



# No charge?

Valuing the natural environment

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# Summary and key messages

**A healthy natural environment is indispensable to current and future economic prosperity. Conserving the natural environment is the most efficient and effective way to deliver a huge range of benefits to society.**

The evidence is overwhelming. A healthy natural environment provides cost-effective solutions to many of the challenges we face; from flooding and coastal defence through to delivering fresh water and adapting to climate change. The economic evidence suggests that the benefits of ecological solutions outweigh the cost, many times over in some cases. For example:

- 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.
- Upland and lowland management to restore floodplains and improve 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 500m 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 would reduce morbidity and mortality rates valued at £1.44 billion for the UK.
- Environmental Stewardship is estimated to deliver savings of 3.46 million tonnes of CO<sub>2</sub>e per year. Without the scheme, greenhouse gas emissions from agriculture in England would be 11 per cent higher. The value of these savings is estimated at around £1.25 billion.

Further, the costs of not looking after the global natural environment potentially run into many trillions of pounds.

- The cost of global biodiversity decline under a business-as-usual scenario is estimated to be as much €14 trillion by 2050 (7 per cent of global GDP).
- A business-as-usual scenario for greenhouse gas emissions could result in costs equivalent to between 5 and 20 per cent of GDP by 2050, whereas stabilising greenhouse gas concentrations would cost as little as 1 per cent of GDP.

**Investing in a healthy natural environment is essential to deliver these benefits**

Investing in a healthy natural environment is critical if we are to deliver these benefits on a scale that makes a significant contribution to future prosperity. The challenges of climate change and food, water and energy security cannot be overcome with technology alone. New ecological solutions are required to deliver multiple services and benefits cost-effectively.

To realise these ambitions and continue to enhance our prosperity, we need unparalleled innovation and a new integrated approach to delivery – an ecosystems approach. This will require:

- a deeper understanding of the economic value of nature and natural capital and the use of an ecosystem services approach to better inform decision-making processes;
- enhanced public investments in the natural environment to deliver greater efficiency and improved outcomes;
- 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.



Longhorn cattle on Skipwith Common SSSI

# The benefits of a healthy natural environment

We cannot truly prosper without a healthy natural environment. It is integral to our health, wellbeing and happiness. In the extreme, nature makes economic progress possible. It underpins everything humankind collectively consumes. It provides raw materials for the production process, for example, timber, fuels, water and critically, food. It shapes the places in which we live and work. It also has huge untapped potential and presents opportunities for future discoveries that may prove critical in the development of our economies and societies, for example, genetic resources and biotechnologies.

Despite this, our natural environment continues to decline at an unprecedented rate. The level of carbon dioxide in the atmosphere is the highest it has been for approximately 650,000 years ([www.ipcc.ch](http://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).

## 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 that losses are slowing, 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 2005-2006 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 than 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

These trends are important and they matter for economic reasons:

- The Economics of Ecosystems and Biodiversity (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 (roughly equivalent to 7 per cent of global GDP).
- The Stern Report on the Economics of Climate Change (2006) argues that a business-as-usual scenario for greenhouse gas emissions could result in costs equivalent to between 5 per cent and 20 per cent of GDP by 2050, whereas stabilising greenhouse gas concentrations in the atmosphere, at an acceptable level (550 ppm CO<sub>2</sub>e – 550 ppm CO<sub>2</sub>e), could cost as little as 1 per cent of GDP.

The economic evidence is equally compelling at national and local levels. For example:

- The 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).
- Meyerhoff and Dehnhardt (2004) found that floodplain restoration projects can deliver significant water quality benefits, with gains outweighing costs by a factor of 2.5 to 4.
- Many managed re-alignment projects have been found to deliver positive returns on investments of many millions of pounds over relatively short (25 years) time periods (eftec, 2009).
- The benefits of reducing eutrophication in water bodies in East Anglia were found to run into many millions of pounds, significantly exceeding estimated costs (Bateman and others, 2006).
- We are losing between 2.8 and 5.8 million tonnes of CO<sub>2</sub> per year from the cultivation and drainage of lowland peat soils (Thompson, 2008). Based on the shadow price of carbon, (£26.5 per tonne of CO<sub>2</sub> equivalent), the annual value of this loss is estimated at £74 million–£150 million.

