# Assessing and responding to climate risks to Natural England's objectives

## Report to the Secretary of State for Environment, Food and Rural Affairs

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NATURAL ENGLAND

# Contents

# Executive summary

The natural environment is vulnerable to climate change. We have already seen changes, for example in species distributions and behaviour, and in coastal processes. Over time, further changes to the living and non-living natural environment are likely to affect whole ecosystems, habitats and landscapes and the way in which they are used and enjoyed by people. At the same time, appropriate management and conservation of the natural environment can make an important contribution to helping society adapt to a changing climate; for example trees can be planted to keep cities cool, or river floodplains used to slow the flow of floodwater.

Climate change is, therefore, an extremely important issue for Natural England in its role to conserve and enhance the natural environment for its intrinsic value, the wellbeing and enjoyment of people and the economic prosperity that it brings. This report outlines the processes we have put in place through our Climate Change Embedding and Risk Assessment Programme to assess the threats and opportunities and to identify and implement appropriate responses. It describes our approach to adapting to climate change, our methodology for assessing climate risks (which attempts to consider both direct risks from the impact of climate change itself, and indirect risks as a result of human responses to climate change), some of the most important threats and opportunities we have identified, and the possible responses that we are considering. Our climate risk assessment work is not yet complete (indeed adaptation is a continuous process), but this report summarises our progress so far.

It is clear that there are some important direct and indirect threats from climate change to our objectives across all our main areas of work – biodiversity; landscape, historic environment and geodiversity; marine; people and access; land management; and sustainable land use, as well as to our buildings and sites and other aspects of business delivery. For example, shifts in species distribution or loss of habitat could affect our ability to maintain our current targets for designated areas and to achieving species recovery plan objectives. Damage to recreational facilities could affect our ability to provide opportunities for people to engage with the natural environment. Current approaches to land management programmes in support of the natural environment could become unsuitable in certain areas as a result of both changes to the natural environment and changes to cropping patterns and farming systems as land managers adapt to climate change. However, there are also significant opportunities, particularly for working with land managers, local communities and other partners to provide environmental benefits for both wildlife and people.

There are a wide range of things we can do to address the threats and opportunities we have identified, and some of these actions are discussed in the report. In the short term, our results highlight the need to continue current good conservation of the natural environment through existing mechanisms, in order to increase the environment's resilience and capacity to adapt. However, we can, and should, start to implement measures to promote resilience of the natural environment, such as increasing the size of sites, increasing habitat and landscape heterogeneity and increasing connectivity between sites. The Making Space for Nature review (Lawton et al. 2010) is a good starting point for this. There are also instances where specific changes are necessary or desirable, for example coastal realignment or recognising changing distribution patterns. Establishing an adaptive management approach where measures are regularly reviewed and lessons learnt for future work should be a top priority. In the longer

term, there are serious challenges to be considered, probably requiring us to review some aspects of our approach to conservation, to ensure that it has the flexibility to accommodate and respond to the likely changes to the natural environment that we cannot prevent.

To effectively address climate change it will be important to consider the full range of services a healthy natural environment provides to people and the complex interactions between climate change and the provision of these services. Sustainable adaptation will be needed across different sectors, requiring strong partnerships involving government agencies, local authorities, non-government organisations, land managers and local community groups.

We hope that the approach and results presented in this report will be helpful to other organisations considering the threats and opportunities presented by a changing climate.

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Section 1:

# Natural England and climate change

## Our role

Natural England is an independent statutory Non-Departmental Public Body, whose role is to conserve and enhance the natural environment for its intrinsic value, the wellbeing and enjoyment of people and the economic prosperity that it brings. Natural England was formally established on 1 October 2006 by the Natural Environment and Rural Communities (NERC) Act 2006.

Our purpose, as set out in the NERC Act, is 'to ensure that the natural environment is conserved, enhanced and managed for the benefit of present and future generations, thereby contributing to sustainable development'.

The Act states that this purpose includes:

- Promoting nature conservation and protecting biodiversity
- Conserving and enhancing the landscape
- Securing the provision and improvement of facilities for the study, understanding and enjoyment of the natural environment
- Promoting access to the countryside, open spaces and encouraging open air recreation, and
- Contributing in other ways to social and economic wellbeing through management of the natural environment.

## The importance of climate change to our work

Climate change needs to be taken into consideration in all Natural England's work for two important reasons:

First, the natural environment is vulnerable to climate change. We know that species are sensitive to changes in climate variables such as temperature and rainfall, and to extreme events such as droughts, storms and heatwaves. We are already seeing changes, in both plants and animals, in geographic distributions and the timing of life events (such as bird migration and appearance of leaves of trees in spring) (e.g. Hickling et al. 2006; Crick 2004). Over time, this will lead to changes in our natural ecological communities of plants and animals. There will also be direct changes to the physical environment, such as changes caused by waves and floodwater, sea level rise and intrusion of salt water into freshwater habitat. In combination, changes to the living and non-living natural environment are likely to cause changes to whole ecosystems, habitats and landscapes and the way in which they are used and enjoyed by people. There could also be indirect effects on the natural environment, as a result of human action in response to climate change (for example, increased water abstraction to cope with water shortages, or increased use of biofuel as a mitigation strategy). This means that there are serious threats to the achievement of Natural England's objectives and probably some opportunities.

Second, appropriate management and conservation of the natural environment can make an important contribution to helping society adapt to a changing climate, by providing a range of valuable services (Gill et al. 2007; Morecroft and Cowan 2010; Natural England 2009a). For example, trees and other vegetation provide shade and shelter for people, crops and livestock, and wildlife. They can reduce water runoff and erosion, help to maintain water quality, and provide an alternative and additional crop to increase farm income and hedge bets against climate risks. Wetlands and functioning river floodplains slow the flow of floodwater and

increase infiltration into the soil, increasing recharge of groundwater. Conserving or recreating intertidal habitat such as salt marsh can provide defence against coastal flooding, absorbing the energy of waves and allowing space for 'storage' of high tides. Intertidal habitats also filter sediments and pollutants, and support shellfish and fish nurseries, helping make fish populations (and fishing industries that depend on them) more resilient to change. Environmental management can also play an important role in climate change mitigation, for example through protecting the large amount of carbon stored in peat soils. A high quality natural environment should therefore be seen as critical infrastructure, and it is important that we maintain its capacity to deliver the key services that underpin our prosperity and wellbeing.

Much of Natural England's work is about enabling the private sector and civil society to protect and enhance the natural environment. A wide range of ecosystem services are delivered by a healthy natural environment and we are committed to working with our partners and stakeholders, using a consultative ecosystem approach, to ensure that the supply of services is secured and enhanced.

## The Climate Change Act and Adaptation Reporting Power

The Climate Change Act (2008) contains an Adaptation Reporting Power. This gives Government the power to direct some organisations – those that have responsibility for critical infrastructure and services that people depend on every day – to report on how they have assessed the risks of climate change to their work, and what they are doing to address these risks. The Reporting Power is the primary lever available to government to ensure that organisations are aware of and preparing for the risks from climate change, in order to ensure that services essential to the country are secure for the long term future.

In addition to the organisations that have been directed to report in this first round of the reporting power, a number of organisations have been invited, or have volunteered, to report. Natural England has volunteered, because of the importance of climate change to our work, and the role we can play in tackling it.

This report describes the processes we have put in place to assess climate risks to our corporate objectives and to identify and implement appropriate responses. It outlines some of the most important risks we have identified so far, and some of the possible responses that we are considering. Our climate risk assessment work is not yet complete. This report summarises our progress so far. (For example, we have so far only identified a range of possible responses to our risks, and have not yet determined specific actions and timescales.) We will publish a more detailed report in late 2011 or early 2012.

Section 2:

# Adaptation work

In Natural England's Strategic Direction 2008-2013 two high-level objectives have set the foundation for fully embedding adaptation to climate change within our work programmes:

- "Our rich biodiversity thrives across the landscape, with ecosystems and habitat resilient to climate change", and
- "The natural environment is resilient in the face of climate change".

These were supported by a number of more specific five-year measures of success:

- National Parks and Areas of Outstanding Natural Beauty demonstrating an increasing level of exemplary management of our finest landscapes: including local character, cultural heritage, tranquillity, biodiversity in favourable condition, exemplary access management, resilience to climate change.
- Ecosystems are healthier, dynamic and delivering increased resilience and capacity to adapt to change.
- Sites of Special Scientific Interest are assessed for their resilience and ability to support healthy dynamic ecosystems that are able to adapt to change.
- Marine ecosystems and habitats have increased resilience and are more capable of adaptation.
- A network of Marine Protected Areas is identified, that contributes to increasing the health and resilience of marine ecosystems.
- A shared vision for adaptation of our landscapes in response to climate change.
- The major risks to the natural environment are understood and addressed by public bodies.
- Increased proportion of habitats and ecosystems in 'resilient condition'.
- Increased numbers of land managers actively managing more land for climate change adaptation and mitigation.

## Building the evidence base

Climate change, and its interaction with the natural environment, is a complex topic, and there is still a lot we don't fully understand. It is vital that we continue to add to our knowledge about climate impacts on the environment and appropriate responses, and that we have the flexibility to develop and modify our conservation strategies in future, in light of new information. We therefore have a strong programme of research into climate vulnerability, impacts and adaptation. This includes a series of studies to assess the vulnerability of the natural environment in England at a range of scales; long term monitoring of environmental change; evaluation of effectiveness of adaptation measures for the natural environment; a project to summarise current understanding of what makes ecosystems, landscapes and habitats resilient to climate change; and a comprehensive review of large scale adaptation and conservation initiatives.

## Delivering adaptation for the natural environment and local communities

We have begun to incorporate findings from adaptation research into our existing conservation delivery work, several aspects of which are already contributing to adaptation and have great potential to make a much larger contribution. For example, our work with land managers through Higher Level Stewardship can help to conserve, restore, expand and buffer semi-natural habitats and make them more resilient to a changing climate, anticipating some of the recommendations of the Making Space for Nature review of habitat networks (Lawton et al.

2010). In some cases, we are using Environmental Stewardship directly to help species under threat from climate change. For example, we are working with Essex farmers using HLS funding to provide suitable new habitat for the Fisher's Estuarine Moth, a rare species dependent on a rare foodplant in coastal transitional zones that is threatened by coastal erosion, storm surge and rising sea levels. Our work on urban green infrastructure has the potential to help reduce the effect of heatwaves, flooding and water shortage on human communities and wildlife (all significant concerns in a changing climate).

With our partners (including the Environment Agency, Forestry Commission, National Parks, local authorities, non-government organisations and the private sector), we are also involved in a wide range of local initiatives across the country to help society become more prepared for a changing climate. Just a few examples include: Cheviot Futures, a partnership of agencies and organisations working with farmers and land managers in north Northumberland to promote simple and practical approaches to adaption; coastal realignment at Alkborough in the Humber Estuary, the UK's largest coastal realignment with an estimated annual flood protection benefit of over £400,000; recreating floodplains on the Long Eau river in Lincolnshire to alleviate flooding of houses and farmland downstream; working with the Moors for the Future partnership to restore peatland in the Peak District, which among other things has restored water quality for human consumption; and the Sustainable Catchment Management Programme in Bowland and the Peak District, a partnership working to apply an integrated approach to catchment management on land owned by United Utilities. (See Natural England 2009a for more information about some of these.)

## Sustainable adaptation

Underpinning all of Natural England's work on adaptation is the understanding that adaptation must be sustainable (see World Commission on Environment Development, 1987). Four principles have been proposed for sustainable adaptation (Macgregor & Cowan 2011). These are:

1. **Adaptation should aim to maintain or enhance the environmental, social and economic benefits provided by a system, while accepting and accommodating inevitable changes to it.** It is important for adaptation to be based on a clear set of objectives that frame the problem in terms of 'what are we adapting for?' (that is, focusing on the benefits we want to obtain).

2. **Adaptation should not solve one problem while creating or worsening others. We should prioritise action that has multiple benefits and avoid creating negative effects for other people, places and sectors.** Many adaptation responses to address socioeconomic factors will have wider consequences for natural systems, and vice versa. Taking an ecosystems-based approach, and applying principles of sustainable development across sectors will be necessary to identify integrated, sustainable adaptation solutions.

3. **Adaptation should seek to increase resilience to a wide range of future risks and address all aspects of vulnerability, rather than focusing solely on specific projected climate impacts.** Actions must be taken in the face of uncertainty in relation to future climate changes, socioeconomic change, and the interaction between them. Therefore it is important to build resilience to cope with a range of plausible futures.

4. **Approaches to adaptation must be flexible and not limit future action.** Increasing the resilience of what we have is a good initial strategy but, in the longer term and under more extreme climate change, transformative approaches will increasingly be needed. New approaches to adaptation will need to be tested and monitored at the appropriate scale so we can learn from experience and revise our approaches accordingly.

As part of this, the concept of 'adaptive management' (Holling 1978) is a very useful strategy. This means taking a flexible approach, with continual monitoring of results and adjustment of management practices if necessary. This can help to resolve the apparent dilemma of on the one hand needing to start adapting, but on the other needing to retain flexibility in the face of considerable uncertainty about the future. The starting point of an adaptive management approach should be to do things that i) would have benefits regardless of climate change (so called 'no regret' options); ii) would have multiple benefits for a range of objectives ('win win' options); and/or iii) would be likely to have significant adaptation benefits, be cheap to implement and easy to reverse ('low regret' options) (UK Climate Impacts Programme n.d.).

Section 3:

# Assessing climate risks and putting climate change at the core of Natural England's work

The evidence suggests that, over the course of this century, climate change will have very serious implications for the natural environment. It therefore presents a huge challenge for organisations such as ours that are responsible for helping to manage and conserve the natural environment. In some areas, in particular our coasts, significant effects of climate change are already apparent; in others, the more serious consequences are probably still some decades away. In all cases action needs to start now to ensure that delivery of our objectives for the natural environment, and the resulting benefits for society, are resilient in a changing climate.

We are working to integrate climate change across all areas of Natural England's work in a systematic and coordinated way, so that adaptation and mitigation becomes a core part of our normal business. This will help to ensure that we make the natural environment and particularly England's biodiversity and landscapes, as resilient as possible to climate change, and will further increase our contribution to wider climate change adaptation and mitigation.

