Making Space for Nature:
A review of England's Wildlife Sites and Ecological Network

Chaired by Professor Sir John Lawton CBE FRS

Submitted to the Secretary of State, the Department for Environment, Food and Rural Affairs on 16 September 2010

FOREWORD

In September 2009, the then Secretary of State in the Department for Environment, Food and Rural Affairs, Hilary Benn, asked me to chair a review of England's wildlife and ecological network. As he pointed out : "With the effects of climate change and other pressures on our land, now is the time to see how we can enhance ecological England further. Linking together areas to make ecological corridors and a connected network, could have real benefits in allowing nature to thrive."

I accepted with enthusiasm, and the first meeting of the panel charged with delivering our report was held in early December. The General Election and subsequent change of Government and Secretary of State in May 2010 could have put paid to the enterprise, but the panel was delighted when the new Secretary of State, Caroline Spelman, picked up the baton and urged us to carry on. The commitment of the new coalition Government to nature conservation in general, and to the promotion of 'green corridors' in particular, is heartening. But as we argue in this report, increasing the connectivity of England's ecological network is only one of the things we need to do if we are to stop the seemingly inexorable decline in the numbers of many species, and the continuing loss of valuable wildlife habitats.

It is not all bad news. As we explain, targeted conservation efforts have turned around the fate of many species and extensive new areas of habitat have been recreated. In other words, given resources, determination and skill, we know what to do, and how to do it. Of course we do not have all the answers, but what we are proposing is the application of techniques and ideas that we know work.

The report argues that we need a step-change in our approach to wildlife conservation, from trying to hang on to what we have, to one of large-scale habitat restoration and recreation, under-pinned by the re-establishment of ecological processes and ecosystem services, for the benefits of both people and wildlife. We are not proposing a heavy, top-down set of solutions. It is a long-term vision, out to 2050, and defines a direction of travel, not an end-point. This vision will only be realised if, within the overall aims, we work at local scales, in partnership with local people, local authorities, the voluntary sector, farmers, other land-managers, statutory agencies, and other stakeholders. Private landowners, land managers and farmers have a crucial role to play in delivering a more coherent and resilient wildlife network.

And it will require leadership from Government. Getting from where we are to where we want to be will not be easy, but it can be done. I would go as far as to say that it *must* be done if England is to remain a 'green and pleasant land'.

The names of the colleagues who made up the panel are below. They and the secretariat provided by Natural England were simply wonderful, and I cannot thank them enough. I look forward to discussing these ideas with all those who care about England's wildlife and wild places, and above all helping to make space for nature a reality.

John Lawton
York, September 2010

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More than 45 organisations responded to our Call for Evidence for the review, and this report has benefitted greatly from the information and ideas that they provided. We list these organisations at Annex 2. Local Record Centres, Wildlife Trusts and others also kindly provided data for the analyses of different types of wildlife sites in Section 4.

We are also grateful to the large number of people from many different organisations who selflessly shared their ideas, data and expertise with the review panel: Paul Armsworth, Pam Berry, Steve Chaplin, Stewart Clarke, Tim Collins, Humphrey Crick, Ben Fraser, Mike Grace, Phil Grice, Julian Harlow, Richard Handley, Alice Hardiman, Katherine Hawkins, John Hopkins, John Houston, Chris Johns, Keith Kirby, Lesley Miles, Mike Morecroft, Tom Oliver, Mike Oxford, Helen Perkins, Simon Pryor, Geoff Radley, Paul Raven, Paul Rose, Matt Shardlow, Dave Stone, Chris Thomas, Jeremy Thomas, Wendy Thompson, Graham Tucker, Kevin Walker, Jon Webb, John Wilding, Paul Wilkinson, Gwyn Williams, James Williams.

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Executive Summary

Do England's wildlife sites comprise a coherent and resilient ecological network? If not, what needs to be done? These are the questions that we aim to answer in this report. We first consider why these questions are important in the context of past, current and future pressures on the environment, and describe what ecological networks are and the benefits they bring. We go on to consider the strengths and weaknesses of our current wildlife sites, before setting out a prioritised set of ecological solutions to improve the network. Finally, we make 24 recommendations for practical action to *Make Space for Nature* and achieve a coherent and resilient ecological network.

Throughout, we stress that what is needed is a step-change in nature conservation. We need to embrace a new, restorative approach which rebuilds nature and creates a more resilient natural environment for the benefit of wildlife and ourselves. This will require strong leadership from government, but is not a job for government alone. It will require effective and positive engagement with the landowners and land managers. And it will need improved collaboration between local authorities, local communities, statutory agencies, the voluntary and private sectors, farmers, other land-managers and individual citizens.

Why is having a coherent and resilient ecological network important?

England's wildlife and landscapes have inspired and delighted through generations. There are strong moral arguments for recognising the intrinsic values of other species and for passing on the natural riches we have inherited to future generations. We have also recently begun to better understand (or perhaps remember) that our natural world is not a luxury: it is fundamental to our well-being, health and economy. The natural environment provides us with a range of benefits – *ecosystem services* including food, water, materials, flood defences and carbon sequestration – and biodiversity underpins most, if not all, of them. The pressures on our land and water are likely to continue to increase and we need to learn how to manage these resources in ways which deliver multiple benefits, for example, achieving profitable and productive farming while also adopting practices which enhance carbon storage, improve flood water management and support wildlife.

Declines in wildlife are a global problem: the World has failed to meet its commitment to achieve a significant reduction in the rate of global biodiversity loss by 2010; Europe has not met its 2010 target to halt biodiversity loss. The report summarises the losses that have occurred, and continue to occur, in England's wildlife. Across species groups we have seen significant declines, in particular since the end of the Second World War, mainly as a result of changes in land use which has led to the loss and deterioration of many wildlife habitats. But it is not all bad news: for some habitats and species the historic patterns of losses have slowed, and in some cases they have been reversed (often through the conservation efforts of statutory bodies, the voluntary sector and landowners). Nonetheless, across many groups of species it is the more 'specialist' species that tend to be in decline while the less choosy, more adaptable 'generalists' tend to be faring better - an indication of ongoing declines in the quality and variety of England's natural environment.

Concern for nature is not new, and considerable progress has been made over the last century to protect wildlife. Voluntary conservation organisations helped to stimulate popular

and Government support, culminating in the National Park and Access to the Countryside Act 1949 which laid the foundations for designating places that are special for wildlife (notably National Nature Reserves and Sites of Special Scientific Interest, SSSIs) and people (National Parks and Areas of Outstanding Natural Beauty). Subsequent legislation has improved first the protection, and more recently the management, of wildlife sites in particular SSSIs. Despite the important contribution designated sites have made, England's wildlife habitats have become increasing fragmented and isolated, leading to declines in the provision of some ecosystem services, and losses to species populations.

Ecological networks have become widely recognised as an effective response to conserve wildlife in environments that have become fragmented by human activities. An ecological network comprises a suite of high quality sites which collectively contain the diversity and area of habitat that are needed to support species and which have ecological connections between them that enable species, or at least their genes, to move. Over 250 ecological networks are being planned or implemented at international, national and regional levels around the world, including in some parts of the UK. Provision for ecological networks is made in a number of international treaties and agreements but England has not yet met its commitments under these agreements. Taking steps to do so, however, will deliver a range of benefits for people as well as wildlife, because of the range of ecosystem services that resilient, coherent ecological networks can provide.

We propose that the overarching aim for England's ecological network should be to deliver a natural environment where: *Compared to the situation in 2000, biodiversity is enhanced and the diversity, functioning and resilience of ecosystems re-established in a network of spaces for nature that can sustain these levels into the future, even given continuing environmental change and human pressures.*

We also recommend that this be underpinned by three objectives:

(1) To restore species and habitats appropriate to England's physical and geographical context to levels that are sustainable in a changing climate, and enhanced in comparison with those in 2000.
(2) To restore and secure the long-term sustainability of the ecological and physical processes that underpin the way ecosystems work, thereby enhancing the capacity of our natural environment to provide ecosystem services such as clean water, climate regulation and crop pollination, as well as providing habitats for wildlife.
(3) To provide accessible natural environments rich in wildlife for people to enjoy and experience.

Future Challenges

Demographic change, economic growth, new technologies, societal preferences and changes in policy and regulatory environments (international, EU and domestic) may all have profound consequences - some potentially positive - for our ability to establish a coherent and resilient ecological network. Climate change, particularly in the longer term, may have the biggest impact of all. We are already seeing a number of changes as a result of climate: shifts in species ranges; changes in the timing of seasonal events (with emerging mismatches in the timing of events for currently inter-dependent species); and habitat preferences altering. Not all changes will be harmful, for example, many of England's

southern species may be able to increase their range by expanding northwards. In the longer term, however, species may struggle to survive, and other impacts such as sea-level rise, an increase in extreme weather events, and other changes to ecosystem processes (e.g. caused by summer droughts) are likely to have further profound, and largely negative, effects.

Establishing a coherent and resilient ecological network will help wildlife to cope with these changes. It will also improve the ability of our natural environment to provide a range of high quality ecosystem services today and in the future. It can help us both mitigate and adapt to climate change by, for example, storing carbon or improving the security of water supplies. We don't know exactly what the future holds, and we don't know exactly which species will be the winners and losers. Conserving the ecosystems and wildlife that we have today will, however, maximise our future options and improve our chances of achieving health and prosperity for ourselves and our children.

The Nature and Status of our current Wildlife Sites and Ecological Network

England has a wide range of different types of statutory and non-statutory sites which, to a greater or lesser extent, support our wildlife. We take a broad view of what comprises a 'wildlife site' and identify three general categories ('Tiers'), which include eleven types of sites. Tier 1 sites are those whose primary purpose is nature conservation and which have a high level of protection (e.g. SSSIs); Tier 2 sites are designated for their high biodiversity value but do not receive full protection (e.g. Local Wildlife Sites); Tier 3 are landscape designations with wildlife conservation as part of their statutory purpose (National Parks and AONBs).

We examine the extent to which these different Tiers of sites separately and collectively comprise a coherent and resilient ecological network by testing the evidence against five attributes that we identify for such a network:

(i) The network will support the full range of England's biodiversity and incorporate ecologically important areas, including special biodiversity.
(ii) The network and its component sites will be of adequate size, taking account of the needs of our natural environment to adapt to climate change.
(iii) The network sites will receive long-term protection and appropriate management.
(iv) Sufficient ecological connections will exist between sites to enable species movement.
(v) Sites will be valued by, and be accessible to people, including sites close to where they live.

We draw upon a wide range of evidence including academic literature, organisational reports, evidence submitted to the panel by more than 45 organisations and novel analyses carried out specifically for this review.

The evidence demonstrates that the SSSI series, as important as it is, clearly does not in itself comprise a coherent and resilient ecological network. Perhaps this should not come as a surprise since SSSIs were not designated with this aim in mind. Looking across all three Tiers of wildlife sites, the evidence demonstrates that only attribute (i) is substantially met; in all other cases there are serious short-comings in the network. Notably, many of England's

wildlife sites are too small; losses of certain habitats have been so great that the area remaining is no longer enough to halt additional biodiversity losses without concerted efforts; with the exception of Natura 2000 sites and SSSIs, most of England's semi-natural habitats important for wildlife are generally insufficiently protected and under-managed; many of the natural connections in our countryside have been degraded or lost, leading to isolation of sites; and too few people have easy access to wildlife.

Many species are now largely restricted to wildlife sites simply because they have mostly been lost from everywhere else. We need to take steps to rebuild nature.

Rebuilding Nature

The essence of what needs to be done to enhance the resilience and coherence of England's ecological network can be summarised in four words: *more*, *bigger*, *better* and *joined*. There are five key approaches which encompass these, and also take account of the land around the ecological network. We need to:

(i) Improve the quality of current sites by better habitat management.
(ii) Increase the size of current wildlife sites.
(iii) Enhance connections between, or join up, sites, either through physical corridors, or through 'stepping stones'.
(iv) Create new sites.
(v) Reduce the pressures on wildlife by improving the wider environment, including through buffering wildlife sites.

We set out an ecological rationale for deciding between these approaches. In general, the first priority is to enhance the quality of remaining wildlife habitat. Increasing connectivity helps, but first there needs to be high quality sites with thriving wildlife populations to connect. Local circumstances are also important. In areas which have large amounts of relatively unfragmented habitat, the best strategy will often be to focus on improving management and enhancing habitat diversity ('heterogeneity'). In contrast, in areas which only have small and isolated sites, it will be better to invest in the restoration and creation of new wildlife habitat.

Importantly, there are trade-offs between these actions: the more we do to improve the quality of existing sites or to reduce the pressures on them by enhancing the wider environment, the less we will need to do to create new wildlife sites.

Establishing a coherent and resilient ecological network

The approaches required to achieve a coherent and resilient ecological network are varied, and we make 24 wide-ranging recommendations. Five themes unite them:

(i) We need to continue the recent progress in improving the management and condition of wildlife sites, particularly our SSSIs. We also make recommendations for how these should be designated and managed in ways that enhance their resilience to climate change.
(ii) We need to properly plan ecological networks, including restoration areas. Restoration needs to take place throughout England. However, in some areas, both the scale of what can be delivered to enhance the network, and the ensuing

(iii) There are a large number of surviving patches of important wildlife habitat scattered across England outside of SSSIs, for example in Local Wildlife Sites. We need to take steps to improve the protection and management of these remaining wildlife habitats. 'Protection' will usually be best achieved through incentive-based mechanisms, but at times may require designation.

(iv) We need to become better at deriving multiple benefits from the ways we use and interact with our environment. There are many things that society has to do that may seem to have rather little to do with nature conservation, but could have, or even should have if we embrace more radical thinking; flood management by creating wetlands is an obvious example. We need to exploit these 'win-win' opportunities to the full. Being better at valuing a wider range of ecosystem services would help this process.

(v) We will not achieve a step-change in nature conservation in England without society accepting it to be necessary, desirable, and achievable. This will require strong leadership from government and significant improvements in collaboration between local authorities, local communities, statutory agencies, the voluntary and private sectors, farmers, landowners and other land-managers and individual citizens

Our recommendations set out a 'direction of travel'. They do not provide a detailed, prescriptive plan of exactly what should happen, where. The precise solutions need to take full account of local opportunities and ambition, although we believe that some form of national framework is required to ensure coherence and cost-efficiencies across the network (what happens in one place will affect what is needed elsewhere).

Partly because we have not set out a detailed, prescriptive plan, and partly because many of the recommendations overlap and interact (i.e. what we have to do to implement one recommendation will often depend upon how successful we are in implementing others), it has not been possible to provide accurate estimates of the cost of each of the 24 recommendations. Nonetheless, taking account of recent comprehensive biodiversity cost-estimates derived by other studies, and including current expenditure, we estimate that the total annual costs of establishing a coherent and resilient network will be in the range of £600 million to £1.1 billion.

The next few years are clearly going to be a time of budgetary constraint, when additional resources are unlikely to be available. We recognise that it will not be possible to take all necessary action immediately, or even soon. We do, however, need to plan for the medium and longer term and *Make Space for Nature*. Amongst this uncertainty, there is one thing of which we can be certain: the sooner we act to establish a coherent and resilient ecological network, the lower the eventual cost and the greater the benefits for us all.

Contents

1. Introduction

There are twenty-seven ancient cathedrals in England. Imagine the outrage that would have ensued in this country if over the last 100 years, twelve had been partly demolished, nine substantially demolished, and three completely obliterated; only three would remain in good condition. Yet this is precisely what has happened to many of England's finest wildlife sites.

Between 1912 and 1915, Charles Rothschild, a banker and naturalist, conducted a survey of sites of conservation importance in England, with a view to setting up a nationwide network of nature reserves. The list, subsequently published in 1916, had 182 sites in England, now widely known as 'Rothschild's Reserves'. The basis on which sites were selected is not perfect and can be endlessly debated, but their subsequent fate is illuminating. In the last detailed analysis, led by Rothschild's daughter, (Rothschild & Marren 1997) the score was:

- Little or no loss 19 (10.4%)
- Less than 50% loss of the habitats for which it was originally listed 84 (46.2%)
- More than 50% loss 58 (31.9%)
- Total loss 21 (11.5%).

These are (or were) the cathedrals of nature conservation, yet we see no great outrage, perhaps because so few people realise what we have so easily lost.

This report seeks the means to redress the balance, which not only applies to the sites identified by Rothschild. Many other important areas for England's wildlife that he did not select have similarly been lost or damaged, and with it the species that depended upon them for survival.

The review looks forward to the middle of this century and deals with terrestrial, fresh-water and coastal environments, but not the sea. By 2050 the impacts of climate change on all aspects of our society, including the conservation of species and ecosystems, will be all too obvious. Our Terms of Reference (Annex 1) asked us to "examine evidence on the extent to which the collection of sites [in England designated for nature conservation] represents a coherent and resilient ecological network capable of adapting to the challenge of climate change and other pressures". We conclude unequivocally that it is not, and that at the present time there are real problems with the size, management and protection of our wildlife sites, linked to a range of other pressures on them. Despite our best efforts, we continue to lose species and habitats at an alarming rate. This is not to say that the current series of protected areas is of no value. Far from it. Without it the scale of losses would have undoubtedly been much worse.

We propose that the overall aim for England's ecological network should be to achieve a natural environment where, compared to the situation in 2000, biodiversity is enhanced with the diversity, functioning and resilience of ecosystems re-established in a network for nature that can sustain these levels into the future, even given continuing environmental change and human pressures. This cannot be achieved within the present framework. It will require a step-change in behaviour from one in which we basically try to hang on to what remains, to one of large-scale habitat restoration and re-creation to make space for nature.

The aim of a really effective ecological network cannot be to set species and habitats in aspic. Nature does not stand still and England's wildlife has always changed. England was largely covered in an ice-sheet 15,000 years ago. The changes in our flora and fauna since then, as the ice-sheets withdrew and species spread back across Europe and hunter-gathering people followed by farmers, have been huge. Change in the environment is not new, and is not the issue. What is new and of great concern is the pace and scale of the changes that modern society now places on the environment - rates of change that make it impossible for many species to keep pace and adapt. We need to make space for nature so that it can adapt and change, rather than simply disappear.

It is not all bad news. As the report shows, not all species are declining, some are increasing, our knowledge and experience of habitat restoration and re-creation is improving, and we have turned around the fortunes of many species by dedicated conservation actions (although overall, we are losing more species than we are gaining). We can succeed if we have the will and the resources, even in a small, crowded island.

Why should we bother? For several reasons. Many people feel a strong emotional connection to nature and will consider the recommendations of this report vital simply because of the intrinsic value they place on our wildlife and a moral conviction that we have a duty to pass on the plants and animals we have inherited to future generations. Recently, however, we have also begun to understand that a healthy natural environment, the creatures that it supports, and the ecosystem processes which underpin it, are crucial for our own well-being, health and economy. We are gradually recognising that 'natural capital' is as vital to current and future prosperity as economic and social capital. As American Senator Gaylord Nelson so aptly put it: "the economy is a wholly owned subsidiary of the environment, not the other way round." The continual erosion of natural capital is a stark warning that we are living unsustainably. A world without space for nature would be a mean, unhealthy, impoverished world.

As a nation we are not alone in unravelling the fabric of nature. What we are doing is a local example, on one small part of the planet, of what is causing a growing, global 'biodiversity crisis'. This report is about what we have to do in England to halt and then reverse these trends. Indeed, we also have international obligations to deliver our share of global conservation efforts. Establishing ecological networks is increasingly recognised as an effective response to a fragmented natural environment, such as our own. For example, in 1995 European Ministers for the Environment endorsed an initiative to establish a Pan-European Ecological Network (PEEN) within 20 years (Bonnin *et al.* 2007). This initiative sought to stimulate the establishment and integration of ecological networks across Europe to produce a coherent network for Europe's wildlife. But although they have formed a core element of national conservation strategies in a growing number of countries for the last 30 years, England has so far not responded by taking steps to establish a truly coherent and effective ecological network. We describe other obligations later in the report (Section 2.2.4).

It is easy to say we cannot afford it. We fundamentally disagree. In 1949 (at a time of great post-war austerity) Government accepted that it had a duty to protect many of the most important wildlife sites, picking up the baton passed to it by the voluntary sector initiated by Rothschild and others, and laid the foundations for our present series of protected areas, at no small cost. In 2010, the UK is again confronted by considerable financial constraints

(although nothing on the scale of post-war problems). We are, however, despite current difficulties, a wealthy nation, and if the coalition Government's very welcome commitments to restoring nature, for example by creating 'green corridors', is to mean anything it cannot be delivered for nothing.

Remember we are laying out a long-term strategy, a desired 'direction of travel', and a set of general principles to guide conservation action in England over the next 40 years. It is not something that can or must all be done tomorrow, or next year. But we will need to invest, as resources become available, and we need to start sooner rather than later. So what will establishing a coherent and resilient ecological network cost? We make general estimates at the end of this report (Section 6.7), but providing a detailed analysis of the cost of each of our recommendations is impossible without a prescriptive, detailed plan for exactly what needs to happen, how much and where. Yet we believe that an enhanced ecological network cannot be established through a process imposed from the centre. Many of the decisions on the priorities for action are best made locally, by the people most familiar with the local challenges, opportunities and requirements. The exact cost will depend what we ultimately decide to do, and how long we take to do it.

We can summarise the essence of what needs to be done in four words: *more, bigger, better* and *joined.* It will not be possible to halt and reverse the collapse of England's wildlife documented in this report without a larger network comprising more areas rich in wildlife, bigger sites, better managed sites, and more inter-connected sites. We fully recognise the pressures there are, and increasingly will be, on land-use in England (see Section 3.1 on the Foresight Land Use Futures Project 2010), but we were asked to consider the case for nature conservation and it is our job to define the direction of travel and set out a vision for what needs to be done.

Delivering our vision is not a job for government alone, or even primarily for government. We will not achieve a step-change in nature conservation in England without society accepting that it is necessary, desirable, and achievable. This will require strong leadership from government and a much better collaboration between local authorities, local communities, statutory agencies, the voluntary and private sectors, farmers, landowners, other land managers and individual citizens. It will require education, explanation, and empowerment. It will also require resources, both money and people. It cannot be 'top down' and imposed. Nor can it be entirely laissez faire. It won't be easy. But it can be done.

It is obvious that statutory agencies with responsibility for the environment, and the voluntary conservation sector will both play a key role in delivering our vision. Just as important, however, is the role of private landowners, land managers and farmers, many of whom invest resources in enhancing wildlife over and beyond the funding they receive through incentive schemes. It is therefore important to engage effectively and positively with this sector. Our vision will only be achieved if society recognises the realities of managing the land and the true costs involved. If we decide as a society what we want, and put the right incentives in place, then the private land sector will provide many of the solutions.

Whilst we were writing this report, several well-meaning colleagues asked us, essentially, "why we had to bother with all these species?" Wouldn't it just be simpler if we could find a surrogate for species – broad landscape character for instance. Unfortunately this point of

view has no basis in science. Landscapes can be richer or poorer in species and you cannot tell just by looking at them from a distance. An analogy helps. Art galleries exist for people to enjoy paintings and sculpture. However pretty the gallery, however striking its architecture, it is useless as a gallery if it contains no works of art. Species keep conservation efforts honest, and there is no surrogate metric that can reliably assess conservation success or failure without knowing what is happening to populations of plants and animals in the landscape. We would know nothing about the global loss of biodiversity without knowing what is happening to species all over the world.

The art gallery analogy is useful in another way. Virtually all England's major conurbations have local art galleries, often set up by visionary Victorians, but others more recently. Many house nationally important collections of particular painters, potters or sculptors. Of course these local galleries are not in the same league as the National Gallery, but they are important, none-the-less. They ensure all our precious eggs are not in one basket and they enrich the lives of local people and visitors alike. People should not have to travel to London to enjoy art. Nor should they have to travel to a National Nature Reserve to see creatures more interesting than a Grey Squirrel, a Feral Pigeon, and Dandelions. An effective ecological network will do for nature what national and local galleries do for art, and enrich our lives in the process.

To deliver the vision of making space for nature, in Section 2 the report first summarises what is happening to England's wildlife and the causes of its decline as well as defining what we mean formally by an ecological network. Then in Section 3 we describe future pressures, particularly the impacts of climate change. Section 4 is a description of the nature and status of our current wildlife sites; it is also a primer in basic ecology that lays the groundwork for action underpinned by science. Section 5 turns that science into solutions, and Section 6 proposes action to deliver them, together with 24 recommendations for action.

2. Why is having a coherent and resilient ecological network important?

2.1 The case for action

2.1.1 The importance of our natural environment

England's rich wildlife and distinctive landscapes have inspired and delighted through generations. Many people feel a strong emotional connection to nature and will consider the recommendations of this report vital simply because of the intrinsic value they place on our wildlife and a moral conviction that we have a duty to pass on the richness we have inherited to future generations. Recently, however, we have also begun to understand the importance of a healthy natural environment and the wildlife that it sustains for our well-being, health and economy. We are gradually recognising that 'natural capital' is as vital to current and future prosperity as economic and social capital.

The natural environment provides us with a range of benefits from simple and obvious things like food, water and many materials, to more complex things like the regulation of climate through carbon sequestration or of flooding through water storage. There are also less tangible aesthetic and recreational services that it provides such as places to relax, seek inspiration or exercise. These benefits that humans receive from the functions of the natural world have been called *ecosystem services*. They are the direct and indirect result of past and present ecosystem processes such as soil formation, water and nutrient cycling and primary production (harnessing energy from sunlight). *Biodiversity* (a convenient technical term that has entered broader usage to capture the diversity of the whole living world, from genes and individual species, through to plant and animal communities and entire biomes) plays a critical role in all of these processes and as a result is often viewed as the vital underpinning for most, if not all, ecosystem services.

The Millennium Ecosystem Assessment published in 2005 introduced ecosystem services to a wider audience and made an assessment of the state of these services on a global scale. A national assessment of these services, the UK National Ecosystem Assessment, is currently underway and due to report early in 2011. There is an increasing interest in attempting to place a monetary value on ecosystem services to help inform policies and other decisions by all sectors (see Defra 2007). In practice, while some services such as food and timber already have defined market values, many are not (and may never be) traded. Some benefits are intangible and difficult to value, even though many of them are simply irreplaceable – the way in which water is filtered and cleaned for example, as it passes through healthy wetlands is for all practical purposes irreplaceable. Valuation is particularly problematic for species that simply enrich our lives (what price a Skylark?) and other cultural services such as the aesthetic qualities of our landscapes. Nonetheless, it has been estimated that the cost of global biodiversity decline under a business as usual scenario could be 14 trillion euros by 2050 (Braat *et al*. 2008). More specific valuations of the benefits derived from ecosystem services, and the cost of their loss, already provide a compelling case for the conservation of our natural heritage in England. For example (see Natural England 2009):

- Floodplain restoration aimed at improving water quality has demonstrated benefit-cost ratios of up to 4:1.
- We are losing between 2.8 and 5.8 million tonnes of CO_2 per year from the cultivation and drainage of lowland peat soils; the annual value of this loss is estimated at between £74 million and £150 million.
- People who live within 500 m of accessible green space are 24 per cent more likely to meet recommended levels of physical activity, while reducing the numbers of sedentary individuals in the population by just 1 per cent could reduce morbidity and mortality rates valued at £1.44 billion for the UK.

As approaches to valuing a wider range of ecosystem services are developed, it is important to realise that most services are provided by the interaction of living and non-living components of nature, rather than by individual species, and that many of the services are provided by the little things about which most members of the public know little, and care even less. Nevertheless, there is good evidence that increased rates of some ecosystem processes (plant productivity for example) are associated with increased numbers of species (Hooper *et al.* 2005; Balvenera e*t al*. 2006; Hector & Bagchi 2007) and as conditions change, different species may fulfil different roles. For example during years of drought a particular plant-species may thrive, maintaining productivity, and taking over a critical role from species which are less tolerant. In an unpredictable world of changing climate there may be even greater need for this insurance or resilience effect through conserving species that do not immediately appear to be useful (Yachi & Loreau 1999). Indeed, at present rates of extinction we will never even name many of the species that are lost, let alone understand the role that most species play in ecosystems. A precautionary approach is not optional, it is essential.

In recent times, management of land has often focused on the delivery of a single process or ecosystem service – food, for example, or timber. As human impact on the environment increases, we will need to learn how to manage land (and water) to deliver multiple services from a given area so that, for example, we achieve profitable and productive farming whilst at the same time adopting practices which enhance carbon storage and slow the flow of flood waters and support wildlife. However, hard-headed realism is needed; we should not assume that we can deliver all ecosystem services effectively from a single plot of land. The provision of some ecosystem services, such as water management and carbon storage, is often highly compatible with biodiversity conservation. Others, such as intensive food production, are not. What is clear, however, is that loss of species will make it progressively more difficult to deliver multiple ecosystem services from an area because this undermines the ecosystems themselves.