- According to research by Defra (2007), Environmental Stewardship is estimated to deliver savings of 3.46 million tonnes of CO<sub>2</sub> equivalent per year against a baseline of there being no scheme. The scheme therefore potentially reduces England's total greenhouse gas emissions by 0.7 per cent annually. Without the scheme, emissions from agriculture in England would be 11 per cent higher than present levels. The value of these savings, using the non-traded price of carbon, is estimated at around £1.25 billion (range £600 million–£1.8 billion).
- 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).
- The overall costs to the economy of physical inactivity in England are estimated to be £8.2 billion per year (Allender and others, 2007).

The following sections look in more detail at specific examples and case studies around: coastal defence, flood protection, clean water, climate change mitigation and direct climate regulation.



21st February 1953: People delivering sandbags and blankets to stricken houses during flooding on Canvey Island.

## Coastal defence

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. Such 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 (<http://www.essex-estuaries.co.uk/1953Floods/htm>). Sea level may rise by 18 cm in the London area by 2050 (Defra 2009) and the risk of significant flooding will be greatly increased.

Inter-tidal 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 inter-tidal 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).

On many low-lying coasts, sea walls have been built to compensate for the loss of these natural defences. In 2006–2007, 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 inter-tidal habitat fronting sea walls can save £4,600 per m in sea defence costs (Empson and others, 1997). An alternative approach to engineering is to restore inter-tidal habitats as coastal defences, so called ‘managed re-alignment’ (see Alkborough Flats case study).

## Alkborough Flats – delivering multiple benefits through managed re-alignment

Alkborough Flats is 440 ha of low-lying land on the south bank of the Humber estuary and is currently the UK's largest managed re-alignment 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 inter-tidal mudflat, saltmarsh and reedbed. The remaining 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 economic valuation techniques, wildlife and wildlife habitat on the site has been valued at £535,000 per year. The restored intertidal area also 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 re-alignment 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)



Alkborough Flats inundated following a breach in the flood defence bank



## Flood protection

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, 2009).

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).

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, 2007). 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.

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 conveys floodwaters more slowly and increases the venting of 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).

## Long Eau Washlands, Lincolnshire – flood storage and biodiversity

The River Long Eau flows through intensively managed agricultural land 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).



Washlands in Lincolnshire



At Barton Broad, Norfolk, establishing fish exclosures led to dramatic improvements in water clarity

## Clean water

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).

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.

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

- it does not generate pollution. Semi-natural habitats are typically nutrient poor and the plants that occur have evolved mechanisms for ensuring any nutrients that do occur are tightly held within the system;
- it can assimilate nutrients generated by other land uses and trap soil particles with nutrients adsorbed on to them.

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 Moors for the Future Partnership, are seeking to restore large areas of upland habitats and ensure favourable land management practices (Yallop and Clutterbuck, 2009).

## 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 million and £3.2 million.

(eftec, 2009)



An un-restored area on Bleaklow



On-going restoration of Bleaklow using heather brash laying techniques

## Climate change mitigation

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.

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 2 years of total UK carbon emissions. In an undamaged state peat remains wet at the surface all year, sequestering between 0.1 tonnes and 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.

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 million–5 million tonnes of carbon dioxide per year, more than domestic aviation and similar to emissions by the UK concrete industry (Thompson, 2008).

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 1 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.

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).



Logs for woodfuel



Trees on streets cool the local environment

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).

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.

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

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

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 600 extra deaths in London (GLA, 2006).

Climate benefits can be achieved from a wide range of vegetation due to shading of surfaces and natural cooling of the atmosphere as leaves lose water. The effect is most marked in woodlands where, beneath the canopy, temperatures can be 3°C –4°C cooler than surrounding areas (Morecroft and others, 1997). Urban green spaces can give a cooling

effect of  $1\text{C}^{\circ}$ – $2\text{C}^{\circ}$  (Bonan, 2008). In winter the shelter from wind by woody vegetation means that buildings lose less heat.

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).

## 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 rainfall, 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).



Green roof on Barclays Bank, Canary Wharf, London



Drax coal-fired power station

## Facing the future – the need for an ecosystems approach

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).

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 a 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.

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 Adviser, 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.

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 while mitigating and adapting to climate change at the same time ([www.ost.gov.uk](http://www.ost.gov.uk)).

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.

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.

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. Pesticide use often results in the development of chemically resistant strains of pest species, while potentially killing off natural pest enemies and pollinating insects.

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).

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).