## Climate Change Embedding and Risk Assessment programme

In 2009 we put in place our Climate Change Embedding and Risk Assessment programme, to assess climate risks to our objectives and identify and agree appropriate actions to be taken in response. The overall aim is to integrate climate change as fully as possible into our core work. The programme will run until 2011/12, by which time adaptation to climate change will be an essential component of all our programme delivery. We are, however, keenly aware that embedding climate change is not a one-off process, and that there will be a need for continued monitoring, reviewing and development of our responses into the future, as our understanding of climate change impacts and adaptation grows. This process, which we have just started, will need to be permanently hard-wired into Natural England's programme of work and the advice we give to others.

There are three main elements to the programme:

1. **Assessment of climate risks to our objectives at national level.** Each of our main work areas is assessing the risks that climate change presents to delivering their objectives, identifying and considering possible responses (and opportunities for delivery of their objectives to contribute to climate change mitigation), and identifying and agreeing specific actions that Natural England will take in the future. The areas that are completing climate risk assessments are:
   - biodiversity
   - landscape, historic environment and geodiversity
   - marine
   - people and access
   - land management
   - sustainable land use

   Although we do not have a specific set of objectives for coastal areas, we recognise that coastal issues are an important and urgent concern that cut across all of the areas above, and so are being reviewed within each area.

   Between them, our objectives in the areas above encompass our desired outcomes for the natural environment; our desired outcomes for people, especially through access to

the natural environment and promotion of outdoor recreation, and through providing ecosystem services to enhance human wellbeing, communities and local economies; and delivery of activities needed to achieve these outcomes.

We will also do a similar risk assessment for our objectives relating to business delivery, which support the areas above (for example our estate, business continuity and staff safety plans).

These risks assessments are partially complete and will be finished by the end of 2010/11, with agreed actions beginning to be taken from 2011/12 onwards. (An initial risk assessment by our land management community started in 2009, and its results are already being implemented.)

We believe that successfully embedding climate change into Natural England's core work must be done in partnership between climate change specialists and people who understand the rest of the organisation and its business, and the results must be owned by individual work areas. For that reason, individual work areas are leading their own climate risk assessments. Climate change specialists have produced a standard methodology to be used, to ensure consistency and facilitate the process, and are providing advice and review.

Climate risk assessment across the work areas above is being done in a coordinated way, to ensure that any gaps, synergies and conflicts are identified and addressed. A steering group has been established, made up of the staff coordinating each risk assessment, as well as climate change specialists, to review and discuss the emerging results of the risk assessments at each stage of the process and help ensure that the results are translated into specific actions in Natural England's corporate plan for the following year.

Information from the national Climate Change Risk Assessment sectoral analyses is being considered as it becomes available, to ensure that our approach is broadly consistent with the national assessment.

2. **Climate risk assessment at sub-national level.** Natural England is currently developing place-specific profiles that set out the environmental potential for each of England's 159 National Character Areas. These profiles will consider landscape character, biodiversity and ecosystem services in an integrated way and provide a strategic framework for more detailed objective setting at finer scales. To ensure that climate change is taken fully into account, we will complete a simple assessment of climate risk and vulnerability for each area, and incorporate the findings of these assessments into the profiles as they are drafted. A first set of National Character Area profiles will be completed by the end of 2010/11, with the remainder completed by the end of 2011/12. Assessing climate risks at the scale of National Character Areas will help us to better understand the spatial aspects of climate-related risks to Natural England's objectives, and will also provide an additional check to make sure that the national assessment has covered all the major risks. National Character Area profiles will be central to our delivery of an effective response to our risks from climate change.

   Risk assessment in National Character Areas will be informed by the experience and knowledge we have gained through completing detailed assessments of the vulnerability to climate change of the natural environment in 12 contrasting National Character Areas across England (e.g. Natural England 2009b, 2009c, 2009d, 2009e) and larger scale vulnerability studies in the south east, north west and west midlands.

3. **Developing a common level of understanding of climate change issues among Natural England staff.** A bespoke web-based training course is being developed that will cover an introduction to climate science, as well as including modules on adaptation, mitigation and communicating climate change. t is being designed to be tailored to the needs of Natural England staff and will be made available to all our staff from 2011 onwards. More detailed climate change training for specific groups of staff, such as land management advisors, will follow.

The risk assessments at both national and sub-national level are informed by our research projects, published literature, and collective knowledge of our specialist staff.

We focus here primarily on the emerging findings of Natural England's national-level risk assessment, with a brief discussion of preliminary work to consider climate risks at sub-national level. This is set out in the following chapters as follows:

**Section 4** outlines our method for assessing climate risks, including climate information used and principles for sustainable adaptation.
**Section 5** summarises the most important risks and possible responses we have identified for each national work area – biodiversity, landscape, historic environment and geodiversity, marine, people and access, land management, and sustainable land use.
**Section 6** briefly provides similar information in relation to our business delivery
**Section 7** describes our plans for assessing climate risks at sub-national level, and summarises some of the findings of climate vulnerability studies we have done in National Character Areas, which will inform our sub-national risk assessment
**Section 8** contains a short conclusion and summarises future work to be done.

Section 4:

# Our approach to climate risk assessment

## Climate change information used

We used information from the recent UK Climate Projections (UKCP09) (Murphy et al. 2009; Lowe et al. 2009). These projections are currently the most definitive evidence base on the UK's future climate. The projections indicate, among a range of other findings, that temperatures will increase across all areas of the UK, more so in summer than in winter and more in the south than the north (e.g. summer mean temperature in southern England could be up to 4.2°C warmer[1]); that mean daily minimum temperatures will increase as well as the mean temperatures for the season; that although overall precipitation might not change to a great extent, winter precipitation could increase greatly in some areas (particularly the west of England, up to +33%[1]) and summer precipitation decrease greatly (particularly in the south of England, down to –40%[1]).

The UKCP09 scenarios contain very detailed information, enabling climate change to be considered across a range of emissions scenarios, geographic areas and probability levels. We used the main trends in the projections, focusing on median values, to provide an indication of the 'direction of travel' of climate change and the range of possible scenarios we should prepare for. However, because of uncertainties – not just in the projections themselves but particularly in complex ecosystem responses and interactions with human behaviour such as changing agricultural practices – we are not planning adaptation for a particular scenario. We are attempting to positively take uncertainty into account by putting emphasis on 'no regrets' measures that are valid under a range of scenarios, and developing adaptive management techniques (see below).

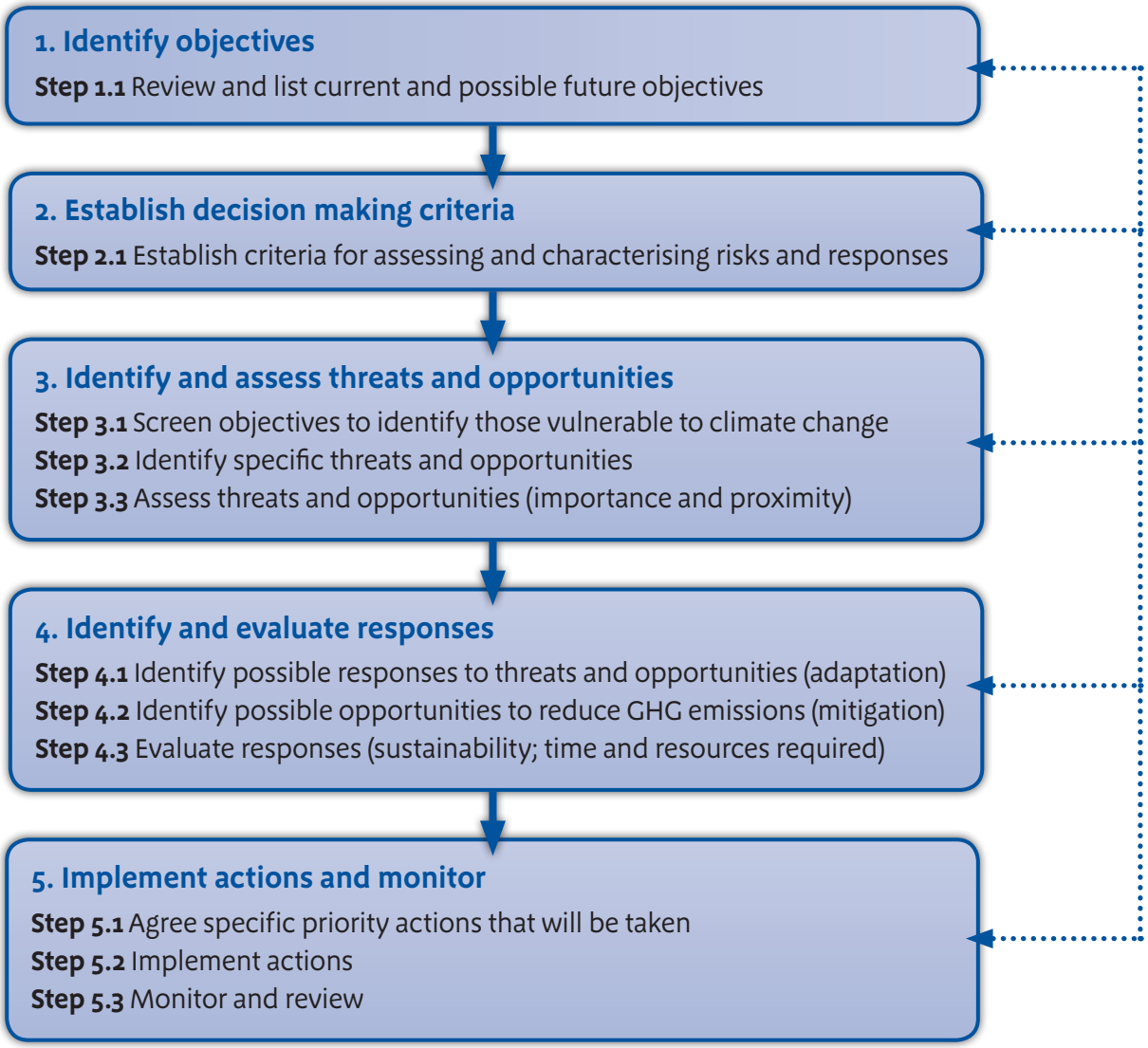
## Risk assessment methodology

All our work areas are using a standard methodology, developed by our climate change specialists, to assess climate risks and responses. The approach of this methodology is consistent with other, published, frameworks for climate risk assessment (e.g. Willows and Connell 2003). Since 2009, we have been developing, testing and refining the methodology through pilot work in Natural England, and through ongoing discussions with colleagues in the Environment Agency.

The main steps of our methodology are depicted in Figure 1 and summarised briefly below. A more detailed description of methods is provided in the annex.

[1]All figures mentioned above are the UKCP09 central estimates (50% probability level) for the 2080s under the medium emissions scenario

**Figure 1. Structure of Natural England's climate risk assessment methodology**




## Part 1. Identify objectives

Risks (whether climate-related or not), and adaptation, make sense only in relation to defined objectives. Therefore, an essential first step in the process was to identify relevant Natural England objectives for each of our main work areas. These provide the reference point and scope for future steps in the assessment process.

We listed the key objectives for each work area, focusing at the strategic level.

## Part 2. Establish decision-making criteria for prioritising risks and responses

We are using five variables to characterise and prioritise our risks and responses:

- The importance of a risk to delivery of our objectives
- The proximity of a risk (the nearness of the point in time at which we estimate there is a reasonable chance our ability to deliver the objective would change under a business as usual scenario)
- The effort and resources required to respond
- The time period required for an effective response, including both the time needed for Natural England to implement the response and the time required for the response to have an effect once implement

- The likely positive and negative side-effects of a response on other objectives, as one measure of its sustainability (see the section on sustainable adaptation above for further aspects of sustainability that we are considering when identifying responses)

### Part 3. Identify and assess threats and opportunities

To focus our attention just on those objectives that are relevant for this risk assessment, we first screened objectives in each work area and identified which appeared potentially vulnerable to climate change related impacts. These objectives were the focus of assessing risks. We also identified objectives that are not vulnerable to but are influenced by climate change. These are things that we can probably still achieve irrespective of how the climate changes, but that might need to be modified to take climate change into consideration. These objectives were not relevant to identifying and assessing risks, but were relevant to identifying responses. This category of objectives often provided potential ways to help respond to risks to our vulnerable objectives. (To illustrate this distinction between 'vulnerable' and 'influenced' objectives: an objective to maintain Sites of Special Scientific Interest is potentially vulnerable, as climate change is likely to affect the natural environment in these sites. By contrast, an objective to give advice to land managers would not be vulnerable, as climate change is unlikely to prevent us from delivering advice, but the advice we provide would need to be modified to include information to help land managers adapt.)

Having identified which objectives were vulnerable, we then identified specific threats, as well as opportunities, trying to consider the full chain of events linking an initial climatic change through to a consequence for our objectives.

We tried to identify both direct risks (resulting directly from climate change) and indirect risks (resulting from human action in response to climate change).

We then assessed the importance and proximity of each risk, as noted above.

### Part 4. Identify and evaluate responses

We identified possible responses to manage threats and to make the most of opportunities. Two aspects were considered when identifying responses: the required action on the ground, and the action for Natural England to take (e.g. action on the ground might be to increase woodland cover; action for Natural England might be to revise land management advice to encourage tree planting). Identifying responses included considering how delivery of those objectives identified as 'influenced' by climate change could make a contribution to addressing risks.

As well as identifying responses to address our risks, we considered how delivery of our objectives could make a greater contribution to reducing greenhouse gas emissions. This, of course is 'mitigation', a separate issue from adaptation and not strictly necessary as part of a climate risk assessment. However, as sustainability is an important part of an adaptation response, we feel it is important to try to integrate adaptation and mitigation as much as possible. (Here we considered only action that Natural England could take to help reduce emissions in the sectors in which we play a role, such as land management. We did not look at actions to reduce emissions from our own work and estate, as Natural England already has a comprehensive plan in place to address this.)

We considered the potential positive and negative side-effects of each of the possible responses identified. We then considered factors affecting the implementation of a successful

response and estimated how much effort/resource would be required to implement each response, and the time required for a successful response to be put in place.

### Part 5. Implementation and monitoring

This stage has still to be completed for most work areas. Once we have fully assessed and prioritised our risks and responses in each work area, our programme steering group will discuss the full set of results to agree a set of integrated actions to be taken across Natural England to address the most important risks. These will include actions that can be taken in the short term, and actions to be considered in the longer term. Individual work areas will incorporate these actions into their part of the corporate plan for future years.