2.1.2 England's wildlife

England's wildlife reflects her geographical position as part of an island nation on the western edge of Europe, with a varied but prevailingly oceanic climate, exceptionally diverse geology and soils, and a long coastline with large tidal ranges. Its natural environment has been strongly influenced by the way people have shaped and farmed the landscapes over thousands of years, so that England now has very few habitats that have not been modified or even created by human actions (exceptions include some sea shores and coastal cliffs).

Consequently, many of the most species-rich habitats of greatest conservation value, such as meadows, heathlands and woodlands, created by centuries of human activities, require ongoing management to retain their nature-conservation interest. Technically, most are best described as '*semi-natural'* rather than 'natural' habitats.

England supports at least 55,000 species (excluding micro-organisms) within a wide range of habitats and ecosystems. Some of our wildlife is of European or global importance and we have a special responsibility to ensure its conservation. For example, England has:

- 18% of the world's heathland and more chalk rivers than any other country in Europe;
- globally important populations of breeding wintering waders and wildfowl in our intertidal and coastal wetland areas;
- internationally important populations of bats and oceanic lichens, and more than half the mainland European species of bryophytes (mosses) including endemic species (found nowhere else in the world);
- about 10% of all the world's species of bumblebees;
- the highest representation of veteran oak trees in Europe in our ancient woodlands and parklands; and
- peatlands, hay meadows and chalk grasslands of international importance.

Many perhaps more familiar creatures are just as valuable. Imagine a summer's day without Skylarks, or spring without Bluebells. Wildlife enriches our lives, just as Mediaeval cathedrals, Monet paintings and Mozart concertos enrich our lives. And yet huge chunks of this rich wildlife heritage have already been lost, or are seriously threatened.

2.1.3 How is our wildlife changing?

As we point out in Section 1, nature does not stand still. England's wildlife has always changed, and change itself is not the issue. What is new and a cause for great concern is the pace and scale of the changes that modern society now places on the environment - rates of change that make it impossible for many species to keep pace and adapt. England's environment is one of the best studied in the world, and the scale of the changes wrought by people, particularly in the second half of the 20th Century, is huge.

Two main drivers of change are:

- *Habitat loss*, and the resulting fragmentation and isolation of surviving patches of semi-natural habitats. Agriculture has changed large areas of our landscape by ploughing, draining and fertilising what were semi-natural heaths, chalk grasslands and lowland wet grasslands. In 2008, for instance, 11 out of the 15 (73%) priority habitats (so called *Biodiversity Action Plan* or BAP habitats - see below and Section 4.1.3) in England were declining as a result of agricultural practices (JNCC 2010). Other unintended consequences of agricultural intensification have been the loss of crucial ecosystem services (e.g. carbon and water storage), and negative impacts on others (e.g. water quality). This is not a criticism of farmers. It is what society wanted, and we will continue to demand food from our land. But the consequences for England's wildlife have been profound. Moreover, forestry, and the construction of

- *Habitat deterioration*. The abandonment of traditional management practices on surviving patches of semi-natural habitats (because they are no longer viewed as economically viable) is a second cause for concern. They include, by way of example, a cessation of grazing on such habitats as flower-rich chalk grassland (resulting in scrub-invasion), and a lack of coppicing in woodland (resulting in a closure of the canopy and much gloomier woods that quickly lose some of their wildlife interest – see for example Kirby *et al.* 2005).

These are not the only changes affecting wild plants and animals in England (JNCC 2010) and some of the others are important, but beyond the scope of this review, except in-so-far as they have implications for the way in which we manage wildlife sites. They include illegal collection and persecution of wildlife and threats from invasive non-native species. An audit of England in 2005 found 2721 non-native species living in the wild (English Nature 2005). Most of these have not had noticeable negative impacts, but a small minority have caused considerable harm, including Grey Squirrels (*Sciurus carolinensis*), Sudden Oak Death (*Phytophthora ramorum*) and Signal Crayfish (*Pacifastacus leniusculus*). The problems caused by non-native species could increase because of climate change.

Amongst other detrimental impacts, arguably the most widespread threat to England's surviving semi-natural habitats is *eutrophication*. Eutrophication is caused by fertilisers applied to agricultural fields draining into rivers and watercourses, and the deposition of nitrogen from the air derived from burning fossil-fuels and intensive live-stock units. It is a global problem (CBD 2010). In England, critical loads of nitrogen (levels at which semi-natural habitats are damaged) are currently exceeded in about 89% of the area of sensitive habitats, with the uplands being particularly badly affected. Studies show a general shift towards fast-growing plant species more responsive to nitrogen and decreases in those species characteristic of less fertile habitats (Carey *et al.* 2008; Countryside Survey 2009). Most freshwater habitats in England are also affected by nutrient enrichment from human activities. About 50% of river stretches may be at risk of failing Water Framework Directive quality objectives due to diffuse phosphate pollution (Mainstone *et al.* 2008). Diffuse pollution is the main cause of unfavourable condition in river *Sites of Special Scientific Interest* (see Section 4.1.1 for a description of SSSIs), mainly caused by nutrient enrichment from agricultural sources. These trends will continue unless the underlying causes are addressed.

The scale of wildlife losses

An overview of habitat loss, and information on the extent of habitats that remain, both within and without protected areas can be found in Section 4.3.2 (particularly in Tables 5 and 6). The consequences for England's wildlife have been profound. Maclean (2010) provides a comprehensive summary. Brutally summarising nearly 700 pages of text, Maclean's authors conclude that habitat destruction, fragmentation and isolation have caused serious declines in many groups (plants, bumblebees, butterflies, moths, dragonflies, Hemiptera ('bugs'), terrestrial snails, reptiles and birds). A lack of suitable habitat management is implicated in declines of many plant populations, 'river flies' (mayflies, caddis flies and stoneflies), freshwater fish, moths, butterflies, bugs, terrestrial and freshwater molluscs, reptiles, and

woodland birds. Agricultural intensification in the 'matrix' around semi-natural habitats has dealt a further blow to molluscs, moths, butterflies, bumblebees, amphibia (newts, frogs and toads), reptiles, mammals (particularly bats), and farmland birds. We simply do not know what is happening to many less well studied groups, but it is unlikely to be any better.

We can flesh out these bare bones. Many readers will be familiar with declines in once common, larger, and more charismatic species. There have been rapid losses of more than 50% in the last 25 years of once common species such as Hedgehogs, House Sparrows and Common Toads, and extinction of many species in some former areas. On average, for example, one species of vascular plant was lost every two years from each English county during the 20th Century; rates of loss were highest from Southern and Eastern counties, where land-use pressures are greatest (Walker 2003). There have also been major declines (>80%) in farmland birds since the 1960s primarily as a result of agricultural intensification e.g. Tree Sparrows by 97%, Corn Buntings by 87%, and Turtle Doves by 85% (Robinson 2010). Butterflies have also suffered; 93% of habitat specialist butterflies and 76% of all butterflies have declined since the 1970s (Thomas 2010). Overall, across our best-known groups, about a quarter of all species are at historically low levels or significantly threatened (Natural England 2010).

Life for other less-loved, and certainly less familiar creatures is also tough going. For example, of the 87 native species of land snails in Britain, 38 (44%) are in decline (Killeen 2010). Rothamsted Research has conducted a systematic survey of UK moths using light-traps since 1964. The total abundance of moths declined by 44% between 1968 and 2002 south of a line roughly from York to Lancaster; there have been no significant declines in numbers north of that line. Over 20% of formerly common moths are now considered threatened using internationally recognised criteria (Fox *et al.* 2010).

It is fair to say that not all these groups of creatures (and other even less familiar ones documented in Maclean 2010) have much appeal for the general public, who may simply not care about (or even welcome) their demise. But 'creepy crawlies' – the little things that make the world work – are vital components of natural food chains (as food for larger organisms and as pollinators for example) and many deliver other vital ecosystem services (see Section 2.1.1). It would be unwise to assume we can do without them. Basically, what we are doing is unravelling the fabric of nature. These are local examples on one small part of the planet, of the growing, global 'biodiversity crisis'. As a nation, we are not alone: globally, the rate of biodiversity loss is not yet slowing despite international commitments (CBD 2010, see Section 2.2.4) and Europe has failed to meet its commitment to halt biodiversity loss by 2010 (EU Council 2010). This report is about what we have to do in England to halt and then reverse these trends.

Everything is not declining and it isn't all bad news

Species

It would be quite wrong to give the impression that every species in England is declining. They are not. Some, for example, are responding positively to environmental changes, including climate change (other species, of course, are threatened by climate change and we discuss issues surrounding our changing climate in more detail in Sections 3.2 and 5.3).

But as our climate warms, and exactly as expected, England is gaining species that are naturally migrating from the near continent. They include some familiar examples, including birds like Little Egrets, Purple Herons, Spoonbills and Cetti's Warblers, several 'new' species of dragonflies and damselflies, Tongue orchids, and less noticed species of Hemiptera (bugs), bees and wasps, and spiders (Maclean 2010). Many of these arrivals from the European mainland appear first (or perhaps are first noticed) in protected areas, which have taken on a new role as nursery areas for these naturally colonising, often welcome, species. As our flora and fauna changes, as inevitably it must with climate change, we need space for nature to readjust and re-assemble.

More generally, and setting climate change aside for the moment to focus on what is happening to native species, at least in well-studied groups it is the habitat specialists that have suffered most of the declines documented in the previous section; generalists (less choosy, more adaptable) species are often holding their own or increasing (Natural England 2008). Examples in Maclean (2010) of groups with some increasing species include butterflies (roughly a third of UK species) and moths (about 70 of some 337). Birds are particularly instructive. Rarer species (those with fewer than 1000 individuals) have tended to fare better, whilst less scarce species (those with fewer than 100,000 individuals) are doing worse (Robinson 2010). The increases observed in some (formerly) very rare English birds (for example Stone Curlews, Marsh Harriers and Cirl Buntings) are a direct result of highly targeted conservation efforts. In other words, when we decide to do something to stop England from haemorrhaging species, we often can. This is good news.

Looking more generally, in an effort to stem such losses, the UK has devised *Biodiversity Action Plans*, or BAPs (Section 4.1.3), which identify species (and habitats) considered to be under threat, and propose actions to stem and reverse the declines. In the last UK BAP reporting round in 2008 (JNCC 2010), based on the original BAP list, 45 (11%) of priority species were reported as increasing in England, 128 (32%) had stabilised, but 86 (22%) were still in decline (the remaining species had either been lost or their trends were unknown or unreported). In other words, deliberate intervention by conservationists has reversed the fortunes of several threatened species. This reinforces the good news that we can make a real difference when we try.

The authors in Maclean (2010) again provide an excellent summary of many of these success stories through targeted conservation action for selected species in groups as diverse as butterflies, moths, grasshoppers, amphibians (frogs, toads and newts), reptiles (lizards and snakes) and birds. The action usually involves some form of active habitat management, and habitat recreation (see below). Moreover, action targeted at a particular species can often (though not always) benefit other species with which it shares habitat. "For example, the restoration of rotational scrub burning and intensive grazing for the Large Blue [butterfly] in Devonshire has resulted in new or greatly increased populations of such Biodiversity Action Plan species as Pearl-bordered, Small Pearl-bordered, High Brown and Dark Green Fritillaries, Grayling and other rarities, including …Wood Lark and Pale Heath Violet" (Thomas 2010). "The creation of new breeding ponds for amphibians brings the additional benefit of a substantial increase in other components of biodiversity. [Ponds] are particularly rich in macroinvertebrates and plants" (Halliday 2010).

Habitats

Nor is it all bad news on the habitat front. Woodlands of all types (except ancient) have expanded since 1945 (Section 4.3.2) and the number of ponds is now increasing (Section 4.3.2). There are also some real success stories with other, targeted habitat re-creation and restoration projects, which frequently underpin the recovery of species like the Large Blue Butterfly (above). Some habitats cannot be re-created except on time-scales of many hundreds of years – ancient woodland among them. Our understanding of how to re-create other habitats is improving. It takes time and often needs careful management (e.g. Morris *et al.* 2006) but there have been a number of successes including lowland flower-rich meadows, heathland, inland wetlands, woodlands (which are still valuable habitats even when not ancient) and coastal marshes. Box 1 briefly summarises some examples. Many such projects serve a dual purpose, for example coastal re-alignment (also known as 'managed retreat') by the Environment Agency (in partnership with conservation bodies) when maintaining current sea-defences becomes too expensive and too difficult because of sea-level rise (see Section 6.2.3). Private industry has also played a part, particularly in the creation of important wetlands after mineral and aggregate extraction (Box 1).

This is all good news. It shows that many (although not all) important and threatened habitats can be re-created to make space for nature.

Box 1. Habitat creation and restoration successes

With biodiversity still in decline, it can be all too easy to overlook the many excellent habitat creation and restoration successes which are helping to turn the situation around. For example, since the launch of the UK Biodiversity Action Plan in 1995, over 800 ha of reedbeds have been created, more than 200 ha of lowland raised bog has been restored and over 3500 ha of species-rich grassland have been created. Habitat creation and restoration often involve partnerships of landowners, NGOs, charitable trusts, businesses and national and local government and we highlight three specific examples here.

The Great Fen
The Great Fen Project will create a 3700 ha wetland between Huntingdon and Peterborough, joining up two National Nature Reserves. The area hosts thousands of species, including many rarities, and the project will restore a mosaic of habitats including fens, wet grasslands, reedbed and woodland. The project, a partnership between the Wildlife Trust, the Environment Agency, Natural England, Huntingdonshire District Council and Middle Level Commissioners, has funding from a wide range of sources including corporate sponsors, Heritage Lottery and Environmental Stewardship. It aims to be a springboard for economic diversification and new business. Current estimates are that the restoration of the wetlands will also prevent the loss of the equivalent of 325,000 tonnes of CO_2 to the atmosphere each year.

Tomorrow's Heathland Heritage
The Tomorrow's Heathland Heritage programme was one of the first major habitat restoration schemes supported by the Heritage Lottery Fund (HLF). Launched in 1997 and led by Natural England (then as English Nature), it aims to make a real and lasting contribution to our natural environment and people's understanding, appreciation and enjoyment of lowland heathlands. THH works through local partnerships with over 140 different organisations across the UK. In England alone, it has restored 34,380 ha of lowland heathland and created a further 2,117 ha, turning around

the fortunes of this important wildlife habitat.

Nature After Minerals
Nature After Minerals (NAM) is a partnership programme between the minerals industry, RSPB and Natural England. It aims to realise the major potential for UK Biodiversity Action Plan delivery via mineral site restoration and works with all relevant stakeholders including operating companies, planning authorities and local communities. Tailored advice provided by the programme has contributed directly to the restoration of over 1,800 hectares of BAP priority habitats.

The future

Despite our best efforts, England continues to lose species and habitats. (Conservation efforts have not been a waste of time. Without them the losses would have been even greater). Stopping and reversing the main threats to England's wildlife means stopping further damage and reversing and compensating for habitat destruction by large-scale habitat re-creation; getting the management of surviving patches of semi-natural habitats right; and making the farmland matrix more benign. These prescriptions cannot be absolute and apply everywhere. But if we bring the key principles into decision making when faced (as we inevitably must be) with hard choices, England's ecological network can be substantially improved, for the benefit of wildlife and people. The rest of this report lays out mechanisms to achieve these goals.

But first we need to set our proposals into their historical context.

2.1.4 Our evolving approach to nature conservation

England has a long history of protecting areas for wildlife, and entire books could (and have) been written about it. Here we briefly summarise some key points that are central to our report.

Voluntary organisations concerned with nature conservation in one form or another emerged in late Victorian times. Amongst these were the National Trust (1895) and the RSPB (1889). Charles Rothschild founded the Society for the Promotion of Nature Reserves (SPNR, now The Wildlife Trusts) in 1912, establishing the first organisation in the UK specifically focused on protecting places for wildlife. Rothschild and his friends compiled a list of the most important wildlife sites (see Introduction), many of which would later become National Nature Reserves and Sites of Special Scientific Interest. At the same time there were growing demands for greater access to the countryside, and a mass trespass of Kinder Scout, Derbyshire (1932) catalysed a campaign to create a series of National Parks open to all.

World War II to Present: 30, 20, 10

In 1941, with Government support, SPNR convened a conference to begin to plan nature conservation in a post-war Britain – a variety of Government Committees began to propose both National Nature Reserves for wildlife and National Parks for people. Ultimately both of

these systems were enshrined in the National Park and Access to the Countryside Act 1949. This was passed by the first post-Second World War Government with all-party support.

There followed 30 years (1950-1980) of designation of sites for wildlife, though the designation was backed neither with adequate protection nor proper management of the sites – indeed, there was not even systematic notification of the sites, so that many owners and managers were not even aware of their existence. The 'green revolution' of agricultural intensification and a burgeoning human population meant that many sites were lost or damaged. The Wildlife and Countryside Act (1981) introduced notification systems and new laws to prevent damage, and some 20 years of significantly increased protection followed, although often sites were still knowingly allowed to deteriorate. During this period a new tier of protection was also introduced by European Directives on Birds (1979) and Habitats (1992). At the turn of the millennium, the Countryside and Rights of Way Act (2000) introduced legislation to encourage, and if need be enforce, proper management of wildlife sites, so that the last ten years (2000-2010) have seen a substantial improvement in the management of the backbone of national wildlife sites, the Sites of Special Scientific Interest (SSSIs) and National Nature Reserves (NNRs) (see Section 4.1 for definitions of these and other types of wildlife sites). Since 2000, under a focused and intensive campaign of management, Government, agencies, national and local voluntary organisations, and tens of thousands of individual farmers and site owners, have worked together to move the condition of the English SSSI series from 50% to 93% favourable (or recovering) – an impressive achievement. We provide more details in Section 4.3.3.

Local Wildlife Sites (LWS – again see Sections 4.1 and 4.3.3 for more details) are identified and selected locally for their nature conservation value. As with SSSIs they take into account the most important, distinctive and threatened species and habitats, but they do so within a regional and local context as well as a national one - the selection process is overseen by a local partnership. Local Wildlife Sites are non-statutory, having only minimal protection through recognition in national planning policy, and are highly vulnerable to damage and loss. They can be used to influence the direction of agri-environment funds but in general their management is under-funded. Local Wildlife Sites are important to future ecological networks, because they not only provide wildlife refuges in their own right but can act as stepping stones and corridors to link and protect nationally and internationally designated sites.

A new visionary, restorative phase of nature conservation

Our first SSSIs and NNRs were designated just before an unprecedented increase in agricultural production and built development. These pressures continued throughout the second half of the 20th century and into the 21st, and for large numbers of species their final refuges are now in NNRs, SSSIs and LWS. But as we have already seen, this putative network is inadequate, because populations of many species continue to decline, or be lost altogether, all over England. So the future cannot be simply about hanging on to the sites that we have. If we are to stem these declines, we have to do more. Very simply we have to allow more space for nature, by restoring chunks of the natural environment on a landscape scale.

The UK took its first steps along the road of restoring our wildlife with the publication of the UK Biodiversity Action Plan (BAP) (Anon. 1994), which was supported by 436 targeted action plans (published in a number of volumes up to 1999) for habitats and species in most need of conservation action. The UK BAP has now been superseded by country-led strategies, including an England Biodiversity Strategy (EBS) (Defra 2003), but the focus on restoration has remained. Action stimulated by the UK BAP and the EBS has led to many of the conservation successes achieved in England in recent years, and described earlier. Following a recent revision of the UK BAP list, there are now 943 species and 56 habitats recognised as BAP priorities in England (see section 4.1.3). The growing size of the BAP priority list calls for a step-change in action. We need to do better.

Many of our citizens care passionately about wildlife and a healthy countryside. More importantly, establishing a truly sustainable future for England is impossible if we do not effectively conserve our natural assets, including our wildlife. If we take the longer view, as we do in this report, and think out to 2050, Government, statutory agencies, the voluntary sector, local authorities, individual landowners and land managers, working together with vision and determination can turn the tide and move England into a new and exciting phase for nature conservation, to make more space for nature. This report sets out the direction of travel required to achieve this vision.

2.2 Ecological networks

2.2.1 What is an ecological network?

Much of England's wildlife is now restricted to certain places, our wildlife sites, consisting largely of semi-natural habitats moulded by millennia of human-use. These sites are essential for the survival of many plants and animals and will remain important even if the species and habitats within them change (see Section 5.3). Surviving in small, isolated sites is, however, difficult for many species, and often impossible in the longer term, because they rarely contain the level of resources or the diversity of habitats needed to support sustainable populations (see Section 4.3.2). However, re-creating large expanses of continuous natural habitat is not a feasible option over most of England. An alternative approach is to secure a suite of high quality sites which collectively contain the range and area of habitats that species require and ensure that ecological connections exist to allow species, or at least their genes, to move between them. It is this network of core sites connected by buffer zones, wildlife corridors and smaller but still wildlife-rich sites that are important in their own right and can also act as 'stepping stones' (see Section 2.2.3) that we call an *ecological network*. 'Wildlife corridors' do not have to be continuous, physical connections: a mosaic of mixed land use, for example, may be all that is needed – it is the permeability of the landscape to species (or their genes) that matters (Hilty *et al.* 2006).

In this report we often refer to 'England's ecological network' in the singular. In fact, networks operate at different geographic scales so that an ecological network for England consists of a network of nested, more local component networks, which we refer to as 'ecological networks' in the plural.

2.2.2 European and global experience of ecological networks

The establishment of ecological networks represents one of the most significant strategic developments in conservation in recent times. Pioneered in Central and Eastern European countries in the 1970s and 1980s, there are now more than 250 ecological networks planned or being established at regional, national and international levels around the World, including parts of the UK such as Cheshire (Bennet & Wit, 2001; Jongman & Pungetti 2004; Bennett & Mulongoy 2006).

Different approaches to ecological networks reflect differences between countries in the extent of their remaining natural habitats, the needs of focal species, the use and availability of evidence, and different cultural approaches to controlling and zoning land-use. In countries where large areas of wilderness remain, for example, these tend to be the focus of the networks. Thus, the North American 'Wildlands' project aims to protect and restore natural heritage through the establishment of a connected system of wilderness reserve networks, with a particular focus on meeting the habitat requirements of large carnivores such as wolves and bears (Noss 1992). In contrast, in Western Europe the most important areas are often semi-natural habitats in relatively small sites which already enjoy a high level of protection and the purpose of the network in these countries is usually to improve the ecological connections between sites and restore lost habitats (Bennett and Mulongoy 2006).

Despite these differences, a number of elements taken together characterize ecological networks (Bennett and Mulongoy 2006):

- a focus on conserving wild plants and animals at the landscape, ecosystem or regional scale;
- an emphasis on maintaining or strengthening ecological coherence, primarily by increasing connectivity with corridors and 'stepping stones';
- ensuring that critical areas are buffered from the effects of potentially damaging external activities;
- restoring degraded ecosystems and ecological processes; and
- promoting the sustainable use of natural resources in areas of importance to wildlife.

Finally, global and European experience provides some useful lessons (Jones-Walters *et al.* 2009; IEEP & Alterra 2010). In particular:

- The network must have **clear aims and a vision**, including quantified performance targets where appropriate. Without these, it is hard to properly design the network, engage stakeholders or assess success.
- **Local stakeholder engagement**, including landowners, is critical and they should be involved from the outset.
- Where appropriate, it is beneficial to establish **multi-functional use** of the network and its component sites, so that local people are not excluded from the benefits it provides.
- There is a need for **local flexibility** in delivery to reflect local differences in implementation options and aspirations.

- A sound **evidence base** is essential. This is important at the design stage to ensure the right sites are included to adequately support species and habitats and other ecological assets; for management of the network; and to assess whether it is achieving its objectives.
- There is a need for effective **protection** of all the network components (not just core areas).
- **Proper funding** is critical, and this need not be just, or even primarily, from government sources.

2.2.3 Components of an ecological network

Ecological networks generally have five components (see Fig. 1) which reflect both existing and potential ecological importance and function. All of these are relevant in an English context.

(i) Core areas
These are areas of high nature conservation value which form the heart of the network. They contain habitats that are rare or important because of the wildlife they support or the ecosystem services they provide. They generally have the highest concentrations of species or support rare species. Core areas provide places within which species can thrive and from which they can disperse to other parts of the network. They include protected wildlife sites and other semi-natural areas of high ecological quality.

(ii) Corridors and 'stepping stones'
These are spaces that improve the functional connectivity between core areas, enabling species to move between them to feed, disperse, migrate or reproduce. Connectivity need not come from linear, continuous habitats; a number of small sites may act as 'stepping stones' across which certain species can move between core areas. Equally, a land mosaic between sites that allows species to move is effectively an ecological corridor. Later (Sections 5.1.1 and 5.1.3) we return to the functioning and design of corridors and 'stepping stones' in more detail.

(iii) Restoration areas
These are areas where measures are planned to restore or create new high value areas (which will ultimately become 'core areas') so that ecological functions and species populations can be restored. They are often situated so as to complement, connect or enhance existing core areas.

(iv) Buffer zones
These are areas that closely surround core areas, restoration areas, 'stepping stones' and ecological corridors, and protect them from adverse impacts from the wider environment. We discuss buffer zones in Sections 4.3.2 and 5.1.1.

(v) Sustainable use areas – 'softening the matrix'
These are areas within the wider landscape focussed on the sustainable use of natural resources and appropriate economic activities, together with the maintenance of ecosystem services (Bennett and Mulongoy 2006). Set up appropriately, they help to 'soften the matrix' outside the network and make it more permeable and less hostile to wildlife, including self-

sustaining populations of species that are dependent upon, or at least tolerant of, certain forms of agriculture. There is overlap in the functions of buffer zones and sustainable use areas, but the latter are less clearly demarcated than buffers, with a greater variety of land uses. We discuss the role of the matrix in limiting or promoting connectivity in Section 4.3.4 and 6.5.

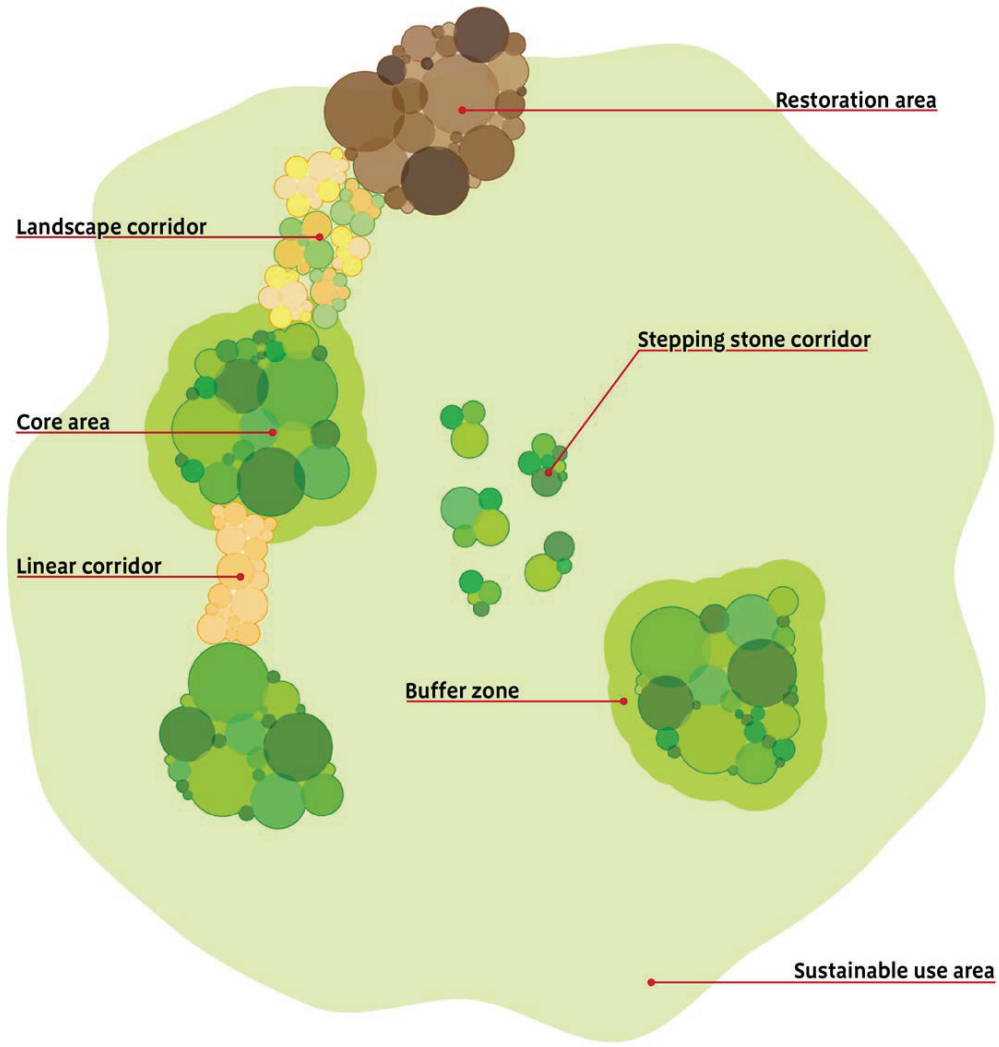

Figure 1. The components of ecological networks (see text for more details)

2.2.4 Ecological networks in international commitments and agreements

The importance of ecological networks has become sufficiently recognised that the need to develop them has been identified in a number of international agreements and policies. For example (after Catchpole 2006):

> The Strategy sets out to achieve the …. "Conservation, enhancement and restoration of key ecosystems, habitats, species and features of the landscape through the creation and effective management of the Pan-European Ecological Network."
> **Pan-European Biological and Landscape Diversity Strategy 1995.**

> Parties agree "to promote and support initiatives for hot spot areas and other areas essential for biodiversity and promote the development of national and regional ecological networks ….. by 2012."
> **World Summit on Sustainable Development, Johannesburg 2002.**

> "By 2006, the Pan-European Ecological Network …. in all States of the pan-European region will be identified and reflected on coherent indicative European maps, as a European contribution towards a global ecological network." and "By 2008, all core areas of the Pan-European Ecological Network will be adequately conserved and the Pan-European Ecological Network will give guidance to all major national, regional and international land use and planning policies as well as to the operations of relevant economic and financial sectors." **5th EU Ministerial Conference, Kyiv 2003.**

> The Commission should ensure that … "the ecological connectivity of Natura 2000 network is supported in order to achieve or maintain favourable conservation status of species and habitats in the face of climate change."
> **EU Biodiversity Stakeholders Conference, Malahide 2004.**

> "Develop and apply instruments that contribute to achievement of conservation management goals through a combination of managing protected area networks, ecological networks and areas outside of such networks to meet both short-term and long-term requirements and conservation outcome in accordance with VII/28."
> **CBD Conference of Parties, VII, Kuala Lumpur 2004.**

> Member states will develop "…policies encouraging the management of features of the landscape which are of major importance for wild flora and fauna" such as "…stepping stones" and other features that are "…essential for the migration, dispersal and genetic exchange of wild species."
> **Article 10, Habitats Directive (Council Directive 92/43/EEC 1992).**

Ecological networks are also encouraged by current planning policy in England:

> "Networks of natural habitats provide a valuable resource. They can link sites of biodiversity importance and provide routes or stepping stones for the migration, dispersal and genetic exchange of species in the wider environment. Local authorities should aim to maintain networks by avoiding or repairing the fragmentation and isolation of natural habitats through policies in plans. Such networks should be protected from development, and, where possible, strengthened by or integrated within it." **Planning Policy Statement 9: Biodiversity and Geological Conservation (2005).**

England has not yet met these commitments and ambitions to establish ecological networks yet doing so could also help meet other related commitments, including:

*"..*that biodiversity decline should be halted with the aim of reaching this objective by 2010.*"* **Presidency conclusions of the EU Summit, Göteborg, 2001.**

"Parties commit themselves to a more effective and coherent implementation of the three objectives of the Convention, to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on earth." **Convention on Biological Diversity, Decision VI/26 of the 6th Conference of the Parties, Johannesburg, 2002.**

"To halt the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, restore them in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss."
EU Environment Council Conclusions, March 2010.

