Summary of evidence: Land use

1. General introduction

This summary sets out Natural England's assessment of the evidence relating to land use. It provides a statement of the current evidence base, presenting:

- what we know (with supporting data and key references);
- areas that are subject to active research and debate; and
- what we do not yet know from the evidence base.

It also provides information on Natural England research and key external research programmes to show how we are seeking to fill gaps.

This summary forms part of a suite of summaries covering all of Natural England's remit. The summaries are not systematic reviews, but enable us to identify areas where the evidence is absent, or complex, conflicting and/or contested. These summaries are for both internal and external use and will be regularly updated as new evidence emerges and more detailed reviews are completed.

2. Introduction to land use

How land and related natural resources are used is critical to the health of our natural environment and its enjoyment. Appropriately designed land use proposals are a key element of the Government's overall objectives for sustainable development.

Natural England works with a variety of institutions and planning processes that affect land and natural resource use in its widest sense. We work especially with the spatial planning system, from national planning policy to local and neighbourhood plans, and individual development proposals. We advise on green infrastructure opportunities; plans and proposals relating to transport, energy, soils and minerals; Shoreline Management Plans; and plans for local water use and quality. There are increasingly diverse delivery mechanisms at sub-national level, such as Local Enterprise Partnerships, that are delivering ambitions for growth and community well-being.

Natural England is not the ultimate decision maker on land and water use, and management of coasts. We reflect our purpose and discharge our duties through the advice that we provide as a statutory adviser and consultee. Our advice covers the full breadth of our remit and is based on our expertise and the best available evidence; and some organisations such as local authorities have specific duties to take account of our advice and also a broad duty as a public body to further the conservation of biodiversity.

The following seven principles underpin the approach that Natural England takes to its work toward creating sustainable use of land and the evidence that is required to achieve it:

1. Helping to protect England's special sites, landscapes and species.
2. Helping shape developments to deliver environmental enhancement and ecosystem services.
3. Advising on strategic plans and policy.
4. Taking a solutions-focused approach.
5. Improving how we work with developers and local authorities.
6. Applying the principles of climate adaptation and the ecosystem approach in land use planning and decision-making.
7. Providing information to help local communities make informed land use choices.

Natural England is therefore concerned with the overall demand for land and water, how we can secure more sustainable, multi-functional uses for land and water and the benefits of ecosystem services. Other summaries in this series address the particular evidence matters relating to challenges such as climate change, biodiversity and the ecosystem approach, and Natural England draws on that information to inform its work and advice on land use. This summary sets out our assessment of the evidence relating to land use, under the following headings:

- The natural environment and the demand for land and water.
- Freshwater and water management.
- Air pollution.
- Coasts.
- Spatial planning and development.
- Soil.
- Energy.
- Transport.
- Green infrastructure.

3. The natural environment and the demand for land and water

What we know:

3.1 Land plays a critical role in providing essential ecosystem services. Ecosystem services are vital for the physical wellbeing of the population such as clean air, water and healthy soils. With some of the most beautiful and historic landscapes in the world, the landscape of the UK underpins our national identity, cultural heritage and mental wellbeing. Furthermore, the productive capacity of land underpins the whole economy through its provision of food, timber and other goods, and through its use for housing, business, transport, energy, recreation and tourism. Greater pressure on land will mean that the requirement for land to deliver multiple benefits will also increase. (Government Office for Science 2010).

3.2 The more efficiently land is used for future settlements the less the negative impact on the natural environment. Careful consideration of housing demand, infrastructure, services, green space, public transport capacity and design of development increases the quality of the environment within settlements and also minimises the impacts of these settlements on the area around them (Natural England 2011a).

3.3 Population increases are putting extra pressure on the limited open space resources of successful cities, according to an online survey of 250 investors, developers, property advisors and public sector workers in 33 European countries about the importance of green space (Gensler and ULI 2011). However 100% of developers indicated a willingness to engage in the development of open spaces.

3.4 Urban ecosystem services contribute to the quality of urban life even if urban citizens are still dependent on global ecosystem services for their survival; the quality of life for urban citizens is improved by locally generated services, eg air quality and noise levels that cannot be improved with the help of distant ecosystems (Bolund and Hunhammar 1999). The provision of many urban ecosystem services in the UK has remained relatively stable but some, including soil quality and regulating climate and noise, are deteriorating (Watson and Albon 2011).

3.5 Three issues are going to have the biggest impact on the relationship between settlements and their natural environments. Climate change, land use change and population size are the three issues most discussed in the literature (Dorling 2011).

3.6 The interactions between the demands on land made by different sectors (eg conservation, agriculture and housing) will require a more coherent and consistent approach to guiding land use and management so that more sustainable and valued outcomes are delivered (Government Office for Science 2010). Government expectation is also that economic growth should be accompanied by higher environmental standards (Department for Communities and Local Government 2011).

4 Freshwater and water management

(To be added to the next edition once an evidence review by the Inter-Agency Freshwater Group has been completed).

5 Air pollution

What we know:

5.1 Atmospheric nitrogen deposition remains a major pressure on biodiversity through its eutrophication and acidification effects. There has been progress in the chemical and biological recovery of acidified soils and freshwaters as a result of measures to reduce sulphur and nitrogen emissions (Centre for Ecology and Hydrology 2012). However recent reviews (eg Emmett *et al.* 2011) have provided strong evidence of the continued adverse impacts of nitrogen deposition on semi-natural habitats in the UK. Critical loads for nutrient nitrogen are exceeded in over 61% of the number of Sites of Special Scientific Interest (SSSIs) and 71% of the number of Special Areas of Conservation (SACs) in England. The area of sensitive habitats where the critical load for nitrogen is exceeded is over 97% (Hall *et al.* 2011). The negative impacts of air pollution on the natural environment are recognised in the Natural Environment White Paper (HM Government 2011a) and Biodiversity 2020 (HM Government 2011b), and the 2013 UK Article 17 report on implementation of the Habitats Directive (JNCC 2013). Only a small decline in UK nitrogen deposition is predicted in the next decade so it is likely that nitrogen deposition will continue to restrict our ability to meet biodiversity commitments.

5.2 The total UK deposition of nitrogen is currently more or less equally attributable to emissions of reduced (ammonia (NH_3)) and oxidised forms (NO_x) of nitrogen. However, as measures to reduce emissions of NO_x have been more effective than measures to reduce NH_3, the relative contribution of ammonia is expected to increase (Centre for Ecology and Hydrology 2012).

5.3 Ammonia (NH_3) emissions are dominated by agricultural sources (approx 86%, Defra 2011a). Declining livestock numbers in the UK have led to a decline in emissions (20% reduction since 1980) but the resulting ammonia concentrations have changed little over the last decade (Centre for Ecology and Hydrology 2012). Both the poultry and cattle sectors are currently seeking to expand

significantly. For economic reasons, many farmers are switching from ammonium nitrate to urea fertilisers, which results in increased ammonia emissions. Ammonia concentrations are highly spatially variable, and emissions from intensive livestock units (such as pig and poultry units) or fertiliser application can create local 'hotspots' of high ammonia concentrations and deposition.

5.4 Nitrogen oxides (NO_x) are emitted from the combustion of fossil fuels: road transport is the largest source in the UK with power generation and combustion (ie other industry) also forming significant sources (Centre for Ecology and Hydrology 2012). Emissions from road transport and electricity generation have decreased significantly since 1989, and reductions in emissions since then have led to a decline of over half in the level of nitrogen oxides in the UK atmosphere. However, whilst there has been a significant reduction in the amount of nitrogen that the UK exports to mainland Europe, the reductions in the emissions of NO_x have not substantially reduced the deposition of nitrogen within the UK: the 62% reduction in emissions of nitrogen oxides between 1990 and 2010 has resulted in a reduction of only 23% in oxidized nitrogen deposition (Centre for Ecology and Hydrology 2012).

5.5 Ground level ozone is a toxic atmospheric pollutant of growing concern, with potentially harmful effects on plant communities (Morrissey *et al.* 2007). It is formed in the lower atmosphere in the presence of sunlight by complex photochemical reactions between pollutants from a range of sources including traffic. Critical levels for ozone effects on vegetation are already widely exceeded and background emissions of precursors in the northern hemisphere are increasing (Natural England 2008; Centre for Ecology and Hydrology 2012).

Areas that are subject to active research and debate:

5.6 At the national scale we need better evidence to achieve targeted reductions in emissions in order to reduce impacts of air pollution on sensitive habitats. Research is underway to better understand the potential for local reductions in emissions to benefit sensitive habitats and sites (Defra 2014) as well as ongoing discussion over the extent to which site management may mitigate nitrogen deposition impacts (Emmett *et al.* 2011; Stevens *et al.* 2011). We are working with Defra, Forestry Commission and others to understand the capacity of agricultural or other land management measures to achieve the necessary reductions in emissions/deposition, and to develop mechanisms to encourage or enable such measures (such as through the new Rural Development Programme for England). Furthermore, work is required to identify the key ingredients for successful uptake and implementation and to determine how best to measure ecological outcomes (indicators of success).

5.7 At the habitat level, we need more quantitative evidence on the effect of incremental additions of atmospheric nitrogen deposition (above the critical load). Given the growth agenda alongside the widespread exceedance of critical loads (and levels) by current air pollution levels, evidence on the effects of additional increments of air pollution arising from a new installation is critical in informing our advice to the Environment Agency and Local Planning Authorities on sustainable development. Evidence is required in terms of both the ecosystem response to the additional pollution and also its effect on potential recovery/ restoration.

5.8 We need a better understanding of the relationship between SSSI condition and local nitrogen sources. Monitoring has shown an inconsistent relationship between SSSI assessments of favourable condition and evidence for exposure to atmospheric sources of nitrogen (Emmett *et al.* 2011; Hall *et al.* 2012). Work is underway through a multi-agency Nitrogen Task and Finish Group, commissioned by the Chief Scientists' Group, to develop a methodology for the better attribution of

nitrogen impacts in site condition assessment (as well as to provide guidance on local 'remedies' to address the issue to inform site action plans).

