaptation and mitigation, biodiversity and landscape conservation and protection of natural resources (see Case study 12).

Case study 12 Investing in the natural environment - agri-environment schemes in England

Agri-environment schemes (AES) have formed the basis of environmental policy for agricultural land in England for over 20 years. They account for approximately 80 per cent of the support made available to farmers and land managers through the Rural Development Programme for England (RDPE). They are the primary delivery vehicle for conservation of the natural environment. Over the RDPE operating period (2007-2013), approximately £2.9 billion will be invested in the countryside, mainly through 'Environmental Stewardship' - the current scheme model. Environmental Stewardship has two main schemes: Entry Level Stewardship (ELS), which is aimed at all agricultural land in England, and Higher Level Stewardship which is targeted at our most important sites.

The development of agri-environment schemes is an ongoing process and this has resulted in the addition of new complementary policy objectives. For example natural resource protection was added in 2005 and climate change adaptation and mitigation in 2008.

The evidence suggests that, on the whole, these schemes make a vital contribution to environmental outcomes in England (see Agri-environment schemes in England. 2009. Natural England). Given the current limited set of policy levers available, Agri-environment schemes are likely, for the foreseeable future, to continue to be the only mechanism for rewarding those who deliver a wide range of ecosystem services from the farmed environment. Continued investment is therefore vital.

5.13 CAP may next change significantly in 2014, when the new EU 'multi-annual financial framework' comes into operation and existing Rural Development Programmes come to an end. As part of this next reform, Natural England believes there is a need for a large-scale transfer of funds from income support to support for sustainable rural development. This includes securing environmental goods and services, such as climate change adaptation and mitigation, which would not otherwise be provided by markets but are nevertheless essential for future well-being.

5.14 Fishing is another industry that receives significant public support, much of which is still aimed at fleet modernisation and boosting capacity. This is despite 88 per cent of European Community stocks being fished beyond their maximum sustainable yield and 30 per cent being outside of safe biological limits (EC 2009). The European Commission has recently concluded that the Common Fisheries Policy (CFP) - the framework that oversees fishing in European seas - has failed and is structurally flawed. Natural England supports the radical reforms proposed by the European Commission and believes the recovery of marine ecosystems needs to be at the heart of the CFP (Natural England 2009). This is critical for the health of many marine species but also essential for long-term food security.

Case study 13 Using taxation to help deliver environmental and economic objectives

Most taxes are not intended to change people's behaviour. In fact, theoretically, a 'good' tax does the exact opposite; it raises revenue for government in the most efficient way possible - without changing people's behaviour (Ekins 2008).

However, in reality most taxes do influence people's behaviour to a greater or lesser extent and some taxes do so very effectively. When targeted at damaging or socially undesirable behaviours and activities, taxes can both raise revenue and make society better off by reducing social costs. For example, a unit tax on air emissions will (other things being equal) reduce atmospheric pollution and raise revenue for government. In these cases, a tax can be market 'correcting' rather than market 'distorting' and lead to social welfare improvements.

Environmental taxes are examples of so-called 'market-correcting' interventions. Since the mid-1990's the UK Government has introduced a range of environmentally-related taxes - for instance, the Aggregates Levy, Landfill Tax and Climate Change Levy. Taxes have also been used very effectively to create price differentials between liquid fuels, thereby encouraging the uptake of cleaner fuels and helping phase-out environmentally damaging alternatives, such as leaded petrol and high sulphur diesel.

The evidence suggests that, over the last decade, environmental taxes have been an effective component of both environmental and fiscal policy. The landfill tax, for example, has provided a powerful incentive to reduce the level of waste going to landfill, thereby encouraging waste reduction and recycling. Revenues from the tax have been used to reduce the level of national insurance contributions and re-invested in local communities through the Landfill Communities Fund (LCF). The LCF has recently passed the £1 billion investment mark since the introduction of the tax in 1996 and has funded over 24,000 local projects (**www.entrust.org.uk**).

There would appear to be significant potential for greater use of environmental taxes as part of a green tax shift - a systematic shift of taxation from 'goods' like labour, to 'bads' like pollution. Proponents argue that not only can significant environmental benefits be achieved, but in economic terms a reduction in taxes on labour will make employment more attractive, and may increase both UK employment and economic output at a time when we really need it (Green Fiscal Commission 2009).

Developing new mechanisms & institutions

5.15 A national, indeed global, debate is needed on how we should collectively seek to honour our environmental commitments and leave future generations with a stock of natural capital that at least offers them the same opportunities and choices we currently enjoy.

5.16 Natural England believes to progress in this area, we need to focus on how to:

- re-connect people with nature and the ecosystem services provided by a healthy natural environment to the extent that it allows real engagement between providers of these services and those that benefit from them; and
- better align our economic activities with our ecological systems so that markets forces can be harnessed to work with nature rather than against it.

Developing environmental markets

5.17 As previously discussed, market forces alone currently fail to provide the right signals to adequately conserve nature. But if harnessed appropriately, market forces can be very powerful drivers of change. There are numerous international examples of where markets have been 'created' to govern the use of environmental resources or incentivise the provision of ecosystem services. Examples include the EU Emissions Trading Scheme for carbon, tradable water abstraction rights in Australia, and individual transferable fishing quotas in Norway, Iceland and New Zealand.

5.18 There is considerable scope to broaden the use of market-based approaches in England (CLA 2009). 'Biodiversity offsetting', where residual impacts of development on biodiversity are offset through investments in habitat restoration and creation elsewhere, has significant potential for further development. Currently, offsetting is required and practiced under the EU Habitats Directive in order to maintain the integrity of the Natura 2000 network but there is significant potential to extend its coverage to tackle biodiversity losses outside of protected areas. Clearly there are opportunities and risks associated with offset mechanisms but these can be overcome through a clear policy framework and effective design and piloting.

5.19 Such market mechanisms will not typically arise of their own accord. Government has an important role to play in creating and sustaining the right incentives and institutions to allow markets to develop and function in an effective and transparent way.

Payment for ecosystem services approaches

5.20 A promising area under the general banner of market mechanisms is the 'payment for ecosystem services' (PES) approach. PES schemes can enable a greater emphasis on the provision of ecosystem services, linking them to specific groups of beneficiaries who are willing and able to pay for them.