2.3 Aims for a coherent and resilient ecological network in England

The England Biodiversity Strategy sets out a vision for England's natural environment (Defra 2006):
"Our vision is for a country – its landscapes and water bodies, coasts and seas, towns and cities – where living things and their habitats are part of healthy, functioning ecosystems; where we value our natural environment, where biodiversity is embedded in policies and decisions, and where more people enjoy, understand and act to improve the natural world about them."

The establishment of a coherent and resilient ecological network is fundamental to achieving this vision. The overall aim for England's ecological network should be to deliver a natural environment where:

Compared to the situation in 2000, biodiversity is enhanced and the diversity, functioning and resilience of ecosystems re-established in a network of spaces for nature that can sustain these levels into the future, even given continuing environmental change and human pressures.

We also recommend three objectives for England's ecological network to underpin this aim:

(1) To restore species and habitats appropriate to England's physical and geographical context to levels that are sustainable in a changing climate, and enhanced in comparison with those in 2000.

(2) To restore and secure the long-term sustainability of the ecological and physical processes that underpin the way ecosystems work, thereby enhancing the capacity of our natural environment to provide ecosystem services such as clean water, climate regulation and crop pollination, as well as providing habitats for wildlife.

(3) To provide accessible natural environments rich in wildlife for people to enjoy and experience.

Box 2: Key concepts – coherent and resilient

A **coherent** ecological network is one that has all the elements necessary to achieve its overall objectives; the components are chosen to be complementary and mutually reinforcing so that the value of the whole network is greater than the sum of its parts.

A **resilient** ecological network is one that is capable of absorbing, resisting or recovering from disturbances and damage caused by natural perturbations and human activities (including climate change) while continuing to meet its overall objectives of supporting biodiversity and providing ecosystem services.

In Section 4 of this report we describe the attributes of a coherent and resilient ecological network and consider the extent to which these are met by England's current collection of wildlife sites. First, however, we briefly consider the scale of the challenges ahead from pressures on land-use, and climate change.

3. Future challenges

The main reasons for the collapse of England's wildlife, summarised in Section 2.1.3 are not going to go away. Indeed they are likely to increase and will be exacerbated by climate change, making the corrective action advocated in this report even more important.

3.1 Foresight Land Use futures

'*Foresight* Land Use Futures: Making the most of land in the 21st century' (Foresight Land Use Futures 2010), is a comprehensive summary of pressures on land-use in the UK. It identifies six major drivers of changes in land-use over the next 40 years:

- **Demographic change**. The England population has risen from 46.4 million in 1971, to 51.5 million in 2008 (Office for National Statistics 2009). This increase, combined with more people choosing to live alone, has had a profound effect on demand for housing and infrastructure. Figures from the Office for National Statistics suggest England's population could increase to 60.7 million by 2033, with an increase of 18% in the proportion of people living in single occupancy houses.
- **Economic growth and changing economic conditions.** Despite periods of recession, the UK economy has grown by an average rate of 6% (retail prices) between 1949 and 1999 (Hicks & Allen 1999). Continued economic growth into the future implies an increase in consumption which may lead to ever-greater demands on our land. Rising global demand for food will affect the amount of land brought into food production and the intensity with which it is farmed.
- **Climate change**. Climate change is already affecting species and habitats directly (see Section 3.2). As our understanding increases, the move to a low carbon economy and society's adaptation to the impacts of climate change will increasingly affect decisions about, and patterns of, land management.
- **New technologies**. New technologies have enabled UK farmers to increase yields of food dramatically since the Second World War, but as we have seen (Section 2.1.3) not without negative impacts on the environment. Looking forward, new technologies may enable society to further increase the productivity of available land whilst reducing pressure on the environment.
- **Societal preferences and attitudes.** During, and for decades after, the Second World War production of food was the overwhelming societal priority from land. Only relatively recently have we come to understand the impact this prioritisation has had on other ecosystem services and biodiversity. Societal preferences will continue to interact with other drivers and may result in conflicting demands.
- **The policy and regulatory environment**. The impact of policy on land-use is particularly clear in agriculture, where government policy drove the intensification of land-use for much of the twentieth century, while the EU Common Agricultural Policy has had a strong influence on how agricultural land is used and managed in recent decades. The directions set by future EU policy and those arising from the complex and multilayered system of governance in England will have a profound influence on how land is used in the future.

The combined consequences of these inevitable changes and developments are impossible to predict with any certainty, except to say that England will experience conflicting and severe pressures on land-use in many parts of the country, but particularly in the south-east.

3.2 The impacts of climate change on species and habitats.

Climate change has already resulted in a number of observed changes to England's wild plants and animals. Predictions about future climate suggest that these changes will continue, with potentially catastrophic effects for some species, but benefits for others. On balance, in the longer term more species are likely to be negatively rather than positively affected. Recent analyses, for example, based on a sample of different kinds of organisms, suggest that by 2050, 15% to 37% of terrestrial plants and animals worldwide could be 'committed to extinction' due to climate change (Thomas *et al.* 2004). We know of no similar analyses specifically directed at England's wild flora and fauna. But we can summarise the changes that are already happening and anticipate what lies ahead.

(i) **Shifts in species' ranges.** All species have a 'climate envelope' within which they can survive and reproduce; outside it they die. As the climate changes, so too climate envelopes will move, and to survive species will need to track these movements. The results are changes in species' local and regional distributions. Changes in distribution attributed to climate change are already happening in a wide variety of organisms in the UK, including migratory species (Austin & Rehfisch 2005). Generalising, at the moment what we are seeing are warmth loving southern species expanding their range northwards (a generally beneficial effect) and some cold-adapted northern species retreating at their southern limit of their distribution (Warren *et al.* 2001; Hickling *et al.* 2005; Franco 2006; Morecroft *et al.* 2009). There has also been a natural spread of new species such as the Bumblebee (*Bombus hypnorum)* and Small Red-eyed Damselfly (*Erythromma viridulum*) into Britain from continental Europe (Hopkins 2009). Many southern species have also been spreading uphill into colder areas as they warm and this is of importance as it will allow some species to move relatively short distances to adapt to climate change, especially on large upland sites (Hickling *et al.* 2006). How long the observed pattern of change will continue remains to be seen. Nor will the actual distributions of species automatically track changes in the climate (as is already the case for some southern species of amphibian and reptiles; Hickling *et al.* 2006). This is either because they are poor dispersers, prevented from dispersing by hostile barriers in the environment, or because other essential components of their environment, food organisms or plants needed as breeding sites, themselves fail to keep pace with climate change. These factors complicate the impacts of climate change and caution against oversimplification. What is clear is that species' distributions are, and will continue to change, with inevitable changes in the species found in protected areas.

(ii) **Seasonal events in spring and summer are occurring earlier**. This pattern is very clear across our natural world and is changing, for example, the first leafing dates of trees (oak-leafing has advanced three weeks in the last 50 years), the flight times of moths and butterflies, egg-laying dates for birds, the first spawning of amphibians, the first appearance of hoverflies and the fruiting times of species such

as blackberry (Beebee 1995; Crick & Sparks 1999; Sparks *et al.* 1997; Woiwood 1997). Recent evidence also shows differential changes in the timing of life-history events by different species in a community, disrupting crucial links in food-chains. Examples include a mismatch between peak caterpillar abundance and the food-needs of nestling woodland birds, and between flowering times and pollinator emergence. In the future such mismatches could disrupt the functioning, persistence and resilience of many ecosystems and have a major impact on ecosystem services.

(iii) **Species' habitat preferences are altering.** The Silver-spotted Skipper Butterfly *Hesperia comma* has begun to breed in a wider range of grassland types in England, mirroring its behaviour further south in Europe, due to increased temperatures (Davies *et al.* 2006). A similar pattern is shown by other species (Thomas *et al.* 2001). In terms of the conservation prospects of these species, this has been a beneficial effect of climate change.

(iv) **Sea-level rise**, caused primarily, but not exclusively, by climate change has already led to loss of intertidal habitat, particularly on the low-lying coasts of south-east England where significant losses of saltmarsh have been recorded from 12 Special Protection Areas. The problem can only get worse (Maclean 2010), and will need action to deal with it (Royal Haskoning 2006; BRANCH partnership 2007).

(v) Climate change models predict more **extreme weather events** – droughts, floods, and storms. Whilst no single extreme event can be attributed to climate change, a trend for increases in frequency can. The possible consequences for an ecological network are illustrated by the tidal surge on the east coast of England in November 2007, which caused widespread inundation of freshwater habitat by salt water; not all such areas will return to their former freshwater state. In woodlands, drought has changed the composition of tree species (Peterken & Mountford 1996), and major storm damage to woodlands may also be increasing in frequency (Quine & Gardiner 2002). Projections indicate that more summer droughts and more winter floods are likely in future.

(vi) **Changes to ecosystem processes** are inevitable, as average climatic conditions change, and the weather becomes more unpredictable. More summer droughts threaten essential hydrological processes, and this may cause serious disruption and degradation of important wetlands.

These changes, some positive and beneficial, but more that are potentially harmful, have consequences for how we provide for, and manage, England's wildlife. There are uncertainties in how much and precisely what ways our climate will change but this is not an excuse for inaction. Indeed, there is much we can do to ensure that conservation actions and policy decisions are robust to these uncertainties (Hopkins *et al.* 2007; Mitchell *et al.* 2007; Smithers *et al.* 2008; see also Box 3). To maximise the capacity of our wildlife to cope with climate change we need to establish an ecological network that is as robust and resilient as possible to current conditions. For instance, we need to ensure we have excellent management over all parts of the network, to increase the population sizes of threatened species, reduce the risks of local extinction, and provide colonists for new sites.

We address these issues in more detail in Section 5.3. This is not a luxury. Establishing a coherent and resilient ecological network to help conserve the biodiversity that we still have will enhance our options and improve our chances of achieving a prosperous and healthy future for ourselves and our children.

Box 3. A summary of principles to underpin action to achieve biodiversity conservation in a changing climate (Hopkins *et al.* 2007)

1. Conserve existing biodiversity
    - 1a. Conserve Protected Areas and other high-quality wildlife habitats
    - 1b. Conserve range and ecological variability of habitats and species
2. Reduce sources of harm not linked to climate change
3. Develop ecologically resilient and varied landscapes
    - 3a. Conserve and enhance local variation within sites and habitats
    - 3b. Make space for the natural development of rivers and coasts
4. Establish ecological networks through habitat protection, restoration and creation
5. Make sound decisions based on analysis
    - 5a. Thoroughly analyse causes of change
    - 5b. Respond to changing conservation priorities
6. Integrate adaptation and mitigation measures into conservation management, planning and practice

4. The nature and status of our current wildlife sites and ecological network

Our Terms of Reference (Annex 1) ask us to "examine evidence on the extent to which the collection of sites [environmental and landscape designations] represents a coherent and resilient ecological network". Why haven't our protected areas prevented our wildlife declines? What are the strengths and weaknesses of our wildlife sites? Examining this evidence, and answering these questions, is the focus of this section.

We describe the different types of sites under environmental and landscape designations, some of which are large areas, in particular England's National Parks and Areas of Outstanding Natural Beauty (AONBs). We consider the protection they provide for wildlife, their quality, the current connections that exist between them, and assess the extent to which they collectively meet the requirements of a coherent and resilient ecological network. The resilience of these sites, and the ecological connections that exist between them, is determined in no small part by the quality of the surrounding landscape. Consequently, we also take account of habitats and features that exist outside of our 'wildlife sites' which nonetheless contribute to England's ecological network.

4.1 England's wildlife sites

4.1.1 Statutory and non-statutory designations

England has a wide range of different types of statutory and non-statutory designation for a variety of purposes: biological, geological, cultural, landscape and access. Amongst these, we have identified three tiers of site of most relevance to this review (see Figure 2). We have made this categorisation because the different types of site differ significantly in terms of their core purpose and in the ways in which they are protected and managed, with important implications for their contribution to England's ecological network. The three tiers encompass eleven different statutory and non-statutory designations (the eleven types are described in detail in Table 1). They also include large areas of private as well as public land.

Tier 1 - Sites whose primary purpose is nature conservation and which have a high level of protection either due to their statutory status or to their ownership.

The largest biodiversity designation type is the series of *Sites of Special Scientific Interest* (SSSI), which forms the backbone of the wildlife protected area series in England. There are also three types of statutory sites designated as a result of international treaties and obligations (*Ramsar Sites, Special Areas of Conservation, and Special Protection Areas*). Overlaps between these international sites exist, and their entire extent on land is also designated as SSSI. *National Nature Reserves* include some of the highest quality wildlife areas, and these are also almost all designated as SSSIs. *Local Nature Reserves* are designated by local authorities; they account for a relatively small proportion of the land area in England (0.3%) and are mostly outwith the SSSI network. Within this tier we have also included land owned and managed for nature by major land-owning NGOs (the National Trust, RSPB, Wildlife Trusts and the Woodland Trust) because of the long-term security and

management their ownership confers on their wildlife sites. Again, many of these NGO sites are SSSIs.

Tier 2 - Sites designated for their high biodiversity value but which do not receive full statutory protection.

The remaining significant wildlife designation type is the '*Local Wildlife Site*'. Defra Guidance (2006) advocates the use of this term but many other names are still used for these sites including 'County Wildlife Site' and 'Site of Nature Conservation Interest'. These are non-statutory sites identified by Local Wildlife Site partnerships, which are often led by local authorities and partnered by a range of local interests. Government policy is to provide protection to them through the planning system. There are more than 42,000 of these sites across England, collectively accounting for over 690,000 ha of wildlife habitat. These important wildlife sites are often neglected and frequently damaged or lost, but their management, and our knowledge about their locations, has recently improved as a result of a local authority performance indicator (currently under review) which encourages management of these sites.

Ancient Woodlands, comprises a second group of Tier 2 sites, which are areas that have had continuous woodland cover since 1600. For the purpose of our analysis, we have used the Ancient Woodland Inventory (Goldberg *et al.* 2007) to identify these sites which includes most ancient woodland, in particular all sites greater than 2 ha. Like Local Wildlife Sites, these are sites of high biodiversity value which do not receive proper statutory protection, although current forestry and planning policy is to avoid their destruction whenever possible.

Tier 3 – Areas designated for landscape, culture and/ or recreation and with wildlife conservation included in their statutory purpose

National Parks and *Areas of Outstanding Natural Beauty* (AONBs) are often considered to be 'landscape' designations. They are designated for their cultural, landscape and (in the case of National Parks) recreational value, but both also have the conservation of nature as part of their primary statutory purpose. Although there are relatively few AONBs and National Parks they are large areas and together cover substantially more land than the more dedicated 'biodiversity' designations in Tier 1 and Tier 2 (see Table 1). There is no overlap between these two types, but 12% of the area of AONBs is also designated SSSI and 24% of the total area of National Parks is SSSI.

4.1.2 Other components of England's ecological network

In addition to these three tiers, other places and features of England's countryside and towns are important components of the ecological network. These include areas of BAP priority habitat (see Sections 2.1.3 and 4.1.3), farmland and woodland, the green belt, rivers, country and municipal parks, urban green space, allotments and private gardens. These contribute to the functioning of the network in a number of ways, for example by providing connections between core patches, as habitats for a large number of species that are not restricted to wildlife sites, and buffering and reducing pressures on the network. In towns and cities, these areas are particularly important. Where appropriate, we take these other elements into account in our analyses and discussion below.

Of particular relevance to this review are linear features that run through our countryside and towns, which can provide important connections. The Habitats and Species Regulations 2010 include a provision (which transposes Article 10 of the Habitats Directive) that "policies relating to the development and use of land" should include policies for the management of features of the landscape which are of major importance for wild fauna and flora, including those "which by virtue of their linear and continuous structure (such as rivers with their banks or traditional systems of marking field boundaries) or their function as 'stepping stones' (such as ponds or small woods) are essential for the migration, dispersal and genetic exchange of wild species" (Regulation 39(3)). We consequently have a legal obligation to protect these important features. For example, under the Hedgerows Regulations 1997 it is against the law to remove or destroy important hedgerows without permission from the local planning authority.

4.1.3 BAP priority habitats

At several points in this report we refer to Biodiversity Action Plans (BAPs) put in place to reverse particularly worrying declines in particular species. The *BAP Priority Habitats* represent the most important natural and semi-natural habitats for wildlife in England, including those for which we have international responsibilities. Many of these habitats fall within one or more of the tiers discussed above, but some do not. Many of them are familiar wildlife habitats including hedgerows, meadows, heathlands, woodlands, sand dunes, wetlands and flower-rich field margins. They are the main habitats that form the core areas, stepping stones and many of the connections of ecological networks. A list of species and habitats of 'principal importance' for the conservation of biodiversity is published under section 41 of the Natural Environment and Rural Communities Act 2006. The 943 species and 56 habitats currently on this list (which include marine priorities, not considered by this review) represent the English component of the UK BAP list and, in line with common usage, we refer to them in this report as 'BAP priority' species and habitats.

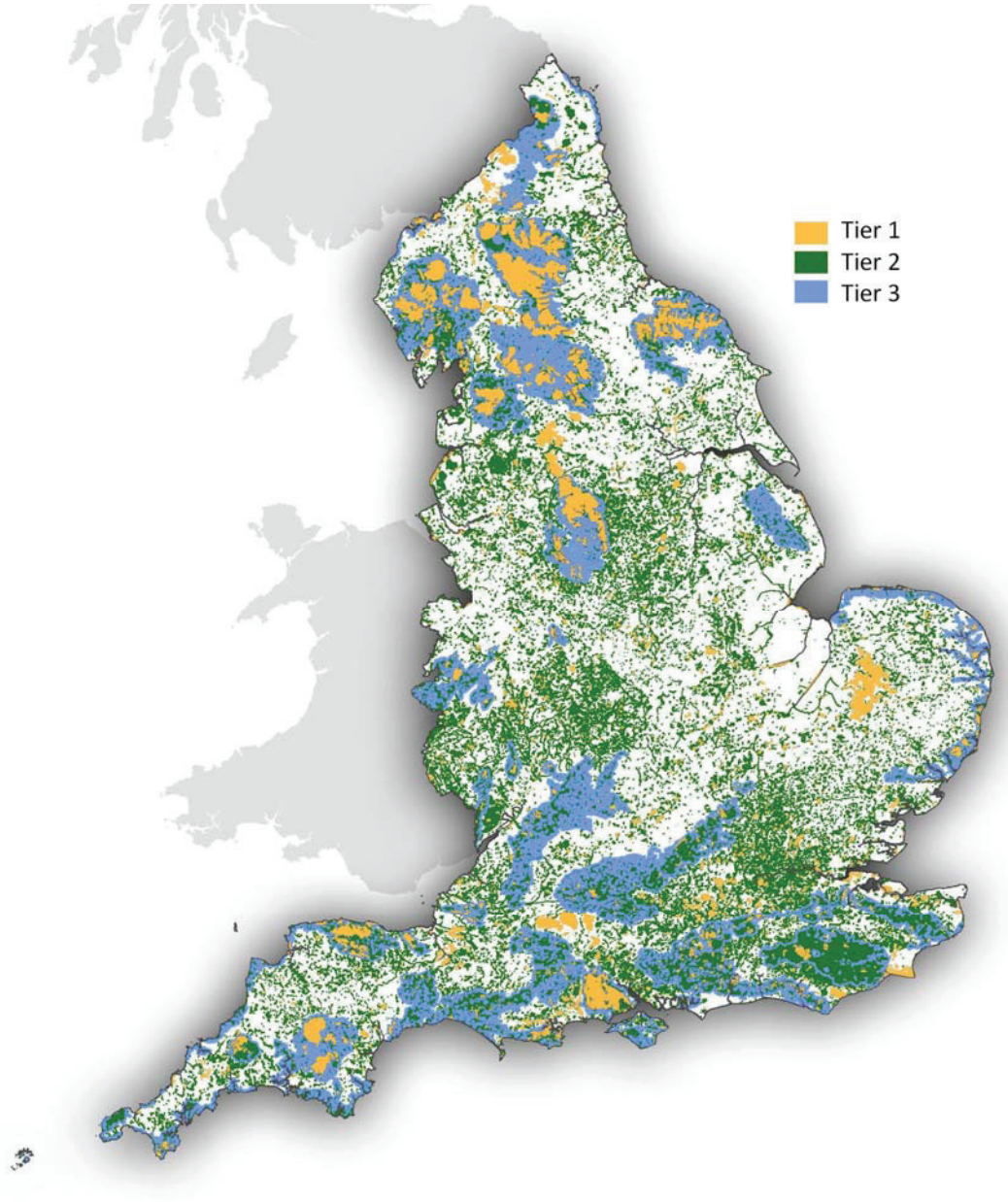

Figure 2. Distribution of the three tiers of wildlife sites (see text for details)

Table 1. The main types of sites whose purpose includes the protection of wildlife

Tier 1: areas whose primary purpose is nature conservation and which have a high level of protection either due to their statutory status or ownership.

Total Area of Tier 1 sites = 925,124 ha (6.93% of England).

Within Tier 1 designations there are substantial overlaps, in particular all SACs, SPAs, Ramsar sites and almost all NNRs are also designated SSSIs.

Tier 1 site type	No. Sites	Area	Comments
Sites of Special Scientific Interest (SSSIs)	3174	810,314 (6.1% England)	This is the main designation in this category. SSSIs are designated under powers derived from the Wildlife and Countryside Act 1981 (as subsequently amended) which places a duty on Natural England to notify any area of land which in their opinion is 'of special interest by reason of any of its flora, fauna, or geological or physiographical features'. Legislation and policy provides a high level of protection for these sites. SSSIs can be designated for biological or geological reasons; only those with a biological designation are included in our Tier 1 sites. The area given and the number of sites, represent SSSIs with biological features above mean high water. Geological and marine SSSIs are excluded.
Special Areas of Conservation (SACs)	240	535,207 (4.0% England)	Special Areas of Conservation (SACs) are strictly protected sites designated under the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) in transposition of the EC Habitats Directive. The Directive requires the establishment of a European network of high-quality conservation sites that will make a significant contribution to conserving the habitats and species identified in Annexes I and II of the Directive. Along with SPAs, these form the 'Natura 2000' series of sites. All terrestrial SACs are also designated as SSSIs
Special Protection Areas (SPAs)	79	477,244 (3.6% England) This is only above MHW	Special Protection Areas (SPAs) are strictly protected sites designated under the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) in transposition of the EC Birds Directive. The Directive requires the identification and classification of Special Protection Areas (SPAs) for rare or vulnerable species listed in Annex I of the Directive, as well as for all regularly occurring migratory species, paying particular attention to the protection of wetlands of international importance. Together with SACs, these form the 'Natura 2000' series of sites. All terrestrial SPAs are also designated as SSSIs

Ramsar Sites	70	124,645 (0.9% England) This is only above MHW	These sites are notified as a result of the Ramsar Convention, an intergovernmental treaty that recognises and protects wetlands of international importance. Government policy is to provide the same level of protection as afforded Natura 2000 sites (e.g. through the planning system). All terrestrial Ramsar sites are notified as SSSIs
National Nature Reserves (NNRs)	223	63,384 ha (0.47%)	NNRs were initially established to protect our most sensitive natural features and to provide 'outdoor laboratories' for research (see also section 2.1.4). In general, NNRs are considered to be the very best examples of SSSIs, conserving some of England's most pristine habitats and rarest species, and it is underpinning SSSI designation which provides them with a high level of protection. 95% of NNRs by area are designated SSSIs. The area that is not designated SSSI largely comprises land on which habitat restoration is planned or underway. It also includes some amenity land.
Local Nature Reserves (LNRs)	1437	37,768 ha (0.28% England)	LNRs are statutory declarations made under Section 21 of the National Parks and Access to the Countryside Act 1949 by local authorities. LNRs may either be managed solely for nature conservation, or also to provide recreational opportunities to communities. 38% of LNRs by area is also designated SSSI.
Voluntary Conservation Organisation land managed for nature	3313	185,425 ha (1.4%)	For the purpose of our analysis we were able to collate data of land owned and managed for nature by the National Trust, RSPB, Wildlife Trusts and Woodland Trust; this represents the majority of this type of land holding. 53% of the area in this sample is also designated SSSI.
Tier 2: areas designated for their high biodiversity value but which do not receive full statutory protection **Total Area of Tier 2 sites = 870,084 ha (6.5% of England)** **N.B. Within Tier 2 designations there are substantial overlaps.**			
Tier 2 site type	**No. Sites**	**Area**	**Comments**
Local Wildlife Sites	42,799	694,494 ha (5.2% of England)	This is the primary designation in this category. LWS are non-statutory sites identified by Local Wildlife Site partnerships, which are often led by local authorities and partnered by a range of local interests. Government policy is to provide protection to LWS through the planning system.

Ancient Woodland sites	27,724	354,583 ha (2.7% of England)	Ancient woodland sites are also non-statutory but they are defined as areas that have had continuous woodland cover since 1600. Government policy is to provide protection to ancient woodland through the planning system and through forestry policy and guidance. For our analysis we have used all sites in the Ancient Woodland Inventory; this includes 148,290 ha of ancient woodland that has been planted with conifers. 50.5% of ancient woodland is also designated as LWS.
Tier 3: areas primarily designated for landscape, culture and/ or recreation, but wildlife conservation included in statutory purpose **Total Area of Tier 3 = 3,142,068 ha (23.5% of England)**			
Tier 3 site type	**No. Sites**	**Area (% England)**	**Comments**
National Parks (inc. The Broads)	10	1,216,117 ha (9.1% of England)	National Parks also have their origins in the 1949 National Parks and Access to the Countryside Act (see also section 2.1.4). They have two primary purposes: conserving and enhancing the natural beauty, wildlife and cultural heritage; and promoting opportunities for the understanding and enjoyment of the special qualities of the park by the public. 23.5% of the area of National Parks is also SSSI.
Areas of Outstanding Natural Beauty (AONB)	34	1,925,951 ha (14.4% of England)	With their origins in the 1949 National Parks and Access to the Countryside Act, AONBs are designated primarily to conserve and enhance the natural beauty of the landscape. They also have two secondary aims: to meet the need for quiet enjoyment of the countryside and to have regard for the interests of those who live and work within them. 11.8% of the area of AONBs is also SSSI.

