Annex 1 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 3 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 A. 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.

Table A Structure of Natural England's climate risk assessment method

1 - Identify objectives	2 - Establish decision making criteria	3 - Identify and assess threats and opportunities	4 - Identify and evaluate responses	5 - Implement actions and monitor
Step 1.1 Review and list current and possible future objectives	Step 2.1 Establish criteria for assessing and characterising risks and responses	Step 3.1 Screen objectives to identify those vulnerable to climate change	Step 4.1 Identify possible responses to threats and opportunities (adaptation)	Step 5.1 Agree specific priority actions that will be taken
		Step 3.2 Identify specific threats and opportunities	Step 4.2 Identify possible opportunities to reduce GHG emissions (mitigation) and broader ecosystem services gains	Step 5.2 Implement actions
		Step 3.3 Assess threats and opportunities (importance and proximity)	Step 4.3 Evaluate responses (sustainability; time and resources required)	Step 5.3 Monitor and review

Part 1 - Identify objectives

Step 1.1 Review and list current and possible future objectives

Risks (whether climate-related or not), and adapting to them, 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 the subsequent 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.

Part 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).

Part 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 for their vulnerability to climate change and assigned each objective to one of three categories:

1) 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).
2) 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).
3) 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 the:

- broad **cause** of the threat (primary climatic change); and

- the more specific **event** that would occur in the area of interest.

We considered not just direct risks (resulting directly from climate change) but also indirect risks (resulting from human action in response to climate change). Therefore where relevant the **human response** relating to the threat was characterised:

- The **effect** of the change whether it was direct or indirect; and finally
- The **consequence** for a particular Natural England objective.

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 causes and second order events that might lead to risks and to think through the possible resulting chain of effects.

Possible **Causes**:

- Changes in rainfall patterns;
- Changes in temperature;
- Changes in rainfall intensity;
- Extreme weather events;
- Sea temperature rise;
- Sea Level Rise; and
- Global effects (climatic changes occurring elsewhere in the world).

Possible **Events**:

- Drought;
- Flooding;
- Increased soil moisture deficit;
- Water-logging of soils;
- Coastal flooding;
- High winds;
- Saline intrusion;
- Change in river discharge;
- Stratification of ocean waters;
- Sea temperature rise;
- River and lake temperature rise;
- Ocean acidification;
- Increased wave height; and
- Increased high tide levels.

Step 3.3 Assess threats and opportunities (importance and proximity)

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

Table B

Importance rating	Description
Severe threat	Irrecoverable damage to major ecosystem structure or function occurs. One of Natural England's major strategic objectives (for example, 5 year measures of success) is impossible to deliver. 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. 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. 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 fairly easily reversed; or moderate damage that will quickly recover autonomously. 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. Negligible negative effect on achievement of NE objectives; no major objectives affected.
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. 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. 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. Climate change significantly enhances an aspect of the natural environment that is currently a high priority for Natural England.

Table C

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 2020.
Medium term	There is a reasonable probability that our ability to achieve the objective will be compromised or enhanced by 2050.
Long term	There is a reasonable probability that our ability to achieve the objective will be compromised or enhanced by 2080.
Very long term	There is a reasonable probability that our ability to achieve the objective will be compromised or enhanced after 2080.

The importance and proximity ratings were each scored from 1 to 5, ie an importance rating 'severe' scored 5, through to 'negligible' rating scored 1, and a proximity score of 'now' scored 5, through to 1 for a proximity rating of 'very long term'. From these scores a threat priority ranking was calculated using a simple additive score of importance + proximity, with threats being ranked as high (7-10), medium (3-6) and low (0-2).

We then rated 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; and
- **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.

Part 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** (for example, action on the ground might be to increase woodland; 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.

Consideration was also given to the capacity of natural England to deliver the action on the ground (**NE's role**), which delivery mechanisms or **levers** would be required, and which **partners** could assist in the delivery of desired response.

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 - for example, 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 considered the impact of our responses on other sectors more broadly than covered by the list above.

Co-benefits were rated using the following scale:

Table D

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:

Table E

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

Two aspects were considered with respect to time period, firstly the time for Natural England to respond, and to change the response if necessary.

Table F

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.

Secondly, time for the response to start having an effect once fully implemented.

Table G

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.

These values were combined to form an estimate of the **time to impact** of a response.

An indicator of the **priority** of each response was determined using the data collected in the above steps using the following technique.

Add score based on following :-

- Give each response a score of 5 if it addresses a high risk, 3 if a medium risk, 1 if a low risk.
- Add 1 if it addresses multiple risks of medium and above, or 3 if it addresses multiple high risks.
- Add 2 if it has very obvious multiple benefits (ie a high score in the mitigation/co-benefits fields).

Accordingly each response received a score out of 10.

The final part of the assessment was to record comments on any assumptions and areas of uncertainty in the methodology, with supporting evidence referenced.

Part 5 - Implement actions and monitor

Step 5.1 Agree specific priority actions that will be taken

Having assessed and prioritised our risks and responses a mapping exercise was undertaken. Each response was mapped across Natural England's different delivery functions. Within each function the response was mapped against the relevant mechanism of delivery.

Following this mapping exercise a set of proposed actions were drawn up for each function by the functional leads by coalescing similar responses where appropriate. The list of proposed actions was then considered and signed off by functional directors. The actions from the individual functions were then combined to form an integrated action plan that highlights actions that can be taken in the short term, and actions to be considered in the longer term. This integrated action plan was considered by the Evidence Group of Natural England and will inform the development 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.

Implementation will involve consultation with partners and stakeholders at both local and national level to develop specific actions.

Step 5.3 Monitor and review

The climate change Community of Practice will be responsible for ensuring monitoring of the Adaptation Plan. In practice this will be delivered through monitoring progress to deliver our corporate plan, and through ongoing monitoring of environmental change.

References

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

Annex 2 Initial screening of function based objectives

To focus the detailed risk analysis on those aspects of our work that are vulnerable to climate change a screening exercise was undertaken on the full range of functional objectives.

Objectives in each work area were evaluated for their **vulnerability** to climate change and assigned to one of three categories: those objectives that are vulnerable (V), whose achievability is likely to be affected by climate change; objectives that are not vulnerable to but are influenced (I) by climate change and objectives that are not vulnerable (NV) to climate change.

The detailed risk analysis covered in Annex 2 focused on those objectives that were categorised as being vulnerable. However objectives determined as being influenced were also included as they frequently played an important role in terms of developing appropriate responses to the threats identified.

Table H Landscape & Biodiversity

Objective	Description	Vulnerability
LB 1	We increase the area of SSSIs in favourable condition whilst maintaining 95 percent area in favourable or recovering condition.	V
LB 2	We work with partners to improve the status of threatened species.	V
LB 2.1	Identify SSSI's that hold high risk species and review management to reduce their threat.	V
LB 2.2	To identify the habitat requirements of all UK BAP species relevant to UK BAP priority habitats. An analysis of the known habitat features required by each species and adjustment for regional variation.	V
LB 2.3	Agree species for research as main priority- projects are grouped into research, advice and delivery, and monitoring depending on the most significant aspect, but all are a combination of these activities.	I
LB 2.4	Species recovery programme - An integrated delivery framework to identify and address the needs of those species in most urgent need of attention so ensuring that we make the best use of all our delivery mechanisms. As well as our agri-environment and land management work, this includes a large number of direct action projects.	V
LB 3	We work with partners to increase the area and improve the quality of our priority habitat networks at the landscape scale.	V
LB 3.1	England Biodiversity Strategy which sets out how the quality of our environment on land and at sea will be improved over the next ten years. At the heart of the strategy is the drive to establish coherent ecological networks that benefit wildlife and people.	V
LB 3.2	Providing priority habitat information & baseline info to other functions.	NV
LB 3.3	Maintain or restore European (Habitats Directive) protected habitats (as in annex 1) and species (as in annex 2) at a favourable conservation status.	V

Table continued...