5.21 By effectively linking beneficiaries with service providers, they have the potential to incentivise truly 'integrated land management' where multiple ecosystem services (for example biodiversity provision, flood risk management, water quality benefits and carbon storage) are delivered on a piece of land. This could greatly increase the potential returns to land managers because earnings from a wider bundle of ecosystem services is likely to be more commercially viable than the provision of individual services in isolation.

5.22 Before such schemes can be implemented wholesale, further work is needed to better understand and measure the delivery of ecosystem services in specific locations. It is critical to assess how different sorts of land-use and land management practices affect the level and quality of service provision. The only way to acquire this knowledge is to experiment and to pilot different approaches. Natural England is in the process of developing three ecosystem service pilots in England (see Case study 15).

Case study 14 Restoring upland peatlands to deliver ecosystem services - SCaMP

The Sustainable Catchment Management Programme (SCaMP) aims to tackle habitat issues and address some water quality issues on a catchment wide basis. The programme, funded mainly through the Water Pricing Review 04 (PR04), applies an integrated approach to catchment management in two key areas of United Utilities (UU) land: Bowland in Lancashire and the Peak District area.

The project covers around 20,000 ha of UU owned catchment land, which help supply some of UU's 7 million customers with their daily water needs. It is also home to some of the UK's most important wildlife, including the hen harrier, the curlew and the stonechat.

The programme is a good example of an effective partnership approach with private, public and non-governmental organisations working together to change the way land is used and managed to deliver a wider range of ecosystem services and benefits. The programme has already restored or secured around 13500 ha of Sites of Special Scientific Interest (SSSI) into favourable or recovering condition. Although the focus is primarily on restoring habitats and enhancing biodiversity, water quality benefits are also expected in the long-term. It is hoped that by restoring degraded moorland catchment areas the current increasing water colour will stabilise in the future. Also by using whole farm plans the viability of each farm is ensured, supporting rural communities. By revegetating bare peat, losses of carbon are reduced and once peat forming vegetation is established, what was a net source of carbon can become a net sink.

SCaMP is a good example of a project delivering multiple ecosystem benefits; improving biodiversity, stabilised water quality, supporting rural communities, enhancing landscape, reducing peat carbon emissions, protecting carbon stores and aiding fragile habitats to withstand future climate change.

So far, the work has included:

- Restoring blanket bogs by blocking drainage ditches - re-wetting to help vegetation and water quality.
- Reinstating areas of eroded and exposed peat - reducing peat loss and establishing vegetation.
- Restoring hay meadows and heather moorland, and establishing clough woodland - all valuable habitats that will improve raw water quality.
- Providing new farm buildings for indoor wintering of livestock and for lambing, and building fences to keep livestock away from areas such as rivers and streams and from special habitats - all of which enhances habitats and reduces the risk to raw water quality.

SCaMP2, covering the remainder of United Utilities land holdings, is currently under development. It aims to deliver interrelated biodiversity, raw water quality, soil carbon sequestration and landscape benefits through sustainable farming.

Case study 15 Natural England's ecosystem services pilot schemes

Upland areas in England have significant potential to provide a broader range of ecosystem services of enormous benefit to society. As outlined in Figure 5, these areas are vital for carbon storage, flood risk management, water quality and supply, recreation as well as being home to many rare and important species.

Natural England is developing three ecosystem service pilots in Cumbria, Yorkshire and the South-West that aim to revolutionise the way in which upland land managers are able to generate wealth. Land-use in the uplands is currently dominated by livestock production. Profitability tends to be low, which is a general characteristic of these marginal farming areas. The sector is, therefore, heavily dependent on subsidies to make ends meet.

Through sound science, financial innovation and new partnerships, the pilot projects will seek transform the economics of upland land management and demonstrate how the provision of a broader range of ecosystem services can be turned into genuine business opportunities. By doing this, it is hoped, the multiple problems of water quality, flooding, carbon and indeed wildlife decline will be addressed in an integrated and cost-effective way.

The pilots are currently in the scoping stages, but it is envisaged that:

- Stage 1 will involve an initial assessment of the services currently provided in pilot areas.
- Stage 2 will require a detailed assessment of the potential of each area to provide a boarder range of ecosystem services, and the land management practices needed to deliver this. Equally important will be to gain an understanding at this stage of potential beneficiaries.
- Stage 3 will consider appropriate valuation of services and explore new arrangements and partnerships to enable payments based on changes in the ecosystem services provided.
- Stage 4 will deliver integrated land management on the ground in the pilot areas so that an optimal range of ecosystems can be delivered subject to local conditions and preferences.

Throughout the pilots we will seek to develop new institutions and partnerships that will link land managers, as providers of ecosystem services, with those that benefit from them. The aspiration is to demonstrate to local beneficiaries the benefits they are receiving and encourage them to enter into tailored local agreements with land managers to supply them.

6 Nature's life support system

Introduction

6.1 The aim of this section is to present some of the available evidence on what the Millennium Ecosystem Assessment terms regulating services, **the benefits people obtain from the regulation of ecosystem processes**. These are the services that maintain the environment in a condition fit for human habitation (EASAC 2009). They are often complex, hidden and difficult to measure. As a result, communicating precisely what they are, how they work at different spatial scales and how much we benefit from them remains challenging.

6.2 An important point is that regulating services are typically not 'produced' in a conventional economic sense. They are largely 'free' gifts from nature, often taken for granted - that is until they are no longer provided or greatly reduced in extent. The examples covered in this section include:

- coastal defence;
- water regulation;
- water purification;
- green house gas regulation;
- direct climate regulation;
- soil regulation;
- pollutant decontamination (waste recycling);
- pollination;
- natural pest control; and
- noise reduction.

6.3 As the evidence below suggests, managing the natural environment to deliver a range of provisioning and regulating services can lead to improved and more efficient outcomes for society as a whole.

Coastal defence

6.4 Our coasts have some of our finest landscapes, tend to be rich in biodiversity and generate significant economic activity through recreation and tourism. In many low lying parts of the coast there has also been extensive development of villages, towns and industry as well as widespread conversion to farmland. These low lying areas are prone to flooding when high tides are accompanied by storms, so-called storm surges. In 1953, a storm surge on the North Sea coast killed 307 people and damaged 24,500 homes (**www.essex-estuaries.co.uk/1953Floods.htm**). Sea level may rise by 18 cm in the London area by 2050 (Defra 2009c) and the risk of significant flooding will be greatly increased.