5.9 We need better understanding of and evidence from dynamic models. Dynamic models extend the critical loads concept, providing predictions of the timing of change. They can potentially be used both to simulate future trajectories of change under different deposition scenarios, and to estimate the changes that would be required to achieve acceptable ecosystem status by a given year ("target loads"). Dynamic models are being continuously refined in response to new scientific understanding and data. We need to explore what these models can offer, particularly in respect of casework related assessments, but also more widely in terms of assessments of national critical load exceedance and recovery.

What we don't know:

5.10 At the local scale we need better tools and benchmarks to model the relative contribution and significance of different sources of eutrophication. This will improve our understanding of the combined effects of atmospheric sources and aquatic sources of nitrogen affecting wetlands and enable targeting of the most significant sources. There is a requirement for a more fundamental understanding of ecological processes that lies behind this operational research need.

5.11 We need a better understanding of how ecosystems respond to changes in pollution loading, in particular the timescales for vegetation responses to critical load exceedance for nitrogen, and the nature and timescale for ecosystem recovery when atmospheric pollution pressures are reduced. Furthermore, we need improved understanding of the longer-term fate of the accumulating store of deposited nitrogen (Centre for Ecology and Hydrology 2012) and its implications for soils, surface waters and ground waters (although work on the latter receptor has recently been initiated by the Environment Agency and the British Geological Survey). This is needed to inform our casework advice and our setting of conservation objectives.

5.12 The extent to which changes in emissions and deposition deliver benefits in other policy areas, and contribute to other ecosystem services, especially water quality objectives under the Water Framework Directive. Implications of continued critical load exceedance for climate change adaptation would also benefit from further study.

5.13 The implications for biodiversity of increasing background levels of ground-level ozone. Background ozone levels have now increased to a level where exposure to ozone may cause adverse effects in semi-natural vegetation, especially in the spring months in upland Britain.

6 Coasts

What we know:

6.1 Coastal areas are an important economic, social and environmental resource (Jones *et al.* 2011), with many competing demands and expectations across a range of sectors, and with a range of regulatory bodies that need to work closely together. Coastal flooding and erosion pose an ongoing risk to people and property. Whilst risks can be managed, there will always be residual risk from an extreme event or a series of events (Environment Agency 2011).

6.2 The storms and tidal surge of winter 2013/14 provided an important test of the resilience of coastal defences and revealed the wider implications in relation to the vulnerability of coastal sites, their resilience and recovery.

6.3 Sea levels are rising as a result of both climate change and post-glacial 'isostatic rebound'; this has led to many changes in our coastline (Cracknell 2005). One current impact is 'coastal squeeze', as rising sea levels trap designated coastal habitats against man-made sea defences (English Nature 2006) Where coastal squeeze of Natura 2000 sites occurs, Government has accepted that there is a legal obligation under the EU Habitats and Birds Directives to provide compensatory habitat. This is increasingly being delivered through the Environment Agency's (EA) Regional Habitat Creation Programmes. These also underpin EA's contribution to Biodiversity 2020 and work to achieve the favourable condition of designated sites where EA has that responsibility.

6.4 Sediment management is an integral part of coastal management and the challenge now is to ensure that this is done sensibly and that 'sediment trapping' in one area does not lead to sediment deprivation (and increased erosion) in another (Eurosion 2004). Changes in sediment availability also have serious implications for setting management objectives for coastal habitats (Orford & Pethick 2006).

6.5 Coastal change is a material consideration which has to be taken into account in all stages of the planning system. Proposals for 'coastal change management areas' were put forward as part of the review of Planning Policy Statement 25 (PPS25) and have been carried through into the National Planning Policy Framework (Department for Communities and Local Government 2012). However it is not clear how and whether these are being implemented. Such areas would aid land use planning for change and should take account of the need to conserve designated coastal habitats (which it may not be possible to do in situ – English Nature & Environment Agency 2003).

6.6 Shoreline Management Plans (SMPs) are evidence-based strategic plans which define: the general risks of coastal change to people, property and the environment; policies for managing the risks; and when and how these should change over three 'epochs' (20, 50 and 100 years), at a scale often larger than administrative boundaries (Defra 2006). Regional Coastal Groups have a key role in using SMPs to inform land use planning policies.

6.7 The degree of stabilisation of some coastal habitats (especially sand dunes) has reduced their ability to evolve and adapt in the face of sea level rise and natural coastal processes, and this reduces their efficiency in providing natural coastal defences, as well as threatening their structural integrity (Rogers *et al.* 2010; Pye *et al.* 2007).

6.8 A significant part of the evidence that Natural England uses comes from wider partnerships such as the Defra-EA research and development Flood and Coastal Erosion Risk Management (FCERM) programme. Reduced funding for research and development generally will require more collaboration, and initiatives such as Living With Environmental Change and Coastal Research Development & Dissemination will become increasingly important in prioritising resources and making use of findings (Sayers *et al.* 2012)).

Areas that are subject to active research and debate:

6.9 Natural England is currently leading a project to develop a methodology that aims to determine the extent of intertidal habitat in a healthy estuary. This evidence base will support

discussions with EA and Defra on flood management habitat creation targets and funding needs. This work also forms a critical element of Water Framework Directive delivery. It will inform our discussions at a local level on individual estuary strategies and whether further managed realignment schemes are needed in order to restore these sites to favourable condition.

6.10 We have only a limited knowledge of the effectiveness of managed realignment schemes in compensating for intertidal habitat losses from development or coastal squeeze. Our knowledge of the effectiveness of compensating for other coastal habitats (eg shingle) is also limited. We have recently initiated some research to address these questions so we can ensure that compensation measures are adequate and are not more onerous than they need to be. There are few other methods that can be used for long-term creation of intertidal habitat, so we rely on managed realignment to replace saltmarsh lost to development and coastal squeeze. In reviewing historical breaches of sea walls and the subsequent saltmarshes that developed, we don't know why the vegetation communities that develop rarely match those of adjacent 'natural' marsh, although recent work has highlighted areas for further research (Davy *et al.* 2011; Mossman *et al.* 2012). Natural England also has a research project underway aiming to develop an understanding of suitable and sustainable methods to compensate for the loss of mudflats affected by development.

6.11 The Coastal Biodiversity Ecosystem Services Sustainability programme is undertaking research into coastal ecosystem services. In particular it will update research by Möller (2006) on wave attenuation and help to determine the relationship between biodiversity and ecosystem services at a range of scales.

What we don't know:

6.12 There is uncertainty over how fast the predicted climate change effects on coasts will occur (Rees *et al.* 2010). There are debates about the scale and degree of post-glacial isostatic change which affects relative sea level rise.

6.13 More evidence is needed to demonstrate the role of coastal processes and coastal landforms in reducing risk, and the scale at which this operates. For example the provision of sediment from cliff erosion is vital for 'sediment recharge' of beaches and intertidal areas, yet any erosion is often seen as negative by coastal communities; similarly healthy saltmarshes play a beneficial role in reducing flood risk, which has been recognised for some time (eg Möller 2006), but would also help to evaluate the wider benefits that derive such as carbon sequestration and nurseries for commercial pelagic fish communities.

6.14 Predicting future habitat change and quality. The Shoreline Management Plans were informed in some areas by CHaMPs (Coastal Habitat Management Plans) (see for example English Nature & Environment Agency 2003); these are studies of Special Areas of Conservation (SAC) / Special Protection Areas (SPA) complexes that predicted future change in extent. Other studies have also attempted to predict change, but there is not always a linear relationship in the data that can be extrapolated to the future. In addition, it is not well understood how to accurately predict the future quality of habitats.

6.15 How successful the second generation of Shoreline Management Plans (SMPs) has been in addressing environmental issues (this was a weakness with many of the first round SMPs). There is a need to review their effectiveness and that of the CHaMPs that informed the approach to nine Natura 2000 site complexes.

6.16 We don't know the appropriate standards of defence for fresh or brackish water protected areas at risk of flooding and whether it is possible to design and engineer very low standards of defence (and hence save money) that are adequate to address the conservation need.

6.17 We don't know how best to integrate adaptation of coastal infrastructure (roads, railways, powerlines etc) with the needs of the natural environment. There is a wide variety of coastal adaptation options available for local communities (Defra 2012), but there is a need to be able to show to coastal stakeholders that integration can be done practically and is financially realistic. Some cross-departmental work has been initiated following the winter storms of 2013/14, to understand how to achieve greater resilience in key infrastructure networks that are vulnerable to extreme weather events.

6.18 We don't know how best to integrate coastal areas into green infrastructure work. There may be opportunities to use the green infrastructure concept to help with adaptation to coastal change and potentially to support and assist in economic regeneration. We do not know where there is the greatest potential or have a clear sense of how the environment could be best used in coastal areas to support economic regeneration.

6.19 Adaptation measures for coastal communities are vital to securing long term and sustainable management of the coast - what measures exist elsewhere in Europe and further afield and are they effective? How are they funded?

6.20 There are large gaps in our knowledge of coastal habitat loss (UK National Ecosystem Assessment (Countryside Council for Wales 2010: coastal margins chapter).

6.21 There is little evidence about the impacts of invasive non-native species at the coast (Natural England 2008), in contrast to the work done on terrestrial and freshwater habitats. Evidence on the distribution and the actual impact of invasive non-native species on different native habitats and species is required as well as evidence on the effectiveness of any mitigation or control measures to justify action.

6.22 Offshore windfarms are a major area of new development, but little evidence is assessed post-consent with regards to coastal processes, in particular impacts of export cable protection. Recent casework suggests that cable burial is not being adequately assessed prior to consent and we need to develop the evidence with regards to impacts of cable routes on coastal processes so that we can ensure this issue is properly assessed.

6.23 We do not know to what extent 'coastal squeeze' is affecting mudflats as well as saltmarshes. There is a lack of evidence about changes in the extent of the intertidal area in most estuaries (and along the open coast). We have only limited information on changes to the low water mark (and at what rate), and whether there is any general lowering of the surface of intertidal mudflats.