Objective	Description	Vulnerability
LB 3.4	Audit of existing condition standards through a project to replace Natural England's current in-house Common Standards Monitoring (CSM) of SSSIs and HLS Indicators of Success with one method called Integrated Site Assessments (ISA). The new approach aims to improve the efficiency of how we collect monitoring data as well as inform how we improve its storage, accessibility and use.	I
LB 3.5	Co-ordination the delivery of Integrated Biodiversity Delivery Areas (IBDA's) throughout England.	NV
LB 4	We support local partnerships in setting integrated landscape and biodiversity objectives for their area and promote restoration of ecological networks at landscape scale.	V
LB 4.1	Establish Local Nature Partnerships throughout England in recognition that diverse partnerships (individuals, businesses and organizations) delivering leadership at a local level will lead to more effective action to improve the Natural Environment.	I
LB 4.2	Establish Nature Improvement Areas which facilitate the step-change in delivery necessary to halt further biodiversity loss, which will be delivered through an integrated landscape-scale approach, delivering biodiversity gains, but also joining up with all other Natural Environment objectives.	I
LB 4.3	Update the National Character Areas (NCA) descriptions to develop more concise and overtly evidence based profiles. It will also include new Integrated Objectives to determine landscape quality and ecosystem services for each individual location.	V
LB 4.4	Deliver Natural England's statutory powers and duties in relation to protected landscapes. Further the management of and support protected landscapes through our advocacy, incentives, advisory and delivery activities.	V
LB 4.4b	Protection and enhancement of Geodiversity features.	V
LB 4.4c	Protection and enhancement of Historic Environment features.	V
LB 5	Contribute to an integrated surveillance and monitoring strategy so that interventions to deliver landscape and biodiversity objectives can be properly informed and outcomes monitored.	I
LB 6	Develop, agree and implement an integrated Landscape and Biodiversity Protected Area Designations Strategy that makes the necessary contribution to the Government response to the Lawton review.	I
LB 7	Develop and implement the External Funding Strategy, and establish a quantified baseline for leverage and 3 year growth targets for 2012/13 onwards.	NV
LB 8	Develop and implement a programme of Natura 2000 and SSSI designations that meets our statutory duties to review existing site networks and ensure they are fit for purpose.	I

Table I Access and Engagement function

Objective	Description	Vulnerability
AE1	We work with others to increase the opportunities for people to access and engage with the natural environment. (This includes Inspiring 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 using 'nature's health service' and helping improve the quantity and quality of greenspace).	I
AE2	Submit Coastal Access Report for 30km of new Coastal Access rights in Weymouth to Secretary of State for approval; and start public consultation on 150km of new Coastal Access rights in the five lead areas. (This includes implementing a walking route around the open coast of England, together with associated spreading room en route. Advise government on new access rights and hand over management to Local Authorities in due course whilst retaining business-as-usual restrictions casework).	I
AE3	Deliver statutory access duties to open access land to agreed standards that maximise the amount of land available for public access, ensuring the least restrictive principle underpins all casework. (This includes delivering the restriction regime with respect to open access land. Review access land boundaries and code of conduct as required by Defra. Ensure public kept aware of access land).	I
AE4	97 percent of the Pennine Bridleway (Southern Section) completed by end March 2012 and new more sustainable management model for National Trails agreed. (This includes reviewing the mechanism of supporting the organisations that manage National Trails to agree a new more sustainable management model. Ensure public are aware of National Trails).	I
AE5	Influence the planning and design of new national, strategic and local initiatives to support access to and experience of the natural environment for as many and diverse a range of people as possible. (Influence the planning and design of new national, strategic and local initiatives to support access to and experience of the natural environment for as many and diverse a range of people as possible, providing evidence, tools and advice).	I
AE6	We confirm a vision and strategy for the management of Natural England’s National Nature Reserves. (Including ensuring NNRs contribute to the restoration and connecting of the natural environment, fully involving partners and civil society).	I
AE7	Ensure National Nature Reserves are managed as exemplar nature conservation sites. (Included are aims to: manage NNRs to ensure that a high percentage of SSSI features are in favourable condition; contribute to the England Biodiversity Strategy by maintaining and enhancing priority habitats and species; and, use NNRs to research and demonstrate nature conservation to underpin and support the development of Natural England's objectives).	V

Table continued...

Objective	Description	Vulnerability
AE8	Natural England's NNRs are providing increasing levels of public enjoyment, partnership working and involvement of local communities in the natural environment. (Including continuing to develop the public engagement opportunities offered by Natural England's NNRs, including physical access, volunteering, education and events).	I

Table J Land Management

Objective	Description	Vulnerability
LM1	We increase the percentage of agricultural land in Higher Level Stewardship.	I
LM1a	Increase the area of farmland under Environmental Stewardship agreements.	I
LM2	We secure more priority habitat under favourable management through agri-environment schemes.	I
LM3	Estates subject to IT exemption conditions are delivering environmental benefits.	I
LM4	Energy Crops Scheme land is contributing to UK renewable Energy targets.	V
LM5	Our RDPE advice is delivering improved resource protection.	I
LM5a	With the Environment Agency, support environmentally friendly farming practice through Catchment Sensitive Farming.	V
LM5b	Help develop a locally delivered catchment based approach under the Water Framework Directive objectives with the Environment Agency and Forestry Commission.	I
LM5c	Continue to support farmers and land owners with practical, tailored advice on the management of their land for environmental benefits.	I
LM6	Support Defra on the CAP reform negotiations, on MESME Project, on EWGS/ES merger and planning for post 2013 RDP delivery.	NV
LM7/12	Increase the extent of ES options that deliver biodiversity, climate change, historical, landscape and resource protection objectives.	V
LM7a	Increase Environmental Stewardship's contribution to ecological connectivity.	V
LM8	Carry out 'Integrated Site Assessments'.	I
LM9	Monitor and Evaluate Environmental Stewardship (inc R&D).	I
LM10	Reduce the Unit Cost of HLS Delivery.	NV
LM10a	Continue to reduce the cost of ES administration.	NV
LM11	Deliver the agreed Land Management contributions identified in the SSSI delivery plan.	I