6.5 Intertidal saltmarshes and mudflats provide us with natural defences against storm surges because as the storm waves pass across them, they lose their energy. Shingle beaches and sand dunes above high water provide a further barrier. However, such habitats are declining due to sea level rise and the supply of sediment to build the intertidal habitats is halted by engineered coastal defences. For example, 1,160 ha. of saltmarsh were lost in Essex and Suffolk between 1973 and 1998 (Cooper and others 2001).

6.6 On many low lying coasts sea walls have been built to compensate for the loss of these natural defences. In 2006-7, approximately £358 million was spent on coastal and inland flood defences, but this is not keeping pace with the erosion caused by sea level rise. It has been estimated that an 80 m deep zone of intertidal habitat fronting sea walls can save £4,600 per metre in sea defence costs (Empson and others 1997). An alternative approach to engineering is to restore intertidal habitats as coastal defences, so called managed realignment (see Alkborough Flats case study).

Case study 16 Alkborough Flats - delivering multiple benefits through managed realignment

Alkborough Flats is 440 ha (1,090 acres) of low lying land on the south bank of the Humber Estuary and is currently the UK's largest managed realignment site and an example of multiple benefits of an ecosystem approach.

In 2006 a 20 m wide breach was cut into the flood defence bank and 170 ha. of land was converted to intertidal mudflat, saltmarsh and reedbed. The remaining 230 ha. of land serves as storage capacity during extreme storm surges. It is calculated that there is an annual flood protection benefit of £400,667.

The whole area isn't available for arable farming, but there is additional income from grazing livestock. The area has become a haven for wildlife with 150 bird species recorded, including thousands of migratory birds such as lapwing and golden plover in winter.

Using willingness-to-pay methods, wildlife and wildlife habitat on the site has been valued at £535,000 per year. In addition the restored intertidal area plays a role in climate regulation (approximately 539 tonnes per year of carbon are trapped in sediments worth an estimated £14,553 per year), air quality improvement, nutrient and pollutant sequestration, and recreation and tourism. There are now 23 such coastal realignment schemes in England, cost-effectively delivering a wide range of ecosystem services, including commercial fish stock nurseries at other sites.

(Everard 2009; Dixon and others 2008)

Case study 17 Hallsands, South Devon - the lost village

In the early 20th century, dredging took place in Start Bay to provide materials for the naval dockyard at Plymouth. This led to the banks of shingle, which protected this ancient fishing village during storms being removed by erosion. In 1917 a storm hit. Almost the entire village was washed away overnight and 36 of 37 houses in the village were destroyed. The village was subsequently abandoned.

Water regulation

6.7 Extensive inland flooding in 2007 focussed attention on the economic and human costs of flooding (Pitt 2008). Climate change is already causing heavier downpours, especially in winter, a trend that is projected to persist and increase flood risk (Defra 2009c).

6.8 Management of flood risk has often been through building flood banks. These are expensive to construct and maintain and can move the flooding problem downstream rather than solving it. Ecosystem-based options exist to reduce the impact of floods. Habitats as diverse as woodland, heathland and wetland have the capacity to slow the surface flow of water into rivers and streams, and store water within the habitat (O'Connell and others 2004).

6.9 Increasing the infiltration of water into the soil, thereby stopping it from running across the surface, is also important. In built-up areas extensive sealing of the soil by development has occurred and farm machinery and heavy stocking can compact soil and reduce its ability to soak-up rainfall (Holman and others 2003; Defra 2007b). Restoring green space in towns and management to open up soil structure, a process in which living organisms play a key role, can reduce flood risk.

6.10 The response to flood risk has often been to deepen channels of rivers and straighten them, so rapidly transferring water and flood risk downstream (Pitt 2008) at extra management cost. Restoring more natural rivers with well-vegetated river channels convey floodwaters more slowly and increases the venting floodwaters onto the undeveloped floodplains, which avoids flooding in built-up areas. In the past, washlands were created for this purpose. (Morris and others 2004).

Case study 18 Long Eau Washlands, Lincolnshire - flood storage and biodiversity

The River Long Eau flows through intensively managed agricultural with low biodiversity over a large surrounding area . Over the years the river channel has been straightened and heavily engineered embankments have been built and maintained, cutting off the floodplain from the river.

In the mid 1990s new flood banks were built set back from the river and the old bank breached to allow flood water to escape the river channel, into 22 ha of floodplain. This alleviated flood risk to houses and farmland downstream.

The former arable area is now managed as pasture and biodiversity has been allowed to re-establish naturally. Wet grassland and marshland has re-established and wildfowl including widgeon, teal, snipe, ruff and curlew occur with around 60 breeding pairs of redshank.

Several extensive ancient washlands, such as the Nene and Ouse Washes, East Anglia, are internationally important wildlife sites, particularly for wintering and breeding birds. A range of other washland recreation schemes have been implemented in recent years, or are planned.

(Morris and others 2004)

Water purification

6.11 A wide range of pollutants can potentially occur in water, but the nutrients nitrogen and phosphorus are particularly problematic. They cause widespread change in the ecology of waters, leading to the death of fish and other organisms, the spread of disease and the creation of algal blooms (Smith & Schindler 2009).

6.12 In some peaty upland areas there has also been an increase in dissolved organic compounds causing staining of the water. The cost of drinking water contamination caused by farming has been estimated at £129 million per year (Jacobs 2008) and water companies are now working with upland farmers to change land management to reduce the water staining at source instead of by conventional water treatment.

6.13 Semi-natural vegetation in catchments is critical to the provision of clean water in two ways:

1) It does not generate pollution. Semi natural habitats are typically nutrient poor and the plants which occur have evolved mechanisms for ensuring any nutrients which do occur are tightly held within the system.
2) It can assimilate nutrients generated by other land uses and trap soil particles with nutrients adsorbed onto them.

6.14 The ability of semi-natural vegetation to retain nutrients can however be affected by the way it is managed. For instance, drainage and burning of peat moorland can result in damage to surface layers, resulting in increased losses of carbon, phosphorus and nitrogen in drainage waters. Projects, such as the one outlined in Case study 19 by the Moors for the Future Partnership, are seeking to restore large areas of upland habitats and ensure favourable land management practices (Yallop and Clutterbuck 2009).