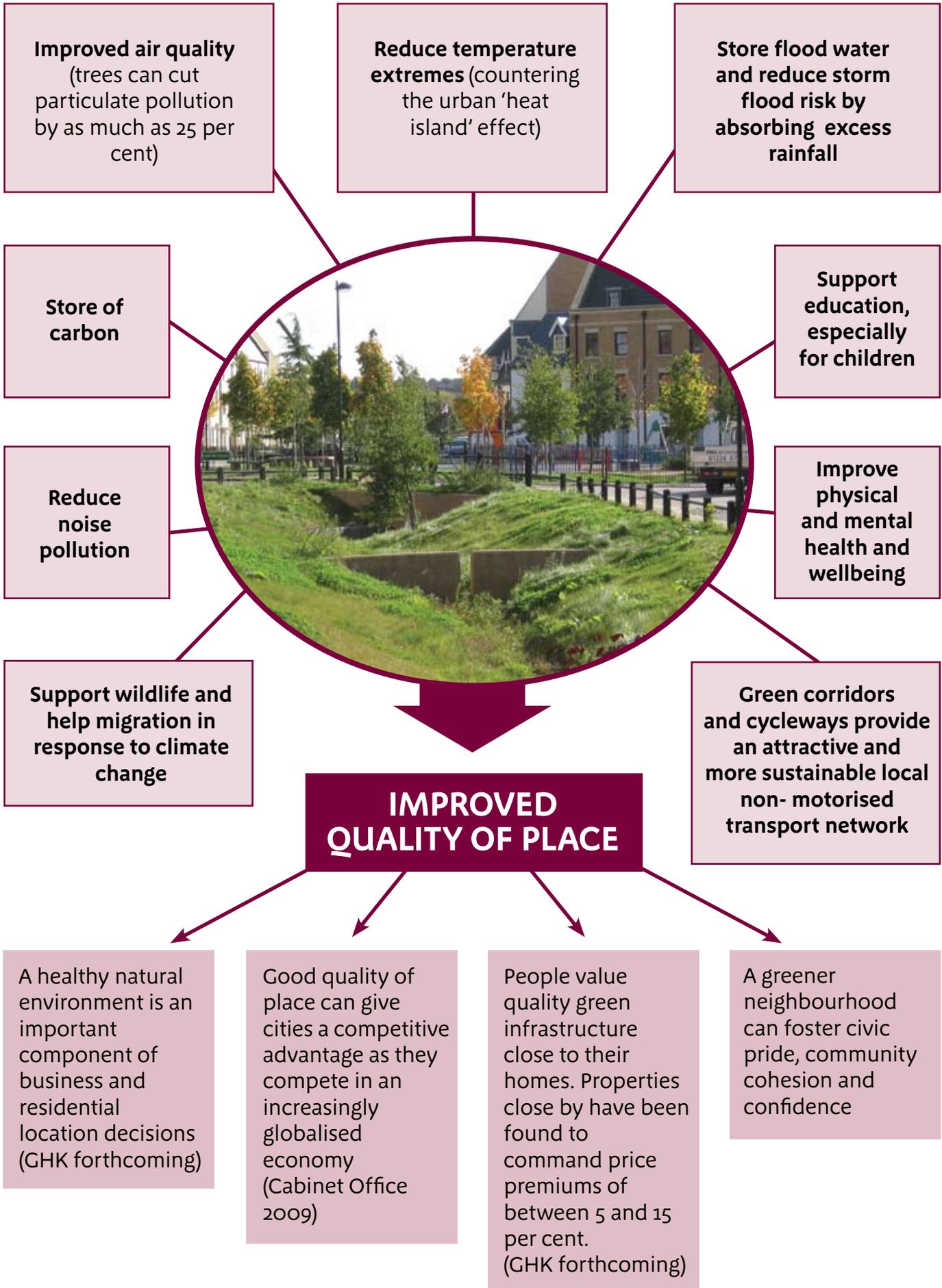
It is unlikely that an ecosystem approach will entirely displace the need for innovative technological solutions. It will not, for example, remove the need for sewerage and drinking water treatment entirely. More often an integration of technological and ecological thinking will offer better solutions, for example integrated pest management seeks to maintain levels of the natural enemies of pest species to complement the use of pesticides.

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 yield benefits 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, to support wildlife and store carbon.

While 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.

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.

Turning urban areas into quality places – green infrastructure and ecosystem services



## Managing our uplands for multiple 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<sub>2</sub> 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 kg 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 4,000-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.

# Investing in a healthy natural environment – identifying solutions and next steps

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:

- Deepening our understanding of the economic value of nature and natural capital, and using an ecosystem services approach to better inform decision-making processes.
- Sustained and long-term investment in natural capital to deliver greater efficiency and improved outcomes.
- 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.