Table K Sustainable Land Use

Objective	Description	Vulnerability
LU1	Secure new priority habitat and Green Infrastructure, delivering ecosystem services, through working with local partners. (KPI LU1 - We work with others to secure new priority habitat and Green Infrastructure, delivering ecosystem services through the planning system).	V
LU2	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 through our inputs to land, water and coastal use plans. (part of previous CCRA SLU objective).	V
LU3	Recognise and incorporate the value of ecosystem services to generate benefits for society and the economy by prioritising interventions and advising on the integration of the natural environment into new strategies and partnerships. (part of previous CCRA SLU objective).	V
LU4	With the Environment Agency, develop a 'single voice' approach with Local Planning Authorities and clearly align our advice. (KPI LU2 - Develop with local partners shared prospectuses for the natural environment in 50 key Local Planning Authorities).	I
LU5	Provide advice on the sustainable use of land, water and coast to communities and local government to support their planning decisions to protect and enhance local environments through the Natural Leaders programme; (land use corporate plan aim).	I
LU6	Help people realise long-term visions for the places they live, whilst acknowledging their short-term needs; (land use corporate plan aim).	I
LU7	Meet our targets for the number of casework responses delivered to agreed deadlines. (KPI LU3 - We will deliver a consistent, timely and high quality advisory service to local government, ensuring at least 95percent of our casework responses are delivered to the agreed deadlines).	NV
LU8	Ensure the environmental assets of land, water and coast 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. (previous CCRA SLU objective - Sustainable land use contributing to natural environment objectives).	V
	Improving Freshwater Environment (new objectives)	
LU9	Secure water quality, air quality, water availability (flows and levels) to achieve conservation objectives for designated sites and wider priority habitats. By developing targets and objectives for air and water quality and water levels and flows; influencing planning mechanisms; implementing management plans (including freshwater non native spp management work); and responding to water and pollution casework.	V
LU10	Contribute to freshwater habitat creation and restoration. Through influencing statutory planning and the work of other agencies, as well as (with L&B) overseeing freshwater habitat targets under the EBS roadmap.	V

Table continued...

Objective	Description	Vulnerability
LU11	Improve the governance structure for water (and pollution) planning. Via influencing development of catchment based approach and join up between planning and funding mechanisms operating at catchment scale.	V
	Improving Coastal Environment (new objective)	
LU12	Recognise that the coast is best managed using solutions that work with coastal processes, enable coastal systems to function as freely as possible and ensure adaptation to both coastal and climate change.	V
	Energy	
LU13	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 - 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. (previous CCRA SLU objective).	V

Table L Marine

Objective	Description	Vulnerability
MN1	Substantial completion of the designation of a Marine Protected Area network in English territorial waters.	V
MN2	Deliver conservation advice to enable relevant authorities to implement MPA management measures.	V
MN3	Deliver an integrated monitoring programme so that all European Marine Sites will be subject to a risk based cycle of condition assessment by March 2012, and plans are in place for baseline monitoring of MCZs.	V
MN4	Work with the fishing industry and fisheries managers in an open and positive manner to protect and enhance the marine environment in English waters.	V
MN5	Promote sustainable use and management of the marine environment through engagement with government, industries, stakeholders and partners; and advise on the implementation of the Marine Strategy Framework Directive (MSFD).	V
MN6	Deliver an effectively planned, managed and monitored marine function that delivers its key targets on time, to agreed quality standards and within agreed resources; and secures efficiencies through joint working with partners across the Defra marine delivery landscape.	I

Annex 3 Detailed summary of risk analysis results

This annex presents a summary of the function-based risk assessment. For each Natural England function, a matrix of numbered threats is shown, assigning each threat a score of either high, medium or low priority according to its importance for Natural England objectives and its proximity in time. The threats are then summarised in text underneath the table, with the level of confidence in the assessment of importance and proximity shown in brackets. For presentation purposes similar threats to individual objectives have been combined. In these cases the worse case importance and proximity rating has been used, and the lowest confidence rating is highlighted. A similar matrix and list of opportunities is then presented.

Following the lists of threats and opportunities for each function, there is a short summary of the major areas of uncertainty that emerged during the analysis, followed by a commentary on the levers available to Natural England to address the risk, major potential barriers, and other organisations we would need to work with. There is then a summary of the priority responses that were deemed to be highest priority. Each of these is divided into two parts: first, the desired change that would help to address one or more risks, together with a list of the risks that would be addressed and an assessment of Natural England's ability to act in this area (scored as either low, medium or high); and second, one or more specific actions that Natural England could take to help to achieve the desired change, showing the ratings given for the level of resources required, the time to act and for the action to start to achieve the desired change, and possible co-benefits. Finally, the sources of information that were used in the identification and assessment of risks and responses are listed.

Landscape and Biodiversity

The Landscape and Biodiversity function brings together Natural England's expertise in landscape, seascape, the historic environment, biodiversity and geodiversity. It works with national and local partnerships to develop a shared purpose and set of integrated plans to deliver our statutory landscape and biodiversity outcomes.

The function works with Defra and other partners to improve the timeliness, coverage and consistency of the reporting of biodiversity outcomes; with local partnerships to take action for biodiversity and help catalyse local and community involvement;

Functional objectives threatened by climate change include work to: implement the agreements made at the Nagoya summit on the conservation & sustainable use of biodiversity; further improve the condition of the Sites of Special Scientific Interest and Natura 2000 networks to ensure that they include all of our most valuable nature conservation and earth heritage features; deliver the European Landscape Convention, UK Geodiversity Action Plan; and provide advice on the maintenance and enhancement of protected landscapes and employ landscape and ecosystem approaches working through National Character Areas, catchments and local authority boundaries.