Case study 19 Moors for the Future sustainable catchment management

Moors for the Future is a private-public partnership established in the Peak District National Park to reverse the degradation of the moorland landscape and encourage its conservation and public enjoyment. The extensive blanket peat bogs of the area have, in the past, been extensively eroded to bare peat and mineral soil by a combination of over grazing, burning and air pollution, locally exacerbated by visitor pressure.

This has degraded many ecosystem services. Through the work of the Moors for the Future Partnership, peatland restoration in the Bleaklow area has reduced the loss of carbon in peat, improved water quality for human consumption, enhanced recreational use and increased the cultural and historical value. Provisional estimates of the annual value of a subset of services provided by the restored peatland are between £1.2 - £3.2 million.

(Bonn and others 2009; eftec 2009)

Greenhouse gas regulation

6.15 Increase of atmospheric greenhouse gases, notably carbon dioxide, is driving climate change. However, more carbon is stored in soils, vegetation and the oceans than the atmosphere, and these carbon sinks play a vital role in regulating climate. A range of habitats, peatlands, woodlands, agricultural land, coasts and the seas, play a role in greenhouse gas regulation.

6.16 Peat develops where wet conditions prevent complete decomposition of plants. Over the past 10,000 years peatlands have removed significant amounts of carbon dioxide from the atmosphere. It is estimated that peat soils in England store 296 million tonnes of carbon (Bradley and others 2005), which is roughly equivalent to two years of total UK carbon emissions. In an undamaged state peat remains wet at the surface all year sequestering between 0.1 - 0.5 tonnes of carbon per ha per year (Dawson & Smith 2007). Peatlands are, however, also a source of the greenhouse gas methane. Despite this, through effective management, they offer the potential to be a significant contributor to wider climate change mitigation.

6.17 In reality many of our peatlands are degraded by drainage, burning and conversion to other land use. Under current management, the drained and cultivated lowland fen peats are likely to emit around 3 - 5 million tonnes of carbon dioxide per year, more than domestic aviation and similar to emissions by the UK concrete industry (Thompson 2008).

6.18 Forests accumulate carbon in their soils and trees. The entire UK woodland and forestry estate stores around 150 million tonnes of carbon (Broadmeadow and Matthews, 2003), which is equivalent to one year of UK carbon emissions. Around 15 million tonnes of carbon dioxide was sequestered by forestry in 2006 and reduced the UK’s carbon dioxide emissions by 3 per cent.

6.19 Wood has the potential to be used as a renewable carbon neutral fuel and the Forestry Commission Woodfuel Strategy aims to increase woodfuel harvesting to substitute for 0.4 million tonnes of carbon per year from fossil fuels (FC 2007). It can also replace materials such as iron, steel and concrete, the production of which involves high fossil fuel use; timber use in house construction could reduce carbon emissions by up to 73 per cent (FC 2006).

6.20 Grasslands are extensive and because of this they store more carbon than any other land use in England (686 million tonnes), with arable land the second largest store (583 million tonnes) (Bradley and others, 2005). Overall, grassland and cropland management in the UK was a net source of 6.87 million tonnes of carbon dioxide in 2005, which is over 1 per cent of total UK carbon dioxide omissions (UK Greenhouse Gas Inventory, 2008).

6.21 If adopted widely, new methods for arable or grasslands management, such as conserving or planting selected species that have a positive effect on soil carbon stored (R. Bardgett and others unpublished), could have climate regulation benefits.

6.22 Saltmarshes and mudflats also store significant amounts of carbon. Research in the Blackwater Estuary, Essex, has shown that 0.44 - 1.7 tonne of carbon per ha per year could be stored by recreating intertidal habitats (Shepherd and others 2007) (see Alkborough case study).

6.23 The largest carbon sink is the ocean which is estimated to absorb almost half of all greenhouse gas from burning fossil fuel and cement manufacture (Sabine and others 2004). Methods to manage ecological processes in the sea to sequester more carbon are the subject of much current research.

Direct climate regulation

6.24 Vegetation can beneficially modify the climate especially in cities, where heat absorbed by buildings, concrete and tarmac raises summer temperatures. This so-called heat island effect makes city dwellers especially vulnerable to heat waves, which are anticipated to increase in frequency due to climate change. The 2003 heat wave is estimated to have accounted for 2139 extra death, many of which were in London (Johnson and others, 2005).

6.25 Climate benefits can be achieved from a wide range of vegetation due to shading of surfaces and the natural cooling as leaves lose water. The effect is most marked in woodlands where, beneath the canopy, temperatures can be 3 - 4˚C cooler than surrounding areas (Morecroft and others 1997). Urban greenspaces can give a cooling effect of 1 - 2°C (Bonan 2008). In winter buildings loose less heat when they are sheltered from wind by woody vegetation.

6.26 Open water habitats reduce temperature fluctuations, cooling surrounding areas by day (Bolund & Hunhammar 1999). Shade from trees has a modifying effect on river and lake temperatures and can be beneficial for fisheries and wildlife, particularly in the face of climate change (Broadmeadow and Nisbet 2004).

Case study 20 Green roofs - an innovative ecosystems approach

Green roofs in which traditional roofing material is replaced by a layer of soil and living vegetation are attracting increasing interest in urban areas. Although they involve higher costs of installation and more regular maintenance, green roofs provide habitat for wildlife and green space for people in towns and cities without sacrificing land for development.

Equally importantly the vegetation layer provides insulation, making green roofs and the buildings on which they are found cooler in summer, and warmer in winter compared to traditional roofs. They can store significant amounts of rain fall, more than 80 per cent in some situations, reducing the flood risk in built up areas.

Due to the added benefits they provide green roofs can be economically favourable compared to traditional roofs, and have the potential to play a significant role in the adaptation of cities and towns to climate change.

(Kumar & Kaushik 2005; Van Woert and others 2005)

Soil regulation

6.27 Soil performs a wide range of functions in the landscape that include storing carbon, supporting plant growth; decontaminating pollutants; preserving archaeological remains and other evidence of past environments, and being reservoirs of biodiversity.