Pocklington Canal SSSI – popular for recreation and important for wildlife

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

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.

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 monetary values 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.

## 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 (see also An Introductory Guide to Valuing Ecosystem Services <http://www.defra.gov.uk/environment/policy/natural-environ/index.htm>)

We are also working closely with Defra and other partners and stakeholders on a number of economic valuation projects due to conclude shortly, including:

- '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;
- '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.

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).

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. 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 critical natural capital itself is not meaningful in this sense.

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

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.

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 while also improving their efficiency;
- using other levers to encourage investment and behaviour change.

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 (Organisation for Economic Co-operation and Development) figures suggest that energy subsidies in OECD countries alone amount to approximately US\$ 80 billion per year, while 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).

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.

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.

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.

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 wellbeing.



Thorne Moors; Thorne, Crowle and Goole Moors SSSI – a lowland raised bog providing carbon storage, water regulation, recreation and conserving biodiversity

## 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 forthcoming Natural England publication *Agri-environment schemes in 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.



Conservation edge to an arable field



Crab fishermen shooting away a string of inkwell pots

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.

## 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-1990s 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](http://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 and institutions

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.

Natural England believes that 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 market forces can be harnessed to work with nature rather than against it.

### Developing environmental markets

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.

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



Local urban green spaces enable people to re-connect with nature

offset mechanisms but these can be overcome through a clear policy framework and effective design and piloting.

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

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.

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.

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.

## 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.



People walking on Dartmoor; one of the pilot areas

## Demonstrating the value of the Natural Environment – 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 previously, these areas are vital for carbon storage, flood risk management, water quality and supply, and 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 to 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 that the multiple problems of water quality, flooding, carbon storage, 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 broader 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 develop 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.

The pilots are due to be launched in November 2009.

# References

- ALLENDER, S. FOSTER, C. SCARBOROUGH, P. RAYENER, M. 2007, The burden of physical activity-related ill health in the UK. *J. Epidemiol Community Health*, 2007, 61:344 – 348.
- BARBIER, E. B., 2009. A Global Green New Deal: Executive Summary, prepared for the Green Economy initiative, UNEP.
- BATEMAN, I. and others (others 6), 2006. Cost-benefit analysis and the prevention of eutrophication. In Pearce, D. (ed.) *Environmental Valuation in Developed Countries*. Edward Elgar, Cheltenham, UK.
- BOLUND, P. & HUNHAMMAR, S., 1999. Ecosystem services in urban areas. *Ecological Economics*, 29, 293–301.
- BONAN, G. B., 2008. *Ecological Climatology: Concepts and Applications*. 2nd edition. Cambridge: Cambridge University Press.
- BRAAT, L., TEN BRINK, P., BAKKES, J., BOLT, K., BRAEUER, I., TEN BRINK, B., CHIABAI, A., DING, H., JEUKEN, M., KETTUNEN, M., KIRCHHOLTES, U., KLOK, C., MARKANDYA, A., NUNES, M., VAN OORSCHOT, M., RAYMENT, M., TRAVISI, C., WALPOLE, M., 2008. The Cost of Policy Inaction: the Case of Not Meeting the 2010 Biodiversity Target, European Commission.
- BRADLEY, R. I., MILNE R., BELL J., LILLY, A., JORDAN, C. & HIGGINS, A., 2005. A soil carbon and land use database for the United Kingdom. *Soil Use and Management*, 21, 363–369.
- BROADMEADOW, M. & MATTHEWS, R., 2003. Forests, carbon and climate change: the UK contribution. Information Note 48. Edinburgh: Forestry Commission.
- BROADMEADOW, S. & NISBET, T. R., 2004. The effects of riparian forest management on the freshwater environment: a literature review of best management practice. *Hydrology and Earth System Sciences*, 8, 286–305.
- CABINET OFFICE, 2009. *Quality of Place – Improving the Planning and Design of the Built Environment*. An Analysis of Issues and Opportunities. Cabinet Office.
- CHRISTIRE, M., & MATTHEWS, J., 2003. The economic and social value of walking in England.
- CJC CONSULTING, WILLIS, K., OSMAN, L., 2005. Economic benefits of accessible green spaces for physical and mental health: scoping study. Forestry Commission.
- CLA, 2009. Private Solutions to Public Problems: Developing Environmental Markets. Country Land and Business Association.
- COOMBES, E. G., JONES, A. P., HILLSDON, M (2009). The relationship of physical activity and overweight to objectively measured green space accessibility and use. *Social Science and Medicine*, under review.
- COOPER, N. J., COOPER, T. & BIRD, F., 2001. 25 years of salt marsh erosion in Essex: implications for coastal defence and nature conservation. *Journal of Coastal Conservation*, 7, 31–40.
- DASGUPTA, P., 2007. Nature and the Economy, in *Journal of Applied Ecology*, 44, 475–487, British Ecological Society.
- DAWSON, J. & SMITH, P., 2007. Carbon losses from the soil and its consequences for land management. *Science of the Total Environment*, 383,165–190.
- DCMS STRATEGY UNIT, 2002. Game Plan: a strategy for delivering Government’s sport and physical activity objectives, London, Cabinet Office.
- DEFRA, 2007. *Research into the current and potential climate change mitigation impacts of Environmental Stewardship*. Research Report BD2302. London: Defra.
- DEFRA, 2009. Marine and Coastal Bill Impact Assessment: Introduction to the House of Commons.
- DEFRA, 2009. *Agriculture in the United Kingdom 2008*. London: Defra. <https://statistics.defra.gov.uk/esg/publications/auk/2008/AUK2008.pdf> Accessed 4 September 2009
- DEFRA, 2009. Adapting to Climate Change: UK Climate Projections. London: Defra.