Threats

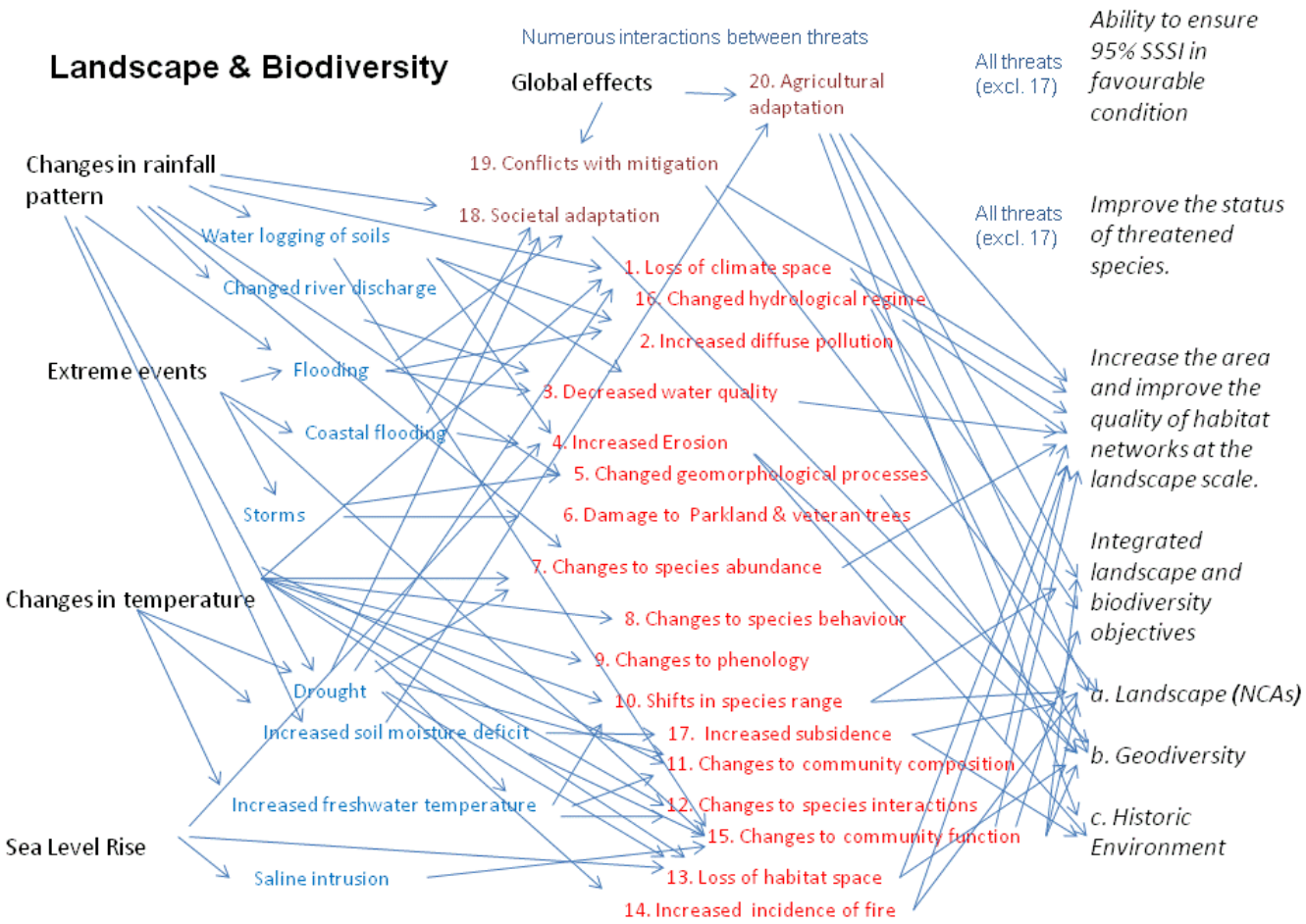

Figure A Threat analysis - Landscape and Biodiversity

Table M Matrix showing the priority of the different threats to Landscape & Biodiversity, according to their importance and proximity

		Proximity				
		Now	**Short**	**Medium**	**Long**	**Very Long**
Importance	**Severe**	(19)	(20)	15		
	Major	10	1,5,7,8,9,11,12, 13,14,16,	(18)		
	Moderate		3,4,6	17	2	
	Minor					
	Negligible					

(red = high; orange = medium; green = low). Indirect threats are indicated in brackets.

High priority threats

1) Loss of climate space (Medium[1]):

- Loss of suitable climate for montane species and those at the southern limit of their range (Berry *et al*. 2005; Britton *et al*., 2009; Franco *et al*. 2006; Mitchell *et al*. 2007; Trivedi *et al*. 2008; Walmsley *et al*. 2007).
- Loss of climate space for key woodland species, such as beech in the SE (Read *et al*., 2009).
- Potential loss of particular habitats including lowland heath, blanket bog and fen for example in the south of England (Clark *et al*. 2010; Mitchell *et al*. 2007).
- Potential loss of oceanic climate likely to affect bryophytes and ferns.
- Changes to river temperatures affecting invertebrate and fish species (Durance & Ormerod, 2007).

5) Changed geomorphological processes (Low/Medium):

- Storm events in combination with high tides and onshore winds will re-shape the coast including increasing coastal erosion and changing deposition patterns (Foresight 2004).
- Changes to river morphological and hydraulic characteristics (Whitehead *et al*. 2009).
- Changes in estuary morphology resulting in major changes to sediment types and productivity of inter-tidal habitats.
- Changes to geomorphological processes, resulting in hydrological and geochemical changes that will damage buried archaeology and sensitive palaeo-environmental remains (Howard *et al*. 2008), or notified features on active sites moving outside the site boundary.

7) Changes to species abundance (High):

- Changes in species abundance and habitat preferences (Morecroft *et al*., 2009; Thomas *et al*., 2008).
- Loss of key species from protected sites (Pearce-Higgins *et al*. 2011).

8) Change to species behaviour (High):

- Change in behaviour of species resulting in changes in niche requirements, for example, grassland butterflies moving to different microclimates.
- Changed patterns and timing of migration (Lehikoinen *et al*. 2004).

9) Changes to phenology (High):

- Changes to the timings of seasonal events (phenology), for example, tree budding and coming into leaf, eggs hatching, animals migrating, and a resulting loss of synchrony between species (Thackeray *et al*. 2010).
- Loss of synchrony between predators and prey (Winder & Schindler 2004; Pearce-Higgins 2010) or species they parasitise (Saino *et al*. 2009).
- Southern range contractions, colonisation northward and uphill (Warren *et al*., 2001; Hickling *et al*., 2006; Franco 2006; Morecroft *et al*. 2009, Pearce-Higgins *et al*. 2011) leading to potential loss of some species in parts of their previous range and expansion in others.
- A reduced ability to achieve our species recovery plan objectives or BAP species objectives through direct changes to their range or habitats (Pearce-Higgins *et al*. 2011).

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[1] Terms in brackets relate to the level of confidence we have in our evaluation of importance and proximity

- Changes to valued landscape character, and the loss of original attributes for which sites were originally designated.

11) Changes to community composition (Medium):

- The composition of communities will change due to changes in the abundance and distribution of their component species (Morecroft & Paterson 2006; Devictor *et al*. 2008; Morecroft *et al*. 2009; Bain *et al*. 2011).
- Changes to biological communities leading to the development of new communities/habitat types resulting in a reduced ability to achieve habitat plan objectives (for example, for montane habitats) of the UK Biodiversity Action Plan (BAP) (Britton *et al*., 2009, Keith *et al*., 2009; Keith 2010).
- Changes to communities for which protected areas were designated and possible knock-on effects on species of conservation concern.
- Range expansions of both native and non-native species and resulting in different levels of competition, predation or disease.
- Generalists species favoured (through increased competitive advantage) over specialists - leading to a homogenisation of biodiversity (Olden *et al*. 2004; Britton *et al*., 2010).
- Changes in habitat types (for example, ancient oak woodlands in the north and west of England being regenerated by beech and loss of beech in the South and East) (Mitchell *et al*. 2007).
- Increased flooding and waterlogging during wetter winters leading to a shift in community composition in wetland and lowland habitats (Mitchell *et al*. 2007).
- Increase in temporary winter ponds replacing permanent ponds leading to significant change in community structure and function.
- Sea level rise and storms leading to flooding and over topping in coastal environments leading large swings in salinity and water levels. Leading to a reduced ability to achieve habitat and species objectives, in particular for freshwater coastal sites that will receive increased influence from brackish water or be converted to intertidal habitat (for example, The Broads).

12) Changes to species interactions (High):

- Range expansions of both native and non-native species and resulting in different levels of competition, predation or disease.
- Disaggregation of food-webs, for example, loss of fish prey populations for internationally important seabird colonies (Moss *et al*. 2005).
- Phenological mismatches (Saino *et al*. 2010).

13) Loss of habitat space (High):

- Loss to ecotones and habitats, in particular the transition between freshwater and saltmarsh, where such transitions are likely to be compromised further by coastal squeeze and where there is a lack of land suitable for managed coastal realignment (Lee 2001; Foresight 2004; DEFRA 2006).
- A reduced ability to achieve protected site, habitat and species objectives, in particular for freshwater coastal sites that will receive increased influence from brackish water or be converted to intertidal habitat (for example, The Broads).
- Impacts on coastal landscapes and historic sites on the coast (Murphy, Thackray & Wilson (2009).
- Insufficient water to support freshwater wetland & other habitats and species.

14) Increased incidence of fire (High):

- Increased fire risk of habitats such as heathland and moors (Mitchell *et al*. 2007).
- A reduced ability to achieve our statutory role in conserving and enhancing the natural beauty of landscapes with national designations, as these designations are currently stated, our targets for SSSIs and protected species.
- A reduced ability to achieve habitat plan objectives (for example, for heathland in a desired condition) under the auspices of the UK Biodiversity Action Plan.