7 Spatial planning and development

What we know:

7.1 Demand for land and competition for different land uses continues. The interactions between the demands on land made by different sectors (eg conservation, energy production, agriculture and housing) will require a more coherent and consistent approach to guiding land use and management so that more sustainable and valued outcomes are delivered (Government Office for Science 2010).

7.2 There have been substantial changes recently to streamline the planning system and planning policy, to encourage growth and to give local communities a greater say (resulting from the Localism Act 2011, Growth and Infrastructure Act 2013 and associated secondary legislation and guidance). These changes are beginning to have an impact on planning decisions (eg National Planning Policy Framework Duty to Co-operate, neighbourhood planning, presumption in favour of sustainable development, greater permitted development rights).

7.3 Plan making activity (both Local Plans and Neighbourhood Plans) has increased significantly since the publication of the National Planning Policy Framework ((NPPF) Department for Communities and Local Government (DCLG) 2012), presenting both opportunities and threats for the natural environment.

7.4 The National Planning Policy Framework is placing greater emphasis on the need for plans to be underpinned by robust evidence (DCLG 2012).

7.5 The number of new homes added to England's housing stock fell to its lowest level for more than ten years in 2012/13 with 124,720 properties added to the housing supply (DCLG 2013a). There are indications that house-building is picking up with annual house-building starts totalling 117,110 in the 12 months to September 2013 (up 16% compared with the year before) (DCLG 2013b).

7.6 Significant impacts on protected landscapes have been identified as a consequence of proposed and consented housing developments in and around protected landscapes. Proposals have been made for a reform of how the major developments test is applied to protected landscapes (Campaign to Protect Rural England 2013).

7.7 There is a risk that the cumulative weight of planned or desired development in England is not environmentally sustainable; it may prevent recovery of biodiversity and ecosystem functioning and resilience to sustainable levels (Land Use Consultants 2006).

Areas that are subject to active research and debate:

7.8 How ecosystem services can be embedded into spatial planning.

7.9 How new local decision-making mechanisms such as Local Enterprise Partnerships (LEPs) will affect the natural environment. LEPs have been created to provide "the clear vision and strategic leadership to drive sustainable private sector-led growth and job creation in their area" and planning for City Deals and Growth Deals can build a better understanding of environmental risks and opportunities and incorporate them into growth plans and delivery mechanisms.

7.10 Assessment of cumulative impacts. Natural England has a series of pilots underway exploring how the assessment of cumulative effects can be undertaken in a proportionate and consistent way.

7.11 The role of biodiversity offsetting in compensating for impacts of development on biodiversity (pilot projects underway).

7.12 The definition of irreplaceable habitats for planning purposes.

What we don't know:

7.13 The scale of the potential contribution of the planning system in delivering Natural Environment White Paper (NEWP) proposals such as Nature Improvement Areas (HM Government 2011a).

7.14 There are opportunities to enhance our evidence base in relation to specific types of development impacts (eg impacts of wind turbines on bats, cumulative landscape impacts of wind turbines, disturbance impacts and effectiveness of mitigation measures on estuarine SPAs).

7.15 We are keen to see enhanced baseline evidence on the special qualities of protected landscapes and associated landscape character assessments. We lack a systematic means of tracking land use changes in designated landscapes and the effect of development on their landscape character.

8 Soil: sustainable land use in relation to development

What we know:

8.1 The importance of protecting the soil and the many ecosystem functions it provides in spatial planning and in the urban environment has generally been under-recognised and undervalued (Defra 2009a). Urban ecosystems can play a key role in improving towns and cities. (Royal Commission on Environmental Pollution 2007).

8.2 Development has a major impact on soil, reducing its capacity to fulfil many important functions (European Environment Agency 2011; European Commission 2006). Soil loss and degradation by sealing is nearly irreversible (European Commission 2005), reducing the soils ability to deliver important ecosystem services. This is recognised in national planning guidance which requires that the benefits of high quality agricultural land are taken into account in planning decision-making and that soils are protected and enhanced. (DCLG 2012).

8.3 Sealing issues can be mitigated in some cases by use of alternative surfacing materials and by building green roofs (European Commission 2011). Development can double run-off, increasing the risks of urban flooding (Royal Horticultural Society 2005) but Sustainable Drainage Systems (SUDS) such as permeable paving or gravel can enable soil to perform its role in groundwater recharge (Woods-Ballard *et al.* 2007; Hou *et al.* 2008; European Commission 2011b).

8.4 Some developments are less harmful to soil functions, or are more amenable to soil restoration. With care, former mineral extraction sites can be restored to high standards for agriculture (MAFF 2000a) and provide important areas for new habitat creation. The Nature After Minerals project is helping to deliver biodiversity outcomes (Davies 2006).

8.5 During construction soils may be subject to loss, compaction and contamination causing loss of and damage to the soils. Careful planning and soil management can reduce soil degradation as well as the overall costs of development (Defra 2009a).

8.6 The use of soil as a raw material is depleting the available in situ resource and in many cases is not considered sustainable. For example, extraction of peat for horticultural use (Defra 2010b; HM Government 2011a) and sand or brick earth (European Commission 2005).

Areas that are subject to active research and debate:

8.7 How soil resources can be managed to optimise land use including through the planning system, for example by encouraging multi-functionality, but recognising that not all soils are inherently suitable for all purposes (Haygarth & Ritz 2009).

8.8 How best to get the ecosystem services delivered by soils better recognised and protected within the planning system, for example by providing better guidance to planners on the potential services provided by different soils (Defra 2009b).

8.9 Extent and significance of loss of soil and 'best and most versatile' (BMV) agricultural land through development or other irreversible land use change. Planning studies have shown that the presence of BMV agricultural land is given consideration, but to varying levels of detail (Defra 2010c).

What we don't know:

8.10 How best to measure the long-term economic and other impacts of development on our national stock of soils (Natural Capital Committee 2013) including our best and most versatile farmland (Government Office for Science 2010), so that these finite resources and their protection can be better quantified, monitored and addressed (Defra 2011c).

8.11 The relative value of soils for other potential and current ecosystem services besides agricultural production and how this could be translated into practical tools for land use planning to support national planning guidance.

8.12 How best to maintain, develop and deploy our existing tools such as the Agricultural Land Classification in a changing planning and environmental context, including making the existing data archive more widely accessible.

8.13 The extent to which current published best practice guidance on soils and soil handling is taken into account in development projects, for example in mineral restoration and construction, and whether there are any gaps or modifications needed to improve outcomes for soils. Current guidance (MAFF 2000b; Defra 2004; Defra 2009a) focuses strongly on physical characteristics of mineral soils with less emphasis on biological impacts and processes (Harris *et al.* 2005) and with little recognition of the distinctive requirements for organic and peaty soils.

8.14 The environmental, economic and social value of urban green space soils. A recent report showed that quality of green space was important, but did not consider the value of the underlying soils (CABE 2010) nor the potential links these have to the successful creation of priority habitats and other green infrastructure.

9 Energy

What we know:

9.1 Significant levels of new energy infrastructure will be needed in the coming years to meet international and national goals for climate change mitigation and energy security. Onshore, we know that this will feature a mix of energy technologies at a range of scales, including gas, nuclear, wind energy, bioenergy and solar farms, as well as transmission and storage infrastructure (including landfall of cables and pipelines connecting offshore energy infrastructure).

9.2 All forms of energy development at all scales have the potential to impact on the natural environment. While some impacts are no different than for any other form of development, there are a number of technology-specific impacts that can arise; these tend to be highly location specific. Through our involvement in the planning process we know that technologies such as wind energy, solar development and transmission infrastructure are often located in previously undeveloped areas, eg in rural or upland locations or on undeveloped coastline, and have the potential to significantly alter landscape character and views, particularly where a number of developments cumulate.

9.3 Power stations usually require water for cooling, which can lead to impacts on terrestrial, freshwater, coastal and marine habitats and species, both in terms of intake (especially where abstraction is from a sensitive/vulnerable water body) and outflow (eg by changing thermal regimes of water that affect). Most power stations can also have air pollution impacts that may affect wildlife and habitats.

9.4 Onshore wind energy does not have to threaten wildlife, but appropriate siting is critical (evidence from the UK, Germany, Denmark, Spain and the UK in European Commission 2011a). Windfarms can affect birds in a number of ways, including indirect habitat loss as a result of displacement by disturbance, and mortality due to collision with turbines (Drewitt & Langston 2006, 2008). Bats are also known to be at risk of collision with wind turbines, but evidence about the extent and significance of impacts is limited. Most of the evidence that is currently available relates to mainland Europe and North America (see, for example, Arnett *et al.* 2008; Brinkman 2004), though some key studies looking at impacts in England are due to report in 2014. The lack of evidence means that the assessment of impacts of proposed development and mitigation techniques relies on a risk-based approach based on what is currently known about behaviour (foraging, commuting, roosting) of different bat species (Natural England 2012c). We also know that windfarms have the potential to impact on peatlands, for example by affecting hydrological processes (Natural England 2010d).

9.5 Most threats in the planning system can be minimised by avoiding landscapes sensitive to different types of renewable energy development and sites with sensitive habitats and concentrations of species known to be vulnerable. The vast majority of proposals that come though the planning system are able to be successfully accommodated in the landscape and avoid harmful impacts on wildlife. This is reflected in the fact that Natural England sustains objections to a very small minority of development proposals overall (Natural England 2014). However, a range of factors influence site selection and some proposals for wind energy and other types of energy development continue to come forward in sensitive locations. There is evidence that a strategic, spatial approach to planning for renewable energy development increases the likelihood of sustainable deployment (Institute for European Environmental Policy (IEEP) and RSPB 2009), but despite some initiatives, like the Department of Energy and Climate Change (DECC) led regional capacity studies (DECC 2010b), adoption of this kind of approach in England has been minimal.