- EFTEC, 2009a. Economic Values for a Healthy Natural Environment. A report to Natural England.
- EKINS, P., 2008. Environmental and behavioural taxes. In Wales, C. (ed.) *Fair tax: towards a modern tax system*, Smith Institute.
- EMPSON, B., COLLINS, T., LEAFE, R. & LOWE, J., 1997. *Sustainable flood defence and habitat conservation in estuaries – a strategic framework*. 32nd MAFF Conference of river and coastal engineers.
- EUROPEAN COMMISSION, 2009. Green Paper: Reform of the Common Fisheries Policy, European Commission.
- EVERARD M., 2009. Ecosystem Services Case Studies – Science Report. Bristol: Environment Agency.
- FORESTRY COMMISSION, 2006. Forestry Facts & Figures. Edinburgh: Forestry Commission.
- FORESTRY COMMISSION, 2007. *A Woodfuel Strategy for England*. [http://www.forestry.gov.uk/pdf/fce-woodfuel-strategy.pdf/\\$FILE/fce-woodfuel-strategy.pdf](http://www.forestry.gov.uk/pdf/fce-woodfuel-strategy.pdf/$FILE/fce-woodfuel-strategy.pdf) [Accessed 4th September 2009].
- GHK (forthcoming). *The Social and Economic Benefits of the Natural Environment: Review of Evidence*. A report to Natural England.
- GLA (Greater London Authority), 2006. *London's Urban Heat Island a summary for decision-makers*. Published [http://www.london.gov.uk/mayor/environment/climate-change/docs/UHI\\_summary\\_report.pdf](http://www.london.gov.uk/mayor/environment/climate-change/docs/UHI_summary_report.pdf)
- GREEN FISCAL COMMISSION, 2009. Lessons from two green tax shifts in the United Kingdom. Briefing Paper One. Green Fiscal Commission.
- HM TREASURY, 2007. Long-term Opportunities and Challenges for the UK: Analysis for the 2007 Comprehensive Spending Review, HM Treasury.
- HOLMAN, I. P., HOLLIS, J. M., BRAMLEY, M. E. & THOMPSON, T. R. E., 2003. The contribution of soil structural degradation to catchment flooding: a preliminary investigation of the 2000 floods in England and Wales. *Hydrology and Earth System Sciences*, 7, 754–765.
- JACOBS, 2008. *Environmental Accounts for Agriculture: Final Report*. Report to Department for Environment, Food and Rural Affairs; Welsh Assembly Government; Scottish Government; Department of Agriculture & Rural Development (N. Ireland).
- KUMAR, R. & KAUSSHIK, S. C., 2005. Performance evaluation of green roof shading for thermal protection of buildings. *Building and Environment*, 40, 1505–1511.
- MEYERHOFF, J., & DEHNHARDT, A., 2004. The European Water Framework Directive and Economic Valuation of Wetlands: The Restoration of Floodplains along the River Elbe, Working Paper on Management in Environmental Planning, Technical University of Berlin.
- MORECROFT, M. D., TAYLOR, M. E., & OLIVER, H. R., 1998. Air and soil microclimates of deciduous woodland compared to an open site. *Agricultural and Forest Meteorology*, 90, 141–156.
- NATURAL ENGLAND, 2008. *State of the Natural Environment*. Sheffield: Natural England.
- NATURAL ENGLAND, 2009. *Sea Fisheries: Steps to Sustainability*. Sheffield: Natural England.
- MORRIS, J., HESS, T. M., GOWING, D. J., LEEDS-HARRISON, P. B., BANNISTER, N., WADE, M. & VIVASH, R. M., 2004. *Integrated washland management for flood defence and biodiversity*. English Nature Research Report Number 598. Peterborough: English Nature.
- O'CONNELL, P. E., BEVEN, K. J., CARNEY, J. N., CLEMENTS, R. O., EWEN, J., FOWLER, H., HARRIS G. L., HOLLIS, J., MORRIS, J., O'DONELL, G. M., PACKMAN, J. C., PARKIN, A., QUINN, P. F., ROSE, S. C., SHEPHERD, M. & TELLIER, S., 2004. *Review of impacts of rural land use and management on flood generation: Impact study report*. R&D Technical Report. London: Defra.
- PITT, M. *Learning Lessons from the 2007 Floods*. London: Cabinet Office.
- SABINE, C. L. and others (15 authors), 2004. The ocean sink for anthropogenic CO<sub>2</sub>. *Science*, 305, 367–371.
- SHARP, S., LOWEN, J. & LILEY, D., 2008. Changing patterns of visitor numbers within the New Forest National Park, with particular reference to the New Forest SPA. Unpublished Report Footprint Ecology.

