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.

4m Water quality

The water quality benefits of the natural environment are reasonably well evidenced. Features such as woodlands and wetlands are particularly useful assets.

Introduction

4.75 Clean water is critical to human health and the wider health of the natural environment. Water pollution can lead to communicable disease, infections, recreational impacts (especially for swimming, fishing and boating), and environmental impacts such as algal blooms and shellfish deaths, which cause subsequent revenue losses.

4.76 Between 2004-05 and 2008-09, water companies in England spent £189 million removing nitrates and £92 million removing pesticides from water supplies in order to meet drinking water standards (National Audit Office 2010). Since 1975, 146 groundwater sources used for public supply have been closed because of quality problems (United Kingdom Water Industry Research 2004, cited in Environment Agency 2007).

4.77 The Water Framework Directive is a European Union directive aimed at improving water quality in surface and groundwater bodies. 74 per cent of groundwater bodies, and 41 per cent per cent of natural surface water bodies in the UK were rated as having good chemical status in 2009 (European Commission 2012)[126]. The average household was found to be willing to pay between £28.7 and £47.4 per year to achieve improvements in water quality under the Directive. This would be worth £587 to £969 million per year for England as a whole (NERA Economic Consulting and Accent 2007)[127].

4.78 When rainfall runs off the land, it carries pollutants into watercourses. In urban areas, polluted run-off is a major cause of diffuse pollution (pollution from multiple sources, which is collectively significant) (Hatt, Fletcher et al. 2008). Agricultural run-off is a key concern in rural areas, and the annual cost of agricultural diffuse pollution in the UK is estimated at £238 million (Jacobs UK Ltd 2008)[128].

4.79 This section contains evidence relating to the environment's contribution to purifying water.

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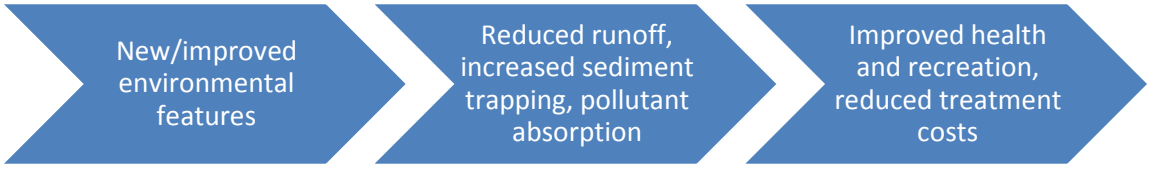
[126] Good chemical status for surface waters is assessed based on acceptable concentrations of over 30 different pollutants found in water. For groundwater the target is no pollution at all.

[127] This study examined six different scenarios to achieve different levels of water quality improvement over time. It focused specifically on recreational, aesthetic and non-use benefits of improvements in water quality (people benefit from the knowledge that water quality has improved, even without seeing or directly benefiting from it). It did not consider commercial, agricultural or water supply benefits. Respondents were willing to pay £28.7 for the 'less stringent objectives' scenario (up to 80% of water bodies at high environmental quality by 2027) and £47.4 for the 'maximum benefits' scenario (100% high quality by 2015).

[128] It is important to be clear that environmental interventions could mitigate, not remove this cost. This figure is an addition of two parts. The first part is figures given by Jacobs for lower water quality in rivers: £62 million, Lakes:£27 million, Coastal bathing water: £11.10 million and estuaries:£3.01 million. The calculations are made on the basis of 'best available data' and reasonable assumptions and then value transfer from stated preference studies. The second part is estimates of the costs to the water industry of removing contaminants at £129 million annually for England and Wales (figure would be higher if Scotland and Northern Ireland were included). This estimate is based on OFWAT data and reasonable assumptions of the percentage of the pollution that should be attributed to agriculture. Given the data available the approach is conservative and appropriate, and the 'true' value is probably considerably higher. The source research for the values transferred has not been reviewed for this study.

Theory of change



How strong is the evidence?

4.80 The evidence that the natural environment contributes to improved water quality is good. This is particularly the case for woodlands, wetlands and other forms of vegetation. As with other benefits, context is important.

Evidence

Green roofs

- Green roofs are most effective at reducing runoff in the smaller more common storms, because they tend to become saturated during major storms. However, most of the diffuse pollution load entering the drains is from these more common storms, and so green roofs have an important role to play in reducing this (Mentens, Raes et al. 2006).