Actions will be implemented through delivery of our corporate plan, with the aim of embedding adaptation so it is considered alongside other environment decision-making in all our work.

We will need to involve and consult our partners and stakeholders to agree the appropriate implementation of specific actions.

We will monitor the effectiveness of our actions, and modify them if necessary, both through monitoring of progress to deliver our corporate plan, and through ongoing monitoring of environmental change.

Section 5:

# Results of climate change risk assessment

The following section summarises the key findings from our climate risks assessments in each key area of work. For each, we have set out Natural England's main objectives and responsibilities, the most important direct and indirect threats from climate change identified so far, any opportunities identified, and some of the types of adaptation measures that we are considering. We have noted any adaptation measures that would also have significant mitigation benefits. Because this work is still under way, we present here a summary of our main findings so far. We have not included the results of the detailed assessment of risk and response variables, which is still being completed and verified. We will publish a more detailed report in late 2011 or early 2012 in which we will present our results in full.

## Biodiversity

Biodiversity (short for biological diversity) is the variety of all life forms: the different plants, animals and micro-organisms, their genes, and the communities and ecosystems of which they are a part. Biodiversity is usually recognised at three levels: genetic diversity, species diversity and ecosystem diversity.

Our **objectives** for biodiversity are:

1. Create, restore and maintain extensive landscapes rich in biodiversity, enabling the natural environment to adapt to climate change and other pressures.

    **a.** Create new, and strengthen existing ecological networks to link, buffer and extend existing biodiversity rich sites.
    **b.** Maintain Sites of Special Scientific Interest in favourable or recovering condition and increase the proportion in favourable condition.
    **c.** Meet recovery plan objectives for specified Biodiversity Action Plan species for which Natural England is taking a lead role, either through direct action or in partnership.
    **d.** Reverse the decline of farmland birds through the application of appropriate stewardship options and Campaign for the Farmed Environment.
    **e.** Deploy agri-environment schemes to maintain, restore and create Biodiversity Action Plan priority habitat in beneficial management.

2. Implementing our Notification Strategy which already has systems in place to act on the recommendations of Making Space for Nature (Lawton et al. 2010), and identify any revisions necessary to reflect the forthcoming coming Natural Environment White Paper.

3. Assess and address the threat of invasive non-native species and make clear the links between the impact of these species, the economy and society.

4. Improve survey methods in order to assess/indicate changes taking place to biodiversity and the related ecosystem services.

Possible **direct and indirect threats** to these objectives include:

- A reduced ability to maintain our current targets for Sites of Special Scientific Interest and habitat condition (objective 2a), and achieve our species recovery plan objectives (objective 1c) due to:

  - Increases in temperature and changes in rainfall patterns causing shifts in species distributions (e.g. range contractions at southern margins, shifts northward and uphill), changes in habitat types (e.g. beech becoming dominant in woodlands of northern England), and the disaggregation of foodwebs (e.g. loss of fish prey populations for internationally important seabird colonies).
  - Sea level rise, resulting in a loss of coastal intertidal habitats, especially where there is a 'coastal squeeze' effect trapping habitats between the rising sea level and hard engineered sea defences.
  - A loss of dunes, shingle structures, wetland and grassland habitats on the coast as a further result of sea level rise, especially where there is a lack of land suitable for managed coastal realignment.
  - Reduced summer rainfall, increasing incidences of summer drought and increasing demands for water, resulting in low flow rates in our rivers and drying out of wetlands.
  - An increase in storm events causing damage to habitats from flooding, high winds etc.
  - Range expansions of non-native species and resulting loss of native species through competition, predation or disease. Where these become abundant, major changes to ecosystem character and processes.
  - Seasonal shifts in temperature and rainfall resulting in changes to the timings of seasonal events (e.g. leaves appearing on trees, eggs hatching, animals migrating), and a potential loss of synchrony between interdependent species (e.g. pollinating insects and flowers).
  - A loss of biodiversity rich sites and sites important for building ecological networks to agriculture, water storage and forestry as climate change and population growth drive the intensification of land use.
  - Increased fire risk in some areas, especially lowland heathlands, as a result of hotter drier summers.

- A reduced ability to maintain, restore and create Biodiversity Action Plan priority habitat through agri-environment schemes (objective 1e), or to strengthen ecological networks by linking existing biodiversity rich sites (objective 1a) due to:

  - A loss of biodiversity rich sites and sites important for building ecological networks to agriculture, as climate change and population growth drive the intensification of agriculture.
  - A loss of quality coastal wetland habitats as a result of sea level rise and due to a lack of land suitable for managed coastal realignment.

- That the objectives for current designations become inappropriate (objective 2) as the

ecological communities on a site change due to shifts in species ranges and ecosystem processes.

However, there are some possible **opportunities:**

- An increase in species richness and an increased likelihood of meeting some Biodiversity Action Plan targets for habitats and species (objective 1) due to:
  - An increase in the range of summer migrants and continental species. As a result of the increasing temperatures, these species will extend their ranges northwards into England, helping to maintain our overall biodiversity (although altering it); by replacing declining species from an area as they shift their own ranges northwards.
  - A generally warmer climate, increasing the potential for some taxonomic groups (e.g. thermophilic insects and species currently only resident in southern England) to increase their range northwards and uphill and colonise new sites. This could result in an increased likelihood of reaching some Biodiversity Action Plan species targets (e.g. Adonis blue, large blue, Dartford warbler).
  - An opportunity to meet Biodiversity Action Plan targets for coastal habitats (especially saline/brackish habitats) through managed realignment of low-lying coastlines, where appropriate, as a strategy for coping with sea level rise and inland to restore biodiverse functional flood plains.
  - Opportunities to restore or expand habitats (such as peat bogs and woodlands) as a climate change mitigation response.

- An opportunity to decrease fragmentation of semi-natural habitats (objective 1a) adjacent to urban areas and increase urban biodiversity, by encouraging urban planners and industry to use 'green infrastructure' more as an adaptation strategy (e.g. using vegetation and water for urban cooling).

- Opportunities to increase partnership working (objective 1c) to achieve more for the natural environment in coastal and other tourist areas. As our summers get warmer more people are likely to holiday in England, resulting in an increase in the use of the countryside, and value the people place on it. This increase in support for conservation from the public could create demand for improved coastal water quality and other environmental improvements, creating opportunities for partnership working in these areas and better outcomes for biodiversity.

## Possible responses

In the short term, it is vital that we continue to conserve existing biodiversity in currently protected areas and other high quality habitats, and to reduce other sources of harm besides climate change, perhaps through the provision of buffer areas around sites, as without these measures other adaptation activities will be ineffective. This will also provide foci for maintaining viable productive populations of key species, as these sites are likely to be the most resilient to climate change because other pressures are already reduced within them. It is also important to conserve the current range and ecological variability of habitats and species, thereby conserving genetic variability and the potential for populations of species to adapt to changing conditions.

One of the main ways we will do this is through Environmental Stewardship agreements with land owners and providing advice on land use and management practices. Through targeted stewardship agreements and partnership working, we will build and strengthen ecological

networks to link existing biodiversity-rich sites, following recommendations from the UK Biodiversity Partnership adaptation principles (Hopkins et al. 2007), England Biodiversity Strategy adaptation principles (Smithers et al. 2008) and Making Space for Nature (Lawton et al 2010).

The risks identified above also suggest there will be a need to review the appropriateness of our current targets and designation strategy. It is inevitable that some of the species that make up ecological communities in England will alter in terms of their climatic envelope, niche requirements and abundance, and our objectives will need to reflect this. We will need to set ambitious targets to maintain high biodiversity and keep habitats in good ecological condition while accepting inevitable changes and not setting unachievable goals to keep things exactly as they are. As part of this, we will continue developing new ways of working with partners to conserve biodiversity. These include:

- Implementing our Notification Strategy which already has systems in place to act on the recommendations of Making Space for Nature (Lawton 2010), and identify any revisions necessary to reflect the forthcoming coming Natural Environment White Paper.

- Considering the objectives of sites and networks and how these can be adapted to pressures such as climate change.

- Increasing partnership projects working at a landscape scale for biodiversity, which will be informed by a research project to review existing landscape scale schemes which Natural England has started this year (2010/11).

- Ensuring habitat creation and restoration enhance existing ecological networks, which will promote movement of more mobile species, encouraging colonisation of new sites and reducing the risks associated with small isolated populations, while being aware of the risks posed by invasive non-native species.

- Increasing the habitat heterogeneity within biodiversity sites and landscapes to increase the chances of species persisting in locally favourable microclimates and soil conditions (e.g. northern slopes and wetter places).

- Working with others to consider how we can make space for the natural development of rivers and coasts in a way that helps both wildlife and people.

We need to have a sound evidence base to support decisions for biodiversity in the face of climate change, and we will do this by maintaining our current evidence programme. Survey and monitoring methods should be enhanced to incorporate assessment/indicators of changes to biodiversity and related ecosystem services which could be climate driven.

We need to do further work to assess and address the threat of invasive non-native species due to climate change and make clear the effects on the economy and society of such species.

Adaptation responses that would also have **mitigation benefits** include:

- Promoting best practise habitat management to:
  - Decrease greenhouse gas emissions, through appropriate soil and water management (e.g. maintaining upland peat bogs).

- Maintain, and where possible, increase carbon uptake and storage by habitats (e.g. possible through recreation of saltmarsh).
- Decrease the fuel required to manage the habitats and sites (e.g. through managing larger patches as single units).
- Reduce the use of fossil fuel based inorganic fertilisers, the over-use of which has an adverse impact on biodiversity, weakening the effectiveness of adaptation measures.

- Promoting appropriate sustainable use of the products from sites and habitats managed for biodiversity (e.g. use of wood as bio fuel to decrease the use of fossil fuels or in the building industry as a longer term carbon store).

## Marine

Natural England works to ensure that our marine and coastal environment is better understood, valued and protected. We are responsible for advising Government and industry on marine conservation and seascape issues in England's territorial waters.

**Objectives**

1. That our marine environment is better understood, valued and protected, enabling the natural environment to adapt to climate change and other pressures.

    **a.** Complete our contribution to a well-managed ecologically coherent Marine Protected Areas network, and then maintain or recover constituent elements (Marine Conservation Zones, Sites of Special Scientific Interest, Special Areas of Conservation, Special Protected Areas and Ramsar) to favourable condition.
    **b.** Recognise the importance of coastal and marine carbon sinks and prevent further sink deterioration which would lead to mass carbon dioxide emissions. Where opportunities are identified, recover historical lost extent of coastal/marine sinks.
    **c.** Meet recovery plan objectives for specified Biodiversity Action Plan species for which Natural England is taking a lead role, either through direct action or in partnership.
    **d.** Implement a national monitoring programme across existing European Marine Sites, and undertake monitoring to obtain robust baseline information for new sites.
    **e.** Identify risk to features within European Marine Sites and encourage best practice in managing activities.

2. The use and management of the marine environment is more sustainable.

   **a.** Address deleterious human impacts and in particular reverse the decline of commercial fish stock through the application of fisheries reforms.
   **b.** Encourage best practice in offshore marine renewable energy projects and other marine industries.
   **c.** Engage stakeholders in dialogue and action to secure marine ecosystems and resources in a healthy state through personal stewardship and support for improved sustainable exploitation and management options.
   **d.** Ensure the achievement of Good Environmental Status in English waters by 2020.

Possible **direct and indirect threats** to these objectives include:

- A reduced ability to maintain Marine Protected Area objectives (objective 1a) including habitat and species condition, seabird populations and species recovery plan objectives (objective 1c) due to:
  - Progressive warming of the seas, resulting in changing habitats and species distributions.
  - An increase in coastal erosion, resulting in a loss of coastal habitat, damage to near shore habitats and steepening of the intertidal beach profiles.
  - An increase in storm events, resulting in damage to habitats due to erosion and loss.
- Temperature stratification of coastal waters, resulting in longer seasonal stratification and reduced vertical water mixing, This may lead to harmful algal blooms that have been associated with fish kills and benthic (organisms living on the sea bed) mortality (objective 1d and e).
- Seasonal shifts in primary and secondary productivity, leading to a loss of synchrony between predator/prey species and invasions of non-native species into new range areas. Possible resulting changes to ecosystem composition may lead to greater challenges in maintaining the above objectives (objective 1 a – e).
- A slight risk of an increase in the negative impact of non-native species on Marine Protected Areas and the economy (objective 1 b and d) due to progressive warming of the seas, which may result in changing habitats and species distributions. There is also a slight increased risk of the introduction of non-native species with associated human health risks entering our waters (objective 2 a, b and d).
- A reduced ability to protect marine and coastal carbon sinks from further deterioration (objective 1b), or recover the historical lost extent of these sinks where opportunities have been identified due to:
  - An increase in coastal erosion leading to the loss of coastal habitat, damage to near shore habitats and steepening of the intertidal beach profiles. It will be necessary to identify suitable land where realignment can take place, but this has the potential to put pressure on some coastal wetland/ terrestrial habitats that act as valuable carbon sinks.
- A reduced ability to ensure sustainable use and management of the marine environment (objective 2); addressing the damaging impacts of commercial fishing practices, encouraging best practice for marine industries and achieving Good Environmental Status of English

waters due to:

- An increase in stress on species with calcium carbonate shells and internal skeletons
- An increase in stress on species with calcium carbonate shells and internal skeletons which are susceptible to acidification of seawater, which is occurring as a result of rising atmospheric levels of carbon dioxide. Additional possible long-term impact on the well-being of species groups and composition of habitats (objective 2a).
- Climate induced changes to population sizes and ranges of fish stocks making it harder to assess the impacts of the fishing industry (objective 2a).

However, there are some possible **opportunities:**

- An increase in warm water species of interest either ecologically and/or economically in the southern waters off England (objective 1), as a result of changes to species ranges with progressive warming of the seas. There is an additional possibility of more viable fisheries for some species extending into the southern North Sea, with range extensions already of 50 – 400km.

## Possible responses

In the short term, we must continue to do all we can to conserve existing biodiversity. This should include conserving protected areas and other high quality habitats and creating new intertidal habitats where current habitats have been lost to sea level rise. As well as protecting habitats and species within Marine Protected Areas, we must ensure that they are representative of the diversity and variety of species and habitats at regional and national scales, and contribute to an ecologically coherent network at the UK scale.