15) Changes to ecosystem function (Medium):

- Increased risk of soil moisture deficiency and changes in soil microbial activity for many terrestrial habitats (for example, beech woodland) impacting on protected sites and landscape character (Mitchell *et al*. 2007).
- Changes in soil water (+/-), leading to loss of elements of soil biota reducing soil function leading to a loss of soil structure, and changes to nutrient cycling/fixing, and soil carbon storage.
- Potential changes to primary production and carbon cycling (Fay *et al*. 2008).
- Changes on the delivery of key ecosystem services such as pollination (Thomson 2010).
- Saline incursion into soils will alter their function, reduce opportunities for agriculture and change their potential for habitat restoration. This could lead to increased pressure to move current agricultural production on to other land to replace saline-affected soils, limiting habitat restoration potential or AE scheme uptake, or lead to loss of lower intensity and semi natural habitats to agriculture.
- Loss of carbon from increased drying of peatlands (Bain *et al*. 2011, Fenner & Freeman 2011).
- Work to monitor landscape change and to take an integrated landscape and ecosystem approach in each National Character Area will not ‘keep pace’ with the rate of possible changes.

16) Changed hydrological regime (High):

- Increased episodic events (flow rate, temperature) caused by extreme events, (Conlan *et al*. 2007).
- Decline in summer flows and increased winter flows (Arnell 2004; Mitchell *et al*. 2007).
- Insufficient water to support wetland and other habitats and species leading to a reduced ability to achieve our species recovery plan objectives for wetland/riverine species (including wetland birds) (Arnell & Reynard 2000).
- Increase in temporary winter ponds replacing permanent ponds.
- Increased stratification and loss of oxygen in freshwater systems, leading to eutrophication, algal blooms leading to a reduced ability to achieve habitat plan objectives for vulnerable rivers and lakes (Whitehead *et al*. 2009).
- Drainage issues for historic buildings, water table changes lead to acidification and destruction of palaeoenvironmental and archaeological remains.

19) Conflicts with mitigation (High):

- Impacts of some renewable energy initiatives on natural systems and biodiversity, for example, tidal barrages, wind turbines on peat or hydro electric dams (Drewitt & Langston 2006).
- Potential conflict between mitigation and adaptation through the creation of wind farms and large reservoirs (for HEP) in protected areas.

- Potential conflict between mitigation and adaptation through the creation of tidal barrages across the Seven, Mersey and other estuarine sites.
- Potential conflict between mitigation and adaptation through afforestation for carbon storage and wood fuel on habitats and sites.
- Potential conflict with bioenergy (Booth *et al*. 2010).
- Over-exploitation of Woodlands managed for production of timber and woodfuel.
- Increased provision of carbon sequestration through planting with fast growing locally inappropriate species such as eucalyptus. Leading to a loss of landscape character & biodiversity function in targeted areas.
- Negative impacts of renewable energy generation projects (for example, wind turbines, biofuels and hydroelectric) on landscape character and sense of place, and on important features and sites.

20) Agricultural adaptation (Medium):

- The introduction of new and different crops and techniques in response to changing climate within the UK (Foresight 2010, 2011).
- Many international and national climatic drivers of change including; the failure of international crops causing changes in agricultural policy and the economics of different crops (Schmidhuber & Tubiello 2007).
- Increased pressure on EU to increase agricultural and/or energy crop output (Schmidhuber & Tubiello 2007; Foresight 2011).
- Changes from pastoral to arable systems in West England due to warmer drier summers;
- Agriculture will require more irrigation to maintain present food production levels (Weatherhead & Knox 2009).
- Re-intensification due to longer growing seasons.
- Potential for farmers to respond to waterlogging and flooding with increased inputs of lime and fertiliser.
- Such changes have the potential to threaten many of our objectives through:
  - Increased pollution either from defuse agricultural sources or through other drivers like increased population or urbanisation (Dunn & Brown 2010).
  - Increased demand for water from agriculture leading to over abstraction from groundwater and rivers.
  - Deterioration (eventual loss) of traditional features including field boundaries, hedgerows and traditional farm buildings impacting on landscapes and historic features.
  - Walls and historic buildings increasingly uneconomic to maintain due to increased changed patterns of rainfall, storms and flooding are abandoned in favour of newer larger more robust agricultural structures negatively impacting the historic environment and landscape character.
  - Areas identified as containing opportunity for restoration of biodiversity used for higher intensity food production.
  - Increase in fragmentation of habitats (reduction in size) and species pathways so decreasing landscape permeability.

Medium priority threats

2) Increased diffuse pollution (Medium):

- Waterlogging leading to soil damage by machinery or livestock when wet, leading to compaction or poaching of soil, and increased runoff, carrying sediment and other pollutants into watercourses.
- Increased nutrient loading due to accelerated soil processes such as the mineralisation of organic matter (Bouraoui, Galbiati & Bidoglio 2002).

3) Decreased water quality (High):

- Lower flows reduce the dilution of nutrients and enhance the potential for toxic algal blooms and reduce dissolved oxygen levels (Whitehead *et al*. 2009).
- Increased nutrient loading of freshwater systems (Bouraoui, Galbiati & Bidoglio 2002; Whitehead *et al.* 2006).
- Increase flooding of ponds and run-off of fine sediment and nutrients into watercourses causing loss of water quality through pollution and eutrophication and siltation (Whitehead *et al*. 2009).
- Increased pollution either from defuse agricultural sources or through other drivers like increased population or urbanisation.

4) Increased erosion (High/Medium):

- Large proportion (around 30%) of English coast susceptible to erosion (Eurosion 2004).
- Projected increase in storm events in combination with high tides and onshore winds will re-shape the coast including increasing coastal erosion (Jones 2011).
- Added effects of erosion, particularly in water channels resulting in a decrease in water quality and a loss of marginal vegetation.
- Increased erosion and slope failure, leading to loss of nationally and internationally important historic and geodiversity features (Prosser *et al*. 2010).
- A reduced ability to achieve our statutory role in conserving and enhancing the natural beauty of landscapes, seascapes with national designations, as these designations are currently stated.

6) Damage to parkland and veteran trees (High):

- Damage to woodland, parkland and hedge habitats due to high winds (Della-Marta & Pinto 2009, Gardiner *et al*. 2010) which will lead to loss of veteran trees.

17) Increased subsidence (Medium):

- Increased shrink and swell of some clay-rich soils which may cause heave damage to historic buildings, walls, or other archaeological features.

18) Societal adaptation (Medium):

- 'Coastal squeeze' effect trapping habitats between the rising sea level and hard engineered sea defences (Doody 2004, Foresight 2004).
- Dynamic nature of coasts constrained by flood defences both current and future through the need to adapt to climate change impacts (the ability of natural habitats to provide sustainable flood defences not realised).
- Realignment of defences over freshwater or terrestrial habitats causing habitat loss.
- Changes to fishing practices to accommodate changing fish stocks.
- Increased demand for water in developed areas and for agriculture leading to over abstraction from groundwater and rivers in some areas that are potentially already under pressure.
- Semi-natural areas in floodplains 'sacrificed' to absorb flood waters.
- Potential damage to geological and geomorphological SSSIs as a result of engineering structures impacting on our SSSI targets.
- Action by other parties to prevent or repair damage from erosion, leading to loss of access to features of geological interest and potential damage to geological and geomorphological SSSIs as a result of engineering structures.