SHEPHERD, D., BURGESS, D., JICKELLS, T., ANDREWS, J., CAVE, R., TURNER, R. K., ALDRIDGE J., PARKER E. R. & YOUNG, E., 2007. Modelling the effects and economics of managed realignment on the cycling and storage of nutrients, carbon and sediments in the Blackwater Estuary UK. *Estuarine, Coastal and Shelf Science*, 73, 355–367.

SMITH, V. H. & SCHINDLER, D. W., 2009. Eutrophication science: where do we go from here? *Trends in Ecology and Evolution*, 24, 201–207.

STERN, N., 2006. *The Economics of Climate Change*, Cambridge.

TEEB, 2009. TEEB Climate Issues Update, September 2009.

THOMAS, C. D., CAMERON, A., GREEN, R. E., BAKKENES, M., BEAUMONT, L. J., COLLINGHAM, Y. C., ERASMUS, B. F. N., FERREIRA de SIQUEIRA, M., GRAINGER, A., HANNAH, L., HUGHES, L., HUNTLEY, B., VAN JAARSVELD, A. S., MIDGLEY, G. F., MILES, L., ORTEGA-HUERTA, M. A., PETERSON, A. T., PHILLIPS, O. L. & WILLIAMS, S. E., 2004. Extinction risk from climate change. *Nature* 427: 145–148.

THOMPSON, D. 2008. *Carbon Management by Land and Marine Managers*. Natural England Research Reports, Number 26. Sheffield: Natural England.

TURNER, R. K., PAAVOLA, J., COOPER, P., FARBER, S., JESSAMY, V., & GEORGIU, S., 2003. Valuing Nature: Lessons Learned and Future Research Directions, *Ecological Economics*, 46, 493–510.

TURNER, R. K., 2006. Limits to CBA in UK and European Environmental Policy: Retrospects and Future Prospects, CSERGE Working Paper, EDM 06–17.

VISIT BRITAIN, 2009. The UK Tourist: Statistics 2008. <http://www.tourismtrade.org.uk/Images/UK%20Tourist%202008-tcm12-45976.pdf> [Accessed on 8th September 2009].



# Acknowledgements

Natural England are grateful to Kerry Turner (University of East Anglia), Jacque Burgess (University of East Anglia), Amanda Borrman (Yorkshire Water), Paul Armsworth (University of Sheffield), Dave Raffaelli (University of York), Dieter Helm (New College, Oxford), Simon Potts (University of Reading), Helen Dunn (Defra), Robert Bradburne (Defra), Paul Morling (Royal Society for the Protection of Birds), members of Natural England's Science Advisory Committee and Jon Lovett for their input and comment on this document. The views expressed in this report are solely those of Natural England.

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People walk past a view of the City of London  
in Richmond Park



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ISBN 978-1-84754-182-6

Catalogue Code: NE220

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