Notes:

1. All values only relate to the area above Mean High Water (MHW), because marine areas are not covered by this review. The total area of England above MHW is approximately 13,348,000 ha.
2. In addition to the sites included in these three tiers there are other areas important for wildlife (including other sites containing priority habitats, and several types of green spaces as identified in section 4.1.2). We consider the role of these areas further in sections 4.3.4 and 4.3.5.

4.2 Datasets and methods

We have drawn upon a wide range of sources to assemble the evidence-base for this report, including academic literature, published reports, and evidence submitted to us by 46 organisations in response to a general call for evidence that we issued in early 2010 (see Annex 2). We have also carried out a number of novel analyses, using geographical information on wildlife sites and BAP priority habitats either held by Natural England (which are available through www.naturalengland.org.uk or www.magic.gov.uk) or provided to us by various sources in response to our requests for data. Inventory data only exists for some BAP priority habitats and so our analyses could not be comprehensive (e.g. no complete inventory yet exists for traditional orchards). For woodland habitats, we used the highest quality inventory which is for a combined 'broadleaved woodland' habitat, which includes several priority woodland types (lowland beech and yew woodland, lowland mixed deciduous woodland, upland mixed ashwoods, upland oakwood and wet woodland). For the analysis of habitat patch sizes (section 4.3.2 and Table 4), only GIS polygons larger than 0.1 ha were included (to exclude 'slivers' which can be created as artefacts of the GIS analysis).

Many of the analyses were based on the three tiers of sites described in section 4.1. For these, a single GIS layer was created for each tier which removed any overlaps between sites within the tier. Consequently, areas reported for each tier of sites does not include any double counting. All our analyses were restricted to areas above Mean High Water (MHW). Analyses of SSSIs were restricted to those which included a biological designation (i.e. those designated only for geological purposes were excluded). Collation of Local Wildlife Site data, provided by a number of Local Record Centres and others, enabled us to conduct the first GIS analyses of these sites.

The analysis to test representation of species within wildlife sites (section 4.3.1) deliberately focussed on two of our less mobile species groups, vascular plants and bryophytes (mosses, liverworts and hornworts) alongside BAP butterflies which are used as an indicator group (Defra 2010). We restricted analyses to data that were available at the highest (i.e. 100 m) resolution in the Threatened Plants Database provided by the Botanical Society of the British Isles; the Threatened Bryophytes Database provided by the British Bryological Society; and butterfly data provided by the Biological Records Centre and Butterfly Conservation.

Analyses of connectivity (section 4.3.4) used techniques to calculate habitat networks (Catchpole 2006). This approach identifies clusters of habitat patches between which movement of wildlife is most likely because of the nature of the intervening land-use. Initially, similar types of BAP priority habitats are aggregated to form a single GIS layer by merging boundaries of adjacent polygons from the inventories of similar habitats (e.g. all grassland types). Four layers were created in this way: grasslands; heathlands; mires, fens & bogs; and woodlands. The next stage was to use a combination of land-cover data, published literature on species dispersal distances, and expert consensus on the permeability of different land cover types to parametise a least-cost model. This enables clusters of habitat patches that are likely to be connected for wildlife to be identified.

4.3 Do England's wildlife sites comprise a coherent and resilient network?

We have seen that England has a varied, even complex, range of wildlife sites, but to what extent do these comprise a coherent and resilient ecological network for England? Earlier, we identified an overarching aim and three objectives for England's ecological network (section 2.3). To be effective in meeting these aims, the component sites and connections of the network will need to have the following attributes (adapted from IUCN-WCPA 2008):

(i) The network will support the full range of England's biodiversity and incorporate ecologically important areas, including special biodiversity. We deal with this in Section 4.3.1
(ii) The network and its component sites will be of adequate size, taking account of the needs of our natural environment to adapt to climate change (Section 4.3.2).
(iii) The network sites will receive long-term protection and appropriate management (Section 4.3.3).
(iv) Sufficient ecological connections will exist between sites to enable species movement (Section 4.3.4).

In addition to these four ecological attributes:
(v) Wildlife sites will be valued by and be accessible to people, and include sites close to where they live.

In the sections that follow, we take each attribute in turn and assess whether it is met by the current collection of sites. Before doing so, however, three general comments are needed.

First, only 6.1% of the land-area of England is designated as SSSI for biological purposes. This value excludes SSSIs designated purely for geological purposes and marine sites, but includes overlapping international protected-area designations (Natura 2000 and Ramsar sites, see Table 1). In itself, this area is significantly less than the 10% protected area coverage for all biomes recommended as a minimum by the International Union of Conservation (IUCN 1993), further illustrating the importance of considering non-SSSI designations when assessing our wildlife sites.

Second, we know that carefully targeted recovery efforts, including research and habitat management, on a species-by-species basis can deliver major success stories for conservation (Sections 2.1.3 and 2.1.4). Species-by-species research and rescue operations clearly have a role to play particularly for species on the brink of extinction or for keystone species that play central roles in an ecosystem. As a general strategy to restore wildlife to much of England, however, they are insufficient. Instead, other actions are also required, not least a set of approaches applied at landscape scales that have the potential to benefit many species.

Third, precision about the appropriate size and connectivity of all protected sites is unrealistic. Species of plants and animals differ enormously in the size of their home-ranges, seed-dispersal distances, population densities, ability to cross hostile landscapes, and so on. A site large enough to protect a plant population with reasonable certainty may be totally inadequate for mobile animals that require much bigger areas and more connectivity between sites. It follows that if we are to reverse widespread declines in many species, and

enhance their distributions in England we need to concentrate on measures that individually and in aggregate will move things in the right direction, by stabilising declining populations and enhancing the abundances and distributions of as many as possible. It is the 'direction of travel' that is important, not unrealistic precision about exactly how big, and where, England's protected sites and the overall ecological network needs to be. It is, however, possible and appropriate to identify when and where the remaining resource is clearly inadequate and to provide some evidence-based estimates on the approximate magnitude of change required.

We now return to the five attributes of a coherent and resilient ecological network. For each, we summarise the evidence, both theoretical and empirical, explaining why the attribute is important and then analyse appropriate data to see whether England's current collection of wildlife sites fulfils the required conditions.

4.3.1 The network will support the full range of England's biodiversity and incorporate ecologically important areas, including special biodiversity.

Ecological rationale

For the network to meet the objective of halting and reversing biodiversity loss, it should include sites that protect, as far as possible, representative occurrences of all of England's semi-natural habitats and native species (Shafer 1999; Pressey & Taffs 2001; Bruner *et al.* 2001). Species and habitats need to be protected in a number of sites across their full range, both to conserve genetic diversity (McNeely 1994) and because species that exist on single or very few sites are vulnerable to unforeseen impacts or random events (such as a harsh winter, pollution events, or flooding - see Section 4.3.2) and, in the longer term, climate change. Protecting several sites for each habitat is also beneficial because it increases the likelihood that poorly known species whose status, distribution, or even very existence are unknown will also be protected within the network (Pressey 1996).

As a result of climate change, some species are likely to move away from sites that they currently occupy (Section 3.2) and species composition of communities will change. Nonetheless, conserving sites that are good for wildlife today is also likely to be a good strategy for conserving wildlife over the long term because these sites typically have a set of characteristics such as low fertility soils associated with high species richness (Grime *et al* 1973) as well as varied hydrology, soils, geology and landform which result in high habitat diversity, the main determinant of species richness in many ecosystems (Section 4.3.2).

A coherent ecological network should also provide protection for areas that contain unique or special wildlife to ensure that these are adequately conserved (Groves *et al.* 2002). This needs to include biodiversity which is of European or global importance for which we have a special responsibility. It should also include areas that contain important or irreplaceable ecosystem services upon which we depend.

Evidence

The *Guidelines for the Selection of SSSIs* (Nature Conservancy Council 1989) set out a systematic approach for the selection of semi-natural habitat and native species in Great

Britain, with an overarching objective of securing the conservation of the full range of habitat and species diversity: in other words, this key aim of the SSSI series is consistent with the *first* attribute of a coherent and resilient network. The detailed guidance on SSSI selection varies to accommodate ecological differences between habitats (for example most lowland grasslands are small fragmented habitats whilst most uplands and coastal habitats consist of extensive, complex habitat mosaics). In general, SSSIs have been designated to protect the largest and most representative habitat examples in each 'area of search' (corresponding in England to a county, or subdivision of a larger county) and consequently they should ensure that the geographical range of each habitat is protected. Further inspection of the data used for our analysis of BAP priority habitats in the next section confirm that all of these habitats are represented in SSSIs in every English region in which they occur.

Species selection guidance for SSSIs is restricted to groups for which most information is available (vascular and non-vascular plants, birds, mammals, amphibians and reptiles, fish, invertebrates) and the emphasis for selection has been to conserve the largest populations of rare species in each area of search, as well as sites with notable assemblages of species. Data provided for this report by Natural England reveal that in total there are 879 habitats and species ('features') for which at least one site has been notified, i.e. the feature is listed as a reason for the SSSI's selection. Of these, 280 features (mostly species) have only one notified site. In some cases, such as the Sussex Emerald moth, this is because there is only one site. In others, the species may occur at many more SSSIs but they are not mentioned in the citation. For example only a single site is notified explicitly for Mute Swan but 150 SSSIs contain wetland bird assemblages in which this species can occur. There are also likely to be many other species that are protected within the SSSI series that are not listed on any citation. This conclusion is supported by a recent analysis of the UK's vascular plants, which found that 88% of 371 threatened species were represented within the SSSI series (Jackson *et al.* 2009) (but obviously 12% were not).

Although the evidence suggests that England's SSSI series broadly fulfils the objective of supporting much of England's biodiversity, there are some recognised gaps in coverage. These include geographical gaps for certain habitats, such as lowland heathlands in west Cornwall and, perhaps more significantly, there are also some habitat types which are very poorly represented in the SSSI series as a whole. They include some arable habitats of botanical importance, and two recently listed BAP priority habitats, *traditional orchards* and *open mosaic habitats on previously developed land*, which can host a range of rare species.

There are also known SSSI gaps for certain types of species. SSSI guidelines for the selection of grassland fungi were only published in 2009 and there have so far been few sites selected for this group (Genney *et al.* 2009). Guidelines are also lacking for other less well known groups including types of algae and many soil-living organisms. A number of notably rare species lie outside the SSSI series, including the endemic lichen *Lecidea subspeira* which is known globally only from a single churchyard in West Sussex; similarly the only English population of Pyramidal Bugle *Ajuga pyramidalis* is not within a SSSI, nor are the only two sites of the freshwater snail *Sphaerium solidum*. Furthermore, a recent survey of the biodiversity potential of 478 brownfield sites in the Thames Gateway found that of 113 rated 'high' in terms of invertebrate interest, only one was designated as SSSI (data provided by Buglife, 2010).

If we move outside SSSIs the range of species included across all tiers will undoubtedly be even higher. Indeed, there are a number of species that are not known to occur in any SSSIs, but which are found in other types of sites. For example, Millook Valley in Cornwall contains several rare and threatened lichens and is not an SSSI but is both owned by the Woodland Trust and within Cornwall AONB. Nearby Lanhydrock Park is another important non-SSSI lichen site, in this instance owned by the National Trust. To investigate this further, we assessed how effectively different types of sites protect a range of species by analysing the proportion of threatened vascular plants, threatened bryophytes (mosses and liverworts) and BAP priority butterflies that are represented within different tiers of designation (Table 2). Our findings indicate that all types of sites could play an important role in ensuring the full range of England's biodiversity is protected. Perhaps most significantly when we combine SSSIs, LWS, National Parks and AONBs together, some 96% of threatened vascular plants, 98% of threatened bryophytes and 100% of BAP priority butterflies were represented in at least one site. Although our estimates for the plants are based on a sample of 50 species of each type the results are similar to the comprehensive study of these species reported earlier (86% vs. 88% in Jackson *et al.* 2009), suggesting that our results are indeed representative.

Table 2. Representation of species within different types of site.
The values in the table show the percentage of species represented at least once within each site series, based on a sample of 22 BAP priority butterflies, 50 threatened vascular plants and 50 threatened bryophytes. There are only 23 BAP priority butterflies in England, for which data were available on 22. See section 4.2 for further information on the data used.

Site type	Threatened vascular plants	Threatened bryophytes	BAP priority butterflies
SSSI	86%	70%	100%
LWS	80%	54%	100%
National Parks	42%	28%	91%
AONBs	68%	68%	100%
All sites combined	96%	98%	100%

This evidence leads us to conclude that, with some exceptions, our current wildlife sites broadly do meet the criterion of supporting the full range of England's biodiversity. This is good news, because it suggests that we have a solid foundation to build upon. But what about the other elements of this attribute – do our current sites also "incorporate ecologically important areas, including special biodiversity"?

According to criteria set out by European Union, the most important (special) areas for wild birds of European importance have been classified under the EU Birds Directive as Special Protection Areas, whilst habitats and other species of European importance are notified as Special Areas of Conservation under the Habitat Directive. Together these European designations represent 78.6% of the SSSI area and they form the English contribution to the EU Natura 2000 network. Particularly notable in this context are the shingle site of Dungeness, the lowland heathlands of the New Forest and the chalk grasslands of Salisbury

Plain, all of which are the largest example of their habitat type in the European Union, and all of which are Natura 2000 sites. England's coastal SPAs are also of great importance as part of an international network of sites for migratory and resident waterfowl. For other habitats, although there are no large English sites, a large part of the EU resource is nonetheless in England, including chalk rivers and species-rich lowland meadows, many of which are SSSIs. We have already mentioned some gaps in coverage (e.g. at least one endemic species outside of the SSSI series), but in general England's current wildlife sites do protect our special biodiversity.

"Ecologically important areas" support particular ecosystem functions or ecosystem services. These have not been a material consideration in the selection of SSSIs or other wildlife sites, except for National Parks and AONBs where supporting recreation and preserving natural beauty are core objectives. Knowledge about the role of wildlife sites in the delivery of ecosystem services is incomplete. However, analysis of the SSSI series in England has shown it makes a disproportionately large contribution to carbon storage, partly because a large proportion of the SSSIs in the uplands are rich in peaty soils (Eigenbrod *et al.* 2009) Similarly a significant part of low lying soft shorelines is notified as SSSI and here salt marsh and other coastal habitats play an economically critical role in coastal flood protection (Empson *et al.* 1997; Möller *et al.* 1999; see also section 6.2.3). Depending upon their ecological setting, many other ecosystem services are likely to be supported by our wildlife sites, including the conservation of the wild relatives of some crops (Maxted *et al.* 2007) and pollination services (Kremen *et al.* 2007; Ricketts *et al.* 2008).

Conclusion

Overall, we conclude that England's wildlife sites generally meet this attribute of a coherent and resilient ecological network: the SSSI series itself provides good coverage of England's biodiversity, which is further enhanced by other Tiers (and we understand that Natural England is currently planning to review the SSSI series which may lead to some of the remaining gaps being filled). The evidence is less robust to test whether it incorporates important ecological areas, although for several key ecosystem services this is clearly the case.

4.3.2 The network and its component sites will be of adequate size, taking account of the needs of our natural environment to adapt to climate change.

Ecological rationale

Despite the good news in the previous section, species confined to small, single, or only a few sites, are unlikely to be adequately protected. Making sites bigger, and having more sites, reduces the risks.

It is almost always the case that large areas support more species than smaller areas (the 'species-area relationship'; Connor & McCoy 1979), both because they support larger populations of individual species that are less likely to fluctuate to local extinction (in a hard winter, for example) and because they are likely to be more physically variable (in their geology, topology, and variety of habitats), providing greater habitat diversity (Rosenzweig

1995; Whittaker & Fernández-Palacios 2007). Another usually beneficial characteristic of larger sites is reduced 'edge effects'. The edges of habitats (for instance a wood) abutting a more hostile environment (a cereal field for example) often differ markedly in microclimate and other characteristics from the habitat centre (Ries *et al.* 2004). In addition, small patches of grassland may be degraded by nutrient pollution from fertilisers and spray drift from adjacent arable land. These edge effects can penetrate surprising distances into a habitat, making them less suitable for many species and effectively reducing the working size of the wildlife site. For obvious geometric reasons, the proportion of 'edge' decreases with larger sites. All sites do, of course, have to have edges and they can be important habitats in themselves particularly when they provide transitional habitats ('ecotones'; see Section 5.1.1).

Less important, but never-the-less a risk for very small populations, are two additional threats, namely those of inbreeding and so-called 'Allee effects' where species breed less successfully or not at all at low densities (Courchamp *et al.* 2009). Both can threaten the viability of small populations on small sites.

It is very difficult to be precise about how much area is needed in general terms to deliver an effective ecological network, not least because this will differ enormously according to the ecology of different species. Relevant factors will, however, include the proportion of any particular habitat that is protected and the extent of habitat losses, particularly in recent times. We consider evidence for both of these below. Although it is impossible to be precise about how much habitat is required for species, as a rule of thumb the species-area relationship (Diamond & May 1976) predicts that losing 90% of habitat will ultimately lead to the extinction of 50% of the species in that habitat, although ecological networks and habitat management should reduce the rates of extinction. Overall, bigger is better, and creating new wildlife habitat will move the network in the right direction. Finally, models suggest that networks of wildlife sites may need to be significantly larger than they currently are to cope with climate change (Hannah *et al.* 2007).

The Evidence

Size of wildlife sites

The vast majority of England's wildlife sites are small (see Table 3). In terms of our main wildlife designations, 77% of SSSIs and 98% of LWS are smaller than 100 ha. These sites have been selected to protect remaining areas of wildlife habitat and so it is not surprising that they are often small. Indeed, for several BAP priority habitats the median patch size is smaller than 2 ha (Table 4). In other words, for some habitats more than 50% of the remaining fragments are smaller than the size of just 2 football pitches.

There are a number of consequences. First, the quality of the wider environment surrounding these small areas is likely to have very significant impacts upon the wildlife within them, because of the 'edge effects' described above, and emphasises the importance of buffering small habitat patches. Second, the small size of sites will mean that many species will not be able to reach sufficient population sizes within them to be self-sustaining, although there is evidence that species can persist in small sites, at least in the short and medium term, if the management is right (Cooper *et al.* 1994; Wells*, et al.* 1998), and/or

there is easy movement of individuals between sites (we discuss the functioning of 'meta-populations' in section 4.3.4).

Third, because so few large sites remain for many habitats, conservation action that increases the size of smaller sites, improves connections between them, or leads to the creation of new large sites is likely to deliver high benefits in terms of improving the resilience of the ecological network. Fourth, the skewed distribution of habitat patch size means that for some habitats a large proportion of the remaining habitat exists in relatively few sites. So, for example, over 40% of our entire extent of lowland calcareous grassland is on Salisbury Plain, the largest example of this habitat anywhere in Europe. Large remaining patches of habitat offer many species the best chance of surviving, and so it is critical that they are well protected and managed. Finally, the two types of site that do comprise only large areas are Tier 3 sites (Section 4.1.1), the AONBs and National Parks. These could be very important for enhancing the resilience of the network by providing large areas of high quality wildlife habitat. Unfortunately, the evidence suggests that this is generally not what they currently do (see Section 4.3.3), but the potential for these areas is considerable.

Table 3. Size of wildlife sites in England.
The size distribution of different types of wildlife sites in England. Because these sites have a skewed size distribution (i.e. many sites are very small), the median (derived by ranking the sites in size order and taking the size of the middle rank) is a better measure of the 'typical' size than the mean. The 90th percentile represents the size of sites below which 90% of all sites occur. Refer to Table 1 for site definitions.

	Site type	Number of sites	Mean (ha)	Median (ha)	90th percentile size (ha)
Tier 1	SSSI	3,174	255.3	25.5	278.7
	NGO land	3,313	56.0	2.4	44.2
Tier 2	LWS	42,799	16.2	4.6	31.1
	Ancient Woodland Inventory	27,724	12.8	3.9	26.2
Tier 3	AONB	34	56,646	35,481	136,201
	NP	10	121,611	124,438	182,051

Table 4. Size of habitat patches for BAP priority habitats.
The size distribution of the core patches of different types of BAP priority habitat in England. Because these areas have a skewed size distribution (i.e. many are very small), the median (derived by ranking the patches in size order and taking the size of the middle rank) is a better measure of the 'typical' size than the mean. The 90th percentile represents the size of sites below which 90% of all patches occur. BAP habitats are described in Section 4.1.3.

BAP priority habitat	Number of habitat patches	Average patch size (ha)	Median patch size (ha)	Size of 90th percentile patch (ha)
Lowland calcareous grassland	4728	10.7	1.9	14.5
Lowland dry acid grassland	2904	18.9	1.8	24.7
Lowland meadows	5769	6.3	2.0	10.7
Upland calcareous grassland	955	15.8	3.1	25.5
Upland hay meadow	284	4.4	2.5	10.8
Lowland heathland	2987	30.8	3.0	52.7
Upland heathland	2857	79.2	4.1	98.1
Blanket Bog	1854	127.4	3.9	86.9
Lowland raised bog	144	69.2	14.1	101.1
Purple moor grass and rush pastures	2982	7.3	1.5	11.6
Reedbeds	1183	44.8	3.3	81.6
Coastal and Floodplain Grazing Marsh	2244	102.4	28.7	169.2
Broadleaved woodland	57453	9.5	3.9	18.1
Coastal Sand Dunes	220	46.0	5.1	126.1
Coastal Vegetated Shingle	144	25.0	1.8	40.0
Maritime Cliff and Slope	655	36.7	3.3	84.1
Mudflats	3361	19.5	0.6	18.5
Saline lagoons	133	6.7	1.0	8.5

Area of habitat protected

Do England's Tier 1, 2 and 3 sites conserve sufficient habitat? Our starting point is to consider how much of the remaining habitat is within these sites. Tier 1 sites, representing our best protected wildlife sites include, on average, 71.1% of BAP priority habitats, although there is a large amount of variation, with low coverage of some habitats such as coastal and floodplain grazing marsh (18.5%) and broadleaved woodland (24.7%) and very high representation of others, including reed beds and coastal vegetated shingle sites (Table 5). For Tier 2 and Tier 3 sites, the average values are 19.5% and 50.8% respectively. There are

significant overlaps across the tiers and so these values cannot simply be summed, but overall if we look at the cumulative proportion of coverage across all tiers, (Figure 3), it is apparent that for most habitats much of the resource is included within at least one tier of wildlife site. Again this is good news, and provides a sound basis for improving the effectiveness of the network. But as 2.1.3 makes clear, it is clearly not sufficient to prevent the decline of many species, across a wide range of types of organisms and habitats.

One of the reasons for the difference in SSSI coverage across habitats is that for some habitats SSSIs are selected to provide only an exemplar representation (this includes the more common habitats such as broadleaved woodlands and upland heathland), which explains the relatively low proportion of some habitats that have been designated. For other habitats the SSSI guidelines are to designate all occurrences that are of a minimum standard (including most types of grassland). In some cases, these guidelines have not been closely followed. Notably, although the SSSI guidelines are to select all occurrences of lowland and upland hay meadows, only about 50% of each of these habitats is protected within SSSIs. For habitats such as these, LWS (which aim to be comprehensive in their coverage) are particularly important (see Figure 3). In certain geographical areas, LWS also play an important role where SSSI coverage is low. For example, in Nottinghamshire SSSIs occupy just 1.5 % of the county while LWS cover 10 %, and in Bedfordshire local wildlife sites cover more than five times the area covered by SSSIs. Tier 3 sites also provide significant additional coverage for certain habitats, including blanket bog and upland heath; these sites are particularly significant in upland areas

Table 5. Representation of priority habitats within the different types of wildlife sites
Values are in square kilometres (km^2) and the percentage of the total area of habitat is also shown in parentheses. Refer to Table 1 for definitions of Tiers 1, 2 and 3.

		Tier 1			Tier 2		Tier 3		
Habitat name	**Total habitat area**	**Area in SSSIs**	**Area in NGO holding**	**Area in Tier 1**	**Area in LWS**	**Area in Tier 2**	**Area in AONBs**	**Area in NPs**	**Area in Tier 3**
Lowland Calcareous Grassland	509.1	355.6 (69.8%)	28.5 (5.6%)	361.5 (71.0%)	113.4 (22.3%)	129.0 (25.3%)	143.37 (29.3%)	95.2 (19.7%)	238.57 (46.9%)
Lowland Meadows	365.9	177.2 (48.4%)	47.6 (13%)	188.2 (51.4%)	149.2 (40.8%)	157.1 (42.9%)	54.4 (15.1%)	42.4 (11.6%)	96.8 (26.5%)
Lowland Dry Acid Grassland	550.4	453.3 (82.4%)	41.6 (7.6%)	459.2 (83.4%)	91.3 (16.6%)	94.3 (17.1%)	132.71 (24.1%)	222.1 (40.4%)	354.81 (64.5%)
Upland Calcareous Grassland	151	113 (74.8%)	2 (1.3%)	113.9 (75.4%)	4.0 (2.6%)	4.0 (2.6%)	19.54 (12.9%)	110 (72.8%)	129.54 (85.8%)
Upland Hay Meadow	12.6	6.4 (50.8%)	0.2 (1.5%)	6.9 (54.4%)	3.3 (26.2%)	3.3 (26.2%)	4.93 (38.9%)	5 (39.7%)	9.9 (78.8%)

Upland Heathland	2264.9	1624.2 (71.7%)	128.1 (5.7%)	1646.3 (72.7%)	145.2 (6.4%)	145.2 (6.4%)	67.39 (36.1%)	134 (31.2%)	201.4 (46.8%)
Lowland Heathland	922	681.1 (73.9%)	104.3 (11.3 %)	698.9 (75.8%)	208.6 (22.6%)	212.0 (23%)	668.9 (29.5%)	1377.9 (60.8%)	2046.8 (90.4%)
Reedbeds	537.2	527.8 (98.3%)	113.1 (21%)	527.8 (98.3%)	29.2 (4.0%)	29.2 (5.6%)	232.8 (26.4%)	239.6 (26%)	472.4 (51.2%)
Fens	190.3	178.9 (94%)	7.8 (4.1%)	179.1 (94.1%)	5.2 (2.7%)	5.2 (2.7%)	99.8 (19.4%)	87.4 (16.3%)	187.2 (34.8%)
Lowland Raised Bog	99.6	86.9 (87.2%)	11 (11.1 %)	87.7 (88.0%)	9.8 (9.8%)	9.8 (9.8%)	4.59 (2.4%)	164.4 (86%)	169.0 (88.8%)
Blanket Bog	2361.6	1573.3 (66.6%)	89.4 (3.8%)	1596.3 (67.6%)	226.4 (9.6%)	226.4 (9.6%)	11.7 (11.7%)	11.2 (11.2%)	22.9 (23%)
Purple Moor Grass Rush Pastures	219.1	153.5 (70.1%)	32.8 (15%)	157 (71.7%)	58.9 (26.9%)	59.0 (26.9%)	796.4 (33.7%)	1075.72 (45.6%)	1872.2 (79.3%)
Broadleaved Woodland	5455.1	1150 (21.1%)	336.6 (6.2%)	1344.4 (24.7%)	106.2 (16.1%)	2928.1 (53.7%)	105.6 (16.1%)	9 (1.4%)	114.6 (17.4%)
Mudflats	659.1	601.7 (91.3%)	60.7 (9.2%)	613.1 (93.0%)	1880.1 (34.5%)	106.2 (16.1%)	23.3 (10.6%)	76.9 (35.1%)	100.2 (45.7%)
Coastal and Floodplain Grazing Marsh	2396.3	418.5 (17.5%)	99.1 (4.1%)	443.9 (18.5%)	227.5 (9.5%)	353.1 (14.7%)	1340.56 (27.7%)	791.3 (14.5%)	2131.86 (39.1%)
Coastal Vegetated Shingle	36	33.5 (93.1%)	10.2 (28.3 %)	33.7 (93.7%)	1.3 (3.7%)	1.3 (3.7%)	156.6 (7.5%)	222.9 (9.3%)	379.5 (15.8%)
Coastal Sand Dunes	101.3	82.5 (81.4%)	14.9 (14.7 %)	84.9 (83.8%)	26.6 (26.2%)	26.6 (26.2%)	10.15 (28.3%)	0.5 (1.4%)	10.7 (29.6%)
Maritime Cliff and Slope	240.6	173.2 (72%)	40.1 (16.7 %)	186.7 (77.6%)	37.0 (15.4%)	39.8 (16.6%)	33.4 (33%)	95.2 (19.7%)	38.7 (38.2%)
Saline Lagoons	9	7.1 (78.9%)	0.8 (8.8%)	7.2 (80.2%)	1.1 (12.7%)	1.1 (12.7%)	141.4 (61.4%)	42.4 (11.6%)	171.5 (71.3%)
Average cover across all habitats		68.4%	9.9%	71.1%	16.2%%	19.5%	25.3%	27.0%	50.8%