- Hotter drier summers with reduced holidaying abroad leading to greater demand for access to sensitive wildlife sites.

Opportunities

Table N Matrix showing the different opportunities for Landscape & Biodiversity, according to their importance and proximity

		Proximity				
		Now	**Short**	**Medium**	**Long**	**Very Long**
Importance	**Major**		(e)			
	Moderate			d,(f)		
	Minor		a,b,(g)	c		

(purple = high; blue = medium; yellow = low). Indirect opportunities are indicated in brackets.

High priority opportunities

e) Societal adaptation (Medium):

- The ability of natural habitats to provide sustainable climate change adaptation, for example, flood defences, recognised and adaptation action benefits both society and biodiversity.
- Increased awareness of the need for alternative approaches to flood risk management, providing opportunities to introduce a more sustainable system using more natural river banks and profiles, which could improve the protection of historic features and geodiversity and enhance biodiversity.
- Increased managed realignment for coastal areas providing an opportunity to meet Biodiversity Action Plan targets for coastal habitats (especially saline/brackish habitats) through managed realignment of coastlines, where appropriate, as a strategy for coping with sea level rise.
- Increased constructed wetlands in order to manage flooding.
- Increased interest from urban planners and businesses in the use of green infrastructure as an adaptation strategy leading to 'green and blue infrastructure' in urban areas. (for example, using vegetation and water for urban cooling) providing an opportunity to decrease fragmentation of semi-natural habitats adjacent to urban areas and increase urban biodiversity.
- Increased number of people using and valuing the English countryside.

Medium priority opportunities

a) Shifts in species range (Low):

- Potential for some taxonomic groups (for example, thermophilic invertebrates) to increase range and colonise new sites; this could result in an increased likelihood of reaching some Biodiversity Action Plan species targets (for example, Adonis blue, large blue, Dartford warbler) and could result in an increase in species richness for some habitats/geographical areas.
- 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.

b) Changes to community composition (Low):

- An increase in general richness of biodiversity driven by colonisation by mobile taxonomic groups.

c) Changed geomorphological processes (Low/Medium):

- New geodiversity features exposed leading to an enhanced ability to support conservation of geological SSSIs; potential enhancement of landscape character and local distinctiveness (Prosser *et al*. 2010).

d) Changed hydrological regime (High):

- Large scale changes to river flow and other processes, creating need for changed management and opportunity to restore natural processes.

f) Alignment with mitigation (Medium):

- Reintroduction of positive woodland management for the production of timber and wood fuel;
- Rewetting/water retention in peatland for carbon sequestration.
- Reduction in energy intensive agricultural practices in response to need for climate mitigation providing an opportunity to shift to more sympathetic soil management practices, leading to improved soil function and a decreased need for agrochemicals.

g) Agricultural adaptation (Low):

- Increased cost of fuel and carbon reducing area under intensive land management increasing the likelihood of meeting some Biodiversity Action Plan targets for habitats and species.

Areas of uncertainty

Topics that require further research to develop our approach include:

- **Effects of climate change on complex interaction between species**. In addition to the differing rates of change in phenology leading to mismatched timings within food chains, species have a wide range of interactions with competitors, parasites, diseases and predators that could be altered as a result of climate change and its affect on habitats. As some species distributions change more radically that others, novel combinations of species will occur with unknown consequences for interactions. Furthermore, there are likely to be local climates that have no analogy with any currently existing ones, potentially leading to the formation of novel ecological communities. Plant-soil interactions may also change, with consequences for nutrient relations.
- **Factors that promote functional connectivity and dispersal across landscape**. The highly fragmented nature of English habitats is widely recognised as a constraint on dispersal for many species and hence on their ability to colonise new sites. However the best methods to ameliorate this, is an area of uncertainty.
- **Non-native invasive species**. Most non-native species in Britain are not a threat and with climate change we may well have to accept and protect many species whose potential range is expanding into the UK, whilst retracting in other, more southerly areas. At the same time, however, non-native species may prove a threat as a result of their invasive nature or because they are pests and diseases. The identification of species that might pose a future risk as a result of climate change or as a result of encouraging habitat connectivity as an adaptation measure continues to be an area of active research.
- **Tipping points in the interactions between climate and ecosystem responses**. Tipping points may be crossed as a result of an extreme climatic event or series of events that push an ecosystem into an alternative stable state, for example an ecological ‘regime shift’ would be a storm surge and coastal flooding event that transformed a coastal reed bed habitat into a saltwater marsh. Understanding the proximity of tipping points is an important area of research.

- **Interactions between different aspects of environmental change**. Climate change will interact with all the other pressures on ecosystems, including land use change, air pollution and invasive species. These complex interactions are poorly understood and have the potential to reduce the capacity for the natural environment to adapt autonomously or to influence human adaptation interactions.
- How to enhance the adaptive capacity of species, habitats, ecosystems and ecosystem services to both gradual climate change and episodic but increasing frequency of extreme events.

Our ability to address the risks

Levers

- A key lever 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).
- Provision advice on the designation and management of protected areas such as Sites of Special Scientific Interest, National Parks, and Areas of Outstanding Natural Beauty, Ramsar Sites and Special Areas for Conservation (SACs) including monitoring their impact and recommending new designations.
- Preparation and review of designated site citations and preparation of management approach.
- Support the preparation of management plans for Areas of Outstanding Natural beauty.

Barriers

- Staff time and resource, including availability of staff with sufficient knowledge and expertise working on delivery.
- May be difficult to get buy in from partners including land owners for measures to combat climate change threats, which many perceive are a long time in the future.
- Adaptation measures are often required in a different location to where the impact is experienced, for example, coastal erosion at one location may be due to sediment movement being restricted at a different location within the coastal cell.
- As change in our landscapes speeds up, delivery mechanisms and management options will need to be increasingly responsive to the adjusting natural environment.
- A key lever is agri-environmental schemes to deliver adaptation on the ground, however, the higher level scheme which provides more options which can be used to combat climate change threats, is often not targeted in areas where there are opportunities to develop an integrated approach which includes responding to climate change risk. Agreements are also usually only ten year agreements, and many measures will need to be in place significantly beyond this time frame, limiting our ability to plan long term.
- Our present system leases change but only for short periods of time - in many instances it would be far more cost effective to buy land to facilitate that change, leaving nature to take its course in a low intervention way.

Our partners and stakeholders

Delivery of the actions required to mitigate the threats and opportunities identified requires the coordinated action of Natural England's functions and a wide range of external organisations. A coordinated approach from Defra and its agencies such as the Environment Agency, Forestry Commission and Marine Management Organisation ensuring coordinated advice and guidance and joined up incentive schemes will be essential.

The authorities that run National Parks and Areas of Outstanding Natural Beauty will have a pivotal role in delivering actions within their protected areas, whilst NGOs such as the National Trust, Wildlife Trusts and the RSPB will play a considerable role within protected areas and in the wider countryside often coordinated through partnerships such as the Biodiversity Action Plan partnerships.

The JNCC, Universities and research councils will have an important role to play in the development and understanding of the evidence base. Whilst Local Record Centres supported by volunteers and the NGOs listed above will play an important role in monitoring change.

Summary of key responses to priority risks and opportunities

Desired change: an **improved understanding of how climate change is affecting the natural environment** in different parts of the country, to inform appropriate action targeted at the most urgent priorities.

- Risks addressed: most/all.
- Natural England's ability to influence this: high.