Areas that are subject to active research and debate:

9.6 Mortality through collision with wind turbines and overhead power lines is known to be a risk for some bird species. While species including geese, raptors and swans are thought to be at higher risk, there is a need for better quantification of risk and consistent approaches to assessment, modelling and reaching a view on the significance of impacts. Work is underway to establish avoidance rates for pink-footed geese, but further study is needed to find cost-effective ways of calculating avoidance rates for other species. In addition, there is no agreed approach to assessing the cumulative

effect of mortality at different sites on overall populations of bird species. It is important that further pre- and post-construction data (eg on bird flight lines in and around wind farms) is gathered, shared and compared to support agreement of methodologies for assessment and judging significance of impacts, as well as site selection, mitigation and decision-making.

9.7 There is uncertainty over the displacement effects of wind turbines on habitat used by birds for feeding and roosting (eg distances at which displacement becomes an issue), and questions over the approach taken to identifying replacement habitat. We also lack a clear methodology for assessing the significance of disturbance, particularly the totality of impact, for example, across a number of estuaries. These limitations inhibit the ability to consider the impact on populations and to find appropriate mitigation measures.

9.8 The effect of wind turbines, large and small, on populations of bats in England. This will need to cover: the extent of bat migration; how bats use air space at different heights; how far bats travel from their roosts; the extent of bat mortality at wind turbine sites; and how bats behave in the vicinity of turbines (Natural England, 2012c). Our knowledge will improve as a result of some of the studies currently underway, but gaps are likely to remain and further studies and post-construction monitoring will be needed to continue to inform the deployment process for wind turbines.

9.10 How to measure the capacity of landscapes and ecosystems to accommodate change before a 'tipping point' or threshold is reached, particularly in relation to wind or solar energy development. Ultimately, the amount and nature of development that a place can accept is a political judgement, but a clearer approach to reaching a view in landscape and ecological terms, and better monitoring of change, are needed to inform those judgements.

What we don't know:

9.11 There is limited evidence about the potential environmental impacts, negative or positive , of solar farm development. Some level of monitoring of residual impacts, locally and more widely, on landscape character and quality is needed to understand and manage change. Better knowledge is needed to quantify risks to biodiversity, for example potential impacts on grassland and soils; to test suggestions that birds and aquatic invertebrates associated with wetlands may be affected; and to understand the significance of such effects (Natural England 2011b). Evidence concerning the type of land being used for operational schemes, how it is being managed, and the effectiveness of mitigation measures is also needed to inform judgements about the location and design of solar farms. Given the promotion of potential biodiversity benefits, better evidence about enhancement measures would also be beneficial for developers.

9.12 Better quantification of risks associated with new onshore oil and gas extraction activities such as shale fracking. While there are similarities with other more conventional forms of mineral extraction, the scale and some of the impacts from shale fracking could be different. The risks associated with potential impacts, direct and indirect damage or disturbance to designated sites, species and protected landscapes need further investigation.

10 Transport

Linear transport networks

What we know:

10.1 Transport has a significant impact on land use. It is estimated that, between 2003 and 2013, the road length for 'all major roads' (motorways and A-roads) in Great Britain increased by 162 miles and the road length for 'all roads' (motorways, A-roads and minor roads) by 1938 miles (Department for Transport 2013a). The total length of road in Great Britain is 245,700 miles, whilst the rail estate comprises around 20,000 miles of track (Network Rail 2014). The National Transport Model central forecast suggests that all motor vehicle traffic in 2040 will be 43 per cent higher than in 2010. The greatest growth forecast is in Light Goods Vehicles (LGVs) traffic which is set to increase by 80% (Department for Transport 2013b).

10.2 Linear transport infrastructure and its operation can have significant negative direct and indirect effects on biodiversity and landscape including habitat loss, habitat fragmentation and barriers to species movements (Bennett *et al.* 2011), visual and noise impacts on landscape character, wildlife mortality, pollution (of air, water and land resources), noise disturbance, and artificial lighting (Damarad & Bekker 2003). It is estimated that 50,000 badgers (of a UK population of some 300,000) (Highways Agency 2002), 3000 barn owls (Barn Owl Trust 2014) and 40-70,000 deer are killed on British roads every year (Langbein 2007). In addition to detrimental impacts on many animal species (Barber *et al.* 2009; University of Bristol 2013), noise from the transport network also detracts from human enjoyment of the natural environment (Jackson 2008).

10.3 Reducing the impacts of new linear transport infrastructure and its operation involves a range of approaches, from avoidance and prevention through to mitigation and compensation. In particular this may include: major route realignment, habitat re-creation, species translocation, landscaping, balancing ponds, tree planting, adapted tunnels, culverts, overpasses, fencing and bird/bat boxes (Damarad & Bekker 2003; European Commission Directorate General Transport 2002). Maintenance, design, location and planting are crucial factors in determining the effectiveness of ecological mitigation for linear transport schemes. Although post-construction monitoring of such measures is recommended, it rarely takes place. Resolving this issue is key to developing successful mitigation measures (Land Use Consultants 2013).

10.4 The existing transport network includes a significant area of 'soft estate'. The Highways Agency manages approximately 30,000 hectares of land, supporting a wide range of habitats, including over 40 million trees (Highways Agency 2002). Network Rail manages approximately 40,000 hectares of land and has an interest in over 200 SSSIs in England covering over 650 hectares of land (Network Rail 2013). Whilst transport operations can have significant adverse effects on wildlife, with appropriate design and management the soft estate and its green infrastructure have the potential to deliver multiple ecosystems services that could benefit biodiversity and ecological connectivity, as well as increasing the resilience of transport infrastructure to climate change (ADAS 2014). Although often fragmenting the landscape, transport corridors provide valuable semi-natural habitats, and can act as linear dispersal corridors for some plant and animal species, providing important connections between ecological sites, and with the potential to aid migration of species as they seek to adapt to climate change (Damarad & Bekker 2003).

Areas that are subject to active research and debate:

10.5 The potential for transport corridors to contribute to ecosystem services and ecological networks. The Natural Environment White Paper commitment 32 (HM Government 2011a) identified the opportunity for transport corridors to enhance ecological connectivity. Alongside this, transport network operators and providers have identified network resilience as a critical issue to their operations. Severe flooding between November and December 2013 in the south west of England cost Network Rail in excess of £12.5m in compensation payments alone (ADAS 2014). The NEWP 32 Green Transport Corridors research, being jointly undertaken by Natural England, Highways Agency and Network Rail, is looking to identify ways in which transport's green infrastructure can be managed to mitigate or reduce such resilience risks, whilst also delivering ecological connectivity and other ecosystem services to benefit people and wildlife.

10.6 Recent research into mitigation measures has highlighted a number of case studies (based on monitoring data) that show successful mitigation for habitat loss and impacts on particular species (Land Use Consultants 2013). The study also found case studies showing mitigation methods that were deemed unsuccessful, largely as a result of poor implementation or poor maintenance. The research, which was commissioned by Natural England, concluded that only a small number of projects had gathered empirical evidence to determine mitigation success, and that analysis of the monitoring data that was submitted to local authorities would greatly improve the current evidence base.

10.7 Lack of consistency in monitoring of some nature conservation mitigation measures for transport schemes. For example recent research has questioned the cost effectiveness of 'wire and ball' bat bridges and this has highlighted the lack of a robust evidence base (Berthinussen & Altringham 2012). In particular there is a need to improve the consistency of pre- and post-construction survey data to allow for a more robust and reliable interrogation of the designs and methodologies used. This will allow comparisons to be made of the success of different mitigation measures for different species and will enable the development of proportionate and effective guidance to support mitigation planning. Research is currently underway that will establish a standardised monitoring methodology that will provide more certainty about which bat mitigation measures work.

10.8 Drainage from highways can impact on the natural environment. SSSI Diffuse Water Pollution Plans identify road run-off as being an issue in a number of water-dependent SSSIs in England. We are working with the Highways Agency and the EA (through the Water Framework Directive) to look at the links between high risk outfalls and the status of water bodies, including water-dependent SSSIs, to identify priorities for remedial work.

10.9 How ecosystem services will be embedded into transport planning. The Natural Environment White Paper (HM Government 2011a), and the Government's National Ecosystems Assessment (Watson & Albon 2011) advocate greater consideration of ecosystem services in decision making. The Treasury's Green Book Supplementary Guidance (Dunn 2012) advises that the UK National Ecosystems Assessment has provided a robust case for accounting for the environment in decision making. Better understanding of how this can be integrated into existing and current transport planning is required. Government's 'webtag' transport appraisal process provides a method for options testing transport policies and projects, looking at economic, social and environmental impacts. Webtag does not currently include an appraisal of ecosystems services, although recent research has started to look at how this could be developed (Department for Transport 2013c).

What we don't know:

10.10 We do not know which land management options could be most effectively employed on the transport soft estate to address network resilience and contribute to ecological connectivity and other ecosystem services. Work on Natural Environment White Paper commitment 32 should help to inform this.

10.11 We do not have a full understanding of the effectiveness of some measures used to mitigate the severance impacts of linear transport schemes on protected species. Work is underway to ensure greater consistency in monitoring, so that we can develop a more robust evidence base.

10.12 We do not have a good evidence base to show how far pollution impacts from transport are a contributory factor affecting the condition of water dependent SSSIs under the Water Framework Directive.

Transport and air quality

What we know:

10.13 Road transport is the sector making the largest contribution to the UK total NO_x emissions, accounting for 33% of emissions in 2010 (Defra 2011a), with power generation and combustion (other industry) also significant (Centre for Ecology and Hydrology 2012). The levels of emissions are predicted to fall in all areas including transport. Transport reductions will occur as a result of the electrification of transport and reductions in vehicular emissions. (See also 5.4).

