

4 Services provided by nature

- 4.1 This section provides evidence about the different services provided by nature. Specific services may be of interest to different policy makers and practitioners, so you may choose to focus just on those. Alternatively, you may be interested in overarching themes such as economic competitiveness, so [Chapter 2](#) and [Chapter 3](#) may be useful in identifying how the environment contributes to those themes.
- 4.2 It is important to note that not all services provided by nature are included here. The ones chosen are the ones which on the basis of current evidence are most important in the context of environmental projects. The ones selected are also those for which we have available scientific and economic evidence.

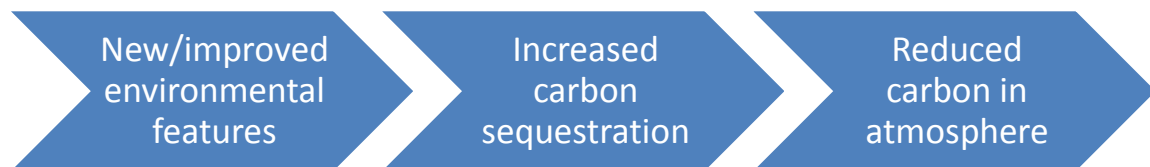
4e Global climate regulation

There is strong evidence that a range of different natural environments can play an important role in sequestering carbon emissions. Conversely, damaging those environments can result in further emissions being produced.

Introduction

- 4.25 Climate change poses a major risk to the environment and the economy. The Stern Review in 2006 estimated that the impacts of climate change were equivalent to losing at least 5 per cent of global Gross Domestic Product (GDP) each year, indefinitely (Stern 2006). Current cuts in carbon emissions are far from sufficient to keep average global temperature increase below 2 degrees, pointing to the need for increased effort in mitigation and adaptation (European Environment Agency 2010).
- 4.26 Other sections of this review have highlighted the way in which the natural environment can help us adapt to climate change, but our ability to adapt is limited. This means that mitigation of climate change remains a challenge. This section contains the evidence that investment in the environment can help us mitigate climate change, often at the same time as adapting to it.

Theory of change



- 4.27 A second theory of change is also important here – degrading soil and vegetation can result in the emission of significant amounts of previously stored carbon into the atmosphere. This is a major issue, particularly for peatlands. Land management activities can also lead to increased emissions of other greenhouse gases, particularly methane and nitrous oxide.

Can the benefit be quantified?

- 4.28 Yes, relationships can be quantified, but the science indicates that sequestration and emission rates are complex and context dependent. International transfer of economic values is facilitated by the fact that the social cost of carbon⁷¹ is the same wherever it is emitted in the world, however some forms of pricing carbon, such as the UK non-traded price are country specific.

How strong is the evidence?

- 4.29 The evidence for this benefit is stronger for some ecosystem types such as forests, than others, including many marine systems. There are important research gaps in evidence of the current scale of carbon storage and carbon management in many habitats (Alonso, Weston et al. 2012).

⁷¹ Pricing carbon emissions is an attempt to include the damage done by carbon within our economic decision making framework. The social cost of carbon is an attempt to work out the cost of the damage done by each tonne of carbon. In contrast the non-traded price is based on the costs imposed on the economy by emitting that tonne of carbon given the UK's climate change reduction commitments (i.e. mitigation cost). It is called the non-traded price because it is used for sectors outside the European Carbon Trading mechanism.

Evidence

Farmland

- It has been estimated that the UK's environmental stewardship schemes reduce emissions by between 0.44% and 0.49% of the 1990 Kyoto baseline over a 100 year time frame. This benefit is largely due to the move to less intensive land management - for instance, reduced fossil fuel inputs, reduced deep tillage, and the use of undercrops (Department for Environment Food and Rural Affairs 2007)⁷². This amounts to net savings of 1.0 million tonnes of carbon dioxide (CO₂) equivalent from Entry Level Stewardship (worth £53 million) and 4.1 million tonnes of CO₂ equivalent from Higher Level Stewardship (worth £211 million) with a combined total of 5.1 million tonnes of CO₂ equivalent (worth £264 million) (FERA 2010).

Forests/woodlands

- It is estimated that 595 million tonnes of CO₂ is stored in UK forests, and net uptake per year is between 9 and 15 million tonnes. Substituting wood for fossil-fuel intensive materials such as concrete, and in energy generation can offer substantial additional benefits in terms of greenhouse gas emissions (Morison, Matthews et al. 2013).
- The woodfuel strategy for England set a target of bringing 2 million tonnes of woodfuel to market annually, entirely from un-harvested material available in English woodlands. It estimates that this would save 400,000 tonnes of fossil fuel carbon and supply 250,000 homes with energy (Department for Environment Food and Rural Affairs 2007).
- An enhanced woodland creation programme involving planting 23,200 hectares could deliver abatement of approximately 15 megatonnes of CO₂ per year by the 2050s⁷³; representing 10% of total emissions at that time (if we assume emissions have fallen as required by the Climate Change Act). Mixed woodlands for multiple objectives can deliver abatement at less than £25 per tonne of CO₂, which is significantly less than the £100 per tonne cost effectiveness threshold set by the Committee on Climate Change (Read, Freer-Smith et al. 2009).
- Valatin and Starling (2010) estimate that in 2009 the value of carbon sequestered by UK woodlands was £680 million. This is additional to the value of the carbon already stored in existing woodlands. Two thirds of the carbon sequestered was in Scotland. On a per hectare basis, woodlands are estimated to sequester 5.2 tonnes of CO₂, with an average value of £276 per hectare per year (Valatin and Starling 2010)⁷⁴.