Action we could take: Further develop our **integrated surveillance and monitoring strategy**. This will include data from Integrated Site Assessments, data from local record offices and other partners, and our own monitoring work on change in the abiotic environment (geodiversity, historic environment and soils) and wider landscape change.

- Resources: Moderate.
- Time: Short term action, short delay to effect.

Desired change: a **national system of protected areas that takes climate change fully into consideration** and is not notified and managed as if the environment is static and unchanging.

- Risks addressed: 1, 5, 7, 10, 11, 12, 13, 16, a, b, c.
- Natural England's ability to influence this: high.

Action we could take: **Integrate climate change into our designation strategy for protected areas**. As part of our statutory duty to review existing designations, work with Defra and other partners to develop, agree and implement an integrated Landscape and Biodiversity Protected Area Designations Strategy, including our Natura 2000 and SSSI designations, which incorporates climate change considerations. This will:

- Reflect potential for changes in species and habitat composition in designated site citations, conservation objectives, condition assessment and guidance for habitat management to allow sites to continue to be important for biodiversity even if they don't contain the species for which they were originally designated.
- Continue to implement the SSSI Notification strategy, which includes a review of boundaries and features of all current SSSIs, making sure that climate change adaptation is also considered.

- Input into the new SSSI guidelines to ensure that changes to features are assessed and taken into consideration. This should include underpinning ecological processes whilst taking into account climate change impacts to increase resilience.

- Resources: Moderate.
- Time: short term action; short delay to effect.

Desired change: all **existing wildlife conservation areas are managed in a way that explicitly addresses climate change**, with appropriate awareness of vulnerability, conservation objectives, management actions and adaptive management. (The appropriate management will vary from site to site depending on the ecosystem and species in question, but should follow established principles for conservation biodiversity under climate change including, for example, increasing heterogeneity of land cover to increase available microhabitats and so increase the chances of species persisting in locally favourable microclimates and soil conditions, for example, including areas with northern slopes and wetter places within sites).

- Risks addressed: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, a, b.
- Natural England's ability to influence this: medium-high.

Action we could take: Developing and providing **detailed advice and guidelines to conservation managers** about possible adaptation actions for different ecosystems. This should bring together our knowledge on the impacts of climate change on the natural environment, including habitats, species, landscape, soils, geology and the historic environment together with suggested adaptive responses.

- Resources: Moderate.
- Time: rapid action; short delay to effect.
- Side-benefits (if implemented): Mitigation through carbon storage/sequestration in soil and vegetation; a wide range of other ecosystem services such as flood alleviation.

Action we could take: ensure that all sites Natural England directly manages (such as National Nature Reserves) are managed according to the best practice guidelines mentioned above. (See NNR section below.)

Desired change on ground: Ensuring habitat creation and restoration enhances **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.

- Risks addressed: 1, 7, 8, 10, 13, a, b.
- Natural England's ability to influence this: high.

Action we could take: Develop better **practical tools and methods for conservation managers to identify where ecological networks should be created or improved**, through increasing patch size, improving habitat quality and variability through the linking of sites. This could include providing spatial data of potential linkages between our larger SSSIs, identifying the key geology and soils types that allow good potential for landscape scale restoration and map out areas of landscape change where space for natural functioning process will need to occur over the longer term. It could also provide a mechanism to build on opportunities presented through the creation of Nature Improvement Areas and green infrastructure routes, as well as more innovative approaches to land use planning and agricultural environmental schemes.

- Resources: Moderate.

- Time: short term action; medium delay to effect.
- Side-benefits (if it leads to action on the ground): mitigation through soil carbon; flood alleviation through river conservation and urban green infrastructure; urban cooling through urban green infrastructure.

Action we could take: plan **Natural England's own ecosystem restoration and re-creation activities** in a way that contributes appropriately to the improvement of ecological networks; particularly through our land management and land use work and through conservation partnerships.

- Resources: Major.
- Time: medium term action; medium delay to effect.

Desired change on ground: **local communities and partners have access to the best available evidence about possible future environmental change** in their area, and about action that could be taken. This would help to enable communities to 'own' the landscape change in their area, and would help them to engage with the positive aspects of living in a naturally dynamic landscape.

- Risks addressed: 2, 3, 4, 5, 6, 11, 14, 15, 16, 18, 19, 20, e, c, f, g.
- Natural England's ability to influence this: high.

Action we could take: **Revise and update all England's National Character Area** profiles to take climate change into consideration. These would include the identification of opportunities for integrated action, based on information and analysis that reflects Natural England's interests, and will be made available as advisory tools to partners and local stakeholders, including local communities to help them set the context for their planning and decision-making.

- Resources: Minor.
- Time: rapid action; short delay to effect.
- Side-benefits: Potential for a range of ecosystem service benefits.

Desired change: **Make Protected Landscapes the most resilient areas** of the UK's Natural Environment to climate change - manage to increase the resilience further and develop a strategy to join some of them up.

- Risks addressed: 11, 14, 15, 16, 18, 19, 20, a, b, e.
- Natural England's ability to influence this: medium (need to work closely with AONBs and National Parks).

Action we could take: Develop improved **guidance and management practices for managing protected landscapes in a changing climate**. 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.

- Resources: Substantial.
- Time: short term action; short delay to effect.
- Side-benefits: mitigation, flood alleviation, recreation opportunities.

Desired change: greater use of **large scale land management** that 'works with nature' to create areas in which ecological processes are re-established or facilitated, to allow large scale changes to our rivers, coasts and associated wetlands. This should provide benefits for wildlife, as well as flood alleviation benefits for human communities.

- Risks addressed: 4, 5, 11, 13, 15, 16, 18, a, b, d, e.
- Natural England's ability to influence this: medium.

Action we could take: build (with partners such as the EA) a **spatial evidence base** of the opportunities for such action, which can be used with partners to inform the location and management of future projects.

- Resources: Moderate.
- Time: short term action; medium delay to effect.
- Side-benefits: mitigation in coastal marsh, flood alleviation, recreation opportunities.

Action we could take: work with others, particularly organisations such as the Environment Agency, local authorities, NGOs and local communities to to consider how we can make space for the natural development of rivers and coasts in a way that helps both wildlife and people.

- Resources: Moderate.
- Time: short term action; medium delay to effect.
- Side-benefits: mitigation in coastal marsh, flood alleviation, recreation opportunities.

Desired change: **Biodiversity Action Plan targets and species recovery programmes retain their relevance** as climate change causes changes in species' distribution and shifts in ecosystems. Consideration is given to the role of additional mechanisms such as species translocation and ex-situ conservation.

- Threats addressed: 1, 6, 7, 8, 9, 10, 11, 12, 14, 14, 15, 16, 20, a, b.
- Natural England's ability to influence this: medium.

Action we could take: work with Defra and other partners in the England Biodiversity Strategy to regularly review the appropriateness of plans and targets.

- Resources: Moderate.
- Time: short term action; rapid effect.

Desired change: the full range of adaptation benefits provided by conservation areas are considered in land use planning decisions.

- Threats addressed: 18, 19, 20, e, f, g.
- Natural England's ability to influence this: medium.

Action we could take: see land use section.

Access and Engagement function - People and Partnerships, Statutory Access and National Nature Reserve Teams

Natural England's Access and Engagement Function has a variety of responsibilities that focus on helping people to enjoy, understand and appreciate our natural heritage. The Function embraces the organisation's statutory access duties, National Nature Reserves (including the direct delivery of nature conservation on those managed by Natural England) and the provision of advice regarding the quality of greenspace and the involvement of communities.