The Marine Conservation Zone Project led by Natural England and the Joint Nature Conservation Committee to identify and recommend Marine Conservation Zones to Government, provides Ecological Network Guidance which aims to ensure that Marine Conservation Zones, along with existing Marine Protected Areas designated under national and European legislation, will fulfil this role. Marine Conservation Zones will thereby contribute to the measures aimed at achieving Good Environmental Status under the Marine Strategy Framework Directive, and the UK contribution to the ecologically coherent network of Marine Protected Areas under the OSPAR Convention on the Protection of the Marine Environment in the North East Atlantic.

In order to enhance resilience and resistance of habitats to climate change impacts, we should also provide areas of full protection from damaging human impacts to enable ecosystem complexity and diversity to rebound back to something akin to 'natural'. Through the Marine Conservation Zone Project, some reference areas for representative and rare and threatened habitats and species will be identified to provide this high level of protection within the network. These reference areas will enable us to better detect the signature of climate change and human impacts in other areas, whilst also doubling up as a network of refugia. Marine Conservation Zones, including reference areas, should be implemented at sufficient scale and distribution in the Marine Protected Areas network to be ecologically viable, and sufficiently robust to withstand the challenges that climate change impacts will present.

In the longer term, such aspects will be important to help us develop 'climate smart Marine Protected Areas', which would include addressing, for example, optimising adaptation and mitigation options and effective management of the sites' carbon footprints whilst ensuring biodiversity objectives are maintained in the long-term.

We need to have a sound evidence base to support decisions for the marine environment in the face of climate change. Survey methodology should be enhanced to incorporate assessment/ indicators of changes to biodiversity and related ecosystem services which could be climate driven. This is being addressed through the UK Marine Monitoring and Assessment Strategy and National Marine Biodiversity and Surveillance Programme - Natural England is a partner in both programmes.

We should assess and address the threat of invasive non-native species due to climate change, act where risks of introductions other than through climate impacts are identified, and make clear the links between the economy and the impact of such species.

We will actively engage with the Marine Strategy Framework Directive to encourage that site based measures be complemented by wider sea measures that work together to effectively maintain and recover biodiversity through the achievement of Good Environmental Status. We must also reduce other sources of harm besides climate change through marine planning, licensing and improved management practices and consistent use of environmental assessments. The Marine and Coastal Access Act 2009 gives public bodies the tools to do this. We also need to continue promoting sustainable coastal management which enables coastal change and adaptation. Together, these actions will help to give our marine wildlife the best possible chance to adapt to changing conditions.

Adaptation responses that would also have **mitigation benefits** include:

1. Improve protection and management of coastal carbon sinks (objective 1b) such as saltmarshes, sea grass meadows, kelp beds and estuarine sediments. This will retain the sequestration ability of existing habitats and avoid very significant emissions of carbon dioxide by deterioration of such habitats due to poor management, pollution and damage and destruction.

2. Encourage better carbon management in the fisheries sector (links to objective 2b and c), applying to construction, engines, gear, operation of fleets, through to more efficient refrigeration and transport infrastructure and the concept of 'fish miles'.

## Landscape, historic environment and geodiversity

England's landscapes are all around us, incorporating the natural environment and including the settings for people's everyday lives as well special places. Landscapes are formed from the interaction of both natural processes and human activity. Each landscape is unique, being a specific blend of its underlying geodiversity, soils, climate, biodiversity, and human influence, both past and present. Landscapes are everywhere, in towns and cities, suburban areas and the countryside, the coast as well as inland areas. Natural England is the Government's statutory advisor on landscape, with specific responsibilities for National Parks and, Areas of Outstanding Natural Beauty.

The 'historic environment' makes a particular contribution to the character and value of all of our landscapes, giving us an understanding of how both landscapes and seascapes have developed. It is all around us, as much of England still has visible clues to past lives and environments. It includes archaeological sites, both designed and evolved landscapes, coastal and marine areas and historic buildings and structures in their settings, showing human influence from all periods of human activity.

Geodiversity, in simple terms, is the variety of rocks, minerals, fossils, soils, landforms and natural processes. Geodiversity plays a major role in defining landscapes and coastlines. Spectacular geological formations form the backdrop to many of our most popular tourist locations. Geodiversity also provides many of the essential natural resources that society and economic growth depend upon.

With landscape, the historic environment and geodiversity acting as such an important foundation for the other aspects of the natural environment that we value, our **objectives** for them are:

1. To build an evidence base that explicitly covers the impact of climate change on all aspects of England's landscapes, including the historic environment, geodiversity and soils. This evidence will be the product of both quantitative and qualitative approaches to assessing the impacts of climate change. We will work in partnership wherever possible, thus making the best use of limited resources. Effective communication of our evidence will be essential.

   To use an integrated landscape approach in establishing the framework for Natural England's work programmes, including people and partnerships, land management and land use. Key elements of this approach will be based on integrated objectives for each of England's 159 National Character Areas. It will include guidance about working at a landscape scale.

   To use this integrated landscape approach as the basis for an integrated monitoring platform, that allows us to answer questions about changes in each NCA, their causes and their significance in terms of landscape character and function, including the impact of climate change.

2. To provide evidence, technical advice and direct delivery to support conservation and management of protected sites, areas and landscapes (National Parks, Areas of Outstanding Natural Beauty, historic landscapes; and geological National Nature Reserves, Sites of Special Scientific Interest and local sites).To provide advice on the safeguarding and management of geological Sites of Special Scientific Interest, to quality assure condition assessments and advise on the scientific coherence of the network of geological sites. To maintain an overview of local geological sites and support standard setting and quality assurance.

3. To utilise larger protected areas such as National Parks and Areas of Outstanding Natural Beauty as exemplars for adaptation, including actions following the Making Space for Nature review (Lawton 2010).

4. To provide an evidence base for mitigation strategies and best practice - including energy infrastructure, peat and carbon.

**Direct and indirect threats** include:

A risk that our evidence work to assess landscape change (objectives 1 and 2) will not 'keep pace' with the rate of possible changes, and that we will have a reduced ability to achieve our statutory role in conserving and enhancing the natural beauty of landscapes with national designations (objective 3). This could occur because of changes such as:

- Reduced soil function leading to a loss of soil structure, nutrient cycling/fixing, water infiltration and soil carbon storage, due to one or both of:
  - Changes to soil water and temperature regimes – general temperature rise and more frequent wetting and drying events would mean elements of the soil biota could not survive in the new conditions. The soil function would suffer, and subsequent increased emissions of greenhouse gases into atmosphere would exacerbate global warming.
  - Increased pressure on soils due to changes in agricultural practices by land managers.

- Although landscapes always change, (and there are ways of managing positively for change, so that existing valued landscapes can be conserved and new ones emerge during periods of extreme change), the potential rate and degree of change does have risks that there will be undesirable effects on landscape character (including historic features and geodiversity), and the biodiversity and ecosystem services supported by landscapes, due to:

  - Increased erosion and slope failure due to a rise in extreme weather events.
  - Loss of access (both direct and indirect) brought about by changes to land form and land cover due to temperature rise, extreme weather events, changes in drainage systems and ground conditions.
  - Changes to geomorphological processes as the climatic conditions generally become more extreme, resulting in hydrological and geochemical changes which will impact on buried archaeology and sensitive palaeo-environmental remains.
  - Loss of valued landscape features, or access to them, or disruption of natural processes as a result of hard engineering put in place to protect threatened infrastructure from the dynamic effects of climate change (e.g. sea level rise, floods and mass land movements).
  - The breakdown of soil structure and function (reducing the soil's ability to protect buried archaeology), as a result of changes to agricultural practices in response to climate change.
  - Changes to biological communities and habitats that help to make up the landscape (see biodiversity section). For example, loss of iconic tree species such as beech trees dying because of increased summer drought, or trees being lost as a result of severe storms and flooding.
  - Increased tree cover with locally inappropriate species as a result of a drive for increased provision of ecosystem services, particularly carbon sequestration.
  - Loss of traditional features including field boundaries, hedgerows and traditional farm buildings as a result of changes to traditional farming practices in response to changing conditions.

- Negative impacts of renewable energy generation projects (e.g. wind farms, biofuels and hydroelectric) on landscape character and sense of place, and on important features and sites.

- Other loss or damage to ecosystem function and services (for example, the potential salinisation of coastal freshwater) due to the rate and severity of changes to landscape systems.

Some direct and indirect **opportunities** include:

- New geodiversity features being exposed by flooding and erosion (objective 3).

- An opportunity to accommodate change to improve the benefits provided by landscapes (their character, biodiversity and ecosystem services), for example by enabling new tree species and their associated plant and animal assemblages to establish (objectives 2 & 4).

- Increased opportunities to understand and adapt to climate change on a landscape scale, if there is an increased drive for large scale adaptation action (particularly following the Making Space for Nature review), and if human communities become increasingly aware of the importance of their local landscapes as a way of helping them adapt to a changing climate (objectives 1 & 2). This would offer the possibility of restoring large scale natural processes and habitats (e.g. coasts and rivers, woodland, wetlands, peat lands), to re-

establish a different kind of landscape balance and better environmental outcomes for human communities.

- An opportunity to shift to more sympathetic soil management practices as the need for climate mitigation reduces energy intensive agricultural practices (objective 5). This would lead improved soil function and a decreased need for agrochemicals.

- Increased opportunities to engage with society and use our historic landscape and geological evidence to help people understand that landscapes are inherently dynamic and to identify the best ways to accommodate future changes (objective 1).

### Possible responses

In the short term, we need to continue to protect and conserve existing landscape and feature interests and to reduce threats from sources other than climate change. We will do this through Environmental Stewardship agreements with land owners and providing advice on land use and management practices. We will need to review our technical and practical guidance, revising where necessary to ensure it addresses managing and working with climate change.

We are developing integrated objectives for all of England's National Character Areas that take climate change into consideration (see section 7 on sub-national risk assessment). These objectives, based on the information and analysis that reflects Natural England's interests, will be made available to partners and stakeholders, including local communities, to help set the context for their planning and decision making.

We need to improve evidence base through monitoring to help us:

- Demonstrate how and where landscape change is happening and what impacts these changes have on landscape character and function.
- Provide the best possible advice about managing change.
- Assess the impact of renewable energy and mitigation developments on our landscapes.
- Use the recently published Beach Management Manual to provide guidance to local communities for managing coastal landscape change.
- Influence the continued development of soft engineering as an alternative to hard engineering schemes.
- Feed evidence of change in the abiotic environment (i.e. geodiversity, historic environment and soils) into landscape scale projects, National Character Area objectives and guidance on adaptation and resilience – enabling us to take a holistic approach for the whole natural environment.
- Develop principles on adaptation and adaptation strategies for protected landscapes, sites and areas with partners and update our site management guidance.

As they change, our protected landscapes should still aim to be exemplary practitioners of the best landscape conservation and enhancement practices. In the medium term therefore, we need to ensure that any guidance and advice on conserving and enhancing protected landscapes reflect our understanding of the dynamic nature of all landscapes, the potential and actual impacts of climate change, and ways of ensuring that these places, as and when they change, continue to be highly valued by society as a whole.

We will need to provide a strong voice on the nature of landscape change. We will need to communicate the potentially negative impacts of a changing climate on our landscape and

historic environment as we know it, whilst promoting the fact that landscapes are inherently dynamic in nature. We need to utilise this fact to explain and interpret change using examples from our evidence base of past change. We will need to advocate the benefits of allowing processes to operate naturally and deliver enhanced ecosystem services.

Our Natural Leaders programme aims to ensure that the natural environment is at the heart of local decision making and local service delivery, through developing shared objectives and a much stronger strategic relationship with local authorities, communities and developers.

By working closely with local communities, we can help them to understand and adapt to climate change, by providing access to the best available evidence, explaining and demonstrating what is possible. Through enabling communities to 'own' the landscape change in their area, we will aim to engage them with the positive aspects of living in a naturally dynamic landscape. We will also need to communicate and train Natural England staff effectively, ensuring we embed thinking about managing climate change across our work.

Adaptation responses that would also have **mitigation benefits** include:

- Promote peat land re-wetting through agri-environment schemes.
- Enhance our evidence base on agricultural practices which increase storage and reduce greenhouse gas emissions.
- Tree planting in appropriate areas and with appropriate species.
- Arable conversion to permanent grassland.
- Coastal realignment where appropriate.

## People and access

This work area involves inspiring people to enjoy and value our natural heritage and advising on and delivering access infrastructure to allow people to make that contact with the natural environment. Natural England has the responsibility to promote access, recreation and public well-being for the benefit of today's and future generations.
Our objectives for people and access are to:

1. Inspire people to value and conserve the natural environment by:

   - increasing the opportunities for new audiences to encounter nature closer to home;
   - promoting projects engaging children and people from areas of multiple deprivation with the natural environment;
   - increasing the number of people participating in health walks;
   - increasing the contributions made by a diverse range of people to support National Nature Reserves, Local Sites and Biodiversity Action Plan species.

2. Deliver the Access Grant Schemes to enable more people from a wide range of groups and areas to enjoy the benefits of a vibrant natural environment.

3. By 2011, develop a sub-national strategic understanding of our access infrastructure and champion strategies for quality access to quality environments.

4. Review the feasibility of developing a series of Champion National Nature Reserves by considering alternative partnership and funding options. Also ensure that the National Nature Reserve estate is fully integrated into the people and access infrastructure.

Possible **direct and indirect threats** to these objectives include:

- A reduced ability to provide increased opportunities for people to engage with and value the natural environment (objective 1), or deliver Access Grants Scheme to allow a wider range of people to enjoy the natural environment (objective 2) due to:
  - An increase in costs to maintain and manage access routes that are affected by flooding and erosion, increases in vegetation growth due to a warmer climate and increases in usage. Repairs may be necessary to maintain areas in poor condition, and realignment may be required as the location of coastal access points change.
  - Prolonged closure of areas of open country to the public due to increasing wildfire risk on areas of statutory open access land. Wildfires are likely to become more frequent as we suffer from more drought events as a result of hotter drier summers.
  - Statutory access maps may become out of date as the land cover they depict alters. Long term changes in temperature and rainfall are likely to change the habitats and landscapes across England, so revisions to these maps will need to allow for this.
  - A reduced appeal of some places in the country at some times of year due to changing weather conditions or loss of landscape character. For example, upland areas could lose their appeal for hill walking due to wetter winters, and warmer winters could reduce opportunities for snow and ice-based recreation activities such as cross-country skiing, snow-shoeing and ice climbing. Landscape change across the Norfolk Broads due to a potentially more saline environment, or erosion of other coastal landscapes as the sea level rises, may alter what people perceive to be the 'special qualities' of those places, and so people may form negative perceptions of the landscape change and feel less engaged with the natural environment.
  - Conversely, an increased appeal of certain areas of the country at certain times of the year, would pose the threats of overcrowding, disturbance to wildlife (e.g. ground nesting birds) and damage to habitats. Hotter, drier summers may put increased pressure on certain areas which are already very popular in the summer (e.g. the Cornish coast or the Lake District). Alternatively, the appeal of some currently popular areas may be reduced due to changes in the landscape character or weather conditions, putting increasing pressure on other areas around the country which currently have limited access opportunities.
  - Reduced availability of local greenspace and routes, and impacts on coherence of local rights of way networks due to localised flooding events, as a consequence of extreme rainfall.
  - Reduced opportunities for Educational Access visits due to potential intensification of agricultural systems as farmers adapt to climate change by changing their farming practices.