Wetlands

- There is good evidence that wetlands bordering rivers are an effective method of preventing diffuse pollution from entering surface water (Gambrell 1994; Gilliam 1994)[129].
- If the UK wetland stock was increased by 10 per cent, the additional water quality benefit is estimated to be worth £292 per hectare per year for inland wetlands, and £1793 per hectare per year for coastal wetlands (Morris and Camino 2011)[130].
- Research into ecological improvements to the river Elbe in Germany concluded that restoring 15,000 hectares of wetland would prevent nitrogen entering sensitive watercourses, providing a nitrogen retention benefit of between €6.9 and €20.5 million. When combined with estimates of the wildlife benefit from willingness-to-pay surveys this led to a benefit: cost ratio for the proposed intervention of between 2.5:1 and 4.2:1 (Meyerhoff and Dehnhardt 2007)[131].

Woodlands

- There is strong evidence to support woodland creation, in appropriate locations, to achieve water management and water quality objectives. Woodlands contribute to tackling diffuse pollution through acting as a barrier and intercepting pollutants before they reach water courses. They help to trap and retain nutrients and sediment in polluted runoff. Targeted

[129] Gilliam 1994 is based on research conducted in the United States. The author quotes studies pointing to 90% effectiveness for nitrogen and 50% for Phosphorous. The author states that wetlands are, in his view, the most important method of influencing diffuse pollution entering surface water in many parts of the US.

[130] Note that these estimates were generated from data largely from other European countries, so may not be entirely accurate in the UK case, particularly given higher population densities and higher GDP per capita.

[131] Willingness- to-pay means that researchers assessed what customers would be willing to pay for that biodiversity benefit in a hypothetical market. The methodology was appropriate and conservative. It is important to note that the bulk of the benefit in the benefit: cost ratios is from the willingness to pay for biodiversity, rather than the nitrogen retention. A sensitivity analysis shows the benefit: cost ratio to be always above 1:1 even if you halve the benefits or double the costs.

woodland buffers along mid-slope or down-slope field edges, or on infiltration basins, appear effective for slowing down runoff and intercepting sediment and nutrients, but the evidence base is limited (Nisbet, Silgram et al. 2011)[132].

- Restored as well as mature buffer zones can be effective at reducing runoff (Vellidis, Lowrance et al. 2002). They are most effective when the runoff water must pass through the root zone, and least effective where rivers are recharged significantly from groundwater (Lowrance, Altier et al. 1997).
- Urban forests intercept rain water and reduce peak run off. This is most effective for smaller storms, but the effect is reduced for larger storms in which canopies become saturated. The effectiveness will vary according to local climate, tree species and time of year (broadleaved trees have no leaves during winter storms) (Xiao, McPherson et al. 1998).

Other

- Sand and soil based filters are an effective means of removing pollutants from urban runoff (Hatt, Fletcher et al. 2008)[133].
- Sustainable Urban Drainage Systems (SUDS), such as detention pools, are an effective method of removing pollutants from water and do not collect levels of pollutants which would require notified disposal (Heal, Hepburn et al. 2006; Napier, Jefferies et al. 2009).
- A monitored rain garden in the USA with a 0.49 hectare catchment was found to remove 973 cubic metres of stormwater runoff, 422 kg of total suspended solids, 783 kg of total dissolved solids, 2 kg of nitrogen and 1 kg of phosphorous per year (Flynn and Traver 2013)[134].
- Test plots in Manchester demonstrated that over a year, the addition of a street tree could reduce stormwater runoff by between 50 and 62 percent, compared with asphalt alone. Grass reduced stormwater runoff by 99 percent compared with asphalt (Armson, Stringer et al. 2013)[135].
- Any measures which increase rainwater infiltration are likely to reduce the number of occasions under which sewerage systems are overwhelmed by large volumes of water with resultant water quality issues (Environment Agency 2007).

Catchment-scale initiatives

- Many blanket bogs have been drained through the cutting of drainage ‘grips’. This degrades the bog, increasing sediment runoff and reducing water quality. Reblocking these grips rewets the peat. The Sustainable Catchment Management Project (SCaMP) in Lancashire and the Peak District has blocked over 85km of grips and reduced grazing pressure on the bogs. Monitoring over five years has shown a statistically significant reduction in dissolved organic carbon (DOC) entering streams and causing discolouration. In the Goyt sub-catchment, DOC levels fell by 45 per cent (Anderson and Ross 2011).
- Catchment Sensitive Farming (CSF) is an approach to minimising agricultural pollution by a range of measures including establishing grass buffer strips near streams, changing planting times to work with seasonal rainfall patterns, and carefully controlling fertiliser application.