6.28 Soil erosion has important consequences for many sectors of society. Water erosion removes 2.2 million tonnes of arable topsoil annually in England and Wales (Environment Agency 2004). Further losses are due to wind, tillage and removal with crops (Owens and others 2006). It has been estimated that soil erosion costs agriculture in England £45 million each year (Defra 2007b). Further costs are borne as soil enters water, increasing flood risk, and damaging drinking water, fisheries, recreation and biodiversity.

6.29 Soil is further damaged due to compaction by machinery and heavy stocking. This limits root development and plant growth; reduces water storage capacity; increases surface water runoff and therefore flooding; and causes release of the potent greenhouse gas nitrous oxide (Defra 2007b). A range of ecological interventions are possible to limit soil erosion. Research in Upper Wharfedale, North Yorkshire concluded that targeted increase of woodland cover by 5.6 per cent, could prevent 80 per cent of sediment from entering the river (Lane and others 2008).

6.30 The climate change predictions for England are for more frequent droughts (causing vegetation die back and soil exposure) and heavier downpours (Defra 2009b). Such conditions are likely to increase the risk of soil erosion and hence increase the need for species rich vegetation which can provide more resilient protection for soil (Tilman & Downing 1994).

Pollutant decontamination

6.31 Most pollutants are decontaminated by natural processes that change them into non-injurious substances or trap them in tissues or sediments.

6.32 Air pollution is a major environmental and public health problem, especially in cities. Vegetation can reduce such risks, largely due to the filtering effects of leaves: 85 per cent of air pollution can be filtered out by a park with trees and 70 per cent can be filtered out in streets with trees (Bolund & Hunhammar 1999). Trees around sensitive sites can dramatically reduce the impact of air borne ammonia from agriculture (Dragostis and others 2006).

6.33 The complex biota in soil are a powerful facility for the breakdown of pollutants. It is estimated that soils degrade or retain 99 per cent of the pollutants they receive (Environment Agency 2006); 110 million tonnes of livestock manures and 1 million tonnes of sewerage are decontaminated by soil each year in England and Wales (Environment Agency 2004).

6.34 Intertidal habitats and seas also decontaminate pollutants, including sewage. Heavy metals such as zinc and copper cannot be broken down biologically yet actively growing saltmarshes have been shown to provide another solution by capturing and storing these elements in their sediments so they no longer cause harm (Andrews and others 2008).

Pollination

6.35 Approximately one third of global food production relies directly or indirectly on insect pollination (Richards 1993). In the UK this is particularly the case for fruits, and some vegetable, edible oil and legume crops (Gallai and others 2009, Williams 1994). It is estimated that a 50 per cent decline of insect pollinators would cost the UK economy £96 million per annum (NAO 2009) and would restrict the quantity and diversity of food production.

6.36 Crops are pollinated by many insect species, including wild and domesticated bees, flies and beetles. The domesticated honey bee *Apis mellifera* is susceptible to a range of virulent parasites and diseases and greatly increased rates of honey bee colony death in recent years are a major concern.

6.37 Between 1985 and 2005 colony numbers in England declined by 54 per cent (Potts and others in press). The problem in England is offset by the fact that much pollination is carried out by wild insects, especially bees. However these too have shown a marked decline in recent years, with a 52 per cent decline of wild bees in Britain since 1980 (Biesmeijer and other 2006).

6.38 Land use in the areas surrounding insect pollinated crops is of importance, as the diversity and abundance of wild pollinating insects is closely related to the proximity of wildlife habitats in the surrounding countryside (Kremen and others 2007, Rickets and others 2008).

6.39 Some forage plants and a great many garden plants are pollinated by insects. However, of greater importance may be the decline of insect pollinated wild plants in Britain (those pollinated by wind and water have increased) possibly due to a decline of pollinating insects (Biesmeijer and other 2006). These losses may reduce the future resilience of ecosystems by reducing species diversity. (see Case study 1).

Natural pest control

6.40 Modern agriculture is heavily reliant upon pesticides to control crop pests. One consequence of this heavy pesticide use is that within a few years of their introduction, resistant strains of pests have developed in response to most organic pesticides (Gray and others 2009).

6.41 Natural enemies also play an important role in controlling pests. Improving the pest control achieved by natural enemies of pests will reduce the need for pesticides. A wide range of predatory insects feed upon crop pests including flies, beetles, spiders and wasps. Highly damaging pest outbreaks are often due to the breakdown of natural pest control.

6.42 Although natural pest control is unlikely to completely remove the need for pesticides, high levels of natural pest control can be achieved. For example, in recent experiments, predators have achieved a 90 - 93 per cent reduction of aphids on wheat (Holland and others 2008).

6.43 In glasshouses the use of predators, parasites and diseases to control pests is well established practice, and a reason for conserving organisms that might be used in the future for biological control.

Noise reduction

6.44 Noise creates health problems in urban areas and the costs have been estimated at 0.2 - 2 per cent of GDP in the European Union. Replacing hard, sound reflecting surfaces with soft vegetated surfaces can have a significant effect; a 50 m wide strip of shrubby vegetation may reduce noise by an amount equivalent to doubling the distance to the source (Bolund & Hunhammar 1999).

Conclusion

6.45 We are only beginning to understand both ecologically and economically the many ways in which management of the natural environment provides regulating services and how these support our economy and prosperity. The evidence highlights a number of clear situations where cost-benefit assessments favour ecological as opposed to technological options. This is partly because technology normally focuses on as single problem in isolation, such as water purification or pest control, and the solution can impact adversely on other ecosystem services.

6.46 Ecological options almost always deliver a bundle of services at any one locality and this feature makes them more cost-effective in many cases.

7 Nature's contribution to human health

Introduction

7.1 The Millennium Ecosystem Assessment highlights the importance of nature and ecosystems to people's health and quality of life.

7.2 Environmental conditions can significantly affect human health. For example, despite huge improvements in public health and ambient environmental conditions over the last century, it is estimated that poor air quality still causes many thousands of premature deaths in the UK every year (on average reducing life expectancy by 7 - 8 months) and costs the economy £20 billion (Defra 2007c).

7.3 A greater concern though is our increasingly sedentary lifestyle. Coupled with dietary factors, this is leading to a growing trend of obesity. The Foresight report (2007) believes that, by 2050, 60 per cent of men, 50 per cent of women and 25 per cent of children under the age of 16 in the UK could be obese. The health and cost implications of this, due to increasing levels of type II diabetes, strokes and heart disease, could be enormous.