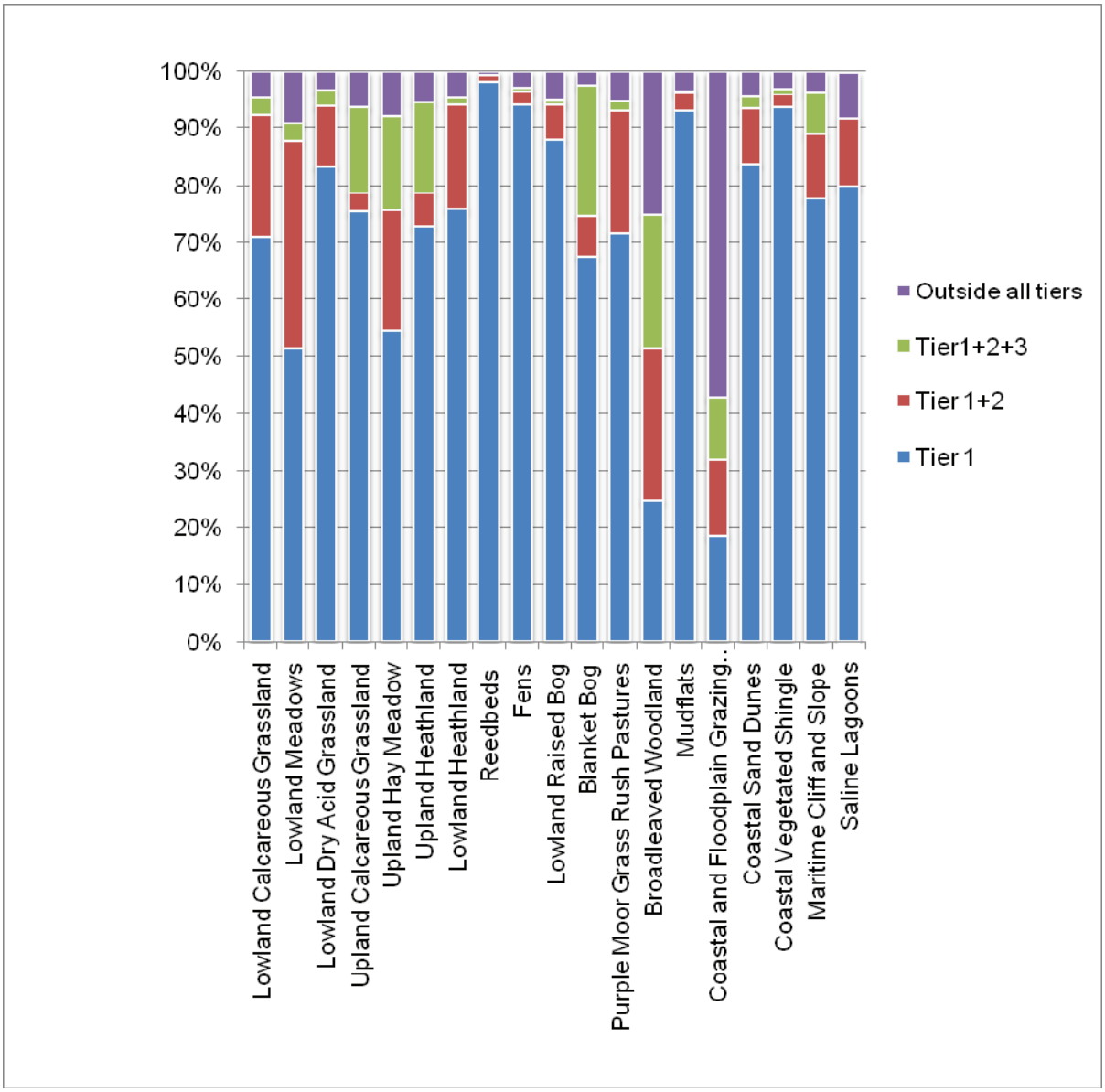

Figure 3. Cumulative proportion of BAP priority habitats within wildlife site tiers

The impact of recent changes in habitat extent

Another way to put the current status of key habitats into perspective is to look at how much has been lost. Although we do not have comprehensive data, the information that is available reveals widespread losses across many habitats, including substantial losses in the twentieth century (Table 6). When we take these changes into account, the picture that emerges is significantly different to the picture created by Table 5. For example, although over 50% of remaining species-rich grasslands (which include meadows and calcareous grasslands) is within SSSIs, this is likely to represent less than 2% of the habitat that existed as recently as 1930. Similarly, while 74% of lowland heathlands that remain are within SSSIs, this represents only 10-15% of the amount that existed in the 19th century, and only some 40% of the lowland heathlands that were present in the 1950s. The losses for some wetlands have been even more severe. In sum in many cases the reason why so much of the present extent of BAP priority habitats is protected within wildlife sites is simply because

they have largely been lost from everywhere else. Ultimately, these habitat losses are the main reason why England's biodiversity has declined and, in many cases, continues to do so (see also section 2.1.3).

In contrast to these losses for many habitats, there have been some increases over similar periods. Broadleaved woodland has increased by about 23% since 1945, although this masks losses in the more valuable ancient woods and total woodland cover today, at 8.4% remains one of the lowest in Europe. In addition, as a result of recent habitat creation and restoration efforts for BAP priority habitats, some of the long-term negative trends are now beginning to be reversed. For example, in the 2008 UK BAP reporting round, eight priority habitats (19% of those for which reports were received) were assessed as increasing or 'probably increasing' in England including reedbeds and lowland heathland. This encouraging progress needs to be continued.

Table 6. Losses of wildlife habitats
Amounts lost relate to England only unless otherwise stated.

Habitat	Amount lost	Timescale of loss	References and Comment
Species-rich grassland habitats (includes meadows and calcareous grasslands)	97% loss in England and Wales	1930-1984	Fuller (1987) More recent losses have also been documented. In Derbyshire 91% of unimproved grasslands surviving in 1983 had disappeared by 1999. In Worcestershire there were losses of at least 64% of meadows between 1978 and 1996 (Stephen 1996).
Ancient woodland	7% loss	c.1930 - 1985	Spencer & Kirby (1992) In addition to this complete loss, about 38% of ancient woodland has been converted to plantations, predominantly of non-native species. These can potentially be restored. Taking a longer perspective, most of England was once wooded but nearly all of this was lost prior to 1600.
Grazing marsh	81% loss	Historic to today	RSPB *et al.* (1997) 1.2 million ha lost. Losses from the early 1930s to mid 1980s include 64% in the Greater Thames, 48% in Romney Marsh and 37% in Broadland.
Fens	99.7 % loss	Since 1637	Thomas *et al.* (1981) 3,400 km^2 lost, leaving just 10 km^2 today.
Lowland Raised Bog	44% loss	Historic to today	Hulme (2008) In addition to this loss, there has been degradation of other areas: the total area of lowland raised bog in the UK which remains largely undisturbed has diminished by 94% from 95,000 ha to c6,000 today.

Lowland heathland	80% loss	1800-1980	Farrell (1993) Much of this loss occurred relatively recently: losses of 40% were reported between 1950 and 1984 for six major heathland areas (Nature Conservancy Council 1984).
Upland heathland	27% loss in England and Wales	1947-1980	Bardgett *et al.(*1995)

Conclusion

With the exception of the landscape designations (National Parks and AONBs), most of England's wildlife sites are small, and so too are the remaining patches of BAP priority habitat. Although our three tiers of sites protect most of the current extent of BAP priority habitats, the amount of habitat left today is much reduced from what it was less than 100 years ago. Indeed, in many cases the reason why so much of the current extent of BAP priority habitats is now within wildlife sites is simply because they have largely been lost from everywhere else.

This evidence has a number of important implications. First, it is important that the remaining semi-natural habitats, corridors and stepping stones are well protected. Second, the amount of habitat that remains and the small sizes of many of the fragments, mean that the current series of protected sites is insufficient to prevent further loss of species. Nor is it generally appreciated that loss of species from surviving habitat fragments can take a long time; some manage to cling on even though their populations are no longer viable in the long term – an effect called an *extinction debt* (Tilman *et al.* 2002). This is both bad and good news. Bad because in the longer term the situation is worse than we think. But good because we may be able to avoid paying much of our current extinction debt by both improving the quality of the habitats that remain and by restoring or re-creating habitats that we have lost. Action to restore habitats that have been lost recently may be more effective than those lost long ago, for which any extinction debt may have already been paid.

4.3.3 The network sites will receive long-term protection and appropriate management.

Ecological rationale

The better we are at protecting and managing remaining areas of semi-natural habitat, the less we will have to do in terms of creating new habitat to establish a resilient network.

Most of semi-natural habitats were created by particular forms of human land-use, often over millennia (Section 2.1.2), and hence depend upon ongoing and appropriate management, for example grazing or cutting, to prevent succession and loss of conservation interest. This is particularly true for mid or early succession habitats such as grasslands and heathlands which would otherwise succumb to scrub encroachment and eventually become woodland.

Ponds and small water bodies may also exhibit relatively rapid changes to their conservation interest through successional processes. Many of our rarer species are associated with early or mid succession stages and disturbed habitats (Webb *et al.* 2010) and so management is critical if these species are to be retained. Better management increases local population densities of target species (Ausden & Hirons 2002), sometimes by as much as two orders of magnitude (Thomas *et al.* in press), which in turn reduces the risk of local population extinction, provides more colonists for range-expansion and increases the viability of local meta-populations (section 4.3.4). In England's fragmented landscape, with its preponderance of many small wildlife sites, management can mimic the patterns of disturbance and habitat variation that would normally be characteristic of much larger landscape mosaics. Management is at times portrayed as 'gardening' our countryside, but it often represents an effective conservation response, by allowing us to make more efficient use of scarce space to conserve biodiversity and ecosystem services. Indeed, habitat heterogeneity can be more important than site size in determining the species diversity of wildlife sites (Báldi 2008).

The Evidence

Site protection

The act of identifying important wildlife sites and designating them as SSSIs has been important in reducing the loss of semi-natural habitats, particularly since 1981 when the Wildlife and Countryside Act significantly strengthened the protection afforded to them. Until then (Section 2.1.4) the emphasis had been on identifying these special sites rather than protecting them, so that even many of 'Rothschild's reserves' were lost or damaged in the second half of the twentieth century (Section 1).

Today, the situation is much improved, with 'Tier 1' sites receiving a high level of protection. Amongst these, the Natura 2000 sites (SACs and SPAs), which account for 78.6% of the SSSI area on land, receive the greatest protection with stringent tests to prevent damaging activities and a requirement for compensatory habitat creation to offset any unavoidable damage. SSSI designation also offers a high degree of protection, for example in planning policy, and in the latest data on the condition of SSSIs only 304 ha (or 0.04%) of the current SSSI network is recorded as 'destroyed' or 'part destroyed' (Natural England data, August 2010). Other Tier 1 sites owned and managed by Voluntary Conservation Organisations are similarly secure as a result of the tenure of the land (as indeed is some additional wildlife habitats owned and managed by private individuals, a point we return to in Section 6). Local Nature Reserves (which comprise less than 38,000 ha, and of which 60% is non-SSSI) are the least secure of Tier 1 sites, but these are nonetheless generally well protected by the planning system.

Wildlife habitats in Tier 2 and Tier 3 do not have the same degree of protection. Planning policy recognises LWS but in practice the protection afforded is relatively weak. As a result, ongoing losses of LWS are occurring. For example, between 1984 and 2008, 130 LWS were destroyed and another 62 reduced in size in Derbyshire alone (Wildlife Trust evidence submitted to this review). Planning policy does, however, provide stronger protection to Ancient Woodlands against development. Although Tier 3 sites (AONBs and National Parks) receive a much higher level of protection than Tier 2 sites, this protection relates to the site as a whole, not the wildlife habitats within the sites. We do not have evidence on the relative

rates of losses of semi-natural habitats in these protected landscapes. In general, BAP priority habitats in the wider countryside are recognised in planning policy, but are not well protected. Woodlands are an exception; they receive additional protection because their removal requires licenses from the Forestry Commission.

Overall, and with the exception of woodland habitats which have their own protection measures, the evidence suggests that only Tier 1 sites are well protected.

Site management

This difference in the level of protection afforded to sites in different tiers is also reflected in differences in management. The Habitats and Species Regulations 2010 make provision for the effective management of Natura 2000 sites. For other SSSIs, changes introduced through the Countryside and Rights of Way Act 2000 provided greater powers to secure appropriate management and take action where this is not in place. There has been good progress in improving the management of SSSIs since this Act, in part driven by a former Public Service Agreement (PSA) target for 95% of SSSIs to be in 'favourable' or 'unfavourable recovering' condition by the end of 2010, as part of the UK's international commitment to halt biodiversity loss. This has been supported by a comprehensive programme of condition assessment of SSSIs to assess site quality. When this report was being written in August 2010, the 95% target was in reach, with 93% of SSSIs now considered to be in favourable condition or under appropriate management and so qualifying as unfavourable recovering (although we note that 63% is currently in this latter category, while just 30% is assessed as actually favourable). Significantly, many of the causes of unfavourable condition for the remaining SSSIs are due to 'off-site' factors that are often outside the control of the site owners or managers. Eutrophication is an example (Section 2.1.3).

There is no equivalent condition assessment for habitats in non-SSSI sites (including non-SSSI Tier 1 sites), although a number of sample surveys exist which generally reveal that condition outside SSSIs is poor. For example, a survey of 500 English non-SSSI grassland sites found that only 21% were in favourable condition, even though the standard applied for these non-statutory sites is lower than in SSSIs (Hewins *et al*. 2005), while none of 104 lowland heaths surveyed in 2005 and 2006 were assessed as being in favourable condition (Hewins et al 2007).

Although the condition of habitats in Tier 2 and Tier 3 sites is poorly known, there are some data on the area of habitat under management. In 2009, as part of the local authority performance assessment process, information was collated on the management of LWS for the first time, revealing that about 33% of these sites were in positive management (Carr 2010). We do not know the overall condition of ancient woodlands, but about half the area of woodland in England is actively managed under a plan approved by the Forestry Commission (Forestry Commission data 2010). In terms of Tier 3 sites, analysis of environmental stewardship information for this report reveal that in AONBs 29% of BAP priority habitats are under management through 'Higher Level Schemes' (HLS, see section 6.3.3 for a general description of Environmental Stewardship). In National Parks, the proportion of BAP priority habitat managed under HLS is 36%. In these protected landscapes, significant areas of additional habitat will also be managed in the 'Classic Scheme' fore-runner to HLS.

Conclusion

Tier 1 sites are generally well protected and increasingly well managed, but a majority of wildlife habitat in Tier 2 and Tier 3 sites are both inadequately protected and often poorly managed.

4.3.4 Ecological connections will exist between sites.

Ecological rationale

Species' distributions are often dynamic. Indeed, many species' populations exist not as spatially isolated groups but as *meta-populations* (Levins 1969; Hanski 1999), sets of local populations linked by the dispersal and movement of individuals to adjacent populations. Butterflies on traditionally coppiced woodland (Hodgson *et al.* 2009) or chalk-downland habitats form meta-populations – individual colonies (often in protected areas) linked by the movement of individuals from adjacent colonies. Maclean (2010) summarises these, and other examples of species that appear to exist as meta-populations, including bumblebees and several freshwater species, including amphibians and molluscs.

Meta-populations have some surprising, but well understood properties (Hanski 1999). If one or more of the linked patches of habitat are lost (either because the habitat is destroyed, or even if it deteriorates through poor management), surviving populations on adjacent patches may decline (and even go extinct), even if surviving patches remain in good condition. Individual populations in a meta-population can 'come and go', like lights blinking on and off. And as the distance between individual populations increases, larger (or better quality) habitats are needed to maintain viable individual populations. The geographic scales over which meta-populations operate vary hugely with the nature of the species under consideration. For tiny invertebrates living in moss-covered rocks it may only be a few square meters; for butterflies a few square km; and the expanding meta-population of England's Red kites may eventually encompass the whole of the country. Plant species may exist as meta-populations linked by either seed or pollen dispersal, but the importance of these processes in sustaining plant populations is unclear (Husband & Barrett 1996) and plants may show other dynamic patterns of distribution (Freckleton & Watkinson 2002).

Species may also require to move between sites for other reasons, in particular:

(i) species whose ranges are expanding or shifting due to climate change (Section 3.2);
(ii) species using resources that are only temporary in the landscape (such as pioneer plant species or species using seasonal ponds);
(iii) species in which the individuals have large ranges; and
(iv) species that are migratory or which use different habitats at different stages of their life cycles.

Many of England's species need to be able to move for one or more of these reasons. Mobile species require both suitable core habitat patches to move to and they need to be able to move between patches. In some situations this will require physical linkages in the form of corridors and stepping stones (Section 2.2.3), but for others it may be more

appropriate to ensure the land between sites – the matrix - is permeable to wildlife, through environmentally-friendly farming techniques.

There are some obvious messages for the design of an effective ecological network:

(a) Maintaining fragments of surviving semi-natural habitats in good condition matters, not only for the species and individuals currently within them, but also for those on adjacent habitat patches linked as a meta-population, and for other mobile and wide-ranging species.
(b) Connectivity matters. As populations in a metapopulation or of mobile species become more and more isolated, it is harder and harder to maintain them, even with excellent local habitat management.

The Evidence

Here we assess two types of evidence regarding connectivity across England. First we assess the quality and extent of habitat features that act as natural corridors: rivers, hedgerows and so on. Second we measure how isolated or connected are wildlife sites in different parts of England.

Natural connections

Rivers provide ecological connections across England. They supply a number of critical ecosystem services, not least water for drinking, crop irrigation and industry, as well as being important places for recreation. They provide a range of wildlife habitats and support species dispersal and migration. As such, their quality and function is very important for ecological networks. Despite recent progress in tackling pollution, recent data indicates that rivers are generally in poor condition. Over 62% of the length of rivers has been severely or significantly modified (Environment Agency 2010) and in 2009 only 22% were assessed as at good ecological status using Water Framework Directive criteria (Environment Agency data from River Basin Management Plans 2009). The situation is little better for river SSSIs - currently only 37% of these are in favourable or unfavourable recovering condition, making rivers the worst performing habitat within the SSSI series (Natural England data 2010).

Ponds are important habitats for a wide diversity of wildlife and can provide ‘stepping stones’ for many species that use freshwater habitats to move across the landscape (Webb *et al.* 2010; Williams *et al.* 2010). An estimated 70% of ponds were lost from England since 1880, with much of the loss occurring in the second half of the 20th century as a result of agricultural change and urbanisation (BRIG 2007). Since 1990, however, this trend has been reversed, and the latest estimates reveal an increase in the number of ponds of 1.4% per annum between 1998 and 2007 across Great Britain (Williams *et al.* 2010). In contrast to the recent increases in numbers there has, however, been an apparent decline in pond quality. In 2007, 80% of ponds were assessed as being of ‘very poor’ or ‘poor quality’, a 17% increase in the proportion of ponds in these categories since 1996 (Williams *et al.* 2010).

Hedgerows were traditionally used to mark the boundaries of fields and to help to manage livestock, but they now constitute a significant wildlife habitat within the farmed environment. One important function they provide for wildlife is as corridors for the movement and dispersal of a range of species including bats, other small mammals and invertebrates (Burel & Baudry 1990; Bright 1998). Since 1945 there have been drastic losses of hedgerows

through removal and neglect, especially in eastern counties of England. Between 1984 and 1990 alone, the net loss of hedgerow length in England was estimated at 21%. The most recent estimates are that the length of managed hedgerows in England decreased by 26,000 km (6.1%) between 1998 and 2007, while the total length of woody linear features in the countryside as a whole decreased by 8,000 km (1.4%) over this time (Countryside Survey 2009). Declines in the quality of hedgerows (as measured by species diversity) were also recorded between 1978 and 1998, although no further declines were recorded in the period up to 2007, reflecting recent improvements achieved with the support of agri-environment schemes (Countryside Survey 2009).

There are other man-made linear features in the landscape that we tend not to think of as corridors, but which can, or could, act to increase connectivity. They include canals and their towpaths, cycle routes, and so on. We revisit these features in Section 6.4.2.

Connections through the wider countryside

Species will often need to move between wildlife sites or habitat patches so via stepping stones or the wider environment, without using continuous corridors (Section 2.2.3). In this section we present the results of a new analysis which ranks the connectivity of English landscapes on a qualitative scale from 'most fragmented and isolated' to 'well connected'. The analysis takes account of the extent of core habitat patches, how isolated the patches are, which habitats are next to each other, and the ease with which species are able to move through the surrounding landscape. It makes some simple, but robust assumptions about the dispersal abilities of focal species, but since the index of fragmentation is a relative ranking, the results are broadly unchanged by using different dispersal rates (see Section 4.2 for more details).

In making comparisons of this sort, we also need an appropriate geographical framework, which takes account of both natural and cultural heritage, including historic land use, hydrology, soils, geology and ecology. National Character Areas[1] provide this framework and we have mapped the relative fragmentation of different parts of England using them (Figure 4). It confirms that major differences exist in landscape connectivity across England, with clear implications for what needs to be done to create a more resilient ecological network in different parts of England. The priorities for action in an area with large amounts of relatively well-connected habitat remaining will often be different to those in an area where sites tend to be small and isolated. We use this information to discuss priorities in Section 5.2.1.

Conclusion

Many species need to be able to move between wildlife sites but, in general, this has become harder for them to do. This is because many 'natural connections' such as our hedgerows, ponds and rivers have been lost or are often in poor condition. In addition, the wider countryside (the 'matrix') has lost some of its richness and complexity, as demonstrate by greater declines in special than generalist species across several groups including birds,

[1] National Character Areas (NCAs) are broad areas of land with a cohesive and distinctive landscape and ecological character, shaped by natural, cultural and historical influences. In total there are 159 NCAs and they provide an integrating framework and context for managing and planning conservation action at local and national levels.

butterflies and plants (see Section 2.1.3). It is possible to compare the levels of fragmentation and connectivity of our remaining wildlife habitats across England, taking account of the size and distribution of remaining habitat patches and the quality of the matrix (Figure 4). This approach works at different geographical scales, which can help inform conservation decisions when planning ecological networks (see Section 5.2.1).

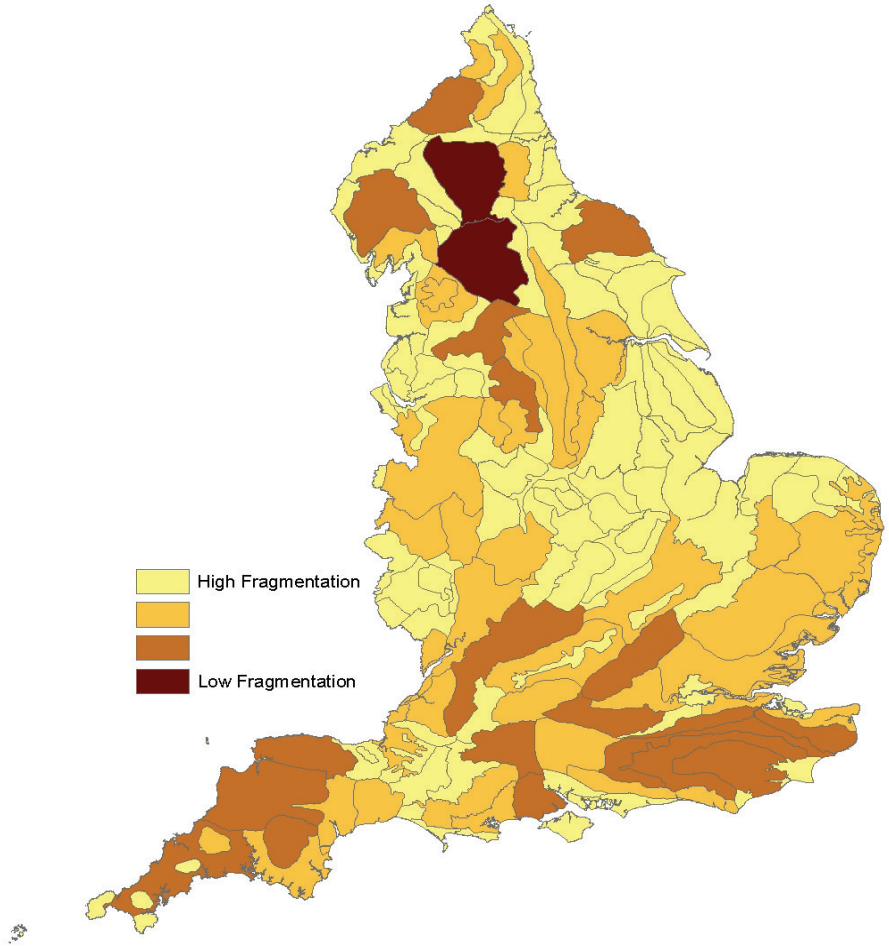

Figure 4. Levels of habitat fragmentation across National Character Areas. This analysis takes account of habitat extent and permeability land between habitat patches to produce a ranking from areas where habitats are most fragmented (lighter) to less fragmented and more connected (darker). From a new analysis carried out by Dr. R. Catchpole, Natural England (see text for further details).

4.3.5 Wildlife sites will be valued by and accessible to people, and include sites close to where they live.

Rationale

Wildlife sites provide many direct benefits for people (see Section 2.1.1). Here we consider health, well-being and quality of life. The connection between better human health and access to nature is well established (Royal Commission on Environmental Pollution 2007); many of the benefits are a result of people being more physically active if they have access to natural environments, and overall levels of physical activity across age groups are positively associated with the proximity and accessibility of green spaces to residential areas (Jones *et al.* 2009), particularly in pre-school children (Baranowski *et al.* 1993).

Evidence on mental health benefits from contact with nature is even more compelling. Stress and symptoms of depression are reduced (Wells & Evans 2003); concentration and self-discipline are enhanced (Faber Taylor *et al.* 2002) and levels of admissions for mental illness decrease (Bowler *et al.* 2010). Attention levels in children with attention deficit disorder increase when they have access to natural spaces (Faber Taylor *et al.* 2001). Children also often prefer to play in natural or wild places, helping them develop cognitive, physical and social skills (Muñoz 2009).

Surveys confirm that people value wildlife and want accessible places where they can experience the natural environment at first hand (TNS Research International 2010). Many people have a ‘special place’ which they can get to from home, to ‘touch base’ with nature more or less regularly, ranging from special days out to visits on their way to and from work and school.

Although there will be some occasions where access needs to be controlled to avoid damaging or disturbing wildlife, providing opportunities for people to experience nature can also benefit wildlife. The level of direct contact with nature is a factor in influencing attitudes towards it (COI 2008) and childhood experience plays an important role in shaping attachment to place. People are more likely to support and care about the establishment and maintenance of an ecological network if they have direct experience of wildlife and are aware of the benefits they receive from it.

The Evidence

England’s wildlife sites provide important opportunities for people to experience the natural environment. Tier 1 sites with statutory protection for nature conservation frequently have public access. Over 50% of open access land designated under the Countryside and Rights of Way Act is also designated SSSI and the majority of National and Local Nature Reserves are accessible on foot either by public rights of way or permissive access. Each year NNRs receive over 14 million visits (Natural England data for 2006), while Wildlife Trust reserves receive 6 million and the number of visits to National Parks is 75 million (Association for National Park Authorities data).

Despite these impressive numbers, it is clear that nature is far from accessible to all. Those living in inner cities and particularly those from poorer households, lower socio-economic groups and minority ethnic groups are less likely to visit the countryside, including National Parks and other wildlife sites (England Leisure Visits, 2005). Part of the problem is the need to travel: people should have opportunities to enjoy and appreciate England's natural heritage close to their homes in the same way they should have opportunities to appreciate culture, art and architecture. Yet there is clear evidence of inequality in the provision of urban green space, including wildlife sites. People from minority ethnic groups tend to have less local green space and it is of a poorer quality (CABE Space 2010), which can exacerbate other social problems. For example, there is greater health inequality between richer and poorer people in areas with low levels of green space than in areas with more green space (Mitchell and Popham 2008).

The area of wildlife sites within or near urban areas is low (Table 7), although Local Nature Reserves and Local Wildife Sites represent exceptions to this, an indication of their accessibility and potential significance to local communities.

Table 7. Area of wildlife sites within or near urban areas.
For this analysis, 'urban areas' are considered to be settlements with populations of at least 10,000 people and the area calculations include all land within the urban area or within 500m of its boundary.

Type of wildlife site or area	Area of overlap (ha)	% of wildlife site series
Sites of Special Scientific Interest	28,793	3.6
Local Nature Reserves	22,106	58.5
Local Wildlife Sites	133,525	19.2
Areas of Outstanding Natural Beauty	41,124	2.1
National Parks	14,966	1.2
Total urban area (including 500m buffer)	2,677,620	n/a

To encourage the provision of natural places close to where people live, Natural England has promoted an Accessible Natural Greenspace Standard (ANGSt, see Box 4). ANGSt was developed by considering the relationship between the size of natural spaces capable of sustaining habitats and species and the distances that people were prepared to travel to experience nature, factoring in the distance parents were prepared to allow children to roam freely (Harrison *et al.*1995).