10.14 Nitrogen emissions are higher close to transport networks – the UK map of NO_2 concentrations clearly delineates the major transport network (Centre for Ecology and Hydrology 2012). Nitrogen emissions from road transport have a highly localised impact (up to 200 m) (English Nature 2004). However maximum NO_x levels from road traffic are much smaller than from point sources, as traffic typically represents a line source of nitrogen emission and disperses more readily than point sources (Defra 2014). There is a substantial body of evidence to show that atmospheric nitrogen deposition is leading to changes in the natural environment, both locally on nature conservation sites and on a large scale in the wider countryside across the UK (eg Stevens *et al.* 2011). The total UK deposition of atmospheric nitrogen is derived more or less equally from the emissions of oxides of nitrogen (NO_x) and ammonia (NH_3) (not all arising from UK sources). Source allocation undertaken for RAPIDS (Identification of Potential Remedies for Air Pollution (Nitrogen) Impacts on Designated Sites) (Stevens *et al.* 2011) identifies transport as one of five key nitrogen pollution sources affecting Special Areas of Conservation. There is some evidence to suggest a similar link between road traffic emissions and SSSI condition but, due to the number of confounding variables, this is not incontrovertibly established (Weigert 2004).

10.15 Aircraft emit a wide variety of pollutants including oxides of nitrogen of (NO_x), volatile organic compounds (VOCs), heavy metals, particulates and ammonia. Air dispersion modelling (Air Quality Consultants 2008) for a number of airports in England suggested that they may contribute an additional 2.9 - 40 ug/m3 of NO_x (figures exclude surface access, ie passenger journeys to and from airports by surface routes, and this will contribute more). The large variation is due to variation in airport size, passenger throughput and, hence, the number of individual flights at each airport (eg Bournemouth vs Gatwick). Due to mixing and dispersion, there is often a rapid decline in NO_x concentrations with increasing distance from the runway/aeroplane taxiing areas/affected roads, but emissions from aircraft

at take-off and landing can still contribute to the overall pollution exposure/burden at nearby sensitive sites.

Areas that are subject to active research and debate:

10.16 At the national scale we need better evidence to demonstrate the number and proportion of protected sites (SSSIs and European sites) in England that are at risk from air pollution from major roads and the associated condition of these sites. We have research underway to start to develop this evidence base and to assess the risk in terms of exposure to NO_x from road traffic and site sensitivity.

10.17 A literature review is currently underway to review the evidence on the ecological effects of air pollution from road schemes which will be used to produce a Natural England report based on the English Nature study of the ecological effects of diffuse air pollution from roads (English Nature 2004), and it will include a summary of road traffic measures for reducing emissions.

What we don't know:

10.18 We don't know yet what constitutes a significant level of nitrogen deposition above the critical load. Around two thirds of all Sites of Special Scientific Interest in the UK exceed their critical loads as a result of current atmospheric nitrogen deposition. In regions where the critical load is already exceeded there is a need to understand how further increases in nitrogen deposition may affect ecological communities. Research is underway to understand this relationship and to define thresholds. This information will help to inform road developers (such as the Highways Agency) in their assessment of what constitute significant effects on ecological receptors from changes in air quality arising from road schemes; and will inform future updates of key guidance such as the air quality chapter of the Design Manual for Roads and Bridges (Department for Transport 2007b).

Aviation

What we know:

10.19 Airports and aviation present specific environmental challenges. Airports and their associated activities can have impacts on the biodiversity and landscapes through direct effects such as habitat loss and fragmentation, visual and noise impacts on landscape character and wildlife mortality as well as indirect effects resulting from changes to air quality, water quality, light pollution levels, noise, disturbance, visual impacts and climate change impacts. Many of these impacts are recognised in recent reports and policy documents (Department for Transport 2013d; Wit *et al.* 2003).

10.20 We know that disturbance of birds, arising from noise/vibration or visual intrusion from aircraft movements and bird control interventions, can affect bird distribution and behaviour, although this varies with species and circumstances. Evidence shows that there is an overlap between the hearing range of birds (up to 10kHz) and the dominant frequencies of air traffic (up to 5kHz) (University of Bristol 2013). Low flights cause the most disturbance, with cliff-nesting and other colonial seabirds (during the breeding season) and flocks of waterfowl (during the winter) being the most vulnerable (English Nature 1999b) – though this research is dated and would benefit from being updated. The Civil Aviation Authority's airport site-safeguarding policies have in the past led to to tensions over water and wetland habitat creation schemes due to concerns about bird strikes (English Nature 1999a) but again this work would benefit from being updated to understand the current impacts of safeguarding policies on habitat restoration objectives.

Areas that are subject to active research and debate:

10.21 Natural England's aviation sensitivity mapping work has identified the protected landscapes that are likely to be sensitive to direct land take, visual, tranquillity and light pollution impacts arising from potential aviation capacity enhancements (unpublished analysis – Natural England 2013b). This work has also identified SSSIs and Natura 2000 sites that are likely to be sensitive to direct land take, air and water quality impacts and disturbance impacts (to birds and bats) from potential aviation capacity enhancements.

What we don't know:

10.22 There is little robust evidence on the effects of overflight on the tranquillity of protected landscapes.

11 Green infrastructure

We know that:

11.1 Green infrastructure (GI) provides a range of ecosystem services including mitigating and helping places adapt to the effects of climate change. There is good evidence for components of green infrastructure providing heat amelioration, reducing flood risk, improving water quality, providing sustainable urban drainage, improving air quality, improving quality of place, increasing environmental quality and aesthetics, increasing habitat area and quality, increasing populations of some protected and/or priority species, and increasing species movement (Natural England 2012a; Saraev 2012).

11.2 Green infrastructure supports a range of socio-economic benefits, including increasing life expectancy and reducing health inequality, improving levels of physical activity and health, improving psychological health and mental well-being, and improving social interaction, inclusion and cohesion. However, these impacts (particularly social interaction and inclusion) are context-specific and may be negative if the green infrastructure is not situated or managed appropriately for the community (Natural England 2012a; Saraev 2012; Forest Research 2010).

11.3 Green infrastructure acts as a catalyst for economic growth by attracting inward investment, attracting increased visitor spending, reducing environmental costs, providing health benefits, generating employment and producing food (Forest Research 2010; EFTEC & Sheffield Hallam University 2013).

11.4 Visits to urban green space provide a high proportion of the visits people take to green places and people tend to visit green space close to where they live. 43 per cent of the visits recorded in the Monitor of Engagement with the Natural Environment (MENE) survey were to green spaces within towns and cities, and 66 per cent of all visits were taken within two miles of home, highlighting the importance of accessible local green space (Natural England 2013a).

11.5 The provision of parks in deprived areas is worse than in affluent areas (CABE Space 2010). People in deprived areas, wherever they live, receive a far worse provision of parks and green spaces than their affluent neighbours. They often do not have gardens, so access to good-quality public green space matters even more. The most affluent 20 per cent of wards have five times the amount of parks or general green space (excluding gardens) per person than the most deprived 10 per cent of wards (CABE Space 2010).

Areas that are subject to active research and debate:

11.6 What evidence is required to support and target green infrastructure so that it delivers the optimum functions (ecosystem services, socio-economic benefits and climate change adaptation and mitigation). Although the evidence on the functionality of green infrastructure is well developed in general and for specific case studies, it is still not possible to assess what ecosystem service benefits might be gained from a potential area of green infrastructure without doing a detailed and costly study.

11.7 The impact of projects that aim to provide environmental improvements in deprived communities. It has not yet been possible to estimate the aggregate scale of outcomes or the size of non-environmental benefits that have arisen as a result of the various programmes and projects that have taken place.

What we don't know:

11.8 The extent of green infrastructure secured through section 106 agreements or similar requirements through the planning system – we do not know what proportion of the area secured through these means is actually delivered and to what standard.

11.9 Where urban green space is located and its quality – we are mapping the green infrastructure that we secure through relevant projects and the development management casework that Natural England handles: however, there will be much more delivery that we are not recording and our data does not provide any indication of the amount and type of green space in any given area.

11.10 What makes a good green infrastructure policy and how effective such policies and strategies are at enabling delivery – although we support the development of green infrastructure strategies (which reflect the strategic approach to green infrastructure advocated by the NPPF (DCLG 2012)), we do not have robust evidence on the impact of these strategies. Equally, although Natural England comments on green infrastructure policies in local plans, we do not have evidence as to what constitutes an effective policy for the local authority, the developer, the local community and the environment.

11.11 Where green infrastructure strategies and policies are in place – we do not have a comprehensive register of green infrastructure strategies around the country nor any information from spatial plan documents such as Area Action Plans, site allocations, and green infrastructure strategy action plans, as to where future green infrastructure is planned.

11.12 The contribution that development and management relating to minerals extraction and transport infrastructure makes to green infrastructure – although work on the Nature After Minerals project suggests that the contribution of the former (at least) may be significant (Davies 2006).

11.13 How to enable Payment for Ecosystem Services schemes to pay for green infrastructure delivery in an urban/peri-urban setting.

12 Current Natural England projects

12.1 Evidence Project Database. A list of current land use research and monitoring projects is available on Natural England's internal systems. We are developing a method to make information about our current evidence projects available to everyone. In the meantime a list of Natural England's evidence projects that were current in 2014 relating to Land Use can be seen on the National Archives at: **http://webarchive.nationalarchives.gov.uk/20140711133551/http://www.naturalengland.org.uk/ourwork/evidence/landuse.aspx**

13 References

ADAS. 2014. *Review of literature on how transport's soft estate has been used to enhance green infrastructure, ecosystem services, and transport resilience across the UK and EU*. Unpublished. [Available from Natural England on request.]

AIR QUALITY CONSULTANTS. 2008. *Derivation of Screening Criteria for Review and Assessment of Airports – 2008 Update*. Bristol: AQC.

ANNERSTEDT, M., NIELSEN, A.B., MARUTHAVEERAN, S. & KONIJNENDIJK, C.C. 2012. Benefits of urban parks: a systematic review. *In: IFPRA World,* 2012, 6, 10-12. Reading: IFPRA. URL: **www.pub.epsilon.slu.se/8995/6/annerstedt_m_120824.pdf** [Accessed 25 September 2014].