7.4 This section explores the some of the ways in which a healthy natural environment can contribute to improved physical and mental health outcomes and the important contribution this can make to the economy and society.

Active outdoors: Physical health and wellbeing

7.5 A healthy accessible natural environment provides people with opportunities for activity that can benefit their physical wellbeing and contribute to local economies. People are active in the natural environment in different ways: they use it as a place to exercise; use it for recreational activity; or it might be the setting for volunteering work.

7.6 Physical inactivity is costly, both for individuals and for the economy. It can:

- Double the risk of heart disease and diabetes.
- Significantly increase the risk of breast and bowel cancer, stroke, dementia, depression, osteoporosis and arthritis.
- Impact negatively on the performance of the economy, not just in terms of health treatment costs but also in terms of lost output. These costs have been estimated at £8.2 billion per year in England (Allender and others, 2007).

7.7 Accessible natural environments increase the opportunity for physical activity by providing open green space that is generally free to use, and the restorative affect of nature may also put people in a 'better frame of mind' to exercise (Hartig and others 1991).

7.8 Green exercise is one way that people are being encouraged to use the outdoors to increase their physical activity. The term 'green exercise' encompasses a range of different outdoor activities, including lead walks, green gym conservation management, and children's outdoor adventure activities.

7.9 The evidence to evaluate many of these programmes is at an early stage of development. However, it is enough for the National Institute for Health and Clinical Excellence (NICE) to recommend outdoor lead walking interventions as a cost effective means of increasing physical activity levels in sedentary adults, especially the elderly (NICE 2006, 2008).

Case study 21 Walking for Health

Natural England's Walking for Health programme is the largest initiative in the UK promoting physical activity to sedentary people. It has over 32,000 (as at April 2009) regular participants. The annual value of health benefits from the programme have been estimated at £11 million in cost-averted savings to health care providers (Natural England 2009a). Being outside is a key motivating factor that keeps many of these people active (Ashley and others 1999).

7.10 A accessible healthy natural environment close to where people live, which is perceived as safe and with a layout that is easy to navigate encourages increased physical activity (Giles-Corti and others 2005; Ellaway and others 2005, Tinsley and others 2002).

7.11 Mitchell and Popham (2008) examined the incidence rate ratios for all-cause mortality in groups with exposure to green space. They found that exposure to green space reduced mortality rates across all groups particularly amongst the poorest in society, saving an estimated 1300 premature deaths in poorer areas each year.

7.12 Other studies looking at the value of green space in relation to physical activity suggest that:

- People who live within 500 m of accessible green space are 24 per cent more likely to meet recommended levels of physical activity (Coombes and others in press).
- Reducing the sedentary population by just 1 per cent could reduce morbidity and mortality rates that have been valued at £1.44 billion for the UK (CJC Consulting and others, 2005).
- Work examining the implications of universal access to green space estimate savings to the National Health Service (NHS) in the order of £2.1 billion per annum due to increased levels of physical activity (Natural England 2009b).

A breath of fresh air: mental health and wellbeing

7.13 Mental ill health, ranging from feelings of stress and anxiety to severe and enduring mental health problems, is a growing burden on our society. For instance:

- At any one time it is estimated that over 16 per cent of the population suffers from depression and anxiety.
- In 2005, 27.7 million antidepressant prescriptions were written in England, costing approximately £338 million.
- About one seventh of the NHS budget is spent on mental health (DH, 2009).
- The cost of depression in terms of lost economic output is estimated to be £12 billion a year (LSE, 2006).
- Mental health illness in total costs the nation an estimated £77 billion (DH, 2009).

7.14 Healthy accessible natural environments have the potential to significantly benefit our mental health by offering opportunities for relaxation and providing places to rest and meet people (RCEP, 2007).

7.15 A growing body of evidence shows that simply getting outside in a green space can reduce levels of stress and anxiety along with other benefits. For example:

- Walking can improve self-esteem, relieve symptoms of depression and anxiety, and improve mood (Mobily and others, 1996).
- Pretty and others (2003) found significant positive changes to mood (anger; anxiety; depression; fatigue; confusion) amongst people participating in activities outdoors.

- MIND (2007) showed significant positive differences in peoples' mental state when walking outdoors in green space compared to walking in a shopping centre.
- Contact with the natural environment can improve levels of concentration, lower stress, reduce symptoms of dementia, and help with the treatment of ADHD (Taylor and others 2001, Talbot and Kaplan 1991, Haas and others 1998).

7.16 The mental health benefits of interacting with the natural environment is only just starting to become clear. The evidence is, however, robust enough for green spaces to be viewed as a vital underpinning component of New Horizons, the new national vision for mental health and wellbeing in England. New Horizons cites urban green space, its community functions and ecosystem services, as an explicit underpinning to support flourishing communities, "building resilience and a secure base" (DH 2009).

Case study 22 Phoenix Futures Conservation Therapy

Phoenix Futures is a charity that runs rehabilitation programmes for substance misusers. One of the options they offer as part of their residential programme is the Conservation Therapy. This aims to help people challenge themselves as individuals; build their self-esteem, self-confidence and motivation by working in wildlife-rich environments. The programme has been running since 1997. Clients originally came only from the Sheffield Rehabilitation Centre to work on Lathkill Dale National Nature Reserve (NNR). The success of the programme meant that it has been extended to other centres and other NNRs around the country. Working with a tutor, clients work on access improvements, such as repairing footpaths, maintaining habitats, and activities such as dry-stone walling.

Tuomi (2004) found that clients participating in Conservation Therapy were 22 per cent more likely to complete their drug rehabilitation programme, completion being a key indicator of sustainable rehabilitation success. Clients participating in the programme identified intrinsic benefits including the development of social skills, teamwork skills, and communication skills (Hall, 2005).

"After all my years of drug abuse, where I seldom completed a task, it was reassuring to learn that I could function as an individual within a team and see a job through, taking pleasure in playing my part in constructing walls, which will still be there in 300 years".

John, Conservation Therapy Participant.