- Increased challenges to overcome to develop a suite of Champion National Nature Reserves (objective 4) as habitat changes render some sites potentially unsuitable as exemplars. Key habitats could alter in condition, reduce, or disappear as a result of changes in rainfall and temperature, including resultant extreme events such as droughts, heat waves and storms.

However, there are some possible **opportunities**:

- There are likely to be increased opportunities for people to engage with and value the natural environment (objective 1) due to:

    - Warmer drier summers, encouraging more people to visit and use the outdoors and more people to holiday in England as opposed to abroad. This will lead to an increased number of people visiting and enjoying the wider countryside and local greenspace.
    - An increased need for community involvement to take action to protect and enhance the natural environment as a result of climate change. A likely increase in maintenance requirements of access routes provides engagement opportunities using 'adopt a path' type schemes (as recommended by the Humberhead Levels Study). Additional volunteers will also be needed to assist in the managing, monitoring and documenting of environmental change in habitats, along with new habitat creation for environmental and ecosystem services benefits.
    - An increased awareness of an interest in using the natural environment (for example urban green infrastructure) to provide services to help communities cope with climate change. This could provide increased opportunities for the public to get involved with environmental restoration projects and also create opportunities for enhanced green space for recreation and improvement of green routes around towns and cities.

## Possible responses

In the short term, Natural England should begin to assess and address the necessary adaptations in the face of climate change. For example, with increased likelihood of wildfires, the fire restrictions legislation placed on open access land may need to be reviewed as currently closures can only be made in 'exceptional circumstances'. Natural England also has statutory duty to remap areas of open country - any review of this should take account of habitat change within its methodologies.

We will need to have a robust evidence base of the effects of climate change on designated access land and on people's behavioural patterns of how they engage with and use the natural environment. We should strengthen our evidence base on visitor patterns to capture increasing or changing numbers of visitors (e.g. through the Monitoring Engagement with the Natural Environment survey). We will also need to ensure there are appropriate monitoring mechanisms in place to capture losses or gains in local greenspace and routes and use these to inform our evidence base. Through partnership working with the highways authorities and the third sector, we should develop management strategies and provide and promote best practice advice on management of greenspace.

National Nature Reserves could be used to provide educational opportunities for local communities to learn about the potential impacts of climate change and the value of the natural environment to help with both adaptation and mitigation; and to explain the concepts of ecosystem services. We should standards-set to ensure tangible examples are used and that opportunities are provided across the country. Best practice advice for volunteers that is adaptable to changing local circumstances should also be developed.

## Land management

Natural England works to help farmers, land managers and others deliver the sustainable management, use and enjoyment of England's countryside. We work closely with Defra, farming and environmental stakeholders, agri-environment scheme agreement holders and community groups.

We manage agri-environment schemes and run land management advice programmes to benefit multiple environmental objectives (Biodiversity, Landscape, Historic environment, Resource Protection, Access). The schemes and programmes we manage or run are:

- Agri-Environment schemes (Environmental Stewardship and the Classic Schemes), providing funding to farmers who deliver effective environmental management on their land. We aim to increase and maintain the area of land covered by agri-environment schemes. We have indicators of success to assess the outcome of Higher Level Stewardship agreements.
- The Energy Crops Scheme, which offers grants to farmers in England for establishing miscanthus and short rotation coppice for their own energy use or to supply power stations.
- A Land Management Advisory Service, designed to help farmers and other land managers to improve their land management for the benefit of wildlife, landscape, public access and other environmental purposes.
- Entry Level Stewardship Training and Information Project, which helps farmers apply for Entry Level Stewardship and Uplands Entry Level Stewardship, and will improve the environmental outcomes achieved by helping farmers to choose and locate the right options on their farm, to provide the maximum benefit for farm wildlife, farmland birds, resource protection and the historic environment.

- England Catchment Sensitive Farming Delivery Initiative (jointly with the Environment Agency), which seeks to raise awareness of diffuse water pollution from agriculture, and to encourage early voluntary action by farmers to tackle the problem in 50 priority catchments.

**Direct and indirect threats** to our objectives for our schemes and programmes include:

Reduced effectiveness of our land management programmes because of:

- Consequences of the direct threats covered in the biodiversity and landscape sections above. For example:
  - Changing species, habitats and biological communities will require us to update our agri-environment management options to avoid them becoming increasingly out of date. Current Environmental Stewardship targeting, prescriptions and recommendations, such as species for planting (e.g. historic parkland restoration, hedgerow trees), may no longer be appropriate. This will affect our ability to meet our Higher Level Stewardship indicators of success and overall objectives of the schemes.

- Changes in cropping patterns and systems (for example shifts in where crop are grown, an increase in new crops, and changes in the livestock sector due to earlier, longer growing seasons), as a result of farmers adapting to climate change will also generate a need to update our land management programmes to reflect changing farming practices. Failure to do so could result in farmers not renewing their Environmental Stewardship agreements, potentially causing a loss of benefits accrued under past agreements.

- Damage to farm infrastructure and disruption to farming activities, as a result of extreme events such as heavy rainfall and flooding, could reduce farmers' ability to maintain the farmed environment.

- Extreme weather events will also directly impact the natural environment, both in terms of increased incidence of soil erosion (run-off and wind), and increased risk of flooding and drought affecting habitats and other environmental features.

**Opportunities** include:

- Increased awareness of climate change and the role of farming and land management in helping to address it, could result in an enhanced drive for pro-active environmental land management. This would create a potential opportunity to promote benefits of existing schemes and programmes for mitigation (e.g. the role of Environmental Stewardship in reducing emissions) and adaptation (positive impact of Environmental Stewardship on provision of habitat networks).
  - Potential to use our land management programmes to promote sustainable adaptation responses to climatic changes, in particular focusing on positive management of resources such as soils, water and wildlife habitats to support adaptation of the natural environment and to support productive farming. For example, the importance of good soil management in future will grow, partly because of water resources and water quality requirements but also because of the vulnerability of poorly managed soils to storm events, especially where these break drought periods.
- As the climate continues to change, an increased demand for alternatives to fossil fuels could provide opportunities to promote sustainable cultivation of energy crops.

- An increased risk of flooding and need to manage runoff water could increase opportunities for Natural England to use its Resource Protection objective to promote re-wetting of floodplains and wetland creation as a sustainable means of helping to manage flooding, providing high quality habitats and helping to achieve our Biodiversity Action Plan targets for species and habitats.

## Possible responses

There is an important role for our land management work to address not just the threats and opportunities outlined in this section, but also risks arising in other functional areas of Natural England. Responses can relate to mitigation (by reducing greenhouse gas emissions and by protecting carbon stores) and to adaptation (both adaptation of the natural environment and of farming systems). We will also need to communicate this advice to farmers, agents and our own advisers.

Working with partners, we can promote sustainable agricultural adaptation to climate change and the use of agri-environment schemes to support that adaptation (e.g. by promoting use our of land management methods that reduce greenhouse gas emissions). We can also develop advice on the management of soils, trees and habitats as carbon stores and to reduce flood risk.

We could use an increasingly strong evidence base of relevant data to embed climate change vulnerabilities in the natural environment into the Higher Level Scheme process. We will also need to update Higher Level Stewardship targeting statements to include actions to promote climate change adaptation defined in completed National Character Area Adaptation Studies. We could look to develop a suite of advisory materials for farmers and farm agents to explain the impacts climate change is anticipated to have on farming in England and how taking up Environmental Stewardship options within agri-environment schemes could have adaptation and mitigation benefits. For example:

- Promoting use of the CALM-ES (Carbon Accounting for Land Managers) tool that we have developed with partners;
- Promoting use of Environmental Stewardship options to increase the area of tree and woodland cover to provide shelter, or fuel whilst increasing carbon stored in the national woodland resource;
- In order to deliver the above advice and guidance successfully, we should ensure that Natural England advisers have the necessary skills to deliver effective advice to land managers on climate change adaptation and mitigation. They will need to have a solid understanding of the likely effects of climate change in their area in order to be able to interpret the relevant evidence base effectively and provide the most appropriate land management advice.

Some adaptation responses which would also have **mitigation benefits** include:

- Identify the greenhouse gas emissions reductions achieved by energy crops planted under the Energy Crops Scheme and promote its benefits.
- Encourage low carbon land management by exploring the potential for existing advisory programmes to extend to include low carbon farming advice and by promoting the CALM-ES (Carbon Accounting for Land Managers) tool.
- Encouraging the planting of trees, in the appropriate places and with locally suitable species, to provide a wide range of adaptation benefits as well as sequestering carbon.

## Sustainable Land Use

In its 2010 discussion document '*An invitation to shape the Nature of England*' government recognises that the natural environment is fundamental to the future of our economy, prosperity and more general aspects of human well being. Sustainable land use is central to maintaining the natural assets and so the ecosystem services on which our future economy and society will depend. In addition to our advisory role to government and others, Natural England has special duties with regard to areas designated for protection of their special biodiversity and landscape value. These cover a significant land area, 7% is designated as Site of Special Scientific Interest and c.25% as Area of Outstanding Natural Beauty of National Park. Within these areas sustainable land use therefore has the potential to deliver a wide range of public benefits and it is important these are maintained and enhanced in the face of climate change, particularly those service of adaptive value under changed climate such as flood regulation.

In addition to climate change, there are other future challenges to sustainable land use and the 2010 Foresight report '*Land Use Futures: making the most of land in the 21st century (Foresight 2010)*', has been very clarifying. We can foresee from this report that in addition to climate change; demographic change, new technologies, societal preferences and policy and regulation will be major additional drivers of change. We will need to accommodate these drivers and the pressures they create in our adaptation response to sustainable land use under changed climate.

Our **objectives** for sustainable land use include:

1. The environmental assets of land and water are used in a way that recognises, protects and enhances the role of the natural environment in underpinning England's economic prosperity and well being, through provision of ecosystem services.

2. That protected sites (e.g. Sites of Special Scientific Interest, Areas of Outstanding Natural Beauty and National Parks) maintain the special values for which they were designated and provide a supply of ecosystem services to society.

3. Through our inputs to national, regional and local land and water use plans, enhance the quality of place, secure Biodiversity Action Plan habitat creation, high quality green infrastructure, new access, enhancements for Biodiversity Action Plan species, reinforce distinctive landscape character and recognise the value of ecosystem services to generate benefits for society and the economy. We aim to achieve this by prioritising interventions and advising on the integration of the natural environment into new strategies and partnerships.

4. Ensure that the EU and UK regulatory and policy framework for the energy, transport, agriculture and other sectors successfully integrate low carbon, low energy and renewable energy with a healthy natural environment.

5. Provide advice on the setting of regional and local targets for renewable and low-carbon energy, ensuring they are based on robust capacity assessments that fully account for the sensitivities of the natural environment.

**Direct and indirect threats** include:

- A reduced ability to successfully influence land and water use plans to protect the natural environment and the ecosystem services it provides. For example, a reduction in Biodiversity Action Plan habitat creation, green infrastructure and new access, and degradation of landscape character benefits (objective 3), as a result of:
  - Changing, and potentially unsustainable, land use in response to climate-related issues (for example food security concerns, increased water supply from reservoirs and expanding markets for biofuels) making it harder to secure new high quality conservation areas.
  - An increase in climate and energy-related casework overwhelming our capacity to provide specific advice on each case.
  - Change in the geographical focus of development to areas of low flood risk, for example, which constrains our ability to deliver environmental benefits to potentially more limited geographical areas.
  - Increasing number of applications with environmentally unsustainable climate change measures, such as major 'hard' flood defence schemes, increasing local water abstraction or storage requirements.

- Unsustainable use of land and water, reducing our ability to encourage use that protects and enhances the value of the natural environment (objective 1) as a result of:
  - Inappropriate changes in agricultural management as a result of changing climatic conditions and/or of indirect climate-related pressures (e.g. for increased biofuel, or increased food production).
  - Unsustainable abstraction of water in water-stressed areas as a result of summer drought, particularly in those areas such as the south east where water resources are already limited.

- Greater involvement in pre-application consultations on matters relating to climate change adaptation or avoidance measures which could have implications for Natural England's ability to effectively engage.

There are also important **opportunities** that we need to seize:

- Greater recognition that by enhancing natural features such as wetlands and more generally soils, water resource adaptation can be improved in terms of quantity and quality, including defence from damaging flooding and reduced low water flows in rivers.

- Opportunities to manage the greenhouse gas flows and carbon stores of the natural environment which increase the quality of their natural assets and their capacity for climate change adaptation. (E.g. coastal realignment, increases in woodland and bog restoration all enhance carbon stores in the natural environment, and at the same time variously protect coasts against increased storms, favourably modify local climates and store water.)

- The incorporation of natural features of adaptive value into new built development, including built structures themselves (e.g. urban green spaces and green roofs which reduce flood risk, and wooded areas which provide local direct cooling).

- Community-led development which brings forward innovative, environmentally beneficial development and a balance of land use appropriate to local climate adaptation requirements.

- A strong impetus for the delivery of multi-functional green infrastructure, and there could be increased opportunities for us to engage with local planning authorities and developers to advise on development design at an earlier stage, resulting in a better set of economic, social and environmental outcomes.

- Increased interest in incorporating climate change adaptation into local transport plans, - by for example, including natural shading by vegetation and sustainable drainage, as well as increased use of cycling and walking routes.