ARNETT, E.B., KENT BROWN, W., ERICKSON, W.P., FIELDER, J.K., HAMILTON, B.L., HENRY, T.H., JAIN, A., JOHNSON, G.D., KERNS, J., KOFORD, R.R., NICHOLSON, C.P., O'CONNELL, T.J., PIORKOWSKI, M.D., & TANKERSLEY JR., R.D. 2008. Patterns of Bat Fatalities in North America*. In: Journal of Wildlife Management*, 72, 61-78. Maryland: The Wildlife Society.

ATKINSON, P.W., CROOKS, S., GRANT, A. & REHFISCH, M. 2001. *The success of creation and restoration schemes in producing intertidal habitat suitable for waterbirds*. English Nature Research Report No. 425. Peterborough: English Nature. URL: **http://publications.naturalengland.org.uk/publication/63026**

BARBER, J.R., CROOKS, K.R. & FRISTRUP, K. 2010. **The costs of chronic noise exposure for terrestrial organisms** *In: Trends in Ecology and Evolution,* **Vol 25, Issue 3**. Philadelphia: Elsevier.

BARN OWL TRUST. 2014. *Major roads and barn owls.* URL: **www.barnowltrust.org.uk/infopage.html?Id=180** [Accessed 25 September 2014].

BELL, S., MONTARZINO, A. & TRAVLOU, P. 2006. *Green and Public Space Research: Mapping and Priorities.* West Yorkshire: Department for Communities and Local Government.

BENNETT, V.J, SMITH, W.P. & BETTS, M.G. 2011. *Toward understanding the ecological impact of transportation corridors.* Oregon: U.S. Department of Agriculture Forest Service.

BERTHINUSSEN, A. & ALTRINGHAM, J. 2012. Do Bat Gantries and Underpasses Help Bats Cross Roads Safely? In: PLOS ONE 7(6). San Francisco: Public Library of Science. URL: **www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0038775** [Accessed 19 September 2014].

BOLUND, P. & HUNHAMMAR, S. 1999. Ecosystem Services in urban areas. *Ecological Economics,* 29, 293-301.USA: Elsevier.

BRINKMAN, R. 2004. Influence of wind turbines on hunting and migration of bats in Baden. *In: documentation of technical seminar "Wind turbines – a threat to birds and bats?"*. Stuttgart: Academy for Nature and Environmental Protection.

BROOK LYNDHURST. 2010. *Improving poor environments – a scoping study.* Bristol: Environment Agency.

BYRON, H. 1999. Biodiversity issues in road environmental impact assessments: guidance and case studies. *In: Proceedings of the Third International Conference on Wildlife Ecology and Transportation.* Florida: Department of Transportation.

CABE SPACE. 2005. *Does money grow on trees?* London: Commission for Architecture and the Built Environment.

CABE SPACE. 2009. *Making the invisible visible: the real value of park assets.* London: Commission for Architecture and the Built Environment.

CABE SPACE. 2010. *Urban green nation: building the evidence base.* London: Commission for Architecture and the Built Environment.

CABE. 2010. *Community green: using local spaces to tackle inequality and improve health.* URL: **www.webarchive.nationalarchives.gov.uk/20110118095356/www.cabe.org.uk/files/community-green-full-report.pdf** [Accessed 19 September 2014].

CAMPAIGN TO PROTECT RURAL ENGLAND. 2013. *Going, going, gone? England's disappearing landscapes*. London: CPRE.

CENTRE FOR ECOLOGY AND HYDROLOGY. 2012. *Review of Transboundary Air Pollution, Acidification, Eutrophication, Ground Level Ozone and Heavy Metals in the UK*. London: Defra. URL: **www.rotap.ceh.ac.uk** [Accessed 19 September 2014].

THE CENTRE FOR LOCAL ECONOMIC STRATEGIES. 2007. *The Contribution of the Local Environment to the Local Economy.* London: Groundwork UK.

COUNTRYSIDE COUNCIL FOR WALES. 2010. *Sustaining Ecosystem Services for Human Well-Being: mapping ecosystem services*. URL: **www.ccw.gov.uk/idoc.ashx?docid=6a6a218b-2217-432d-b1d4-2f920fa3f9de&lang=en&version=-1** [Accessed 19 September 2014].

CRACKNELL, B. 2005. *'Outrageous waves': global warming and coastal change in Britain through 2,000 years.* Phillimore: University of California.

DAMARAD, T. & BEKKER, G.J. 2003. *Habitat Fragmentation due to Transportation Infrastructure: Findings of the COST Action 341*. Luxembourg: Office for Official Publications of the European Communities.

DAVIES, A.M. 2006. *Nature After Minerals – how mineral site restoration can benefit people and wildlife*. Sandy: RSPB. URL: **www.afterminerals.com/docs/nature%20after%20minerals%20report%20-%205mb.pdf** [Accessed 19 September 2014].

DAVY, A. J., BROWN, M. J. H., MOSSMAN, H. L. & GRANT, A. 2011. Colonization of a newly developing salt marsh: disentangling independent effects of elevation and redox potential on halophytes. *In: Journal of Ecology*, 99(6), 1350-1357. London: British Ecological Society.

DEPARTMENT FOR COMMUNITIES AND LOCAL GOVERNMENT. 2011. *Laying the Foundations: A Housing Strategy for England.* London: DCLG. URL: **www.communities.gov.uk/publications/housing/housingstrategy2011** [Accessed 19 September 2014].

DEPARTMENT FOR COMMUNITIES AND LOCAL GOVERNMENT. 2012. *National Planning Policy Framework.* London: DCLG. URL: **www.communities.gov.uk/documents/planningandbuilding/pdf/2116950.pdf** [Accessed 19 September 2014].

DEPARTMENT FOR COMMUNITIES AND LOCAL GOVERNMENT. 2013a. *Net supply of housing: 2012-3, England.* London: DCLG. URL: **www.gov.uk/government/uploads/system/uploads/attachment_data/file/255431/Net_Supply_of_Housing_England__2012-13.pdf** [Accessed 19 September 2014].

DEPARTMENT FOR COMMUNITIES AND LOCAL GOVERNMENT. 2013b. *House Building: September Quarter 2013, England.* London: DCLG. URL: **https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/282775/House_Building_Release_-_Dec_Qtr_2013.pdf** [Accessed 19 September 2014].

DEFRA. 2004. *Defra Guidance for the Successful Reclamation of Minerals & Waste Sites.* London: Defra. URL: **www.webarchive.nationalarchives.gov.uk/20090306103114/www.defra.gov.uk/farm/environment/land-use/reclamation/index.htm** [Accessed 19 September 2014].

DEFRA. 2006. *Shoreline Management Plan Guidance: Volume1: Aims and Requirements.* London: Defra. URL: **www.defra.gov.uk/publications/files/pb11726-smpg-vol1-060308.pdf** [Accessed 19 September 2014].

DEFRA. 2009a. *Construction Code of Practice for the Sustainable Use of Soils on Construction Sites*. London: Defra. URL: **www.defra.gov.uk/publications/files/pb13298-code-of-practice-090910.pdf** [Accessed 19 September 2014].

DEFRA. 2009b. *Safeguarding our Soils - A Strategy for England*. London: Defra. URL: **www.archive.defra.gov.uk/environment/quality/land/soil/documents/soil-strategy.pdf** [Accessed 19 September 2014].

DEFRA. 2010b. *Consultation on reducing the horticultural use of peat in England*. London: Defra Soils Policy Team. URL: **www.archive.defra.gov.uk/environment/quality/land/soil/peat/** [Accessed 19 September 2014].

DEFRA. 2010c. *Application of Best and Most Versatile Land Policy by Planning Authorities. Project* SP1501. London: Defra. URL: **www.randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=2&ProjectID=17207** [Accessed 19 September 2014].

DEFRA. 2011a. *Emissions of Air Pollutants in the UK, 1970 to 2010.* London: Defra.

DEFRA. 2011b. *Rural Development Programme for England Evidence Plan 2011/12.* London: Defra.

DEFRA. 2011c. *Cost of Soil Degradation in England and Wales.* Project SP1606. London: Defra. URL: **www.randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=16992** [Accessed 19 September 2014].

DEFRA. 2012. *Coastal Change Pathfinder Review: Final Report.* London: Defra. URL: **www.defra.gov.uk/publications/files/pb13720-coastal-pathfinder-review.pdf** [Accessed 19 September 2014].

DEFRA. 2014. *Identification of Potential Remedies for Air Pollution (Nitrogen) Impacts on Designated Sites (RAPIDS).* Unpublished report.

DEPARTMENT FOR TRANSPORT. 2003. *Air Transport White Paper*. London: Department for Transport.

DEPARTMENT FOR TRANSPORT. 2007a. *Transport Trends*. London: Department for Transport.

DEPARTMENT FOR TRANSPORT. 2007b. *Design Manual for Roads and Bridges.* London: Department for Transport.

DEPARTMENT FOR TRANSPORT. 2013a. *Transport Statistics for Great Britain 2013*. London: Department for Transport.

DEPARTMENT FOR TRANSPORT. 2013b. *Roads and Traffic TSGBO7, Road Length (miles) by road type in Great Britain annual from 1914: Table TSGB0709 (RDL0103).* London: Department for Transport.

DEPARTMENT FOR TRANSPORT. 2013c. *Applying an Ecosystem Services Framework to Transport Appraisal*. London: Department for Transport.

DEPARTMENT FOR TRANSPORT. 2013d. *Aviation Policy Framework 2013*. London: Department for Transport.

DEPARTMENT FOR TRANSPORT, LOCAL GOVERNMENT AND THE REGIONS. 2002. *Green Spaces, Better Spaces. Final Report of The Urban Greenspaces Taskforce.* London: Department for Transport, Local Government and the Regions.

DEPARTMENT OF ENERGY AND CLIMATE CHANGE. 2010a. *2050 Pathways analysis.* London: Department of Energy and Climate Change.

DEPARTMENT OF ENERGYAND CLIMATE CHANGE. 2010b. *Renewable and Low-carbon Energy Capacity Methodology - Methodology for the English Regions.* London: Department of Energy and Climate Change. URL: **https://www.gov.uk/government/news/decc-publishes-methodology-for-renewable-and-low-carbon-capacity-assessment** [Accessed 25 September 2014].