Case study 23 Rethink volunteers - Willow work aides mental health

People living with severe mental illness have discovered a new interest after working with willow at the Lawrence Weston Moor Local Nature Reserve in Bristol. Patients and care workers from the mental-health charity Rethink came to the reserve and worked with an Avon Wildlife Trust willow artist. The group learnt all about willow; its historical role in farming and rural crafts, and the traditional ways of managing willow trees. They then cut willow wands to take back to their day centre.

"People were thrilled by the visit," said Sally Oldfield, LNR Officer.. *"Although everyone in the group lived nearby, none had ever been to the reserve before".* Back at the day centre, the patients used the willow wands to create stars, hearts, wreaths and planters. They even planted a willow-bed to give them the raw materials for more workshops in the future. Beyond the therapeutic value of these activities it is hoped that educating people about the importance of natural materials such as willow, will help traditional woodland skills live on.

"I have a real problem with motivation. I find it difficult to concentrate on things because of my medication, but I'm really into this".

Rethink group member

Conclusion

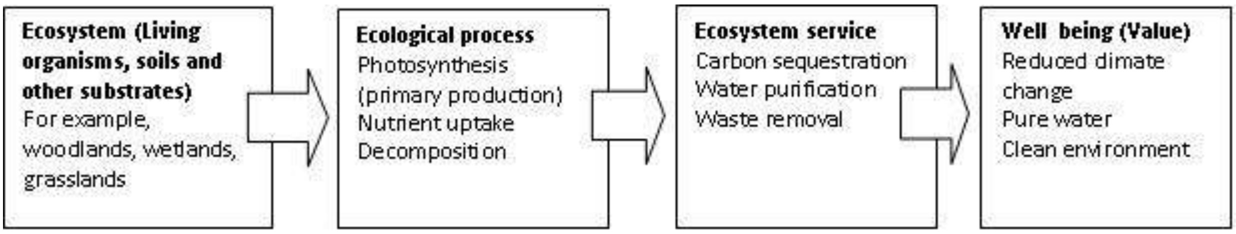
7.17 Functional ecosystems supporting good quality natural environments influence peoples' health and happiness. Good quality natural environments make a positive contribution to peoples' wellbeing, especially if they are accessible on a daily basis. They do this by influencing our physical and mental health; providing an arena for our leisure and recreational activities; by being neutral spaces where we can engage with others building the social capital of our communities.

7.18 A suitable healthy natural environment in the right places, can generate cost-averted savings through our health services. With the right investments, and commitment to sustain functional ecosystems and urban green spaces, there is significant scope to save much more through our Natural Health Service (2009a).

8 How many species are needed to deliver ecosystem services?

8.1 Usefulness, in the narrow sense of maintaining our everyday life at the most basic level, is not the only reason for conserving biodiversity, but it is an important one. A key question, therefore, is how much biodiversity, and particularly how many species, are needed to support ecosystem services and our wellbeing? This is in the narrow sense of material, as opposed to our cultural, spiritual and intellectual, needs.

8.2 For a small number of services, such as pollination and the use of wild plants in crop breeding, the species provide the service directly. With enough research it would be possible to identify and count them - 303 plant taxa in the UK are genetically closely related to a major food species (Maxted and others 2007).



(modified from Haines-Young and others 2006)

Figure 6 The linkage between ecosystems, ecological processes, and ecosystem services to create human well being

8.3 However, for many other ecosystem services (such as water purification, erosion regulation, greenhouse gas regulation) the link between species and the individual services is much less clear. This is because the service is provided at **the ecosystem level, not the species level**. That is, most services are provided, by the sunlight-fuelled interaction of organisms with: i) each other; and ii) the non-living parts of the ecosystem (see Figure 1). Basic research into the ecological processes that underpin ecosystem services therefore plays an important part in our understanding of the link between species diversity and ecosystem services.

8.4 Ecosystems are complex and such experiments produce a variety of results and have the limitation of being small scale or laboratory based. The same experiments carried out in range of localities can generate different results (Hector and others 1999) and some species have more effects on individual processes than others (Englhardt & Richie 2001; Cardinale and others 2006).

8.5 In the greater number of experiments, however, increased rates of the ecosystem processes underlying ecosystem services are associated with increased numbers of species (Hector & Bagchi 2007; Balvenera and others 2006; Hopper and others 2005).

8.6 Research suggests that after a certain point, adding further species (most of this research has been done on plants) does not increase a given ecological process, but different species affect different processes. For example some plants may have high productivity, while others may be slow-growing but efficient at capturing nutrients from the soil. For multiple services to be delivered, higher levels of diversity are therefore likely to be required than for a single service (Hector & Bagchi 2006).

8.7 Even where increased species diversity is not associated with an increase in an ecosystem processes, it can decrease ecological process variability, the so-called insurance effect, buffering the ecosystem and the services it provides as conditions fluctuate (Yachi & Loreau 1999; Dang and others 2005; Cottingham and others 2001). In other words, increased species diversity can result in increased ecosystem resilience, as shown by grassland experiments carried out in the United States where diverse grassland plots subjected to severe drought recovered far more quickly than species poor plots did (Tilman & Downing 1994).

8.8 The consequences of reduced diversity are clearly shown in arable faming where large areas are planted with one species. As a consequence there are year-to-year fluctuations in yield due to climate, and a range of chemical and other interventions are needed to prevent even greater variation due to pest and diseases. These factors would have less impact on species-rich vegetation, albeit with lower maximum yields.

8.9 Although the accumulating evidence points to a general, but not universal, association of higher diversity with provision of multiple ecosystem services and increased resilience, many species are rare in a given ecosystem. It seems unlikely that such species have a critical ecological role, but they may be important for other services such as genetic conservation and conservation as a cultural service in its own right. Given the desirability of maintaining higher species diversity to support multiple ecosystem processes, the additional costs of maintaining these rare species is unlikely to be high.

8.10 In the face of climate change species that are rare today could play a critical ecosystem role as they may increase to take over the role of now abundant species, which decline as climate changes. Many rare species in the UK are warmth loving southern species at the northern edge of their range. They are more abundant further south in Europe, and therefore may increase.

9 An overview of provisioning services from farming, forestry and fisheries

Introduction

9.1 Although gathering wild foods, medicinal plants, reeds and other wild products still occurs in England, the overall scale of these activities is small, as is typical of a developed economy. The exception is the case of wild caught fisheries, discussed below. Where there are markets, they are for niche products, such as thatching reed and making cordials and foods made from wild flowers and fruits.