- Increased climate change expertise in local communities through practice of open source planning, to provide guidance on how to provide locally appropriate multiple benefits from the environment, including climate change adaptation.

## Possible responses

We need to ensure we have a strong evidence base in order to provide the public and industry with best practice examples and advice on how to integrate climate change principles into their planning developments. Good advice requires knowledge, so initially we need to ensure that climate change is included as part of the training and tools resource forming part of the advisor toolkit. We will also need to secure resources for training and guiding both development and our engagement with development.

We need to build positive, effective partnerships with industry through a shared understanding of the way in which the natural environment underpins our economy more generally, and specific businesses in particular. For example, our increasing work with the water industry to secure water supplies which are of a higher quality and quantity. Amongst other things, positively engaging with industry about the mutual benefits of

the natural environment and ecosystems services means we could see better informed planning applications requiring a reduced consultation process and unleash private sector entrepreneurialism. For business and a wider sector of society we should provide best practice examples of development with climate change adaptation provided through multi-functional green space and other green infrastructure.

As a trusted and respected source of advice on sustainable planning, we should influence Local Planning Authorities to recognise the role that the environment contributes to their social and economic aspirations, and use our interventions around spatial plans to take a sustainable view of climate change adaptation by providing advice and best practice examples to Local Planning Authorities on ecosystem services solutions to climate change adaptation (e.g. rethinking the role of floodplains) in planning policies. We should also include environmentally beneficial climate change adaptation in our suite of training products provided for town planners.

We should also provide advice to local communities on ecosystems services and climate change adaptation for biodiversity and landscape. This advice should be tailored as far as possible to local circumstances and capacity building. We should particularly ensure there are adequate, cost-effective guidance resources available to communities with open source planning applications. These advice resources could be hosted by the Natural England external website.

Adaptation responses that would also have **mitigation benefits** include:

- Increased public access to high quality green spaces which potentially provide direct climate regulation, flood risk reduction and a greater opportunity for wildlife to respond to climate change, but also recreational access and enjoyment of nature near to home, reducing the use of carbon-based transport.

- Creation and restoration of a wide range of habitat types which enhance adaptation and store carbon or emit fewer greenhouse gases. For example, restoration of intertidal habitats which protect coasts against storms and store carbon, woodland creation which cools local climate in summer and stores carbon in vegetation and soils, and creation of species rich grasslands and heaths which reduce overland water flows and improve infiltration and so reduce floor risk, but which also create less nitrous oxide than fertilise agricultural areas.

- Encouraging developers to examine options that deliver multiple benefits for the natural environment including: adaptation by direct climate cooling by vegetation, alongside mitigation by carbon storage, and greenhouse gas reduction either through environmental management (e.g. conserving soil carbon stores during development), or provision of options which reduce emissions (e.g. recreational development based upon the natural environment sited where less transport is required).

- Mechanisms to direct renewable energy applications to most environmentally appropriate areas. Work in partnership with industry and local planning authorities to identify suitable low-risk sites with capacity to take renewable energy development.

- A more streamlined approach to planning consultations which makes greater use of up-front advice and guidance on matters relating to ecosystem services. This will encourage more sustainable development which is more resilient to climate change, which in turn, helps to reduce the planning burden on Authorities, developers and Natural England.

Section 6:

# Business delivery: facilities, business continuity and safety

As well as the work areas discussed above, which are specific to Natural England's statutory purpose, like all other organisations we have more general responsibilities to ensure we have suitable facilities for our work, are able to continue to deliver the most important elements of our work despite disruption, and can provide a safe working environment for our staff. Key requirements here include:

- Ensuring that our staff are safe, both in our offices and when travelling or out in the field;
- Maintaining suitable and properly-functioning buildings and other parts of our estate to be able to deliver our work;
- Being able to cope with disruption and continue to support critical areas of our work, and continue to deliver key services (including payments) to our customers; and
- Ensuring that our delivery partners and suppliers similarly act to ensure staff safety and continued delivery.

The main **threats** from climate change in this area are likely to arise from extreme weather events, such as the following:

- Heatwaves making the ambient temperature inside our buildings uncomfortable or unsafe for our staff and visitors.
- Flooding making offices or other sites unusable or inaccessible.
- Flooding creating unsafe conditions for staff in the field, for example advisers visiting farms, staff working on nature reserves or carrying out environmental monitoring.
- Flooding presenting risks to visitors to our National Nature Reserves.
- Increased incidence of fires, e.g. on moorland, making conditions unsafe for staff in the field and visitors to our sites.
- More intense rainfall and possible storm events increasing building maintenance costs.

**Responses** we are considering:

- Ensuring that business continuity plans take potentially more frequent and more severe extreme weather events into account to ensure continued delivery of our key work.
- Continuing to review climate risks to our office buildings and other parts of our estate (following an initial audit done in 2009/10).
- Ensuring that extreme events are considered in safety guidelines and procedures for staff in the field.
- Reviewing arrangements in our offices for responding to periods of extreme hot weather.
- Exploiting the potential of technology to enable remote and flexible working (including home working) to both enhance 'business as usual' operational flexibility and provide contingency options in the event of incidents and problems.

Section 7:

# Sub-national climate risk assessment: preliminary work

Consequences of climate change, their relative importance, and appropriate adaptation actions, will in many cases be specific to individual places and depend on local conditions, pressures and aspirations. Therefore it is necessary for us not only to identify broad risks to our objectives at national level, but to explore risks and possible adaptation responses at a finer spatial scale. This will help us to understand the relative importance and specific potential consequences of our climate risks in different places, and to use this knowledge both to guide our own conservation work and to provide information that can help local communities make decisions for the natural environment in their area.

As noted in section 3 above, we will consider important climate risks and responses in each of England's 159 National Character Areas, as part of a project to produce updated profiles for each area. This will be informed by the findings of work we have done to assess the vulnerability of the natural environment to climate change at three spatial scales: at national scale, in three different regions, and at the scale of National Character Areas. In particular, it will build on the detailed studies we have done in 12 National Character Areas, which has enabled us to consider some consequences of climate change in more detail for particular places. The information below provides a brief summary of some of the findings and outcomes of our first four studies, published in 2009 (Natural England 2009b, 2009c, 2009d, 2009e).

## Cumbria High Fells: a mountainous landscape in northwest England.

The natural environment in this area is likely to be affected particularly by an increase in temperature, an increase in winter rainfall and a decrease in summer rainfall. Impacts are likely to include a move of warmth-loving species towards more northerly facing slopes and higher ground, with cold tolerant species on the highest tops and northerly slopes being at risk of extinction; peat bogs drying out and consequential increased carbon losses to the atmosphere; reduction in lake levels and increasing lake and river water temperatures. Footpaths being eroded by a combination of increased summer drought, recreational pressure and increased frequency of intense rainfall events. Adaptation actions include encouraging native woodland regeneration in higher areas to help species find suitable habitats at higher altitudes as the climate warms, the restoration of peatland so that it is in a better condition to withstand the additional pressures of climate change, a more holistic approach to water management in the uplands, and continuing projects which improve the resilience of footpaths.

The report has enabled three priority land management strategies to be identified, all of which have multifunctional benefits in a changing climate. These strategies – sustainable grazing regimes; restoration of blanket bog; targeted increases in scrub and woodland – are now being delivered by Natural England and our partners. These strategies all provide responses to the impacts of climate change thought to be most relevant to the area, supporting biodiversity and protected sites, enlarging and buffering sites, thus improving habitat networks, and mitigating against the impacts of intense rainfall. Mapping of opportunities for habitat creation and restoration and an Ecosystem

Services pilot project in the Bassenthwaite catchment have identified where the biggest gains can be made through new Higher Level Stewardship applications; the Lake District National Park has embedded the need for these land management actions in its Partnership Plan; and delivery by partners, for example through the SCaMP2 programme, supports our work through Higher Level Stewardship. Our work with the Environment Agency developing its River Restoration Strategies is also enabling work to be planned around the re-naturalisation of water courses, which should improve their capacity to cope with flooding events. The catchment management plan developed by the Environment Agency in response to last year's flowing of Cockermouth identified that land use change in the upper Derwent Catchment is needed to reduce flood risk.

## The Norfolk Broads: a low lying wetland landscape in eastern England.

Impacts on the Broads are likely to be more significant than for many other areas of the country as a result of coastal erosion and sea level rise. Salt water is likely to increasingly intrude into the freshwater lakes, causing habitat change and species loss, and due to the increased likelihood of both flood and drought. Adaptive actions might include revision of river dredging regimes, planting wet woodland in flood plains and restricting recreation at times of poor water quality.

One of the main implications of our study has been a raising of the profile of the vulnerability of the Broads to climate change. Our experiences have also highlighted the need for other sectors to consider adaptation and the necessity for adaptation planning in the Broads to integrate the interests of communities, the economy and the environment.

Our adaptation plan highlighted the benefits of adaptation of the floodplain to a more natural functioning condition. We have been working with partners to deliver a demonstration site at Hickling National Nature Reserve. Here funds from several sources, including Environmental Stewardship and flood management monies are being used to deliver floodplain adaptation and a different environmental outcome. This will require modification of the conservation objectives for this designated site.

The Broads Authority has a long history of freshwater lake restoration from the eutrophic state, with many notable successes. Its current lake restoration strategy takes account of the risk of increasing saline intrusion, prioritising investment to lakes isolated from the river system and those furthest upstream.

## Shropshire Hills: a hilly farmed landscape in western England.

Possible impacts here include a loss of mature trees in the landscape as these succumb to extended droughts and more severe storms; changes in the viability of some crop varieties and livestock breeds; and damage to historic buildings caused by an increase in soil erosion during peak rainfall events. Adaptive actions identified include extending existing areas of semi-natural habitat and creating new areas; pollarding mature trees in historic parklands to make them less susceptible to storm damage; and promoting a greater variety of tree species to eventually replace existing mature trees.

During the study it became apparent that fragmentation of habitats, not just in the Shropshire Hills but across the whole of the west midlands, had left the remaining fragments increasingly vulnerable to climate change. The need to reduce habitat fragmentation was subsequently recognised as a priority action within the West Midlands Climate Change Action Plan. A project was started, in partnership with the West Midlands Climate Change Office and the West Midlands Biodiversity Partnership and funded by Defra and Natural England, to produce maps identifying suitable areas for habitat creation. As each map was produced, vulnerability to climate change in each grid square was assessed, to highlight where apparently suitable areas for new habitat might become less suitable as the climate changes. This is helping us to identify which sites and habitats are likely to be viable in the longer term and to target Environmental Stewardship funding for habitat creation where it will be most effective.

## Dorset Downs and Cranborne Chase: a chalk landscape in southwest England.

The natural communities that currently characterise the landscape are likely to change, particularly as a consequence of drought. For example, the shallow rooting beech, which is common in Dorset, is likely to decline, but small leaved lime needs warmth to set seed and will probably be able to increase. Veteran trees of all species are more likely to be felled by storms. However, in woods the impact of these storms can also be positive, creating glades that species adapted to sunlight can occupy. Our assessment suggested that vulnerability is highest on the dip slopes and plateaux of the chalk downland.

Adaptation actions that Natural England is promoting with partners as a result of the study include: re-establishing chalk grassland or native woodland adjoining water courses to reduce downstream flooding; creating naturally functioning floodplains to allow greater water storage and the evolution of new wetland habitats; actions to adapt the tree and woodland resource of the area to climate change, such as improving management around existing veteran trees, planting locally native replacements for existing mature trees, re-establishing pollard regimes, buffering and increasing the size of small woods in intensive agricultural areas; and restoration or creation of schemes designed to improve water storage on farms, to reduce vulnerability to projected drier periods whilst providing additional wetland habitat.

Section 8:

# Conclusions and future work

## Some emerging conclusions

Although this work is not yet finished, it is already clear that there are some important direct and indirect threats to our objectives, and we will need to take these very seriously. There are also some potential opportunities to be seized. Some of the key threats and opportunities are summarised in Box 1 and Box 2.

### Box 1. Summary of some key threats across our work areas

A reduced ability to maintain our current targets (if these are treated in a static way) for species and habitats within statutory designations (e.g. Sites of Special Scientific Interest, Marine Protected Areas) or to achieve our species recovery plan objectives, due to shifts in the ranges of species and habitats, habitat loss or damage, and changes to seasonal events.

Our statutory designations potentially becoming outdated and inappropriate as the ecological communities on a site change.

A reduced ability to carry out habitat management such as maintenance, restoration or creation of Biodiversity Action Plan priority habitat or marine and coastal carbon sinks or to strengthen ecological networks, due to a lack of or damage to suitable sites, changing species distributions, sea level rise and a lack of influence over land and water use plans.

A reduced ability to provide opportunities for people to engage with the natural environment in some places at some times, due to damage to recreation facilities, increases in maintenance costs, a reduced availability of local greenspace, or changes in the recreational appeal of certain places.

Current approaches to environmental land management programmes becoming unsuitable, as a result of both changes to the natural environment and changes to cropping patterns and farming systems as land managers adapt to climate change, or less effective as climate pressures reduce farmers' capacity to participate in schemes.

A reduction in the effectiveness of a range of aspects of our work as a result of unsustainable use and management of land, water and the marine environment (for example inappropriate changes in agricultural management, damaging commercial fishing practices and unsustainable abstraction of water) in response to climate-related pressures.

### Box 2. Summary of some key opportunities across our work areas

Some species being likely to benefit from a changing climate – for example expansions of southern Biodiversity Action Plan species, such as Dartford Warbler and benign colonisers such as the Spoonbill.

Opportunities to provide people with improved access to the natural environment arising from possible changes in people's use of the natural environment as the climate warms.

Increased recognition of the value of ecosystem services for adaptation and thus increased opportunities to provide environmental solutions – such as coastal realignment, functioning flood plains and urban green infrastructure – to local communities and so achieve multiple social, environmental and economic benefits.

Opportunities to use landscape scale change to improve ecosystem services and the benefits provided by a landscape (e.g. large scale habitat restoration to improve biodiversity and landscape character).

Opportunities to work with land managers to achieve adaptation benefits for both the natural environment and farming (and contribute to mitigation by reducing greenhouse gas emissions and protecting carbon stores).

Opportunities to increase partnership working to deliver environmental benefits for both wildlife and for people (e.g. improving coastal water quality), increasing both direct benefits to society and our likelihood of reaching certain Biodiversity Action Plan targets for species and habitats.