DORLING, A. 2011. *How does the relationship between settlements and their surrounding land help inform work on the optimum patterns of future development for the natural environment?* Unpublished report from Natural England. [Available from Natural England on request.]

DREWITT, A.L. & LANGSTON, R.H. 2006. Assessing the impacts of wind farms on birds. *In: Ibis*, 148, 29-42. Peterborough: BOU.

DREWITT, A.L. & LANGSTON, R.H. 2008. Collision Effects of Wind-power Generators and Other Obstacles on Birds. *In: Annals of the N.Y. Academy of Sciences,* 1134, 233-26. New York: N.Y. Academy of Sciences.

DUNN, H. 2012. *Accounting for environmental impacts: Supplementary Green Book guidance*. London: HM Treasury.

EFTEC & SHEFFIELD HALLAM UNIVERSITY. 2013. *Green Infrastructure's contribution to economic growth: a review.* London: Defra & Natural England. URL: **www.randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=19056#Description** [Accessed 19 September 2014].

EMMETT, B.A., ROWE, E.C., STEVENS, C.J., GOWING, D.J., HENRYS, P.A., MASKELL, L.C. & SMART, S.M. 2011. *Interpretation of evidence of nitrogen impacts on vegetation in relation to UK biodiversity objectives*. JNCC Report, No. 449. Peterborough: JNCC. URL: **www.jncc.defra.gov.uk/page-5895** [Accessed 19 September 2014].

ENGLISH NATURE. 1999a. *Aerodrome safeguarding and nature conservation*. Peterborough: English Nature.

ENGLISH NATURE. 1999b. *Disturbance effects of aircraft on birds. Information Note.* Peterborough: English Nature.

ENGLISH NATURE. 2004. *The ecological effects of diffuse air pollution from road transport.* English Nature Research Report, No. 580. Peterborough: English Nature. URL: **http://publications.naturalengland.org.uk/publication/133002**

ENGLISH NATURE. 2006. *Coastal Squeeze, saltmarsh loss and Special Protected Areas* English Nature Research Report, No. 710. Peterborough: English Nature. URL: **http://publications.naturalengland.org.uk/publication/62014**

ENGLISH NATURE & ENVIRONMENT AGENCY. 2003. *North Norfolk Coastal Change Habitat Management Plan.*

ENVIRONMENT AGENCY. 2008. *Spotlight on business: 10 years of improving the environment.* Bristol: Environment Agency.

ENVIRONMENT AGENCY. 2011. *National Flood and Coastal Erosion Risk Management Strategy for England.* URL: **www.official-documents.gov.uk/document/other/9780108510366/9780108510366.pdf** [Accessed 19 September 2014].

ENVIRONMENTAL AUDIT COMMITTEE. 2010. Air Quality Fifth Report of Session 2009-10. London: The Stationery Office Limited.

EUROPEAN COMMISSION. 2005. *Soil Atlas of Europe*. URL: **www.eusoils.jrc.ec.europa.eu/projects/soil_atlas/pages/23.html** [Accessed 19 September 2014].

EUROPEAN COMMISSION. 2006. *Thematic Strategy for Soil Protection. Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions.* URL: **www.eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52006DC0231:EN:NOT** [Accessed 19 September 2014].

EUROPEAN COMMISSION. 2011a. *Guidance Document: Wind Energy Developments and Natura 2000.* Luxembourg: Publications Office of the European Union.

EUROPEAN COMMISSION. 2011b. *Report on best practice for limiting soil sealing and mitigating its effects.* Luxembourg: Publications Office of the European Union. URL: **www.ec.europa.eu/environment/archives/soil/pdf/sealing/Soil%20sealing%20-%20Final%20Report.pdf** [Accessed 19 September 2014].

EUROPEAN COMMISSION DIRECTORATE GENERAL TRANSPORT. 2002. *Cost 341 Habitat Fragmentation due to Transportation Infrastructure: The European Review*. Luxembourg: Office for Official Publications of the European Communities.

EUROPEAN ENVIRONMENT AGENCY. 2011. *Urban soil sealing in Europe.* URL: **www.eea.europa.eu/articles/urban-soil-sealing-in-europe** [Accessed 19 September 2014].

EUROSION. 2004. *Living with Coastal Erosion in Europe: Sediment and Space for Sustainability. Part IV - A guide to coastal erosion management practices in Europe: Lessons Learned*. URL: **www.eurosion.org/reports-online/part4.pdf** [Accessed 19 September 2014].

FOREST RESEARCH. 2010. *Benefits of green infrastructure*. Report to Defra and DCLG. Farnham: Forest Research.

GARBUTT, A. & BOORMAN, L. 2009. Managed Realignment: Re-creating Intertidal Habitats on Formerly Reclaimed Land. *In:* G.M.E. PERILLO, E. WOLANSKI, D. R. CAHOON & M. M. BRINSON, eds. *Coastal Wetlands: An Integrated Ecosystem Approach.* Amsterdam: Elsevier B.V.

GENSLER & ULI. 2011. *Open Space: an asset without a champion?* London: The Urban Land Institute.

GOVERNMENT OFFICE FOR SCIENCE. 2010. *Foresight Land Use Futures Project - Final Project Report*. London: The Government Office for Science. URL: **https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/288843/10-631-land-use-futures.pdf** [Accessed 19 September 2014].

GOVERNMENT OFFICE FOR SCIENCE. 2011. *Foresight Land Use Futures Project, High Level Steering Group - One Year Review February 2010 – May 2011.* London: The Government Office for Science.

GROUNDWORK UK. 2012. *Grey Places need Green Spaces - The case for investing in our nation's natural assets.* London: Groundwork.

HALL, J., EMMETT, B., GARBUTT, A., JONES, L., ROWE, E., SHEPPARD, L., VANGUELOVA, E., PITMAN, R., BRITTON, B., HESTER, A., ASHMORE, M., POWER, S. & CAPORN, S. 2011. *UK Status Report July 2011: Update to empirical critical loads of nitrogen report to Defra Critical loads exceedance estimates for UK*. Report to Defra under contract AQ801 Critical Loads and Dynamic Modelling. London: Defra.

HALL, J., FIELD, C., STEVENS, C., LEITH, I., SHEPPARD, L. & BEALEY, W. 2012. *Air Quality Risk Assessment and SSSI Survey project: To refine the understanding of air quality risk assessments (based on modelling) and site specific responses to atmospheric ammonia pollution.* Unpublished report to Natural England.

HARRIS, J.A., GROGAN, P. & HOBBS, R.J. 2005. Restoration ecology and the role of soil biodiversity. *In:* R. BARDGETT, M. USHER & D. HOPKINS, eds *Biological Diversity and Function in Soils,* 319-342. Cambridge: Cambridge University Press.

HAYGARTH, P.M. & RITZ K. 2009. *The future of soils and land use in the UK: Soil systems for the provision of land-based ecosystem services.* Land Use Policy 26S S187-197. URL: **www.webarchive.nationalarchives.gov.uk/20121212135622/www.bis.gov.uk/assets/foresight/docs/land-use/jlup/22_the_future_of_soils_and_land_use_in_the_uk_soil_systems.pdf** [Accessed 19 September 2014].

HIGHWAYS AGENCY. 2002. *Biodiversity Action Plan.* London: Highways Agency.URL: **https://web.archive.org/web/20030625171153/www.highways.gov.uk/aboutus/corpdocs/biodiversity/index.htm** [Accessed 25 September 2014].

HM GOVERNMENT. 2011a. *The Natural Choice: Securing the Value of Nature.* The Natural Environment White Paper CM8082. London: The Stationery Office.

HM GOVERNMENT. 2011b. *Biodiversity 2020: A strategy for England's wildlife and ecosystem services.* London: Defra.

HOU, L.Z., FENG, S.Y., DING, Y.Y., ZHANG, S.H. AND HUO, Z.L. 2008. Experimental study on rainfall-runoff relation for porous pavements. *In: Hydrology Research*, 39, 181-190. London: IWA Publishing.

INSTITUTE OF EUROPEAN ENVIRONMENTAL POLICY. 2004. *The Potential Environmental and Rural Impacts of Biofuel Production in the UK.* London: IEEP.

INSTITUTE OF EUROPEAN ENVIRONMENTAL POLICY & THE ROYAL SOCIETY FOR THE PROTECTION OF BIRDS. 2009. *Positive Planning for Onshore Wind Energy*. Sandy: RSPB. URL: **www.rspb.org.uk/Images/Positive%20Planning%20for%20Onshore%20Wind_tcm9-213280.pdf** [Accessed 25 September 2014].

JNCC. 2011. *Indirect Land Use Change from biofuel production: implications for biodiversity.* Peterborough: Joint Nature Conservation Committee.

JNCC. 2013. *UK Article 17 EU Habitats Directive Report.* Peterborough: Joint Nature Conservation Committee.

JACKSON, S., FULLER, D., DUNSFORD, H., MOWBRAY, R., HEXT, S., MACFARLANE, R. & HAGGETT, C. 2008. *Tranquillity Mapping: developing a robust methodology for planning support.,* Technical Report on Research in England, January 2008 (revised). Newcastle: Northumbria University.

JONES, L., ANGUS, S., COOPER, A., DOODY, P., EVERARD, M., GARBUTT, A., GILCHRIST, P., HANSOM, J., NICHOLLS, R., PYE, K., RAVENSCROFT, N., REES, S., RHIND, P. & WHITEHOUSE, A. 2011. Chapter 11, Coastal Margins. *In: The UK National Ecosystem Assessment Technical Report.* Cambridge: UNEP-WCMC. URL: **www.uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx** [Accessed 25 September 2014].

LAND USE CONSULTANTS. 2006*. A Practical Toolkit for Assessing Cumulative Effects of Spatial Plans and Development Projects on Biodiversity in England.* English Nature Research Report, No. 673. Peterborough: English Nature. **http://publications.naturalengland.org.uk/publication/64008**

LAND USE CONSULTANTS. 2009a. *Are Natural England's objectives being realised through development control casework?* Unpublished report to Natural England.