Grassland

- Grassland restoration can result in sequestration of carbon emissions at between 4.03 and 11.62 tonnes of CO₂ equivalent per hectare per year. By contrast, conversion from grassland to arable land can produce additional emissions of between 3.48 to 6.23 tonnes of CO₂ equivalent per hectare per year (Alonso, Weston et al. 2012).
 - Similarly, conversion of blanket bog to improved grassland is estimated to result in increased carbon emissions of 8.68 tonnes of CO₂ equivalent per hectare per year, or 22.42 tonnes of
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⁷² These figures do not take into account displacement of food production, either within the UK, or overseas, which could radically change the outcome. This points to the need to consider demand for food products as well as production methods. The results also assume no reversion to previous practices, and reversion is quite likely when the current schemes come to an end, suggesting we need to consider countryside management over a longer timeframe.

⁷³ The 23 200 ha per year is based on 14 840 ha of additional planting per year on top of the assumed ongoing 8360 ha.

⁷⁴ Note that this analysis uses the Department for Energy and Climate Change central social value of carbon of £53/tCO₂ in 2009.

CO₂ equivalent per hectare per year for conversion to cultivated grassland. Conversion of deep lowland fens is estimated to have a similar impact of 20.58 and 26.17 tonnes of CO₂ equivalent per hectare per year emitted for improved and cultivated grassland conversions respectively (Alonso, Weston et al. 2012)⁷⁵.

Greenspace

- A 2.16 hectare landscaped green belt in Leipzig, Germany was estimated to sequester between 38 and 223 tonnes of CO₂ per hectare over 50 years, net of construction and maintenance emissions. The higher value represents a scenario with high tree growth rates, and low mortality. However, if the green belt was planted with lawn only, this was estimated to **produce** between 2.52 and 6.54 tonnes of CO₂ per hectare over the same period (Strohbach, Arnold et al. 2012)⁷⁶.
- Carbon stored above ground in vegetation in the city of Leicester is estimated at 231,521 tonnes, with 97% of that being stored in trees (Davies, Edmondson et al. 2011).

Marine

- Coastal and marine ecosystems are vital global carbon stores. Saltmarsh, in particular is important. Unlike the ocean's vast carbon stores, which are beyond direct human management, carbon storage and sequestration by salt marshes can be improved through management, including managed realignment of sea walls (Andrews, Samways et al. 2008).
- Salt marshes are estimated to store 2.1 tonnes of CO₂ equivalent per hectare per year on average, and sea grasses also have the potential to sequester large amounts of carbon, with estimates of 0.2 to 2 tonnes of CO₂ equivalent per hectare per year (Alonso, Weston et al. 2012)⁷⁷.
- The Isles of Scilly contain 23.5km² of kelp, 3.1km² of seagrass and 383.1km² of phytoplankton habitat. Total annual sequestration of carbon via photosynthesis is estimated at 136,495 tonnes of carbon per year, predominantly from phytoplankton, followed by kelp then seagrass. The total value of this carbon sequestration is estimated at £53.8 million over 100 years (Mangi, Davis et al. 2011)⁷⁸.

Peatlands

- Peatlands in England contain an estimated 584 million tonnes of carbon. Degradation of peatlands through drainage, burning, agriculture and peat extraction results in this carbon being released to the atmosphere. If the full amount of carbon stored in peatlands was released to the atmosphere, this would be equivalent to 2.14 billion tonnes of CO₂, or five times England's total annual CO₂ emissions (Natural England 2010).

⁷⁵ Most of these estimates are based on the results of a single study, and should therefore be used with caution.

⁷⁶ Note that this analysis did not include consideration of the impacts of future climate change on tree growth and mortality rates. Climate change may also affect maintenance requirements (for instance, supplemental watering during drought, or storm debris removal).

⁷⁷ Most of these estimates are based on the results of a single study, and should therefore be used with caution.

⁷⁸ This is likely to be a significant underestimate, as it uses a flat 3.5% discount rate over 100 years, and also uses a maximum carbon price of £23/tonne. The UK government recommended carbon price for the non-traded sector was £57 per tonne in 2011, rising to £293 in 2100. However, it also does not account for production of N₂O by saltmarsh, which may reduce the net sequestration effect.

- Peatland restoration in England could deliver emissions reductions of up to 2.4 million tonnes of CO₂ equivalent per year. At the central non-traded carbon price of £52 per tonne of CO₂ equivalent this is a benefit of £124.8 million per year (Natural England 2010)⁷⁹.

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⁷⁹ The complicating factor is that peat bogs also emit methane, at different rates depending on factors such as the water level. More research is needed in this area but the balance of probabilities is that is that peatland restoration will be carbon beneficial.