It is clear that there are some important links among climate risks and responses across work areas. Some important risks, such as the consequences of changes to species and ecosystems, have implications for many or all areas of Natural England's work. Risks identified in one work area will also often create risks for other areas. For example, our people and access work will need to take into consideration possible changes in tourist patterns as an indirect consequence of changes in biodiversity and landscape, when considering how best to encourage and promote people's engagement with the natural environment. And some areas of our work that are not vulnerable to climate change will still have an important role in addressing risks identified in other areas. For example, our work on planning and land management advice has a crucial role to deliver responses to threats identified for biodiversity and for landscape, historic environment and geodiversity. This underlines the importance of taking a coordinated approach in developing an integrated set of risks and responses for our whole organisation, while at the same time identifying issues and responsibilities for each work area.

We have based our assessment on the best available evidence. However, many of the threats and opportunities we have identified are based on expert opinion, and subject to considerable uncertainty, not just about the rate and scale of future climate change but, even more so, the possible cascade of effects on natural systems, and on the way that people will respond to all these changes. Nevertheless, it is important to consider the full range of threats and opportunities, however uncertain, to build a picture of the future implications for our

organisation that can be improved over time as further information becomes available. It will be important to ensure that our Evidence Programme continues to address climate change adaptation as a priority and that we learn the lessons from the research and experience of others.

Our results indicate that climate change is already a pressure on the natural environment that needs to be taken into consideration alongside other pressures. The results highlight the need to continue current good conservation of the natural environment through existing mechanisms, in order to increase the environment's resilience and capacity to adapt. This includes removing existing non-climate pressures, as far as possible, to give the natural environment the best chance to adapt to a changing climate. We should also start to implement measures to promote resilience of the natural environment, such as increasing the size of sites, increasing habitat heterogeneity and increasing connectivity between sites. There are also instances where specific changes are necessary or desirable, for example coastal realignment or recognising changing distribution patterns.

Establishing an adaptive management approach where measures are regularly reviewed and lessons learnt for future work should be an immediate top priority. Constant monitoring and flexible adaptive management will be crucial for ensuring appropriate local management interventions in a changing environment. Monitoring schemes should include reference areas that can be used to guide our judgement in comparable areas elsewhere.

In the longer term, there are serious challenges that need to be considered. It appears likely that we will need to review some aspects of our approach to conservation, to ensure that it has the flexibility to accommodate and respond to likely changes to the natural environment that we cannot prevent. This will be necessary not just to cope with threats but also to exploit opportunities.

We need to improve our understanding of what features and attributes improve the natural environment's resilience and capacity to adapt to climate change and provide necessary services to society. We also need to improve our knowledge about how these features can most effectively be maintained or enhanced, and how we should measure success in managing a changing environment. We will need to acknowledge that the natural environment will change, as it has in the past, and that an important role for us is to provide appropriate management to give it the 'space to adapt' on its own – this could mean accepting new species, habitats and landscapes. The challenge will be to accommodate inevitable changes while ensuring that we make every possible effort to conserve the biodiversity, ecosystem services and landscapes we value and the important benefits the natural environment provides to people. We must not allow change to be an excuse for compromising conservation.

Overall, our desired outcome is for a healthy natural environment, rich in biodiversity and distinctive landscapes, providing a wide range of benefits and services to people, including a high quality natural environment accessible to all local communities. Specific targets for places and species are a means to achieving this outcome and are likely to need to be modified, over time, to be more suited to long term future scenarios of extreme climate change. As the climate changes we will need to adapt our targets and measures to reflect changes to what constitutes appropriate favourable condition of particular places and favourable conservation status of species and habitats.

In some cases the management of sites and landscapes may continue in a similar way, although the species they support may change. In other cases however, different parts of the country might need to be managed quite differently from each other and from the way they are managed now. There might be difficult decisions to make, but there are precedents for accommodating even major changes. For example, at Porlock in Somerset we worked with partners to review unsustainable beach management practices at a coastal Site of Special Scientific Interest where a storm had breached the coastal ridge and changed a previously freshwater/terrestrial site to a saline system. The Site of Special Scientific Interest was successfully re-notified on the basis of the quite different, but equally valuable, new ecosystem and geomorphological processes that had been created.

These are long term questions that we are starting to explore. They will have to be considered carefully, on the basis of the evidence base that we and others are building, and decisions made in close collaboration with partners and local communities.

In addressing climate change, it will be important that we take an ecosystem approach, and consider the full range of ecosystem services a healthy natural environment provides to people, and the complex interactions between climate change and the provision of these services. There will be two aspects to this:

- First, there will be services we could need more of in the future, to help us cope with the effects of climate change, as mentioned in the first section of this report. These include coastal protection, prevention of flooding and low flow of water during periods of drought, and regulation of local climate as by the shading effects of trees and woodlands.

- Second, the provision of some services could be compromised by climate change and we need to manage ecosystems to reduce such impacts. For example, timber production could be affected by the negative effects of climate change on some tree species requiring more diverse tree planting, whilst reduced water supply would be compromised by climate-induced drought, which can be addressed by increasing water stored in wetlands and more generally in ground water stores.

To address these challenges, effective partnerships will be needed. In some cases Natural England has a leading role as a result of our statutory purpose (e.g. in the case of recreation access to the natural environment) or through providing agri-environment schemes. In other cases other bodies (such as the Environment Agency in the case of flooding, or the Forestry Commission in the case of timber production) have the leading role. In all cases, however, broad delivery partnerships will be needed to safeguard and enhance environmental benefits, involving government agencies, local authorities, non-government organisations, land managers and local community groups.

Another, closely related, important issue that has emerged from our adaptation work is the importance of understanding links between adaptation for the natural environment and adaptation by other sectors, and of approaching adaptation in an integrated and sustainable way. For example, the predominant land use in England is agriculture, a sector that – like nature conservation – is likely to be significantly affected by climate change. Adaptation by agriculture is likely to have important consequences for the environment, and therefore adaptation for these two sectors needs to be considered in an integrated way. As highlighted in Box 2 above, many of the opportunities we have identified involve working with other sectors to achieve multiple adaptation benefits.

The results from the forthcoming first National Climate Change Risk Assessment will provide invaluable information that will illuminate cross-sectoral issues of importance to Natural England. Another highly relevant initiative is the Living With Environmental Change programme, which brings together all the major UK funders of environmental research (including natural England and Defra) to co-design, co-produce and co-deliver research on environmental change, its implications and its management. This programme provides excellent opportunities to increase the adaptation evidence base through cross-disciplinary research that meets the needs of delivery bodies such as Natural England.

## Future work

We will complete the risk assessment work outlined above, following the methodology outlined in the Annex. This will include detailed assessment of importance and proximity of risks and resources and time required for, and co-benefits of, responses. We will discuss the results of this across all our work areas, and agree a prioritised set of integrated risks and responses for Natural England. We will then agree specific actions, which will be incorporated into our corporate plan from 2011/12 onwards.

We will complete the other elements of our Climate Change Embedding and Risk Assessment programme, as outlined in Section 3. In particular we will consider climate risks at sub-national level across all 159 of England's National Character Areas.

We will publish a more detailed report on all Natural England's climate risk assessment work at both national and sub-national scales in late 2011 or early 2012.

Finally, it is important to acknowledge that assessing climate change risk and vulnerability, and adapting our work, will be an ongoing process. The work we are currently doing will provide a strong foundation and help to further integrate awareness of and action on climate change across Natural England. However, as the issues discussed above clearly show, there will be a need for continual monitoring, review and improvement in the future as our understanding of climate change develops. To help achieve this, we will maintain our strong programme of research on climate change and the natural environment, working within the Living With Environmental Change programme as appropriate, and ensure that the findings of this research continue to inform the delivery of our statutory responsibilities.

## References

Crick, H.Q.P. (2004) The impacts of climate change on birds. *Ibis* 146 (suppl.1): 48-56.

Gill S., Handley J., Ennos R. & Pauleit S. (2007) Adapting cities for climate change: the role of the green infrastructure. *Built Environment 3*: 115-133

Hickling R., Roy D.B., Hill J.K. Rox R. & Thomas C.D. (2006) The distributions of a wide range of taxonomic groups are expanding polewards. *Global Change Biology 12:* 450–455

Holling C.S. (ed.) (1978) *Adaptive environmental assessment and management*. Wiley, New York.

Hopkins J.J., Allison H.M., Walmsley C.A., Gaywood M., Thurgate G. (2007) *Conserving biodiversity in a changing climate: guidance on building capacity to adapt*. Defra, London.

Lawton J.H., Brotherton P.N.M., Brown V.K., Elphick C., Fitter A.H., Forshaw J., Haddow R.W., Hilborne S., Leafe R.N., Mace G.M., Southgate M.P., Sutherland W.J., Tew T.E., Varley J., & Wynne G.R. (2010) *Making Space for Nature: a review of England's wildlife sites and ecological network*. Report to Defra.

Lowe J. A., Howard T. P., Pardaens A., Tinker J., Holt J., Wakelin S., Milne G., Leake J., Wolf J., Horsburgh K., Reeder, T., Jenkins G., Ridley J., Dye S. & Bradley S. (2009), *UK Climate Projections science report: Marine and coastal projections*. Met Office Hadley Centre, Exeter, UK.

Macgregor N.A. & Cowan C.E. (2011) Government action to promote sustainable adaptation by the agriculture and land management sector in England. In Ford J.D. and Berrang-Ford L. (eds) *Climate change adaptation in developed nations: from theory to practice*. Springer, Netherlands

Morecroft M.D. & Cowan C.E. (2010) Responding to climate change: an essential component of sustainable development in the 21st Century. *Local Economy 25*: 1–6.

Murphy, J.M., Sexton, D.M.H., Jenkins, G.J., Boorman, P.M., Booth, B.B.B., Brown, C.C., Clark, R.T., Collins, M., Harris, G.R., Kendon, E.J., Betts, R.A., Brown, S.J., Howard, T. P., Humphrey, K. A., McCarthy, M. P., McDonald, R. E., Stephens, A., Wallace, C., Warren, R., Wilby, R. & Wood, R. A. (2009), *UK Climate Projections Science Report: Climate change projections*. Met Office Hadley Centre, Exeter.

Natural England (2009a) *No charge? Valuing the natural environment*. Natural England, Sheffield

Natural England (2009b) *Responding to the impacts of climate change on the natural environment: The Broads*. Natural England Research Report NE114. Natural England, Sheffield.

Natural England (2009c) *Responding to the impacts of climate change on the natural environment: The Cumbria High Fells*. Natural England Research Report NE115. Natural England, Sheffield.

Natural England (2009d) *Responding to the impacts of climate change on the natural environment: Dorset Downs and Cranborne Chase*. Natural England Research Report NE116. Natural England, Sheffield.

Natural England (2009e) C*limate change impact assessment and response strategy: Shropshire Hills character area*. Natural England Research Report NE117. Natural England, Sheffield

UK Climate Impacts Programme (n.d.) *Identifying adaptation options*. **http://www.ukcip.org.uk/images/stories/Tools_pdfs/ID_Adapt_options.pdf**

Willows R. & Connell R. (eds) (2003) *Climate Adaptation: Risk, Uncertainty and Decision-Making*. UK Climate Impacts Programme, Oxford

World Commission on Environment Development (1987) *Our common future*. Oxford University Press, New York.

Annex:

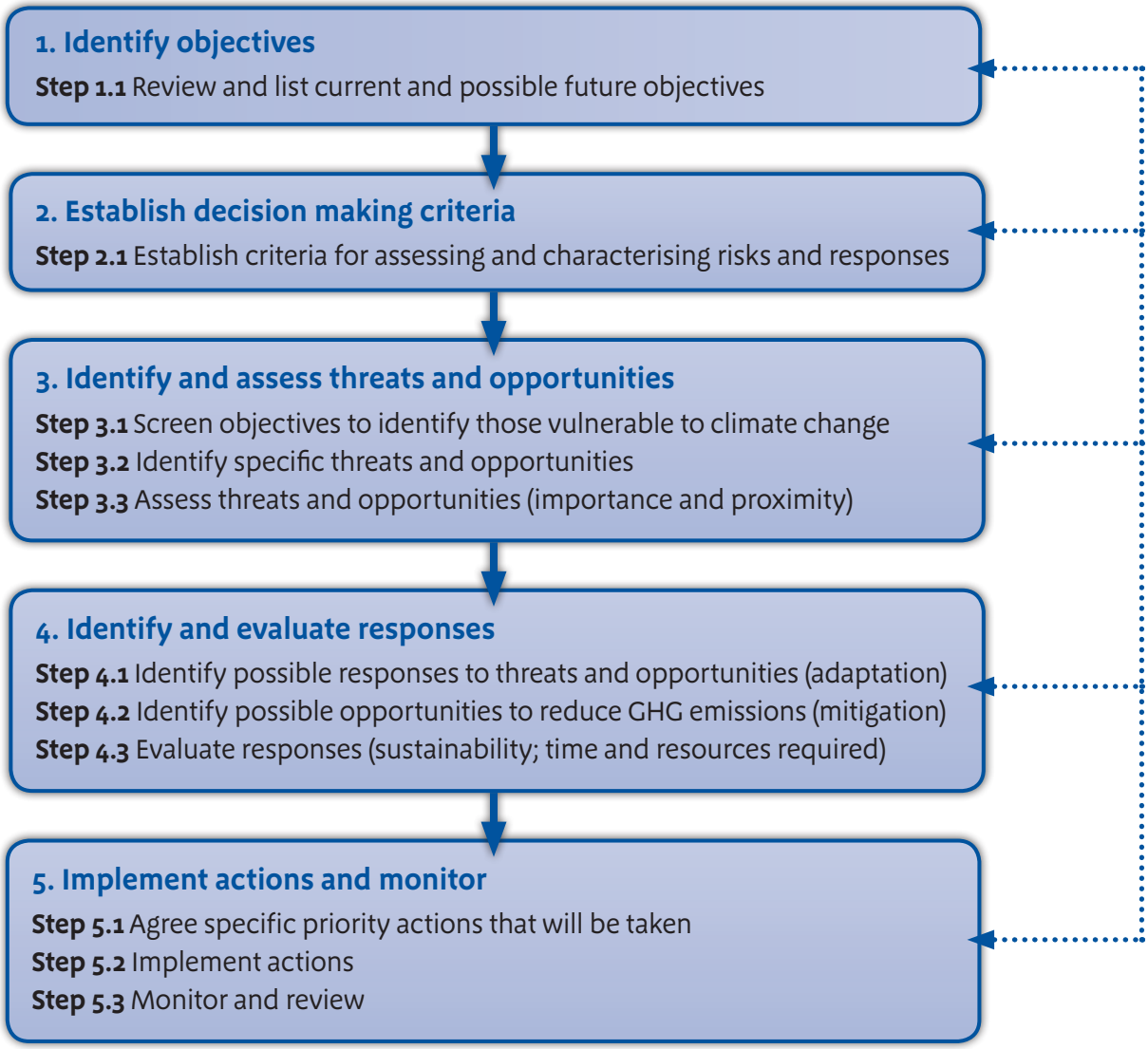
# Risk assessment methodology

This annex provides a detailed outline of the methodology we have followed to assess climate risks and identify appropriate actions to be taken in response. It expands on the brief summary given in section 4 of this report.