No complete picture exists of where the Accessible Natural Greenspace Standard has been met across England, but in the Thames Gateway approximately 50% of the population do not have access to 2 hectares of greenspace within 300 metres.

Box 4. Accessible Natural Greenspace Standard

Everyone, wherever they live, should have accessible natural greenspace of at least:

- 2 hectares within 300 metres (5 minute walk) from home
- 20 hectares within 2 kilometres of home
- 100 hectares within 5 kilometres of home
- 500 hectares within 10 kilometres of home
- 1 hectare of Local Nature Reserve per 1000 population.

Conclusion

With the exception of Local Nature Reserves, which are designated partly as places for local communities to enjoy, and (to a lesser extent) Local Wildlife Sites, most wildlife sites are not close to urban areas, where most people live. This highlights the need for action to enhance biodiversity within urban areas, including outside wildlife sites. We return to this in Section 6.2.3.

4.4 Conclusions: does England have a coherent and resilient ecological network?

England has a varied series of wildlife sites. In this section we reviewed the evidence on the extent to which these together comprise a resilient and coherent ecological network by assessing these sites against five attributes (section 4.3.):

(i) The network will support the full range of England's biodiversity and incorporate ecologically important areas, including special biodiversity.
(ii) The network and its component sites will be of adequate size, taking account of the needs of our natural environment to adapt to climate change
(iii) The network sites will receive long-term protection and appropriate management
(iv) Sufficient ecological connections will exist between sites to enable species movement.
(v) Sites will be valued by, and be accessible to people, including sites close to where they live.

By considering three Tiers of sites, we have taken a broad view of what comprises a 'wildlife site'. Many people will first think of SSSIs when they think of wildlife sites, but the SSSI series, as important as it is, clearly does not in itself comprise a coherent and resilient ecological network. Perhaps this should not come as a surprise since SSSIs were not designated with the aim of establishing an ecological network. We have seen that 'Tier 2' sites and 'Tier 3' landscapes have considerable potential to make a greater contribution towards England's ecological network, if the habitats within them were better managed and more secure.

Looking across all three Tiers of wildlife sites, we conclude that only attribute (i) is substantially met; in all other cases there are serious short-comings in the network. Notably, many of England's wildlife sites are too small; losses of certain habitats have been so great

that the area remaining is no longer enough to halt additional biodiversity losses without concerted efforts; with the exception of Natura 2000 sites and SSSIs, most of England's semi-natural habitats important for wildlife are generally insufficiently protected and under-managed; many of the natural connections in our countryside have been degraded or lost, leading to isolation of sites; and too few people have easy access to wildlife.

We are far from where we need to be, but it is not too late. With appropriate action, these short-comings can be addressed. In our next sections we consider how.

5. Rebuilding nature

In the last section we concluded that our current collection of wildlife sites do not represent a coherent and resilient ecological network. To resolve the specific shortcomings identified in Section 4, and the continuing losses of habitats and species documented in Section 2.1.3, we need some guiding principles - generic practical solutions – to rebuild England's wildlife and wild places, to underpin the creation of a coherent and effective ecological network. We set these out in this Section. We make no assumptions here about the approaches or mechanisms used to achieve these solutions: these are gathered together in Section 6. In particular, although it is important that wildlife-rich habitats and sites are protected, we make no assumptions about how that protection should be achieved. Designation is just one option, and in many situations effective incentive-based solutions (rewarding landowners for the public goods their land is providing) will be preferable.

As we explain in the Introduction (Section 1) this is a long-term strategy, a desired 'direction of travel', and a set of general principles to guide conservation action in England over the next 40 years. It is not something that can all be done tomorrow, or next year. But the sooner we start, the better, and if we delay it may be too late.

5.1 The ecological options

One approach to rectifying the challenges facing England's wildlife would be to start again. We could specify much more precisely the desired distribution, size, location and connectivity of sites, designed from first principles, across all the ecologically significant habitats in England. There are numerous reasons why we do not favour this approach, not least because, as we have already seen, our current wildlife sites make an important contribution to England's ecological network and the vast majority would be re-selected by any such process. We also do not favour a heavily top-down major new designation process and we need to recognise the major constraints arising from existing patterns of private and public land-ownership.

However, we can say that for many species and habitats the present suite of sites is inadequate, either in management or extent, with continuing losses of wildlife in many parts of the country (see Section 2.1.3). We therefore provide a series of options to halt and reverse these declines building on the ecological principles summarised in Section 4.3.

5.1.1 The options

We highlight five key approaches to rebuild nature and addresses the weaknesses of the current series of wildlife sites identified in Section 4. We need to:

(i) Improve the quality of current sites by better habitat management.
(ii) Increase the size of current wildlife sites.
(iii) Enhance connections between, or join up, sites, either through physical corridors, or through 'stepping stones'.
(iv) Create new sites.
(v) Reduce the pressures on wildlife by improving the wider environment, including through buffering wildlife sites.

All these options can be used in isolation or in combination with others. Figure 5 illustrates many of the ideas in schematic form. We now briefly consider some of the issues behind the five approaches that together provide the toolkit for developing a more coherent and resilient English ecological network.

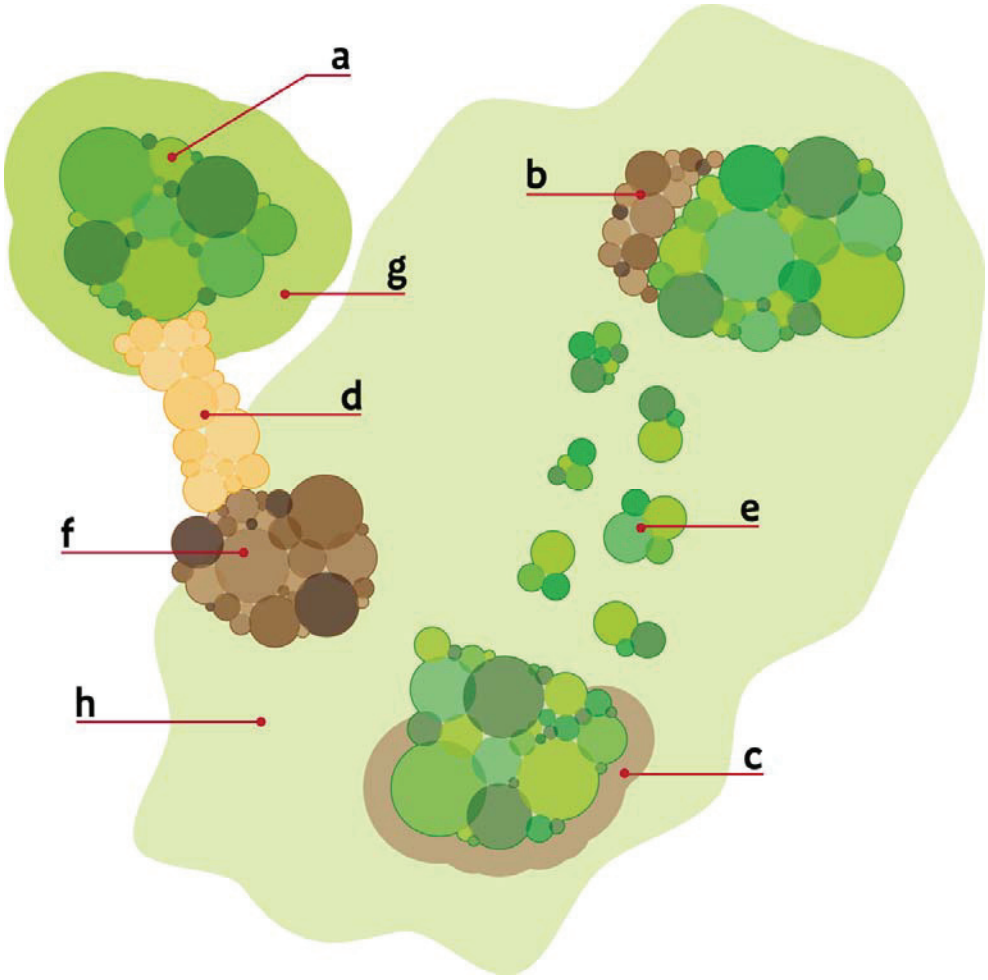

Figure 5. Enhancing ecological networks
Approaches include: improving the quality of habitat patches (a); making existing sites bigger (b), which can include creating ecotones (c – see section 5.1.3); enhancing connectivity through a continuous corridor (d) or a stepping stone corridor (e); creating new sites (f); and reducing pressures on sites either by establishing buffer zones (g) or enhancing the wider environment (h).

5.1.2 Improving the quality of current sites by better habitat management

Although habitat quality on SSSIs is improving (and is a success story – see Section 2.1.4), many are still not in good condition and important non-SSSI sites and habitats such as Local Wildlife Sites are often under managed (Section 2.1.4). Investment in the management of existing wildlife habitats (Section 4.3.3) is an absolute priority if England is to have an

effective ecological network. It is the natural world's equivalent of mending the roof; if the roof leaks, most other efforts at maintenance fail. Habitat heterogeneity can be particularly important in enhancing site quality for a range of species (Section 5.2.2). Good management of sites can lead to enormous benefits for wildlife. For example, the population density of large blue butterflies can vary by up to two orders of magnitude depending upon the management of the site (in particular the availability of the larval foodplant). Populations in high quality sites are less likely to go extinct and produce up to 100 times more emigrants which may colonise new areas (Thomas *et al.* in press).

Space is precious and the better we manage our remaining wildlife sites and the habitats within them, the less area we will need to create new habitats to establish a coherent and resilient ecological network. We have emphasised the benefits of large sites and in this regard National Parks and AONBs (our largest sites) have great potential. We need to make our current sites work harder so that they deliver more for wildlife and provide enhanced ecosystem services.

5.1.3 Increasing the size of current sites, enhancing connections between, or joining up, sites, and designating new sites

We deal with these three prescriptions together, because they raise some interesting issues about priorities for action. For the sake of developing the argument, we have not, in this section, distinguished between bringing existing habitats into the network, and creating new habitats.

Consider the following question: other things being equal, a finite budget, and a fixed area of new land to bring into conservation management, what strategy would maximise conservation benefits?

(i) Increase the size of existing wildlife sites.
(ii) Create new wildlife areas, either as many small sites or a single large site of equivalent area.
(iii) Increase connectivity by physical corridors, or stepping stone sites.

Whether new sites are regarded as stepping stones or stand-alone core wildlife areas is largely subjective and context-dependent.

There is a rich, largely theoretical, ecological literature on these issues (e.g. Hilty *et al*. 2006, Falcy & Estades 2007; Hodgson *et al.* 2009; Tjorve 2010), but no definitive, practical answers because of differences between species (good vs. poor dispersers, for instance), the geographic scale being considered, and the type of habitat. However, since choices are unavoidable, wider practical considerations suggest that the hierarchy of benefits (and including the better management specified in 5.1.2, which is the bedrock of an effective network) runs:

Better management of existing sites > Bigger sites > More sites > Enhance connectivity > Create new corridors.

The appropriate points at which to enter this hierarchy will differ with habitat type, and where we are in England, issues to which we return in Section 5.2.1. We have already explained

why the first priority is to improve existing sites, but why do we choose this hierarchy for the remainder of the options?

Bigger sites

Over large parts of England (for example regions that currently have few or no large wildlife sites) our first choice would be to make existing wildlife sites bigger through habitat restoration or creation. Bigger sites are preferable to small ones because (as explained in Section 4.3.2) on average: they contain more species than small sites; they have proportionately less edge; they potentially have greater topographic, geological and hydrological diversity, facilitating species' adaptation to climate change for example (see Section 5.3); and large sites make it easier to restore and promote more natural geological, ecological and hydrological processes, and the ecosystem services on which society depends (Section 2.1.1). These aims need to be taken into account when deciding which wildlife sites to enlarge, and what habitat to restore or create. For example, there are species that require ecotones (the transition between or blending of two different habitats to create 'messy edges') for their survival (e.g. Pearce-Higgins *et al.* 2007). Ecotones often get squeezed out as land management hardens the boundaries between habitats, and one approach to habitat creation is to 'soften' these boundaries to allow a more gradual transition between habitats or land uses.

Because large sites favour more natural processes, they may require less direct management and, where intervention is required, there are often economies of scale. Consequently, large sites tend to be less costly to manage per unit area than small sites (Ausden 2007); indeed some desirable forms of management (grazing for instance) are very difficult or impossible on small sites (Lack 2010).

More sites

For a given area of land, again in many but not all parts of the country, our next choice would be to create several smaller wildlife sites, preferably as part of a chain of stepping-stone sites that together enhance connectivity for dispersing species. Also, for many species that are poor dispersers (for example the ground flora of ancient woodland), the better management of existing, but currently unmanaged habitat in a series of new small, well-managed sites would have considerable conservation benefits.

Enhance connectivity

Many existing landscape features (natural and man-made) increase connectivity between different parts of the network at various scales (Figure 5, Section 2.2.3). They include stepping stone habitats, and linear features such as rivers, canals, cycle-routes, railway embankments and hedges. Enhanced connectivity in a meta-population reduces the risk of regional extinction (Section 4.3.5). Improving the quality of connections can also enhance the functioning of natural ecological processes, such as through improving water flows. From a purely pragmatic point of view, it may be more cost-effective to promote and enhance the existing network of green corridors and stepping stones (by appropriate management, and by widening them) than to go in for wholesale establishment of new corridors.

Corridors

The idea of joining together existing sites by creating totally new linear corridors across an inhospitable landscape has intuitive appeal. The assumption is that species will use the corridors to move from one protected site to another. There is evidence that species do use new corridors to disperse (Sutcliffe & Thomas 1996; Gilbert-Norton *et al.* 2010), albeit with expected differences between the types of organisms involved, but there is no evidence that creating corridors actually works in a metapopulation context to boost population survival. Pragmatically, it may also be more difficult to establish sufficient new linear habitat to create corridors than it is to establish stepping stones across the landscape (see above). For these reasons, we place the creation of new physical corridors last in our hierarchy.

5.1.4 Reduce the pressures on wildlife by improving the wider environment, including through buffering wildlife sites.

We have deliberately not included this option in the 'hierarchy of choices' because it seems to us to be of a qualitatively different nature to the issues in 5.1.2 and 5.1.3. Essentially, the more we improve the wider environment within which wildlife sites sit, the less we will have to do of the other options to establish a coherent and resilient ecological network. In Section 4.3.2 we briefly discuss the need to buffer sites, particularly small, isolated ones. Buffering involves managing the area surrounding a wildlife site in ways which reduce adverse effects on the site, and sustain positive landscape interactions (Jongman & Pungetti 2004). One example of a positive interaction is the enhancement or creation of ecotones in the buffer (see Section 5.1.3). More generally, the effect of buffer zones is to improve the quality and the effective area of wildlife sites.

For many species of conservation concern, the most intensively managed agricultural land, urban areas, transport infra-structure, and the general paraphernalia of modern life present insurmountable obstacles to dispersal, and impossibly hostile environments in which to live. (Not all human-dominated landscapes are hostile to nature – many 'brown field sites' are rich in insects, and urban gardens and allotments can be havens for wildlife). Nor are designated protected areas immune from adverse human impacts, for example, diffuse nitrogen pollution derived from burning fossil fuels and from agriculture poses a serious threat to the plant communities found on low-nutrient soils, and to water bodies (Section 2.1.3).

Across species groups, specialist species tend to be faring less well than generalists, reflecting the ongoing losses of the little patches of habitat and features that make our countryside habitable for wildlife (and attractive to people). We need to put the complexity and interest back. These problems require action across the whole of society. Many farmers, for example, are adopting agricultural practices that make the farmed landscape more hospitable for wildlife. This has many benefits – reducing the pressures on wildlife sites, enhancing the ecological connections so that species can more easily move, and making space for some types of nature that can live in the wildlife-friendly areas created. Other necessary actions – the 'greening' of our cities, the reduction in nitrogen emissions from car exhausts and so on – lie outside the scope of this report, but they are increasingly recognised by society as important, and effective action would undoubtedly benefit wildlife.

5.1.5 The essence of the solutions

We can summarise the essence of the key solutions in four words: *more, bigger, better* and *joined.* It will not be possible to halt and reverse the collapse of England's wildlife documented in this report without a larger network of more wildlife sites, bigger sites, better managed and more heterogeneous sites and more inter-connected sites. Some of the greatest gains will be where we achieve all of these, alongside reducing the pressures on the wider environment by working at a landscape-scale (e.g. Box 5). How we get from where we are to where we ultimately need to be will require vision, determination and partnership. The practical mechanisms to achieve this vision are brought together in Section 6. Before moving to section 6, however, we need to briefly elaborate on some of the guiding principles.

Box 5. Landscape-scale conservation in the South Essex Marshes

In south Essex, on the north bank of the River Thames, a wide range of local partners has worked together to restore an area covering 10 km^2 to wetland habitats, created from a mix of grazing marsh, arable farmland, brownfield and restored landfill sites.

Restoring this area has involved working with regeneration agencies, local authorities, landowners and businesses and extensive consultations with local communities and statutory agencies. For example, in partnership with the Environment Agency, the RSPB is working to create compensatory habitats identified in the Thames Estuary 2100 strategy. The landscape scale of the habitat creation means that the site will make a real contribution to wildlife's adaptation to climate change.

The creation of extensive areas of wet grassland has resulted in increases in water birds including avocet and lapwing, as well as water voles and great crested newts. Buglife and the RSPB have worked together to create and manage new habitats to restore the fragmented Thames Terrace invertebrate communities. A partnership with the Port of London Authority on the 15,000 hectares within their control creates direct connections with terrestrial and marine ecosystems on a truly landscape scale.

Extensive networks of multi-user trails and access improvements have been created, informed by community consultation, ensuring that new facilities are desired and relevant. Developed from a landscape of farming and industry, this wide partnership has created and restored habitats to deliver high quality green space, rich in wildlife and, for the first time, accessible to people.

5.2 Some important elaborations on the options

5.2.1 Guidance on where and what

The real world is complicated, and 'all other things are not equal'. Does this have any bearing on the priorities laid out in Section 5.1.3? Practical use of the prioritisation suggested in 5.1.3 must, for instance, take into account both the type of habitat, where we are in England, who owns and manages the land, and the potential conservation gains. Importantly, action at one stage in the hierarchy affects how much is required elsewhere – so, for example, improving management of existing sites means we will need to create less new habitat to establish a resilient network.

Some habitats in England have suffered much greater damage and loss than others (Section 4.3.2, Table 6). The prevention of further losses among these habitats should be a priority, and where possible these habitats should be targeted for re-creation. Restoration of other less threatened habitats may have to have lower priority. However some habitats of considerable conservation significance are effectively impossible to re-create on the scale of several human life-times; ancient woodland and limestone pavement are good examples. The protection of surviving remnants should be an absolute priority.

Where we are is also important. As described in Section 4.3.4 *National Character Areas* have been defined across England, each with a distinctive geology, hydrology, patterns and types of land-use, local architecture and surviving remnants of semi-natural habitats and, by analysing the distribution of habitat networks, it is possible to assess their relative levels of habitat fragmentation (see Section 4.3.4 and Figure 4). This sort of approach works at a range of geographical scales and it can help to turn our generic high-level recommendations into practical solutions on the ground, leading to a different set of priorities in different places. Large swathes of northern England, for example, have very large areas of unfragmented, semi-natural habitats, including considerable areas of SSSI. In these areas, it will often make more sense to accept that we already have enough large wildlife sites, and concentrate instead on improving management and enhancing habitat heterogeneity (Figure 6). The situation in those parts of England where sites are small and isolated is very different. Here large, new wildlife sites (created through enhancing existing remnant habitat and by habitat recreation) may often deliver greater gains to the ecological network (there is little point in increasing connectivity when there is precious little left to connect).

Creating new wildlife-rich sites in those parts of the country where nature is currently thin on the ground would also improve people's access to the natural environment (see Section 4.3.5). People should not have to travel hundreds of miles to enjoy butterfly-rich meadows or singing skylarks. But such benefits will have to be weighed against the fact that the conservation gains per pound spent will be much greater in some locations than others, and easier or more difficult to achieve depending upon land-ownership, conflicting demands on land-use, and the willingness of all segments of society to sign up to deliver the vision.

Decisions about precisely what action(s) to take are often best made locally (within an agreed overarching set of objectives, based on the principles we have enunciated), by local communities, private landowners, local authorities, statutory bodies and wildlife charities working together. There are also well thought through frameworks to inform and, where necessary, co-ordinate such actions, including The Wildlife Trusts' vision of a *Living Landscape*, the RSPB's *Futurescapes*, emerging proposals for landscape-scale initiatives from the England Biodiversity Group, Regional Opportunity Maps[2] and the Wetland Vision for England[3]. In Section 6 we consider ways in which landowners can be incentivised so that they can help deliver a coherent and resilient ecological network and promote the notion of *Ecological Restoration Zones*, as an important part of the solution.

[2] Regional Opportunity Maps have been produced over the past five years by consortia of local and national voluntary conservation organisations and agencies to map out potential areas for habitat restoration and creation.

[3] http://www.wetlandvision.org.uk/

Figure 6. Prioritising action
Four very different areas of England suggest different priorities for enhancing ecological networks, ranging from a landscape with large areas of semi-natural habitat (a) to one with very little (d). In all cases, the first priority is, however, to ensure existing wildlife sites are of good quality (see text).

5.2.2 Enhancing small-scale heterogeneity

Variety is the spice of life, and many of England's landscapes have become increasingly monotonous. There are fewer 'messy edges' (ecotones), ponds, old hedges, rough corners in fields, gaps in the woodland canopy and so on than there used to be. Putting more heterogeneity, in all its forms, back into the landscape as part of better management and habitat recreation and restoration is essential, and often simple to do. More healthy ponds (Section 4.3.4), for example, mean a lot more wildlife (Halliday 2010). The *Batscapes Project* led by Bath and North East Somerset Council between 2003 and 2007, involving 35 different land-holdings, promoting a wide range of community-led activities; a key feature was protecting and enhancing bits of the landscape important for bats (Haysom *et al*. 2010). More of such activities will make a real difference. Indeed, studies have found that habitat heterogeneity can be more important than size in influencing the species diversity of wildlife sites (Báldi 2008).

5.2.3 Re-wilding

'Re-wilding' is a term that has been introduced in recent years to mean areas where nature is simply left to get on with itself, without human intervention. To many people it is more than simply large-scale habitat re-creation and nature conservation (British Ecological Society & Natural England, 2009). In the Netherlands, establishment of the Oostvaadersplassen - 6000 ha of open water, marshland and wet and dry grassland with trees and shrubs – has captured the attention of conservationists, but also divided them. To sharpen debate, 6000 ha is an area c. 8km x 8km, or a bit smaller than a 10km square on an English OS map, so it is large, but not very large on a world view. But for a crowded country, it is big.

The Oostvaadersplassen can be seen as 'pure' re-wilding, but the term has also been applied to other less extreme projects, for example the reduction of management intervention at the 'Knepp wildland' project in Sussex or in Ennerdale in the English Lake District. In Ennerdale, Galloway cattle are managed, but otherwise the valley relies strongly on natural processes to shape its landscape and ecology, in the manner envisaged in Section 5.1.3 for all big protected areas.

Re-wilding may be part of the suite of options for future conservation but it cannot be a substitute for the need to restore wildlife habitats closer to people over large areas of the country.

5.2.4 Re-introductions

Many species have disappeared from large areas of the country where they were once common, and some are now extinct in England (Section 2.1.3). With no source populations nearby, or none at all, habitat re-creation and restoration alone will not bring back species to large parts of England. Under these circumstances, re-introduction of species may be appropriate. It can also be spectacularly successful when coupled with careful habitat re-creation, restoration and management, for instance the restoration of rotational scrub burning and intensive grazing for the Large Blue butterfly, re-introduced in Devonshire (Section 2.1.3). Red Kites now grace the skies over large areas of England after successful

re-introduction programmes. So we are in favour of carefully targeted re-introductions, particularly of charismatic 'flagship' species that enrich England's wildlife, and often allow other threatened, but still surviving species to flourish alongside them.

But we also add a note of caution. Re-introductions are often expensive, time consuming, and difficult (although there are exceptions, e.g. see Maitland & Craig 2010). To date there have been very few successful re-introductions of species extinct in England (and by 'successful' we mean that the species has re-established a self-sustaining population that requires no human intervention other than habitat management). There are a very large number of threatened species and no real prospect of ever being able to re-introduce any more than a handful of them were we to lose them. Reintroductions will be few and far between - better to protect and enhance what we have got than to strive to put them back after they have gone.

5.2.5 If we add to the network should we discard any existing bits that are no longer fit for purpose?

Are there situations where we should consider de-designating sites, even SSSIs? The answer cannot be "never", and there will be some situations where sites cannot be sustained or repaired, but in our view it should be "very rarely". The question assumes that there are sites that no longer serve (and crucially could not be made to serve, now or in the future) useful conservation purposes. Many designated sites have a set of characteristics such as low fertility soils associated with high species richness (Grime et al, 1973) as well as varied hydrology, soils, geology and landform which result in high habitat diversity, the main determinant of species richness in many ecosystems (e.g. Rosenzweig 1995). If areas are under-performing we need to understand why, and consider whether they could be restored to spaces for nature by following the approaches laid out in this Section and Section 6.

5.3 Climate change

All these prescriptions will inevitably be affected by climate change as we look to the mid-point of this century. The potential impacts on England's wildlife are summarised in Section 3.2. To maximise the capacity of England's wildlife to cope with climate change we need to ensure the network of protected areas is as robust and resilient as possible to current conditions. The options laid out in the preceding sections, and the approaches to deliver them summarised in Section 6, are needed now; but they will become increasingly important in the future.

The responses of conservation managers to climate change can be grouped under four headings:

- Ensure we have excellent management of all parts of the network, to increase the population sizes of threatened species, reduce the risks of local extinction, and to provide colonists for new sites.
- Allow species to migrate naturally to stay within their climate envelope. The importance of increased connectivity (stepping stones, corridors and a more benign matrix) to allow species to move significant distances is obvious in this context. But

many species with very poor powers of dispersal, and those in poorly connected landscapes will be unable to move fast or far enough to survive.

- Deliberately move species to new areas outside their current geographic ranges. This very notion deeply divides the conservation community, and can pose significant legal problems if a species is not currently found in the wild in England, but could survive here if introduced. In practice, time and cost probably means that relatively few species, native or non-native, are likely to be considered for serious deliberate translocation beyond their current geographic ranges.
- Promote landscape level heterogeneity within protected areas, to enhance the chances of species to stay within their climate envelope by small-scale, local movements, rather than longer-distance dispersal (Hopkins *et al.* 2007). As touched upon in Section 5.1.3 (Bigger sites), this is an argument for large protected areas, embracing geological, hydrological and topological diversity. Habitat heterogeneity can buffer populations against climate variation and has been shown to promote population stability (Oliver *et al.* 2010). To capture the idea simply, butterflies or plants currently living on the south side of the hill may find refuge by 2050 further up the hill, or on its north side. Looking at it another way, a 1˚C decrease in temperature equates to moving 100 km towards the pole or 130 m uphill (Hopkins 1922; Kerr & Kharouba 2007) so avoiding (at least some of) the impacts of climate change is about 1,000 times easier by moving uphill than by changing latitude. In the longer run, of course, this approach may fail; but it is an intelligent component of adaptive management. On the time-scale envisioned in this report it offers the best prospect for many species in a changing world, and is a critical component of making space for nature.

5.4 Conclusions

To make space for nature we need more, bigger, better and joined up sites to create a sustainable, resilient and more effective ecological network for England. Practically this requires actions under five headings, all of which we currently do to a greater or lesser extent. So we need to do more to:

- Improve the quality of current sites by better habitat management.
- Increase the size of current wildlife sites.
- Enhance connections between, or join up, sites, either through physical corridors, or through ‘stepping stones’.
- Create new sites.
- Reduce the pressures on wildlife by improving the wider environment, including through buffering wildlife sites.

These actions will help to establish an ecological network that meets the needs for wildlife and people today, and one that is more resilient to the future. There are trade-offs between these actions: the more we do to improve the quality of existing sites or to enhance the wider environment, the less we will need to do to create new sites. Our actions need to be adaptive, adjusting to what works as we progress.

We now turn to the approaches required to achieve these ends. As we will see, they are varied and delivering each goal almost always requires the use of several approaches. Like Section 5, Section 6 is not prescriptive. What is most suitable to achieve the network objectives for one part of England or for one type of habitat, may be very different for another, and will be strongly influenced by local opportunities and aspirations. We provide a repair manual, not a detailed plan.

6. Establishing a coherent and resilient ecological network

6.1 Introduction

We have come through a time of significant wildlife declines but now have the opportunity to turn the tide and embrace a new, visionary restorative phase of nature conservation (section 2.1.4) to create a resilient and more coherent ecological network. We are at a pivotal point.