9.2 In contrast, the outputs from farming, forestry and fishing, the main producers of provisioning services, are carried out over much larger areas, and the outputs can be measured in millions of tonnes. Their impact on many other ecosystem services is complex and the ecological character of the largest part of England and her seas is strongly influenced by past and current activities of these sectors.

9.3 Importantly, the largest part of the produce from these activities are bought and sold in markets, and for most farming, forestry and fishing enterprises, the main source of income is from the sale of these goods. Such enterprises are strongly incentivised to make decisions that maximise the supply of provisioning services, even where this results in the loss of public benefits from other ecosystem services.

9.4 Although the output from farming, forestry and fishing comprise around only than 1per cent of Gross Value Added (GVA) in the UK (**www.ons.gov.uk**), the food, timber, and fuel they provide play a vital role in our prosperity and well being. Food, with water, air and personal security, is one of the most basic of all human requirements.

9.5 The sharp spike in world food and fuel prices in 2008, coupled with increasing world population and greater consumption in countries such as India and China, has again emphasised the possible vulnerability of UK food and wood supplies, and the potentially larger role of land based industries in fuel production.

9.6 A key challenge therefore is to achieve a level of provisioning services required by society without unacceptably compromising the supply of other ecosystem services, an integration often lacking in the 20th century. The available evidence suggests that to give pre-eminence to provisioning services over other ecosystem services will deliver a balance of service that will not meet many of society's needs (Chan and others 2006).

Farming

9.7 Approximately 70 per cent of the land surface of England is farmed, giving farming a greater role to play in the provision of ecosystem services than any other industry.

9.8 The total value of UK farm production including non-food products was £19.8 billion in 2008, a particularly favourable trading year. Taking into account value added by processing and marketing, the trade gap for food, animal feed and drink in 2008 was £15.2 billion. It might therefore be argued that this represents an under supply of provisioning services (Defra 2009a). While narrowing the trade gap may be desirable, it is not possible to produce all imported provisions in England, as for example Mediterranean and tropical fruits. Others can only be produced at disproportionate cost and it makes economic (and sometimes ecological) sense to buy them where conditions, particularly climate, are more suitable and they can be produced more efficiently. For example, the UK is particularly suitable in parts for milk production (Defra 2009a).

9.9 Food is not the only product of farming. Since 2002 energy crops have become increasingly important and between 2004 and 2007 the area of oilseed rape grown in England under the energy aid payment scheme for conversion to bio diesel increased twenty-fold, from 10,862 to 240,032 ha., with much smaller areas of the grass *Miscanthus* and short rotation coppice grown as biomass energy crops (National Non-Food Crops Centre 2009).

9.10 The 20th century saw an increased specialisation of farms so that today most can be broadly classified as based upon either livestock or arable production (Clothier and others, 2008), although the sectors are linked because a proportion of arable production is feed for livestock. Livestock rearing is based upon grasslands and rough grazing land and concentrated in the North and West of England and the more difficult land to cultivate elsewhere. Arable farming is concentrated in the South and East and on the better land. This geographical distinction has important consequences for the supply and vulnerability of ecosystem services, associated with factors such as the greater risk of soil erosion on cultivated land, and greater storage of carbon by grassland soils.

Forestry

9.11 The area of woodland and forest in the UK has increased over many decades due to the planting of non-native conifers, so called softwoods, and more recently significant expansion of broadleaved trees, so called hardwoods (Hopkins & Kirby 2007). Despite this the UK is one of the least wooded countries in Europe (Forestry Commission 2008).

9.12 Provisioning services from forestry in the form of timber, wood-fuel, wood pulp and other forest products therefore play a relatively small role in the economy. However, many of the regulating services (for example, carbon storage) and cultural services (for example, recreation) provided by woods and forests are of significant economic importance (Willis and others 2003), and broad leaved woodlands in particular are of considerable conservation and landscape importance in part due to the relative scarcity of the resource.

9.13 In the UK 8.4, million tonnes of softwood and 0.4 million tonnes of hardwood were harvested in 2008 (Forestry Commission 2009). Only a small proportion of the harvested softwood is from England, as Scotland has by far the largest area of UK softwood plantation (Forestry Commission 2008). The great majority of the wood consumed by UK sawmills comes from domestic sources but overall UK processing industries have a heavy reliance upon imported forest products, particularly wood pulp and paper (Forestry Commission 2009). Approximately 80 - 90 per cent of our wood and wood-product consumption is imported.

9.14 Only 40 per cent of the annual increment in England's woodlands is harvested. The aim is to utilise an additional 2 million tonnes of this as wood fuel, enough to heat the equivalent of 250,000 homes, saving an estimated 0.4 million tonnes of carbon emissions (Forestry Commission 2007). One benefit of this strategy will be to bring many broadleaved woodlands back into management; this could benefit their biodiversity which has declined in part due to lack of management (Kirby and others 2005).

9.15 Even if the utilisation of current woodland is greatly increased, this will not make a major difference to our continued dependence on imported wood and wood-products unless there is also a substantial reduction in the overall wood-usage and/or a substantial increase in woodland area.

9.16 Wood is renewable material that has the potential to substitute in many situations for non-renewable or more energy-intensive materials such as concrete or brick. Therefore the balance is likely to be towards an expansion of forests, particularly conifer forests because softwood, rather than hardwoods, forms the bulk of the demand.

Fisheries

9.17 No other provisioning service demonstrates the importance of effective natural resource management more directly than the case of sea fisheries. The harvest of England's seas is almost exclusively of wild caught species. Currently fish landings are regulated under the EU Common Fisheries Policy (CFP) so they do not accurately reflect the health of fish stocks. In 2008, 19,000 tonnes of cod and 33,000 tonnes of haddock were landed in the UK. In each case this was significantly less than landings in 1994 - a reduction of 72 per cent and 65 per cent respectively (Marine and Fisheries Agency 2008).

9.18 A problem of global significance is the unsustainable harvesting of sea fish at a higher rate than natural reproduction. This can result in the decline and potentially a complete economic collapse of the fish stock, as seen in the North East Canada cod fishery in the early 1990s. In 2002 50 per cent of the UK catch by value came from stocks that were borderline or unsustainable (Cabinet Office 2004).

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