Our methodology is based on guidance by the UK Climate Impacts Programme, Defra and the Environment Agency (Willows and Connell 2003), and is quite closely aligned with the methodology being used by the Environment Agency in its own climate risk assessment work.

The main parts, and individual steps, in the methodology are summarised in Figure 1 below. Although these are presented in a linear structure here for clarity, it is important to note that risk assessment is an iterative process, so at each point there is often a need to go back and re-evaluate or add information to previous steps before continuing. The whole process is in fact circular, as monitoring of the effectiveness of responses might in time lead to modification of the objectives on which the whole process is based.

**Figure 1. Structure of Natural England's climate risk assessment methodology**




Each of the steps in the process is described below.

# 1. Identify objectives

### Step 1.1 Review and list current and possible future objectives

Risks (whether climate-related or not), and adaptation, make sense only in relation to defined objectives. Therefore, an essential first step in the process was to identify relevant Natural England objectives. This provided the reference point and scope for future steps in the assessment process.

Each of our work areas listed its main objectives. Because this risk assessment is focusing on strategic risks to Natural England, and because climate change requires long term planning, we tried to focus on current high level objectives that are likely to continue to be applicable into the foreseeable future.

# 2. Establish decision-making criteria

### Step 2.1 Establish criteria for assessing and characterising risks and responses

We identified five important factors that would help to characterise and prioritise our risks and responses:

- The **importance** of a risk to delivery of our objectives. (Risks with major effects on our objectives will be higher priority than risks with only small effects.)
- The **proximity** of a risk (the nearness of the point in time at which we estimate our ability to deliver the relevant objective would change under a business as usual scenario). (The closer in time a risk is, the more urgently we need to address it.)
- The **effort and resources** required to respond. (The greater the effort required to address a risk, the more carefully we need to consider it.)
- The **time** period required for an effective response (including both the time needed to implement a response, and the time for the response to have an effect). It is important to consider not just when a risk might start to affect us, but how long in advance we would need to prepare our response.
- The likely positive and negative **side-effects** of a response on other objectives, as one measure of its sustainability. We should prioritise responses that have multiple benefits, and avoid adaptation in one area that constrains adaptation in or otherwise negatively affects another area.

(The scales used to rate each of these variables are outlined below in steps 3.3 and 4.3.)

# 3. Identify and assess threats and opportunities

### Step 3.1 Screen objectives to identify those vulnerable to climate change

To focus our attention just on those objectives that are relevant for this risk assessment, we first screened objectives in each work area and assigned each objective to one of three categories:

**i.** Objectives that are vulnerable, whose achievability is likely to be affected by climate change. For example, an objective to maintain Sites of Special Scientific Interest is potentially vulnerable, as climate change is likely to affect the natural environment in these sites. These objectives were the focus of assessing risks (in part 3 of the methodology).

**ii.** Objectives that are not vulnerable to but are influenced by climate change. These are things that we can probably still achieve irrespective of how the climate changes, but that might need to be modified to take climate change into consideration. For example, climate change is unlikely to prevent us delivering advice to land managers, but the advice we provide will need to be modified to include information to help land managers adapt. This category of objectives often provide opportunities to help respond to risks to our vulnerable objectives, and for working with others to deliver wider benefits (for example, providing environmental solutions to help communities cope with the effects of climate change). These objectives were not relevant to identifying and assessing risks (part 3), but were relevant to identifying responses (part 4).

**iii.** Objectives that are not vulnerable to climate change.

### Step 3.2 Identify specific threats and opportunities

Having identified vulnerable objectives, we then identified specific threats and opportunities. To consider the full chain of events linking an initial climatic change to a consequence for our objectives, risks were described in terms of:

- cause (relating them to a primary climatic change),
- event that would occur in the area of interest
- and consequence for a particular Natural England objective.

We tried to consider not just direct risks (resulting directly from climate change) but also indirect risks (resulting from human action in response to climate change).

In steps 3.1 and 3.2 (screening objectives and identifying specific risks), the following check lists were provided as an initial prompt to help identify the primary climatic changes and second order effects that might lead to risks and to think through the possible resulting chain of effects.

#### Likely climatic changes and sea level rise

- Hotter summers
- Drier summers
- Warmer winters
- Wetter winters
- More frequent storms

#### Possible direct and indirect effects of climate change

Direct effects

- Drought
- Longer growing season
- Heatwave
- Increased soil moisture deficit
- Flooding
- Storm damage
- Water-logging of soils
- Coastal erosion
- Coastal flooding

- Erosion
- Saline intrusion
- High winds
- Change in river flow

Possible indirect effects

- Changing agricultural practices (what is produced, where it is produced, how it is produced)
- Increased or decreased visitor numbers to a particular area
- Increased abstraction
- Increased flood defences and other infrastructure

### Step 3.3 Assess threats and opportunities (importance and proximity)

We assessed the importance and proximity of risks using the following scales:

Importance

| Importance rating | Description |
|---|---|
| Severe threat | Irrecoverable damage to major ecosystem structure or function occurs.<br>One of Natural England's major strategic objectives (e.g. 5 year measures of success) is impossible to deliver.<br>Serious damage to the organisation's reputation. |
| Major threat | Major environmental damage; recovery potential uncertain; major reduction in ecosystem service provision, with uncertainty about recovery without major expense.<br>There is a serious negative effect on Natural England's major strategic objectives, requiring major re-evaluation of work programming and diversion of funding streams to initiate restoration attempt. |
| Moderate threat | Important environmental damage; recovery likely only over the medium term; medium-term disruption of ecosystem service provision.<br>There is a moderate effect on Natural England major strategic objectives, likely to result in delay in achieving them, or some diversion of funding to facilitate recovery. |
| Minor threat | Minor environmental damage that can be reversed fairly easily, or moderate damage that will quickly recover autonomously.<br>Short-term disruption to small-scale ecosystem services, structure or function. Moderate effects on less important objectives within Natural England's corporate plan. |
| Negligible threat | Transient or limited impact on ecosystem services, structure or function.<br>Negligible negative effect on achievement of Natural England's objectives; no major objectives affected. |

| Importance rating | Description |
|---|---|
| Minor opportunity | An opportunity which, if exploited, could slightly improve our ability to deliver small aspects of a current or future objective more easily or more cheaply.<br>Climate change enhances an aspect of the natural environment that is currently a minor priority (or only a small part of a priority area) for Natural England. |
| Moderate opportunity | An opportunity which, if exploited, could enhance to some extent our ability to deliver a current or future objective more easily or more cheaply.<br>Climate change enhances an aspect of the natural environment that is currently a medium priority for Natural England. |
| Major opportunity | An opportunity which, if exploited, could greatly enhance our ability to deliver a current or future objective more easily or more cheaply.<br>Climate change significantly enhances an aspect of the natural environment that is currently a high priority for Natural England. |

Proximity

| Proximity rating | Description |
|---|---|
| Now | Our ability to achieve the objective is already compromised, or enhanced by climate change |
| Short term | There is a reasonable probability that our ability to achieve the objective will likely be compromised or enhanced by 2030 |
| Medium term | There is a reasonable probability that our ability to achieve the objective will be compromised or enhanced by 2060 |
| Long term | There is a reasonable probability that our ability to achieve the objective will be compromised or enhanced by 2100 |

We also attempted to rate how much confidence we have in our evaluation of importance and proximity, using the following scale:

- low – based on few, incomplete or inconclusive impact studies, or on expert judgement only
- medium – based on expert interpretation of a number of (potentially conflicting) impact studies
- high – based on impact studies that give a consistent picture but do not explore uncertainty fully
- very high - based on many impact studies that give a coherent picture and explore uncertainty fully

### Climate information used in part 3

In all the steps in part 3, and especially in 3.3 (assessing importance and priority of risks), UKCP09 projections were used. The UKCP09 median projections for rainfall, temperature and sea level rise under a medium emissions scenario were used as the primary 'direction of travel' of climate change over this century. More extreme scenarios (90% under high emissions) were considered to ensure that the full range of possible risks was explored.

## 4. Identify and evaluate responses

### Step 4.1 Identify possible responses to threats and opportunities (adaptation)

We identified possible responses to all threats and opportunities. Two aspects were considered: action on the ground, and action for Natural England (e.g. action on the ground might be to increase woodland; action for Natural England might be to revise land management advise to encourage tree planting). Identifying responses included considering how delivery of those objectives identified as 'influenced' by climate change could make a contribution to addressing risks.

### Step 4.2 Identify possible opportunities to reduce greenhouse gas emissions (mitigation)

As well as identifying responses to address our risks, we considered how delivery of our objectives could make a greater contribution to reducing greenhouse gas emissions. This of course is mitigation, a separate issue from adaptation and not strictly necessary as part of a climate risk assessment. However, as sustainability is an important part of an adaptation response, we feel it is important to try to integrate adaptation and mitigation as much as possible. We considered the following sources of greenhouse gas emissions that are particularly relevant to Natural England's work:

- Loss of $CO_2$ from soils, especially peat soils, for example through degradation of peat bogs and fens
- $N_2O$ emissions from use of fertilisers and from animal waste in agriculture
- Loss of $CO_2$ through degradation of intertidal habitat such as salt marsh

When identifying responses, we considered the following broad categories of land/environmental management that can help to maintain carbon stores, sequester carbon or reduce emissions include:

- Reducing $CO_2$ emissions from land use through protection, restoration and/or creation of peat, fens, intertidal habitat, forests and preventing disturbance of soils
- Reducing non-$CO_2$ emissions by improving efficiency of agricultural production:

We did not consider reducing the $CO_2$ emissions from our own work and travel, which is already being addressed through Natural England's sustainability targets.

### Step 4.3 Evaluate responses (sustainability; time and resources required)

To further aid prioritisation of our adaptation efforts, we evaluated the possible responses we had identified.

Ideally, our responses to climate change should provide integrated solutions with multiple benefits – e.g. help a range of aspects of the natural environment, and society as a whole, adapt while also reducing greenhouse gas emissions.

We considered the potential positive and negative side effects of each of the possible responses identified, using the following ecosystem service categories as a prompt.

- flood and erosion regulation
- carbon storage/sequestration
- local climate regulation (shade, temperature regulation, storm shelter etc.)
- water purification
- water supply/storage
- biodiversity
- sustainable fuel production
- food production
- recreation and health benefits provided by the natural environment
- cultural and 'sense of place' benefits provided by distinctive landscapes

To identify truly sustainable solutions, we will also try consider the impact of our responses on other sectors more broadly than covered by the list above.

Co-benefits were rated using the following scale:

| Co-benefits rating | Description |
|---|---|
| Multiple benefits | Response would produce strong co-benefits for multiple ecosystem services |
| Some co-benefits | Response would have benefits for at least one other environmental objective/ecosystem service |
| Neutral | Response would have no significant benefits for other ecosystem services/environmental objectives |
| Negative effects | Response might have potential significant conflicts with other objectives |

We then considered factors affecting the implementation of a successful response. We considered the levers available to Natural England to implement the response, and any potential challenges and barriers. We estimated how much effort/resource would be required to implement each response, and the time required for a successful response to be put in place, using the following scales:

Effort/resources

| Effort & resource rating | Description |
|---|---|
| Minor | The response is a minor change to existing work.<br>There are no major institutional barriers preventing implementation.<br>We can implement the response using existing resources. |
| Moderate | The response is a reasonably significant change to existing work.<br>There are some barriers in our way and/or some work (e.g. research) to do to clarify exactly what needs to be done.<br>We will need to re-allocate resources . |
| Substantial | The response is a major change to existing work, or a new piece of work.<br>There are significant barriers that need to be overcome (e.g. factors outside the organisation's influence; gaps in current levers) and/or significant research projects required.<br>We will need some additional external resources to adapt. |
| Major | The response is a major piece of new work.<br>There are serious barriers to be overcome.<br>We would need significant additional external resources to adapt. |

Time required

Time for Natural England to respond, and to change the response if necessary

| Time/flexibility rating | Description |
|---|---|
| Rapid | Action could be taken or modified within two years |
| Short term | Action could be taken or modified within five years |
| Medium term | Action could be taken or modified within ten years |
| Long term | Action would take longer than ten years |

Time for the response to start having an effect once fully implemented

| 'Lag time' rating | Description |
|---|---|
| Immediate | Once implemented, the response would have an immediate effect |
| Short delay | There would be a delay of a few years before the response had the desired effect |
| Medium delay | There would be a delay of up to a decade before the response had the desired effect |
| Long delay | There would be a delay of several decades before the response had the desired effect |
| Very long delay | There would be a delay of well over 50 years before the response had the desired effect |

# 5. Implement actions and monitor

## Step 5.1 Agree specific priority actions that will be taken

Having assessed and prioritised our risks and responses, our programme steering group will discuss the full set of results to agree a set of integrated actions to be taken across Natural England to address the most important risks. These will include actions that can be taken in the short term, and actions to be considered in the longer term. Individual function areas will incorporate these actions into their part of the corporate plan for future years.

## Step 5.2 Implement actions

Actions will be implemented through delivery of our corporate plan, with the aim of embedding adaptation so it is considered alongside other environment decision-making in all our work.

There will be a need to involve and consult partners and stakeholders at both local and national level over implementation of specific actions.

## Step 5.3 Monitor and review

We will monitor the effectiveness of our actions, and modify them if necessary, both through monitoring of progress to deliver our corporate plan, and through ongoing monitoring of environmental change.


Natural England is here to conserve and enhance the natural environment, for its intrinsic value, the wellbeing and enjoyment of people and the economic prosperity that it brings.



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