LAND USE CONSULTANTS. 2009b. *Evaluation of NE's Effectiveness in influencing North West Regional Spatial Strategy & Local Development Frameworks*. Unpublished report to Natural England.

LAND USE CONSULTANTS. 2013. *Literature review and analysis of the effectiveness of mitigation measures to address environmental impacts of linear transport infrastructure on protected species and habitats (NECR132).* Sheffield: Natural England. URL: **http://publications.naturalengland.org.uk/publication/6184646404472832**

LANGBEIN, J. 2007. *National deer-vehicle collision project England 2003-2005.* London: The Deer Initiative.

MAFF. 2000a. *Evaluation of Mineral Sites Restored to Agriculture.* Project LE0206. URL: **www.webarchive.nationalarchives.gov.uk/20090306103114/www.defra.gov.uk/farm/environment/land-use/restore/index.htm** [Accessed 19 September 2014].

MAFF. 2000b. *Good Practice Guide for Handling Soils*. URL: **www.webarchive.nationalarchives.gov.uk/20090306103114/http:/www.defra.gov.uk/farm/environment/land-use/soilguid/index.htm** [Accessed 19 September 2014].

MORRISEY, T., ASHMORE, M.R., EMBERSON, L.D., CINDERBY, S. & BUKER, P. 2007. *The impacts of ozone on nature conservation.* JNCC **Report 403**. Peterborough: Joint Nature Conservation Committee.

MÖLLER, I. 2006. Quantifying saltmarsh vegetation and its effect on wave height dissipation: results from a UK east coast saltmarsh. *Journal of Estuarine, Coastal, and Shelf Sciences*, 69(3-4), 337-351.

MOSSMAN, H. L., DAVY, A. J. & GRANT, A. 2012. Does managed coastal realignment create saltmarshes with 'equivalent biological characteristics' to natural reference sites? In: *Journal of Applied Ecology, 49(6), 1446-1456.*

NATURAL CAPITAL COMMITTEE. 2013. *The State of Natural Capital 2013 – Towards a framework for measurement and valuation.* URL: **https: www.environmentbank.com/files/state-of-natural-capital-report-2013-1.pdf** [Accessed 19 September 2014].

NATURAL ECONOMY NORTHWEST. 2008. *The Economic Value of Green Infrastructure.* Green Infrastructure North West. URL: **www.greeninfrastructurenw.co.uk/resources/The_Economic_Value_of_Green_Infrastructure.pdf** [Accessed 19 September 2014].

NATURAL ENGLAND. 2008. *State of the Natural Environment 2008.* Natural England Reports No 85. Sheffield: Natural England. URL: **http://publications.naturalengland.org.uk/publication/31043**

NATURAL ENGLAND. 2009. *Mapping values: the vital nature of our uplands.* Natural England Reports No 209. Sheffield: Natural England. URL: **http://publications.naturalengland.org.uk/publication/47001**

NATURAL ENGLAND. 2010a. *Natural Leaders: actions for local environmental leadership.* Natural England Commissioned Reports No 47. Sheffield: Natural England. URL: **http://publications.naturalengland.org.uk/publication/45008**

NATURAL ENGLAND. 2010b. *Lost Life: England's lost and threatened species*. Natural England Report No 233. Sheffield: Natural England. URL: **http://publications.naturalengland.org.uk/publication/32023**

NATURAL ENGLAND. 2010c. *Green Belts: A greener Future*. Natural England Report No 236. Sheffield: Natural England. URL: **http://publications.naturalengland.org.uk/publication/38005**

NATURAL ENGLAND. 2010d. *Investigating the impacts of windfarm development on peatlands in England*. Natural England Reports NECR032. Sheffield: Natural England. URL: **http://publications.naturalengland.org.uk/publication/43010**

NATURAL ENGLAND. 2011a. *Spatial Targeting: Guidance for using spatial (geographic) data strategically for environmental and environmentally led socio-economic outcomes.* Sheffield: Natural England.

NATURAL ENGLAND. 2011b. *Solar Parks: maximising environmental benefits.* Natural England Technical Information Note 101. Sheffield: Natural England. URL: **http://publications.naturalengland.org.uk/publication/32027**

NATURAL ENGLAND. 2012a. *Microeconomic Evidence for the Benefits of Investment in the Environment – review.* Sheffield: Natural England. URL: **http://publications.naturalengland.org.uk/publication/6692039286587392**

NATURAL ENGLAND. 2012c. *Bats and Onshire Wind Turbines (interim guidance).* Natural England Technical Information Note 051. Sheffield: Natural England. URL: **http://publications.naturalengland.org.uk/publication/35010**

NATURAL ENGLAND. 2013a. *Monitor of Engagement with the Natural Environment: the national survey on people and the natural environment. Annual report from the 2012-2013 survey.* Sheffield: Natural England. URL: **http://publications.naturalengland.org.uk/publication/5331309618528256**

NATURAL ENGLAND. 2013b. Aviation sensitivity maps. Unpublished. [Maps available on request to Natural England].

NATURAL ENGLAND. 2014. *2013/14 Annual Report to the Department for Communities and Local Government.* Sheffield: Natural England.

NETWORK RAIL. 2013. *Network Rail 2012/13 Sustainability Update.* London: Network Rail.

NETWORK RAIL. 2014. *Our history, key facts*. London: Network Rail. URL: **www.networkrail.co.uk/aspx/729.aspx** [Accessed 25 September 2014].

ORFORD, J. & PETHICK, J. 2006. Challenging assumptions of future coastal habitat development around the UK. *Earth Surface Processes and Landforms,* 31, 1625-1642. New Jersey: Wiley.

PYE, K., SAYE, S. & BLOTT, S. 2007. *Sand Dune processses and management for flood and coastal defence.* Defra R&D Technical Report FD1302/TR. London: Defra.

RACKHAM, O. 1986. *The History of the Countryside*. London: J.M. Dent & Sons.

REES, S., ANGUS, S., RHIND, P. & DOODY, J.P. 2010. Coastal Margin Habitats. *In: Marine Climate Change Impacts Project Annual Report Card 2010-11, MCCIP Science Review, page 21.* Lowestoft: MCCIP. URL: **www.mccip.org.uk/annual-report-card/2010-2011.aspx** [Accessed 19 September 2014].

ROGERS, J., HAMER, B., BRAMPTON, A.H. , CHALLINOR, S., GLENNERSTER, M., BRENTON, P. & BRADBURY, A. 2010. *Beach Management Manual (Second edition).* London: CIRIA Publishing.

ROYAL COMMISSION ON ENVIRONMENTAL POLLUTION. 2007. *Twenty-sixth report: The Urban Environment*. London: The Stationery Office.

ROYAL COMMISSION ON ENVIRONMENTAL POLLUTION. 2009. *Artificial light in the environment*. London: The Stationery Office.

ROYAL HORTICULTURAL SOCIETY. 2005. *Gardening matters: Front Gardens - Are we parking on our gardens? Do driveways cause flooding?* URL: **www.rhs.org.uk/science/pdf/climate-and-sustainability/urban-greening/gardening-matters-front-gardens-urban-greening** [Accessed 19 September 2014].

SARAEV, V. 2012. *Economic Benefits of Greenspace: a critical assessment of evidence of net economic benefits*. Edinburgh: Forestry Commission.

SAYERS, P., BREW, D., TARRANT, O., COOPER, N. & WALLIS, M. 2012. *A Framework for Coastal Research,Development and Dissemination (CoRDDi)* Report: SC090035/R. Bristol: Environment Agency.

STEVENS, C.J., SMART, S.M., HENRYS, P., MASKELL, L.C., WALKER, K.J., PRESTON, C.D., CROWE, A., ROWE, E., GOWING, D.J. & EMMETT, B.A. 2011. *Collation of evidence of nitrogen impacts on vegetation in relation to UK biodiversity objectives*. JNCC Report 447. URL: **www.jncc.defra.gov.uk/page-5894** [Accessed 19 September 2014].

UK BIODIVERSITY STEERING GROUP. 1995. *Biodiversity: the UK Steering Group Report Volume 2: Action Plans (Tranche 1 Species and Habitat Action Plans)*. London: UKBSG.

UNIVERSITY OF BRISTOL. 2013. *The Effects of Noise on Biodiversity, Defra Science and Research Report N0035.* London: Defra.

URBAN REGENERATION & GREENSPACE PARTNERSHIP. 2010. *Benefits of green infrastructure.* Report to Defra & CLG Contract Number WC0807. London: Defra.

WATSON, A. & ALBON, S. 2011. *The UK National Ecosystem Assessment: Synthesis of the Key Findings*. Cambridge: UNEP-WCMC.

WEIGERT, K. 2004. *National risk assessment: and evaluation of the number and types of SSSIs and risk from road traffic pollution.* MSc Thesis, University of Bradford.

WIT, R.C.N., DAVIDSON, M.D. & DINGS, J.M.W. 2003. *Meeting External Costs in the Aviation Industry.* Delft: Commission for Integrated Transport.

WOODS-BALLARD, B., KELLAGHER, R., MARTIN, P., JEFFRIES, C., BRAY, R. & SHAFFER, P. 2007. *The SUDS Manual*. London: CIRIA.

WOLTERS, M., GARBUTT, A. & BAKKER, J.P. 2005. Salt-marsh restoration: evaluating the success of de-embankments in north-west Europe. *In: Biological Conservation,* 123, 249-268.

Further information

Natural England evidence publications can be downloaded from the publications and products catalogue: **http://publications.naturalengland.org.uk/**. In particular see **Natural England summaries of evidence**. For information on Natural England evidence publications contact the Natural England Enquiry Service on 0845 600 3078 or e-mail **enquiries@naturalengland.org.uk**.

Author

Joanna Russell **joanna.russell@naturalengland.org.uk**

We would welcome your comments on this summary - please send them to the author at the above address.

Copyright

ISBN 978-1-78354-171-3