The previous Section laid out guiding ecological principles for achieving this aim. As we have repeatedly argued, we are defining a direction of travel that will only be achieved by consensus and collaboration, rather than a highly prescriptive blueprint for exactly where the network must be enhanced. Nor is there any suggestion that everything has to be done everywhere. What will be appropriate in one part of England may not be appropriate in another. Required actions fit into a hierarchy with better management first, and the creation of physical linear corridors last (Section 5.1).

The approaches for achieving these ends are varied, and delivering each goal almost always requires the use of several levers. This section considers these different approaches, and makes recommendations about the actions that follow to make them effective. We must never lose sight of the fact that we are seeking a step-change in the way we deliver nature conservation in England. Without that step change all the evidence points to the fact that the slow, downward spiral of wildlife loss will inevitably continue.

Our recommendations are wide-ranging – they need to be because of the scale of the challenges - but there are five big messages in this section:

(i) The management and condition of England's current series of wildlife sites, particularly the SSSIs, has improved markedly in the last decade (Section 2.1.4). It is the beginning of a great success story and the momentum must not be lost. Anything we do to enhance the network further must not detract from the ongoing need to manage existing wildlife sites to the highest standards. If we do not achieve this, all other efforts will be depressingly pointless.

(ii) We need to properly plan ecological networks, including restoration areas. Restoration needs to take place throughout England. However, in some areas, both the scale of what can be delivered to enhance the network, and the ensuing benefits for wildlife and people, will be very high. These large areas should be formally recognised as *Ecological Restoration Zones* (ERZs), using all the levers at our disposal. ERZs are the gold-standard for places where we should focus efforts to achieve the shift to the restorative phase of nature conservation.

(iii) There are a large number of surviving patches of wildlife habitat scattered across England outside SSSIs. Many of them, but by no means all, are recognised as Local Wildlife Sites (Section 4.1.1). Most are both poorly protected and poorly managed. Many of these sites have the potential to make an important contribution to an enhanced ecological network, and some will be particularly significant in this regard.

Several of the approaches in this section offer opportunities to both better manage and better protect them.

(iv) There are many things that society has to do that may seem to have rather little to do with nature conservation, but could have, or even should have if we embrace more radical thinking. There are many more win-wins that we are currently not making the most of, representing a waste of resources. Ecosystem service provision (Section 2.1.1) is a clear example, where society's need to maintain water-quality, manage inland flooding, deal with coastal erosion, and enhance carbon storage (to name but four), if thought about creatively, can deliver significant societal benefits, and a more effective ecological network.

(v) We will not achieve a step-change in nature conservation in England without society accepting that is necessary, desirable, and achievable. This will require strong leadership from government and a step-change in collaboration between local authorities, local communities, statutory agencies, the voluntary and private sectors, farmers, landowners and other land-managers and individual citizens. It will require education, explanation, and empowerment. It will also require resources, both money and people. It cannot be 'top down' and imposed. Nor can it be entirely laissez-faire. It won't be easy. But it can be done.

Climate change looms over all our efforts to enhance England's ecological network. Bluntly, it threatens our wildlife, but it also, paradoxically, creates opportunities and requires some advances in our thinking about the designation of sites and their management. A larger, more effective ecological network is one of the mechanisms that will help society cope with climate change, by restoring hydrological processes for instance, or by providing significant green-spaces in our towns and cities to reduce the heat-island effect.

The sections that follow explain the approaches to deliver our vision. We make 24 recommendations, which together make a coherent package. First, in section 6.2 we deal with the things we must do to identify and protect the components of the network – the role of local planning for example. Then we move on to the critical role that management must play in section 6.3, followed by approaches that can be deployed to create new components in section 6.4. We briefly consider how we can enhance the wider countryside, and in doing so reduce some of the pressure on the network in section 6.5, and make a final recommendation to the Secretary of State about monitoring and evaluating progress in Section 6.6. None of this will be achieved without money. We conclude with a discussion about resources in Section 6.7.

6.2 Identifying and protecting England's ecological network

Establishing a coherent and resilient ecological network requires careful planning to ensure the contributions made by existing network components are maximised and new components, such as planned restoration areas, corridors and buffers, are in effective places, thereby ensuring we use precious resources and land in the most efficient ways. Strong protection of existing semi-natural habitats is generally the most cost-effective strategy, because replacing destroyed habitats is more expensive and technically difficult

than retaining them in the first place, and for some habitats it is impossible on any realistic time-scale (Section 2.1.3).

In this section we consider how we can better plan and protect the various components of an ecological network without imposing unreasonable additional burdens on landowners and land managers. We consider the need for proper planning to achieve a coherent ecological network; the need to protect wider ecosystem services as well as current biodiversity; the role of publicly owned land in protecting the network; the part designation can play; and finally we consider other wider measures that provide protection to ecological networks.

Protection does not necessarily mean designation. The wildlife sites and other areas that form part of, and surround, the network all belong to someone and the most direct way of securing the network is through sympathetic ownership and management of the land. Private landowners are crucial stewards of the countryside, and many invest resources in enhancing wildlife over and beyond those which they receive through incentive schemes (which are discussed later). Conservation NGOs also own and/or manage a significant amount of land and make an invaluable contribution to wildlife conservation.

6.2.1 Planning a coherent and resilient network

We need a coordinated spatial approach, with strong leadership, that enables ecological networks to be properly identified. This will require identifying existing and potential network components, including areas important for the functioning of ecological processes, and including places where restoration will occur. England's planning system is well suited to this task. Key principles of spatial planning include:

- shared vision;
- long term focus;
- multi-stakeholder involvement and ownership;
- coordinated and integrated action; and
- joint working across jurisdictions and boundaries.

The need for strong local ownership and involvement in the establishment of a more coherent network, mean that local authorities have an obvious lead role in identifying and mapping ecological networks. They already have a 'biodiversity duty' under section 40 of the Natural Environment and Rural Communities Act 2006 (see Section 6.2.4). A recent review of this duty (ENTEC 2010) concluded that, although the duty had generally had a positive impact, performance and understanding is very variable across local authorities. The review recommended that the Government should take action to support improved implementation. Given the importance of establishing ecological networks to fulfilling their biodiversity duty, we urge the Government to rapidly clarify that the duty on local authorities includes planning coherent and resilient ecological networks, including restoration areas.

Significant progress towards the kind of spatial plans that are needed has been made by the various biodiversity mapping initiatives that have already occurred across England, including Living Landscapes, Futurescapes, Regional Opportunity Maps and the Wetland Vision for England (see Section 5.2.1). We recommend that these approaches are built on and refined. In addition, because many ecological networks will cover more than a single local authority's

jurisdiction, local planning authorities will have to work together. We consider that National Character Areas (Section 4.3.4) provide a good spatial basis for ecological networks. To ensure locally led initiatives contribute to a coherent network for England, they also need to be informed by a national framework and supported by the expertise that resides in national agencies, voluntary conservation bodies and landowners.

Recommendation 1. Local authorities should ensure that ecological networks, including areas for restoration, are identified and protected through local planning. Government should support local authorities in this role by clarifying that their biodiversity duty includes planning coherent and resilient ecological networks.

An effective and efficient planning system is fundamental if we are to deliver a coherent and resilient ecological network. The planning system does not provide outright protection to any sites but it has an essential role to play in ensuring that the presence of a wildlife interest is recognised and properly taken into account in decisions about land-use.

Policy has long recognised the importance of designated sites in relation to competing land uses (most recently in Planning Policy Statement 9 'Biodiversity and Geological Conservation' and draft PPS 'Planning for a Natural and Healthy Environment, Communities and Local Government, March 2010'). However, a stronger presumption against inappropriate development, as currently applies to Green Belts, should be considered for other network components, for example through the proposed National Planning Policy Framework.

Recommendation 2. Planning policy and practice should:

- **continue to provide the strongest protection to internationally important sites and strong protection from inappropriate development to SSSIs.**
- **provide greater protection to other priority habitats and features that form part of ecological networks, particularly Local Wildlife Sites, ancient woodland and other priority BAP habitats.**

6.2.2 Ecological Restoration Zones

As plans for ecological networks are developed it will be possible to make the network bigger, better and more connected throughout England (including urban areas), for the benefit of both wildlife and people. There will, however, also be some areas within which both the scale of what can be delivered and the scale of the benefits will be very high. These areas should be formally recognised as *Ecological Restoration Zones* (ERZs). Although the characteristics of ERZs will vary across the country according to what is possible and what is needed, these will be places where:

- a shared vision for an enhanced, resilient natural environment exists among local communities, landowners, local authorities, NGOs and government agencies;
- significant enhancements of the ecological network over large areas are planned (and subsequently implemented) by enlarging and enhancing existing wildlife sites, improving the ecological connectivity between sites and/or creating new wildlife sites;

- the surrounding land use is better integrated with the management of the network, so that businesses remain profitable while reducing the pressures upon sites and improving the ability of wildlife to move between them;
- wildlife habitats and underpinning ecosystem processes are restored, so that the ecological network is both better able to cope with pressures and change, and can help to reduce climate change and its impacts; and
- people are inspired by their enhanced experience of the natural world.

Ecological Restoration Zones are fundamental to the step-change that is needed if we are to establish a coherent and resilient ecological network. Doing so will require investment but, as we have explained elsewhere (Section 2.1.1), the value of the ecosystem services provided will, particularly over the longer term, often far outweigh any cost.

> **Recommendation 3. Ecological Restoration Zones (ERZs) need to be established that operate over large, discrete areas within which significant enhancements of ecological networks are achieved, by enhancing existing wildlife sites, improving ecological connections and restoring ecological processes. We further recommend:**
>
> - **ERZs should be proposed and implemented by consortia of local authorities, local communities and landowners, the private sector and voluntary conservation organisations, supported by national agencies.**
> - **To start and support this process, and recognising current financial constraints, we also recommend resources be provided, which can be accessed through a competition, to implement 12 ERZs in the next three years.**

Many of the approaches and financial levers that follow for establishing a more coherent and resilient ecological network as a whole are also, of course, means by which ERZs can be delivered. In terms of the resources for the competition that we recommend be established, we anticipate that these could come from a range of sources across public, voluntary and private sectors.

6.2.3 Identifying and protecting ecosystem services

The natural environment provides ecosystem services that are essential for our well-being, health and economy (see section 2.1.1). An important aim for England's ecological network is to restore underpinning ecological and physical processes to secure the provision of these services (section 2.3). In this section, we discuss four of them: space for water, space for dynamic coasts, space for carbon storage and space for people to enjoy the natural world. All four involve activities that as a society we need, or want, to do anyway, and in which we must invest. This section is about encouraging smarter investment to deliver multiple benefits, for instance, better management of water *and* making space for nature. (We reserve consideration of direct payments to landowners for ecosystem services for section 6.3.4.)

Space for water

Water, too much and too little, poses serious risks for society, and we have to manage these risks. Climate change will bring more extreme weather, with drier summers and more intense rainstorms, for example, and will make difficult problems more difficult.

Simplifying, water management can involve 'hard' solutions and 'soft' solutions. Hard solutions ('pouring concrete') will at times be needed. But we are also coming to realise that soft solutions have much to offer. If designed correctly, they can deliver the security that society demands in a cost-effective way, and be highly beneficial to wildlife, and allow us to retain the flexibility for adaptive management in the face of an uncertain climate future. Examples include: reservoirs with 'natural' banks and bays; Sustainable Drainage Systems (SuDS); the restoration of river meanders, upland peat-bogs (see below) and lowland wetlands to hold back flood-water; and reedbeds to remove pollutants (not least those causing eutrophication – see Section 2.1.3). Water companies often find that positive land management is by far the most cost effective way of addressing water quality problems (e.g. see Box 6). By using the Periodic Review mechanism to fund land management rather than new water treatment works, they save customers money, as well as unlocking potentially huge benefits for wildlife. A legal framework already exists to use soft solutions much more effectively - the Water Framework Directive (WFD).

The Water Framework Directive encourages management at catchment scales to protect inland and coastal waters, as well as groundwater. It requires Member States to 'aim to achieve good status' in all water bodies by 2015 taking account of both ecological and chemical qualities. In response, in 2009 the Environment Agency published River Basin Management Plans (RBMPs) that classify and set objectives for water bodies which include around 40% of England's rivers, our largest lakes, water-dependent Natura 2000 sites and 170 SSSIs. These plans indicate that despite considerable progress to tackle acute pollution over the past 20 years, major problems still remain: 22% of rivers and 25% of all water bodies met 'good status' requirements in 2009, a figure that is set to grow to around 30% by 2015. Because they take a whole-system approach, RBMPs potentially provide a basis for protecting and enhancing the inland and coastal freshwater components of an ecological network. Flood and Coastal Erosion Risk Management also has a key role to play in shaping the freshwater environment. Together these plans provide an opportunity to integrate the design of ecological networks with our needs to manage water now and into the future. This will require leadership, and full engagement with landowners and other stakeholders.

Recommendation 4. Public bodies and statutory undertakers planning the management of water resources should:

- **make space for water and wildlife along rivers and around wetlands;**
- **restore natural processes in river catchments, including in ways that support climate change adaptation and mitigation; and**
- **accelerate the programme to reduce nutrient overload, particularly from diffuse pollution.**

Box 6. Working Wetlands: a partnership of farmers, industry and conservation in a Living Landscape

The Devon Wildlife Trust's Working Wetlands project is a 7 year Living Landscape initiative established in 2008 and working in the Culm area of northern Devon. This is a rich landscape shaped by centuries of farming. The project focuses on 65,000 hectares of land which represents the headwaters and main tributaries of 4 major rivers (Taw, Torridge, Exe and Tamar) where concentrations of wildlife-rich habitats are found, including internationally important Culm grasslands and populations of rare species such as Marsh Fritillary butterflies. Working Wetlands aims to supports farmers to maintain these wildlife-rich habitats in good condition, and to restore or re-create habitats that have been neglected or lost. The project provides an integrated package to farmers including free whole-holding advice, help in securing Environmental Stewardship, the loan of specialist machinery, and grazing services for wildlife-rich habitats. Training and advice is also provided to help ensure key rural skills such as winter swaling are not lost to future generations.

Working Wetlands has recently joined forces with South West Water (SWW). As part of the water industry's 2009 Periodic Review, Ofwat agreed that SWW and other water companies could invest in land and assets outside their ownership. Between 2010 and 2015 SWW will invest almost £9m in their *Upstream Thinking* initiative, which aims to provide clean water through helping landowners choose farming methods which enhance water quality while also protecting natural resources and improving the quality of wildlife habitats. SWW has calculated that the benefit-to-cost ratio of *Upstream Thinking* is over 65:1. By investing in schemes to develop cleaner more reliable water supplies the company can reduce costly and energy-intensive water treatment projects.

In just two years, Working Wetlands has worked with farmers to bring over 700 hectares of Culm grasslands into recovering or favourable condition. The project has overseen restoration of Culm grassland on over 73 hectares of former Sitka spruce plantation and 50 hectares of improved grassland, helping to reconnect areas of Culm grassland across the landscape. It has secured positive land management changes to over 45km of riverside land. The project is creating a Living Landscape whilst also providing a financial life-line for farmers and a cost effective means of improving water quality.

Space for dynamic coasts

As with freshwater, as a society we have to invest in coastal management, and again using soft solutions - exploiting natural ecosystem services to deliver effective coastal zone management - can bring considerable benefits for wildlife. For example salt-marshes are very significant carbon sinks. Salt-marshes, mudflats, shingle beaches and sand dunes provide natural flood defences from the sea by reducing the energy of waves and acting as barriers to storms and high tides (see also Section 4.3.1). All these habitats are important for wildlife. It also makes sense to maintain them, and in appropriate places re-create them, to protect people and property. Climate change, which will lead to sea level rise and increased incidence of severe storm events, means that we will need these natural defences more than ever in the future.

Obviously hard solutions – built coastal defences – will continue to be essential along large stretches of England's coast. But rising sea-levels and the increasing costs of maintaining hard defences mean that along some stretches of coast the existing built defences will become unsustainable (section 2.1.3). Indeed this is already happening in parts of England. Abandoning hard defences is hugely controversial, but in some places the most cost-effective shoreline management solution may be to re-align the coast to protect people and property further inland, and at the same time making space for nature on a dynamic coast.

Recommendation 5. Authorities responsible for measures to reduce the risks from coastal erosion and flooding should do so in ways that enhance ecological networks where possible. This can be achieved by taking full account of the natural dynamism and functioning of the coast, thereby allowing wildlife and habitats to move and evolve.

Space for carbon storage

We have already noted that salt-marshes store carbon. So do many other ecosystems. Across the UK as a whole, woodlands store around 150 million tonnes of carbon in their soils and trees (Broadmeadow & Matthews 2003). The Forestry Commission plans to increase the area of woodlands in England to sequester more carbon. We believe these plans can go hand-in-hand with plans to enhance England's ecological network, providing trees are not planted on open habitats that are themselves important for wildlife such as chalk grasslands and heathlands.

In contrast, other important carbon-storing habitats, including species-rich grasslands and particularly peatlands (Section 4.3.1), are not adequately protected or even properly recognised for the contribution they could make to mitigating climate change. Peat soils in England are estimated to store 296 million tonnes of carbon (Bradley *et al.* 2005), roughly equivalent to two years of total UK carbon emissions. In an undamaged state, peat remains wet at the surface all year sequestering between 0.1 - 0.5 tonnes of carbon per hectare per year (Dawson & Smith 2007), but in reality many of our peatlands are degraded by drainage, burning and conversion to other land use and under these conditions they become net emitters of large quantities of carbon (Thompson 2008).

In the context of ecological networks, substantial areas of peat (particularly in upland areas of England) are already designated because of their wildlife value and much of the remainder is within our National Parks. Lowland peat is generally less well protected. Improved management for wildlife largely matches what is needed to improve carbon storage and so there is considerable scope to align society's need to reduce green house gas emissions with peatland conservation. These same actions will also bring additional benefits in terms of water quality and water-flow management. At present there seem to be no coherent plans to achieve these multiple benefits.

Recommendation 6: Government should produce a strategy to ensure that we protect and secure multiple benefits from our carbon-rich soils and peatlands, and maximise their contribution to ecological networks.

Natural spaces for people

The natural world contributes to people's health, well-being and quality of life. There is compelling evidence that access to natural spaces provides a wide range of benefits to people, including improved physical and mental health, greater self-esteem and improved concentration levels in children (Section 4.3.5). Natural spaces can also help foster pride and a sense of belonging among local communities, and reduce anti-social behaviour (Communities and Local Government 2007). Establishing more coherent and resilient ecological networks will help to secure these benefits for more people, particularly in towns and cities, where more than 80% of us live and where the disconnect with nature is often greatest.

Towns and cities in England contain a wide variety of green spaces, some of which are already recognised as important wildlife sites including SSSIs and Local Nature Reserves. They also contain brownfield sites, parks, playing fields, allotments, cemeteries, churchyards and gardens which can support wildlife; indeed, some urban areas are richer in plants and animals than nearby intensively used countryside. Urban green spaces, particularly those with substantial numbers of trees are also extremely important in reducing the 'urban heat-island' effect (Royal Commission on Environmental Pollution 2007), a benefit that will become more important with climate change.

Techniques are improving to integrate the traditional management of urban green spaces with wildlife-friendly approaches, from simple things like mowing regimes (see Box 7) to sustainable drainage systems (SuDS) and the design of buildings. We welcome the coalition government's commitment to "*create a new designation – similar to SSSIs - to protect green areas of particular importance to local communities"* and we encourage government and local authorities to ensure that this new designation is at the heart of ecological networks in our towns and cities (as well as rural areas) delivering benefits for people and wildlife.

Recommendation 7. Responsible authorities should take greater steps to reconnect people to nature by enhancing ecological networks within urban environments, including wildlife-friendly management of green spaces, and by embedding biodiversity considerations in the need to adapt to climate change.

Box 7. Natural asset management in Stoke on Trent

In Stoke on Trent, the City Council has launched a Natural Assets group, which brings together the local bodies for wildlife and space management. The group, chaired by the Local Authority, includes Natural England, Staffordshire Wildlife Trust, the Woodland Trust, British Waterways, Groundwork, current regional bodies, the Environment Agency and is supported by a secretariat from the Forestry Commission.

By understanding and aligning each others' agendas the group is determining where maximum synergies can be achieved. For example, with the joint aim of making space for nature and creating appropriate wildlife corridors, the group is has mapped their combined land holdings and forward plans, to see what can be created and safeguarded. This has for the first time graphically illustrated

where the gaps and opportunities lie.

One immediate outcome from this work has been that the city council has aligned its abundance of low-grade, tractor mown public open space with the tree planting and woodland creation priorities of the Woodland Trust. There are now new proposals for future woodlands with plans for over 6,000 trees to be planted over the next 3 years. Another option being explored with Staffordshire Wildlife Trust is to use green hay, or wild flower seed, from its nearby Churnet Valley Living Landscape to transform swathes of amenity grassland into valuable wildlife corridors that can link the City to its rural hinterland.

6.2.4 Protecting and managing elements of the network in public ownership

A large area of land is owned by national and local government and other public bodies. We should not underestimate the important role that this land already has, and potentially could have, in securing England's ecological network. For example, public bodies (as defined under s28G of the Wildlife and Countryside Act 1981) own nearly 50% of all terrestrial SSSIs (Natural England data 2008).

Some of this land is critical to England's ecological network. In some cases, this land was acquired for a purpose that protected its ecological interest as an unforeseen by-product, such as military training land held by MoD, or flood risk management land held by the Environment Agency. In other cases, land was acquired specifically because it was of the highest ecological importance, such as by the predecessor bodies to Natural England and the National Parks, to protect and manage it for future generations. We do not expect there to be a net increase in the area of land owned by government, indeed the trend may be in the opposite direction. Therefore, any disposal of the public estate must protect the role this land plays within England's current and future ecological network, particularly for the highest value wildlife sites, such as National Nature Reserves.

Public landowners include a diverse range of agencies, institutions and organisations, for example the Prison Service, Highways Agency, local authorities, schools and internal drainage boards. Although the land owned by these organisations has to perform many functions, we have no doubt it could continue to fulfil these while also making a more significant contribution to England's ecological network. Solutions that take better account of nature while also delivering other benefits can often prove cost-effective. Wildlife-friendly planting of grass verges can, for example reduce maintenance costs (see also box 7). These solutions also provide many opportunities to enhance people's access to, and understanding of, nature.

All public bodies have a 'biodiversity duty' under section 40 of the Natural Environment and Rural Communities Act 2006 which gives them a responsibility to have regard to the purpose of the conservation of biodiversity. Associated government guidance on complying with this duty (Defra 2008) emphasises that conservation includes taking steps to restore and enhance biodiversity. We believe that there is scope to achieve much effective conservation action on publicly owned land, and we have already recommended that this duty on local authorities be clarified to emphasise the essential contribution of ecological networks to meeting the duty's aims (recommendation 1).

Recommendation 8. Public bodies owning land which includes components of England's current or future ecological network should do more to realise its potential, in line with their biodiversity duty. Further, before disposal of any public land, the impact on the ecological network should be fully evaluated. Where such land is identified as having high wildlife value (existing or potential) it should not be disposed of unless its wildlife value is secured for the future.

6.2.5 Protection through designation or purchase

Across different systems of site designated (see section 4.3.3), only SSSIs and European designations (the 'Natura 2000' sites, which on land are all also SSSIs), provide high levels of protection to components of the ecological network. Other designations, notably Local Wildlife Sites, do not receive sufficient protection. There appear to be three options which are not mutually exclusive: we either need to find different, better ways of protecting Local Wildlife sites and other remaining areas of semi-natural habitat of high wildlife value (in particular BAP priority habitats) through the planning system (Section 6.2.1); or we need to provide incentives for private owners to secure their future (for example see Section 6.3.3); or we need to designate more areas as SSSIs (for example, where key gaps in the SSSI series exists, Section 4.3). In practice, a combination of these three approaches is likely to be the most cost-effective solution.

Although incentives will often be the preferred solution, there may also be times when, in consultation with landowners, purchase of critical sites proves to be the most cost effective and appropriate solution to help achieve the aims of England's ecological network. For example, one option to prevent the continuing losses of upland hay meadows (a habitat that is now extremely rare, see Section 4.3.2) would be to buy them from willing vendors. Based on current land prices (RICS report 2010) we estimate that purchasing the entire non-SSSI resource of upland hay meadows would cost approximately £3 million - £5 million.

Recommendation 9. The government should ensure that the remaining areas of high conservation value that currently are not well protected are effectively safeguarded.

If SSSIs (or indeed other wildlife sites) are to form the backbone of a more coherent and resilient ecological network in future, they need to better take account of climate change and the need to protect ecosystem functions and dynamic processes. Most SSSIs have been notified for specific wildlife features, for instance particular species (see section 4.1.1), and consequently most do not specifically protect these wider functions, such as hydrological processes. There are, however, recent cases where SSSIs have indeed been designated to do so, for example notification of parts of the Humber estuary SSSI took account of the dynamic nature of the coast and allowed for 50 years of predicted change. This approach to designations needs to become the norm.

Recommendation 10. When determining the boundaries of designated sites, responsible authorities should take better account of the need to support underpinning ecological processes and of anticipated environmental change.

6.3 Managing components of the ecological network

Effective management of wildlife sites is critical to the functioning of the ecological network. In many areas it will be the single most important requirement (Section 5.1.2).

In this section we consider the extent to which existing approaches are sufficient to provide effective management for components of the network. We consider the management of designated wildlife sites; the contribution of our large areas of protected landscapes; the role of financial incentives schemes in supporting management of sites; potential new approaches relating to payment for wider ecosystem services; and finally we consider the essential role of high quality and integrated advice and support to land managers. In doing so, we assess the financial mechanisms, regulatory controls and other approaches that are available to manage ecological networks and consider how these could be developed or better deployed to improve their coherence and resilience.

6.3.1 Managing designated wildlife sites

The heart of England's ecological network needs to be high quality sites which support thriving populations of wildlife from which species can disperse to other parts of the network and which deliver a range of essential ecosystem services (Sections 2.2.3 and 5.1.2). Enormous progress has been made in recent years agreeing conservation objectives and putting management in place for Natura 2000 sites and other SSSIs (see Section 2.1.4) and yet, because ecological recovery takes time, 63% of SSSIs are still in 'unfavourable recovering' condition (Section 4.3.3), i.e. management approaches have been agreed or put in place, but the site is not yet meeting its objectives.

> **Recommendation 11. The recent progress in improving the management of SSSIs must be sustained, with the aim of moving the condition of sites from 'recovering' to 'favourable'. Investment in the management of the SSSI series must be maintained.**

The management of Local Wildlife Sites is an even greater cause for concern (Sections 2.1.4 and 4.3.3), with less than a third of sites under positive conservation management. No national assessment of the condition of these sites has been made. In the last couple of years, however, the awareness and management of LWS has improved as a result of local authority performance assessment indicator NI 197, which is currently under review. Whatever the future of local authority performance indicators, the recent positive trend in improving the management of Local Wildlife Sites needs to be sustained. This will require proper engagement with landowners so that they are aware that their land has been identified as LWS, together with the provision of management advice and support.

> **Recommendation 12. Local authorities should take responsibility for the identification and monitoring of Local Wildlife Sites and the management of LWS must be improved.**

Climate change will test the current management regimes of many of the sites within the network (Sections 3.2 and 5.3), and may require new approaches to setting conservation

objectives and new habitat management techniques and standards. This is obviously a challenge, but it is also an opportunity to evolve our approach to managing habitats including introducing new and cost-effective techniques.

Recommendation 13. Responsible bodies should revise conservation objectives for SSSIs and other wildlife sites to respond to the effects of climate change - in particular by aiming to enhance habitat diversity and support underpinning ecological processes, whilst taking account of the requirements of current species and habitats.

6.3.2 Managing protected landscapes

England's National Parks and Areas of Outstanding Natural Beauty frequently contain a richness of wildlife which contributes to their special qualities. Although they are designated for a number of reasons, the statutory purpose of both of these designations includes the conservation of nature (See Section 4.1.1), and they together contain more than 50% of SSSIs by area. Despite this, the evidence that protected landscapes provide biodiversity benefits over and above those delivered by SSSI or LWS designations outside these areas is mixed. Nonetheless these large areas undoubtedly provide an excellent base for delivering a more effective ecological network, not least because their legal standing, governance and management plans provide a basis for coordinated action to integrate effective ecological networks with landscape and other uses, including farming, education, recreation, tourism and the provision of other ecosystem services.

We believe that National Parks and AONBs should become exemplars of coherent and resilient ecological networks. This will require strong leadership and high levels of cooperation between landowners, public bodies, businesses and the voluntary sector.

Recommendation 14. In view of the opportunity presented by their existing statutory remits, in National Parks and AONBs:
(a) favourable condition of SSSIs should be achieved as quickly as possible;
(b) non-SSSI semi-natural habitat should be brought under management equivalent to SSSI standards; and
(c) other land should be managed so as to enhance connectivity.