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[132] However the Forest and Water guidelines advise against using conifer woodland in nitrate vulnerable zones with less that 650mm annual rainfall – they evaporate so much water that they can concentrate the nitrogen.

[133] This study found leaching of phosphorous but suggested that it was probably native to the soil used, rather than a failure of the filter to capture pollution from the runoff.

[134] This particular rain garden was 405 square metres in area. It should be noted that the rate of pollutant removal would be expected to reduce over time due to sedimentation, if this was not removed.

[135] This test was conducted using three test plots, each 9 square metres. They contained either asphalt, asphalt and one street tree, or grass. The authors note that the year of test was drier than average.

Water quality monitoring demonstrated that the CSF programme in England reduced pollutant loads by up to 30 per cent in targeted sub-catchments (Environment Agency 2011)[136].

- In order to meet its drinking water requirements under the US Safe Drinking Water act, New York City opted to seek a waiver on the filtration requirement by investing in a comprehensive watershed protection programme in the Catskills-Delaware watershed, which supplied 90 per cent of the city's drinking water. New York spent $1.5 billion over 10 years to avoid $6 billion in capital costs and $300 million annual operating costs (Postel and Thompson 2005)[137].
- In 2010 New York City published a plan to improve water quality in the New York Harbor System through reducing Combined Sewer Outflows following storms. The approach aims to use SUDS, including street trees, swales, bio-infiltration, and blue and green roofs, to capture the first inch of rainfall on 10 per cent of the impervious area in combined sewer watersheds over 20 years. It is estimated that this will reduce combined sewer overflows by 1.5 billion gallons a year. The report estimates that a mixture of SUDS and grey infrastructure will allow it to meet its objectives for $5.3 billion as opposed to a purely grey strategy costing $6.8 billion (New York City 2010)[138].
- Similar problems are faced in London; every year 12 million tonnes of untreated sewage enter the Thames because of storm overflows, with discharges 50 – 60 times a year. In August 2004, heavy rainfall led to pollution events that killed tens of thousands of fish, left sewage debris and significantly increased E. Coli levels and so enteric disease (Environment Agency 2007)[139].

Link with climate change

- All regions of the UK have experienced an increase in the amount of winter rain that falls in heavy downpours. For all regions an increase in winter rainfall and a decrease in summer rainfall is projected by the 2040s, increasing the risk of polluted run-off (Department for Environment Food and Rural Affairs 2009). This makes climate change mitigation a key action to prevent diffuse pollution becoming worse. A significant amount of climate change is already 'locked in', so interventions using the natural environment to absorb pollution will be increasingly important in coming decades.
- Climate change is likely to lead to increased use of pesticides (Boxall, Hardy et al. 2010). Nutrient inputs may decrease, however increased temperature, reduced summer rainfall, and increased winter rainfall and the increased use of irrigation may increase transmission leading to increased water pollution (Boxall, Hardy et al. 2010). Climate change may also reduce soil organic content (Jenkinson, Adams et al. 1991), which would exacerbate problems of polluted runoff. Without mitigating action this would increase human exposure to agricultural contaminants (Boxall, Hardy et al. 2010).

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[136] Whilst changes in nutrient loads were variable across sub-catchments, pesticide loads decreased consistently across all the catchments studied – total annual pesticide loads fell by 26 per cent.

[137] Notice that just the annual operating costs of the filtration plant would cost more than the ecosystems approach, without the capital expenditure. The effectiveness of this programme is based on US Environmental Protection Agency continuing to grant the waiver on the filtration requirement, which may get more difficult as development in the Catskills-Delaware increases and stricter federal drinking water standards are introduced. The scheme has led to important economic, environmental and recreational benefits within the watershed, as well as the benefits to New York. It is important to note how different the context is from the UK though; more than three-quarters of the watershed is forested.

[138] Note that these are pre-project estimated costs, rather than project evaluation costs. Blue roofs are roofs that can hold water and release it after the storm surge. Other expected benefits of using SUDS are a reduced urban heat island effect, energy conservation, carbon sequestration and improved air-quality. Higher property values are also cited, but see the section on property prices to put this in economic context.

[139] Note that the natural environment may be able to help, but grey infrastructure is realistically still the most viable method to solve issues of this scale.

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