6.3.3 Managing ecological networks through incentive schemes

Agri-environment schemes (AES), supported through the Common Agricultural Policy and co-financed by national funds, are currently the main mechanism for environmental management in the countryside. This includes funding for the management of Natura 2000 sites, SSSIs and other wildlife sites, provided they are not owned by central government or its agencies (local authority owned sites can receive agri-environment support). The two agri-environment schemes available in England are the English Woodland Grant Scheme (EWGS) and Environmental Stewardship. The EWGS, together with regulation and voluntary compliance with UK Forestry Standards, has successfully encouraged positive woodland management (Kirby 2003). Any future revision of AES should make provision for woodland management, but our main concerns lie with the future of Environmental Stewardship.

Managing wildlife sites through Environmental Stewardship

Initiated in England in 1987, and intended to cover implementation costs and replace the income which could be gained by farming land more intensively, agri-environment schemes for farmed areas of England have been progressively improved through a dedicated programme of research and evaluation. The current scheme, Environmental Stewardship (ES), is a multi-objective scheme which seeks to conserve wildlife as well as enhancing landscape, protecting the historic environment, promoting public access and protecting natural resources.

All agricultural land is eligible for ES, which has two tiers, Entry Level Stewardship (ELS) and Higher Level Stewardship (HLS). Within each tier there are a range of options available to landowners, providing the flexibility both to manage existing sites, restore other and to create new areas of habitat and other network features. HLS is best suited to the management of many ecological network components, and we discuss it here. ELS is more simple and flexible and we mainly consider its contribution in section 6.5.1.

HLS is a targeted scheme, designed so that agreements are primarily granted in areas that have been identified as important for achieving the scheme's biodiversity or other objectives. Agreements are also granted to sites outside target areas if they can deliver against key scheme objectives, enabling them to be used to manage designated sites, Local Wildlife Sites and additional areas containing priority BAP habitats or significant populations of priority species. Individual agreements are for 10 years and each is designed with the input of professional advisers. Significantly for the establishment of a coherent ecological network, options can include the restoration and creation of habitat.

HLS and its predecessor schemes have shown notable success in recovering populations of farmland birds (Peach *et al.* 2001; Bradbury *et al.* 2008) and other species (Woodcock *et al.* 2008), and priority habitats including hay meadows (Critchley *et al.* 2003) and calcareous grassland (Hewins *et al.* 2008; see Natural England 2009 and Box 8). Associated research and evaluation programmes have enabled the scheme to be progressively refined, to better achieve its objectives (e.g. Stevenson *et al.* 2007). HLS's main current limitations are the amount of total funds available and the fact that agreements can be quite complicated to set up and require considerable and ongoing advice to achieve the best quality agreements. Consequently, due to resource limitations, HLS is not available to all land managers. This needs to be addressed, as does the demonstration of the potential merits of the scheme to farmers and land managers, to encourage uptake; farmers already engaged in Environmental Stewardship have a key role to play in influencing others.

Despite these limitations, we consider HLS to be the single most important tool for managing many components of England's ecological network. Without it, moving the management of SSSIs towards favourable condition would have been impossible. It must be adequately resourced if it is to continue to be a suitable tool for managing core network sites. We do, however, have concerns about the 10 year term of HLS agreements. This may be a long time in terms of European and domestic funding streams, but it is not long in terms of many farm businesses and it is very short when considering the long-term aims of a resilient and coherent ecological network.

Recommendation 15. The Higher Level Scheme of Environmental Stewardship must be retained and properly resourced as the single most important tool for maintaining and expanding the most significant areas of priority habitat and populations of priority species. Consideration should be given to improving the quality of advice and putting longer term agreements in place to ensure sustained ecological benefits, while retaining the buy-in of land managers.

But HLS cannot be expected to deliver everything. At the moment, for example, there is no targeted mechanism that is suitable for establishing buffer zones and potentially ecotones within them (as described in Sections 2.2.3 and 5.1.1), nor to establish stepping stone habitats or corridors. Although HLS could be used to do this, it would be a high cost option. Instead, we see advantages in taking this kind of management forward through a simpler, lower-overhead, scheme that pays more than ELS and can be more precisely targeted.

To be successful, such a scheme would need to incorporate features designed to ensure environmental effectiveness without detailed one-to-one input from an advisor and as such, could be considered as an 'ELS-Plus'. These features might include regionally or locally tailored 'menus' or groupings of options, for example to buffer a particular site or sites. The scheme could include some relatively straightforward, but higher cost options, which are currently unsuited to ELS. These would allow it to fund, for example, arable reversion and hedgerow restoration.

Recommendation 16. A new type of Environmental Stewardship scheme is needed, particularly to help buffer sites and establish stepping stones and ecological corridors. This should be simple to administer, be available in key areas, and provide support for high cost but relatively simple management measures.

Box 8. Restoration of the Pevensey Levels

The Pevensey Levels cover 4,300 Ha of marshland between Eastbourne and Bexhill-on-Sea in East Sussex. It is designated as a Ramsar site and SSSI because of its outstanding importance for birds, plants and invertebrates which thrive in a mosaic of dykes, ponds and grasslands. Most of the land is owned and managed by private individuals but 184 ha of the area is designated a National Nature Reserve (NNR).

Twenty years ago, there was concern that there had been a significant loss of the wet grassland for which the site was designated and the associated breeding bird numbers were in chronic decline. Thanks to innovative land managers in the area, and support from Natural England advisers, the management of the whole area was improved through restoring water levels and improving cattle grazing. Today, funding is provided through the Higher Level Scheme. The whole area, not just not the NNR, now supports thriving wildlife. The agri-environment scheme funding has had a multitude of benefits, restoring an important wildlife habitat whilst keeping families and communities together, and allowing businesses to flourish.

6.3.4 Habitat management and enhancements through payment for ecosystem services

There has been a welcome increase in recent years in the creation of new, small-scale markets to fund nature conservation management. Some people are prepared to pay a premium for products that bring benefits for wildlife, for instance charcoal from coppiced woodlands, and meat or wool from livestock used for conservation grazing.

There is, however, enormous potential to capture wider values from the way we use and manage our land. Understanding the links between biodiversity and a wider range of ecosystem services is rapidly improving (sections 2.1.1 and 6.2.3) and we are increasingly able to place values on such services (e.g. Defra 2007). The urgent and logical next step is to develop markets that enable these values to be realised for services such as water quality, flood risk management, climate regulation and other benefits.

If we take into account the potential values of a broad range of ecosystem services, the benefits of establishing and managing a coherent and resilient ecological network could, in many situations, outweigh the costs many times over. There is an urgent need to develop market mechanisms through which landowners can realise the value of the ecosystem services that their land provides to society.

> **Recommendation 17. The government should promote economic approaches that will favour conservation management by stimulating the creation of new markets and payment for ecosystem services, to ensure that the values of a wider range of ecosystem services are taken into account in decisions that affect the management and use of the natural environment.**

6.3.5 Providing integrated advice and support for management of the network

Farmers and other land managers are critical to the success of establishing a coherent and resilient ecological network. As individuals, they are generally extremely adept at delivering outcomes (usually food) from their land. In doing so, they manage a complex suite of requirements and opportunities while optimising their allocation of assets. If we now require a different suite of environmental outcomes from our land, such as enhanced wildlife and other public goods, these same managers will undoubtedly be just as innovative and effective at delivering them, provided the incentives and policies are appropriate. But in order for them to deliver greater benefits for wildlife as one of the arms of their business, they need:

(i) Consistent and sensible regulation applied fairly and evenly across the industry.
(ii) Provision of the latest thinking, leadership and advice with evidence based knowledge and research in a manner which encourages changes in behaviour for the right business reasons. Personal contact, with knowledgeable advisers is important.

The overall aim should be to achieve a much more aligned and co-ordinated land-based activity, with coherent priorities that help to deliver the ecological network and other strategic outcomes for the public good in a transparent manner.

An opportunity exists to build on the Defra Whole Farm Approach by encouraging the development of 'Whole Farm Plans' which incorporate long term wildlife and environmental objectives alongside commercially driven (e.g. food production) objectives. These plans would reflect the individual circumstances of each land holding and integrate society's requirements (e.g. pollution control, wildlife habitat management across boundaries, establishment of buffer zones) with the commercial imperatives required to sustain a reasonable return for those owning and/or managing the land. Whole Farm Plans could be agreed at a local level and do much to re-engage agriculture with local communities. A key to success will be establishment of, ideally, a single point of contact for the farmer at a local level.

Recommendation 18. Government needs to establish a consistent, integrated and long-term expectation of land managers to deliver parts of the ecological network. In doing so, consideration should be given to:

- **providing more readily available, high quality advice; and**
- **developing the Defra Whole Farm Approach to provide an opportunity for those managing land to enter into a 'Whole Farm Plan' which integrates all aspects of a farm's environmental and productive potential, simplifies regulation, increases transparency and gives long term commitments to both farmer and the public.**

6.4 Establishing new components of the ecological network

Protecting and managing components of England's ecological network is essential, but will not be sufficient to make the network resilient and coherent. In some places we will need to establish new components (Sections 2.2.3, 5.1 and 6.2.2). Creating new habitat should not be undertaken lightly: it can be technically difficult; it needs to be done in the right places taking account of the underpinning soil, geology, hydrology and topography; and it represents a long-term commitment.

Many of the approaches that we discussed in the previous section can also support habitat creation. In particular, agri-environment schemes contain options for the management, restoration or establishment of different habitats. Here we focus on three additional approaches that we believe hold considerable potential for establishing new network components: better targeting of habitat creation and restoration efforts across public, private and NGO sectors; making existing connections that exist across our countryside function as ecological corridors; and a potential new funding mechanism for habitat creation through biodiversity offsets.

6.4.1 Establishing new wildlife sites through habitat creation and restoration

Habitat creation and restoration is already carried out or funded by a wide range of organisations including government departments and agencies, voluntary conservation organisations, the Heritage Lottery Fund, grant-giving charities, landfill tax bodies, businesses and private landowners (see Box 1). There are signs that the rate of habitat creation may increase in the future, at least for some habitats. For example the coalition government's commitment to launch a tree planting campaign could provide substantial

benefits for wildlife and people if, broadly speaking, the right trees are planted in the right places. Overall, we see a need to harness the significant potential to better focus on the delivery of an ecological network, in particular by supporting the restoration and creation of habitat in Ecological Restoration Zones.

Recommendation 19. Habitat creation by government and its agencies, grant-giving trusts, businesses and the voluntary sector requires greater focus on the needs of ecological networks, in particular the need to contribute to Ecological Restoration Zones.

Private land has enormous potential to deliver many of the enhancements to the network that are needed. Just as landowners can play an important role as effective stewards of existing wildlife habitats, we believe that they should also be properly rewarded to do more to create new habitats. This is a long-term commitment. Extending existing tax incentives to encourage the creation, improvement and long-term maintenance of wildlife habitats out of private resources would, we believe, be justified by the resulting environmental and social benefits. Landowners could be encouraged to respond to the challenge by the promise of reliefs from capital taxation no more generous than those that farmers and the owners of family businesses have been routinely allowed for many years. Income tax incentives might also play a useful part.

Recommendation 20. Government should consider extending tax incentives to encourage landowners to make long-term commitments to the creation of new wildlife habitats that benefit ecological networks.

6.4.2 Improving connections for wildlife

For wildlife sites to function as a network, it is important that organisms are able to move between them (Section 4.3.4). This requires ecological connectivity and there are a number of ways that this can be achieved, for example, we have already discussed the role of stepping stone habitats and improving the quality of land in between sites. There are also linear features that already exist which are well suited to enhancing connectivity across our countryside. These include both natural and made-made corridors such as rivers, canals (Box 9), road verges, hedges, cycle routes and railway embankments (Section 4.3.4). Managing these in wildlife-friendly ways can both improve ecological connectivity and also for some increase access to nature for people. Wildlife rich cycle routes and canal towpaths are obvious examples.

Recommendation 21. Public bodies and other authorities responsible for canals, railways, roads, cycle ways and other linear features in the landscape, should ensure that they better achieve their potential to be wildlife corridors, thereby enhancing the connectivity of ecological networks, and improving opportunities for people to enjoy wildlife.

Box 9. Canals create natural connections for wildlife and people

The canal network is one of the most accessible and well-used facilities for recreation in the country. It is not often appreciated that 96% of a waterways' use is on the land, not the water. A key strength of the waterway network is its multi-functionality and the links it creates between urban areas and the wider countryside. Canals and rivers also comprise high quality wildlife habitats, used by a wide range of species, including many that are rare or protected. British Waterways' network in England includes over 54 SSSIs, many of which are canal or navigable river.

In 2009 there were 346 million visits to waterway towpaths in Great Britain, of which over 80% were for leisure or recreation. Surveys of towpath visitors indicate that 62% consider that the presence of the waterway towpath helps increase the amount of physical activity they regularly take. Improving just a single kilometre of canal towpath will, typically, attract an additional 40,000 visits, generate a further £50,000 of visitor spend for local communities (securing 1.3 jobs), deliver quality of life benefits of £20,000 and up to £18,000 of additional health benefits, and save around 100 tonnes of CO_2 every year

Example - Droitwich Canals Restoration
The restoration of the Droitwich Canals will open up a 21 mile ring of cruising waterways in Worcestershire. The environmental benefits associated with the restoration include the creation of 5 ha of reedbed and the regeneration of 24 ha of biodiversity-rich brownfield land. The restoration will create a continuous wildlife corridor enabling priority species such as water vole, otter and bats to forage and disperse further afield. It is estimated that the completion of the restoration will result in 322,000 additional visitor days each year, 12000 cycling visits, 2000 canoe visits, 3500 angling visits and the creation of 196 full-time jobs. This is likely to contribute an additional £2.75 million to the local economy and an increase in the value of adjacent housing of over £3 million.

(Source: British Waterways)

6.4.3 Biodiversity offsetting and developer contributions

Biodiversity offsets established through the planning process are another mechanism that could be used to enhance ecological networks. Offsets are activities designed to compensate for residual and unavoidable harm to existing wildlife sites caused by development activity. We discuss the idea in some detail because it is not something that we have dealt with elsewhere in this report.

In England, mandatory offsetting is currently only required where development of overriding public interest has significant impacts on the Natura 2000 network or sites occupied by European protected species. Planning policy encourages, but does not absolutely require, local authorities to ensure compensation for development impacts on biodiversity (e.g. PPS9 through s106 agreements). Based on the evidence of developer contributions in England and other biodiversity offsetting schemes from around the world, including the use of 'conservation credits' and habitat banking in other countries, there are a number of principles that must underpin an effective system:

(i) Biodiversity offsetting must not become a 'licence to destroy' or damage existing habitat of recognised value. In other words, offsets must only be used to compensate for genuinely unavoidable damage. Development should avoid

adverse impacts first, mitigate impacts second and compensate for unavoidable impacts as a last resort.

(ii) Where developers propose to create replacement habitat there needs to be some certainty that the habitat type can be (re-)created. Applying the precautionary principle, and recognising that some habitat creation schemes may be less successful than initially planned, each individual offset scheme should aim to achieve a net gain for biodiversity.

(iii) Benefits should be secured in the long term with supporting mechanisms in place to deliver long term management (often more than 25 years).

(iv) There must be recognition that some habitats cannot be re-created (e.g. ancient woodland) while others can take decades to develop their wildlife interest.

(v) 'Receptor areas' for creating habitat must not be places of existing high wildlife value.

(vi) Suitable multiplier ratios need to be applied to compensation in recognition that the new site may be of a different value to the network than the original one, and to take account of factors such as distance from the site of the damage, the time needed for habitat creation, the types of habitat being lost and accessibility for people. Usually, these multipliers will be greater than one, but they need not always be.

(vii) Wherever possible, the created habitat should be in place before the original site is lost.

(viii) Offsets should be used to compensate both for the loss of current wildlife sites and for damage to other wildlife network components, for example areas identified as important for ecological restoration or connectivity but not yet managed as such.

(ix) Opportunities should be taken to pool habitat compensation from different developments so that larger habitat blocks can be created. There should be community agreement on what is to be achieved (and what contributions are expected) through local plans, so developers are clear at the outset what scale of contribution is expected from them.

We conclude that in the context of establishing and maintaining ecological networks:

a) There are risks that biodiversity offsetting could undermine ecological networks if they lead to any reduction in the levels of protection afforded to wildlife sites and habitats. It may be possible to mitigate these risks by ensuring that a system of biodiversity offsets is underpinned by a clear set of principles, as proposed above.

b) A well-managed scheme can bring benefits to the ecological network by effectively pooling a number of offsets required for separate small developments into a larger and more beneficial habitat block. This can be done without imposing additional burdens on developers.

c) The operation of a system of biodiversity offsets could deliver net gains for wildlife by providing an opportunity for developers (or other interested organisations) to buy additional *conservation credits* as part of their social responsibility commitments. The financial value of the credits could also

reflect the value of other ecosystem services such as carbon storage (Section 6.3.4)

d) A responsible authority needs to be identified to oversee the administration of biodiversity offset schemes and verify effective offset delivery.

e) We need to further develop the evidence base in a number of important areas including:
   - refining creation and restoration techniques for certain habitats;
   - establishing the appropriate multipliers needed to ensure full compensation, and developing rules for offsetting 'out of kind' (where damage to one type of habitat is compensated for by providing another);
   - verifying the market mechanisms through which biodiversity offsets can operate effectively in an English context.

We suggest that the evidence base is developed, and the overarching principles tested, through pilot schemes in willing local authority areas.

Recommendation 22. If a formal system of biodiversity offsets is to be introduced, pilot schemes should be established to test and refine its operation, to ensure it meets the conditions we have set out for a safe and effective system.

6.5 Improving the countryside

The ways in which the wider countryside outside the ecological network – the matrix – is managed is important. If the matrix is hostile, protected sites need to be large, but even small sites can support thriving wildlife if the land around them is sufficiently benign. A richer, less hostile environment around the network will also, in itself, provide space for nature and support the provision of ecosystem services at landscape scales.

One approach to reducing pressures is to establish buffers around specific sites (Section 2.1.3) and we have already identified the need for a new type of incentive measure for this purpose (Section 6.3.3)). Because this report is focussed on the network of wildlife sites, we have not provided a comprehensive assessment of ways to enhance the wider environment. Instead, we briefly consider the importance of voluntary incentives, before finally highlighting a number of other measures to reduce pressures on the network.

6.5.1 Entry Level Stewardship

Entry Level Stewardship (ELS) is designed to be a simple, multi-objective, flexible scheme, open to all agricultural land managers in England. It is the companion to the Higher Level Scheme (see section 6.3.3) and within it land managers are free to select any combination of options they feel suits their farming operation. Options are designed to be deliverable without advisory input or targeting, and as such are intended to be 'light touch' and to have minimal impacts on conventional and productive farming operations. The scheme is capable of delivering the requirements of some species with dispersed populations, able to improve the permeability of the wider countryside for some species, and to reduce inputs around priority

statutory or wildlife sites. The scheme is also able to provide financial incentives for some basic management, on habitats like low input grasslands.

ELS has been hugely popular with land managers with almost 67% of eligible agricultural land now under agreement. The 'hands off' approach means the scheme is relatively inexpensive to administer, and processing of agreements is quick and simple. Agreements are for 5 years. To date, the scheme has, however, been generally less successful than was hoped at delivering conservation outcomes (Davey *et al.* 2010), although benefits from particular options have been demonstrated (Field *et al.* 2010; Pywell *et al.* 2010). Free choice of options for applicants has resulted in skewed uptake, favouring hedgerow management, low input grassland and margin enhancement. Consequently, the combinations of options required to achieve key outcomes are not necessarily taken up in a coordinated fashion (e.g. Merckx, et al. 2009). There are also concerns that some options are not as successful as they could be (more complex field margins are an example) because they require more management guidance than is available. and that ELS might be more successful if farmers collaborated by co-ordinating their plans. Farmers may also be demoralised by the apparent failure of their management efforts. The mid-term review of ELS recognised some of these shortcomings in design and delivery. As a result, Natural England has introduced a programme of increased advice in an attempt to help ELS work more effectively. The farming industry has also developed a Campaign for the Farmed Environment (Gibbs 2010) to encourage better uptake of key options, from which the lessons need to be learned.

Recommendation 23. The design and delivery of the Entry Level Scheme of Environmental Stewardship needs to be improved, in particular to ensure key options are taken up in appropriate combinations over a sufficient area. Delivering a more effective ecological network may require refinements to the schemes, such as rewarding farmers who act cooperatively.

6.5.2 Achieving good environmental standards

There are further significant issues about the state and management of England's natural environment with implications for the ecological network, but which we consider to be outside the scope of this review. These particularly relate to improving the quality of the wider environment, and the persistence of small habitat patches. We raise them here to highlight their significance. They include:

(i) Environmental Impact Regulations do not provide sufficient protection for wildlife habitats, in particular small fragments. We note that the European Commission is currently reviewing these guidelines, and the government should consider whether this provides an opportunity to provide better protection for remnant habitats.

(ii) The minimum standards for agriculture and forestry set out in cross-compliance guidelines (such as Good Agricultural and Environmental Condition) should ensure that the pressures on ecological networks are reduced. It is important that these standards are enforced so as not to disadvantage those many landowners who adhere to them.

(iii) Eutrophication, in particular from diffuse sources (Section 2.1.3), is now one of the main threats facing freshwater and terrestrial habitats. Concerted action is needed to address this growing threat to the environment.

6.6 Monitoring and evaluation

Our final recommendation reflects the need to evaluate how the process of establishing a coherent and resilient ecological network has progressed and to assess whether the network is achieving its aims.

Recommendation 24. The Secretary of State for the Environment, Food and Rural Affairs should be advised on progress against recommendations in this report after two years, with a full evaluation of the outcomes for England's ecological network after five years.

6.7 Money matters

We were asked in our Terms of Reference to take "account of the ecological, economic and social costs and benefits [and] make costed and prioritised recommendations." We have set out what needs to be done to reverse the decline in England's wildlife, identified the priorities for action and highlighted the significant ecological and social benefits of establishing a coherent and resilient ecological network.

What will our recommendations cost? Providing accurate estimates for each separate recommendation is impossible, not least because they overlap and the cost of implementing one will often depend on our success in implementing others: if, for example, we make good progress with improving the condition of England's wildlife sites we will need to do less to create new ones. We have also set out a 'direction of travel', not a blueprint for exactly what needs doing and where. The cost will depend on how long the journey takes, and what we ultimately decide to do. We also believe that an enhanced ecological network cannot be established through a process imposed from the centre. Many of the decisions on the priorities for action are best made locally, by the people most familiar with the local challenges, opportunities and requirements. Different parts of England need different solutions.

Nonetheless, there are some general conclusions about costs that can be made, including more specific estimates for certain recommendations. Recently, the annual costs of meeting England's BAP objectives have been estimated to be £573 million (GHK 2010). GHK also calculate the current expenditure on BAP to be about £400 million, leaving a shortfall of £173 million per year (GHK 2010). A similar value for biodiversity requirements was reached by a more comprehensive analysis of the costs of meeting environmental land management policy objectives (Cao *et al.* 2009). This estimated the annual cost of meeting biodiversity objectives at £624.4 million, taking account of managing SSSIs, BAP priority habitats, certain widespread species assemblages, achieving woodland expansion objectives and buffering wildlife sites. Further, this study estimated the combined cost of meeting other environmental objectives for water management (flood risk and water quantity measures), climate change

mitigation (protecting the major carbon stores in peat and woodland), soil quality, resource protection (including improving water quality) and public access at an additional £517.3 million. Some (if not many) of these additional costs would be relevant to establishing a coherent and resilient ecological network, giving a potential total cost of £1.14 billion. These estimates did not include any costs associated with regulatory compliance.

We estimate that the total annual costs of establishing a coherent and resilient ecological network are likely to lie somewhere between these two cost estimates, i.e. in the range of £600 million to £1.1 billion. In terms of the costs of individual recommendations, there are relatively few that we can provide reliable estimates for, either because of the nature of the activity or because the level of action has not yet been sufficiently defined. We can be more specific for some (Table 8) but it is important to note that these are already included in our total cost estimates for the network. We also do not assume that all of these costs will be met by government, indeed we expect that non-government sources of funding will play a greater role in the future (in particular if our recommendations relating to market mechanisms and developer contributions are implemented).

The next few years are clearly going to be a time of budgetary constraint, when additional resources are unlikely to be available. We recognise that it will not be possible to take all necessary action immediately, or even soon. We need to plan for the medium and longer term and, amongst this uncertainty, something that we are sure of is that the sooner we act, and the better we are at focussing our actions to enhance the Network, the lower the eventual cost will be.

Table 8. Indicative estimates of cost for quantified recommendations.
Double counting between recommendations is not controlled for in these estimates and the costs also include expenditure that is already being incurred (e.g. on current SSSI management).

Recommendation summary	Description of costs and comments	Estimated annual cost
3. Establish Ecological Restoration Zones (ERZs) – competition to establish first 12.	Although this will mostly be delivered through the implementation of other recommendations (such as for SSSI and BAP habitat management and habitat creation), this cost concerns the part of the recommendation to establish a competition to implement 12 large ERZs in the next 3 years. Our cost estimates for each of these are £0.25 million in the first year and £0.5 million for each subsequent year. We recommend this level of funding should be provided for at least five years.	£3 million in first year. £6 million in subsequent years.
11. Achieve favourable condition of SSSIs	Costs are for the management of SSSIs. Estimate is taken from NAO (2008).	£96 million
12. Manage LWS	Assumes costs for LWS are similar per unit area to SSSIs (i.e. £89 per ha). Estimate is for management of all LWS land.	£62 million
14. In National Parks and AONBs (a) achieve favourable condition of SSSIs;	(a) is already included in costs for Rec. 11 (b) estimate based on area of BAP habitat within NPs and AONBs which is outside SSSIs (= 343,000 ha) and assumes costs are similar per unit area to	£30.5 million

(b) manage other BAP habitat to SSSI standard; (c) enhance connections	that of SSSIs (i.e. £89 per ha). (c) will depend on level of action.	
15. Retain and properly fund HLS	Assumes that a fully funded HLS would be sufficient to cover 10% of eligible land. Source: FERA (2010).	£241 million

7. Concluding remarks

Having carefully examined the evidence, we have concluded that England's collection of wildlife sites, diverse as it is, does not comprise a coherent and resilient ecological network even today, let alone one that is capable of coping with the challenge of climate change and other pressures. The evidence is equally compelling that *Making Space for Nature* to establish such a network will make efficient use of scarce land and resources, and deliver many benefits to wildlife and people.

We have proposed a guiding vision and three objectives for a future ecological network. We have set out what needs to be done to address the weaknesses of the current network and made 24 recommendations for action.

Ours has been the easy part of the task. The real work lies ahead.

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Annex 1

Terms of Reference for the Review

Across England large areas of land are protected under environmental and landscape designations. Both within these designations and outside them the Government and others have invested in protecting, enhancing and restoring important wildlife habitats, including innovative approaches such as re-wilding initiatives. The review will:

-examine evidence on the extent to which the collection of sites represents a coherent and resilient ecological network capable of adapting to the challenge of climate change and other pressures;

-examine the evidence base to assess whether a more inter-connected network would be more effective today and in the future and, if so, how this could be delivered;

-taking account of the ecological, economic and social costs and benefits, make costed and prioritised recommendations on any measures that should be taken including how Government and other organisations can work together to deliver the recommended model.

The review will report to the Secretary of State for Environment, Food and Rural Affairs by June 2010. It will be chaired by Professor Sir John Lawton. Natural England will work closely with the review and provide the secretariat.

The review will complement the National Ecosystem Assessment which is currently being prepared. It will take account of the continuing importance for ecosystems of the wider countryside and urban areas and will draw on the results of the Foresight project on Land Use which are scheduled for January 2010.

Annex 2

Respondents to Call for Evidence

The *Making Space for Nature* panel would like to extend its sincere thanks to the following organisations who submitted evidence to the review.

Amphibian & Reptile Conservation (ARC)
Bat Conservation Trust
Bournemouth & West Hants Water plc
British Trust for Ornithology (BTO)
Buglife
Butterfly Conservation
Countryside Council for Wales
Centre for Ecology and Hydrology
Church of England
Country Land and Business Association (CLA)
Confederation of Forest Industries
Campaign to Protect Rural England (CPRE)
Crown Estate
Deer Initiative
English Heritage
English National Park Authorities Association
ENTRUST
Environment Agency
Environment Bank Ltd
Food and Environment Research Agency (FERA)
Forestry Commission
Game & Wildlife Conservation Trust
GeoConservation UK
Grasslands Trust
Herefordshire Nature Trust
Hymettus Ltd
Institute of Ecology and Environmental Management (IEEM)
Leicestershire & Rutland Wildlife Trust
Ministry of Defence
Moorland Association
National Farmers Union (NFU)
National Trust
Natural England
Norfolk Biodiversity Partnership
One NorthEast
Plantlife
Pond Conservation
Royal Agricultural Society of England

Royal Society for the Protection of Birds (RSPB)
Thames Water
Vincent Wildlife Trust (VWT)
Wildlife & Countryside Link
The Wildlife Trusts
Woodland Trust
Yorkshire Water