The work of the Function underpins Natural England's statutory purpose to protect, conserve and manage the natural environment for the benefit of present and future generations.

The Function is responsible for providing advice on matters specified in Natural England's general purpose which relates to: securing the provision and improvement of facilities for study; understanding and enjoyment of the natural environment; and promoting access to the countryside and open spaces and encouraging open-air recreation.

Natural England's aspiration and intention to increase the number and range of people who benefit from the natural environment is undiminished: we want people everywhere to experience and enjoy nature in their day-to-day lives because we know it contributes to their own wellbeing, which, in turn leads to more people valuing nature. We work with others to increase the opportunities for people to access and engage with the natural environment.

Our analysis considers our Team's work in two separate parts: objectives relating specifically to our work on National Nature Reserves; and objectives for statutory access and engaging people with the natural environment.

National Nature Reserves

We aim to manage our National Nature Reserves as exemplar nature conservation sites contributing significantly to public enjoyment and understanding of the natural environment and the provision of ecosystem services, and explore opportunities for civil society and local communities to become more involved.

The specific objectives to achieve this that are under threat from climate change are to: confirm a vision and strategy for the management of Natural England's National Nature Reserves; ensure that National Nature Reserves are managed as exemplar nature conservation sites; and, that Natural England's NNRs provide increasing levels of public enjoyment, partnership working and involvement of local communities in the natural environment.

Threats

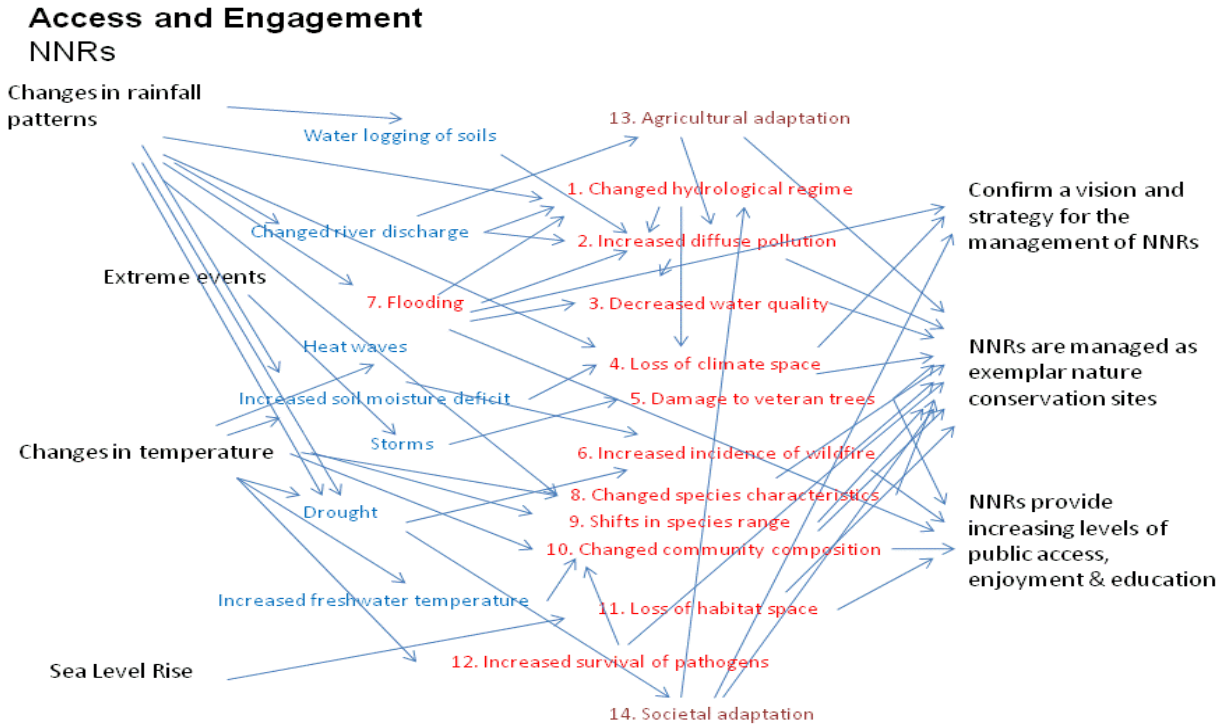

Figure B Threat Analysis - Access and Engagement: NNRs

Table O Matrix showing the priority of the different threats to National Nature Reserves team objectives, according to their importance and proximity

		Proximity				
		Now	**Short**	**Medium**	**Long**	**Very Long**
Importance	**Severe**					
	Major	6,8	9,10,11	7		
	Moderate	12	1	2,3,4,(13),(14)		
	Minor			5		
	Negligible					

(red = high; orange = medium; green = low). Indirect threats are indicated in brackets.

High priority threats

6) Increased incidence of wildfire (Medium):

- Drought and extreme high temperatures leading to increase incidence of wildfires in vulnerable habitats, especially heathland, lowland raised bog and blanket bog NNRs. Increasing resources required to manage sites to minimise impacts of wildfires (for example, fire breaks) and impact of those on landscape (Albertson *et al*. 2010).
- Restricted access on NNRs as a result of access land closures.

8) Changed species characteristics (High):

- Temperature driven change in behaviour of species resulting in changes in niche requirements (for example, grassland butterflies moving to different microclimates) (Davies *et*

al., 2006; Isaac *et al*. 2010) is increasing the complexity and costs of management to understand, create where necessary and maintain appropriate habitat niches on NNRs.

- Increased growth of some plant species, particularly invasive generalists leading to increased costs to maintain visibility of and access to NNR features, including geological features.

9) Shifts in species range (High):

- Shifts in species ranges (for example, southern range contractions, colonisation northward and uphill), leading to changes or potential loss of some species in parts of their previous range and expansion in others (Davies *et al.* 2006, Dockerty, Lovett & Watkinson 2003, Parmesan *et al*. 1999, Pearce-Higgins *et al*. 2011), could lead to an inability to meet current habitat and species objectives.

10) Changed community composition (High):

- Species compliments of NNRs changing: **a)** loss (or significant reduction) of key, often specialist species with effects on others in turn; tricky decisions on whether to put conservation effort into retaining species, or at least at what point to 'let them go'; **b)** new species colonising, or significant increase in species already present, often generalists (McKinney & Lockwood 1999, Olden *et al*. 2004), some of which may have adverse impacts on ecosystems. Both these effects could lead to an inability to meet current habitat and species objectives.
- Loss of specialists and increase in generalists leading (McKinney & Lockwood 1999, Olden *et al*. 2004) to a general reduction in what makes reserves special places for the public and therefore increasing the challenge of engaging the public.
- Increased stratification and loss of oxygen due to increased temperatures in freshwater habitats, leading to eutrophication and algal blooms (Durance & Ormerod 2007). NNRs with aquatic features affected as food webs may be interrupted with consequent species changes.

11) Loss of habitat space (High):

- Sea level rise and increased storms leading to a loss of coastal intertidal habitats, (Lee 2001) especially where there is a 'coastal squeeze' (Doody 2004) effect trapping habitats between the rising sea level and hard engineered sea defences, supra-littoral and adjacent terrestrial habitats (Foresight 2004).
- Fundamental changes to east coast NNRs with major losses of valuable habitats, species and geodiversity features. In many cases, no easy areas to retreat to due to abutting high value, improved agricultural land.
- Access to coastal NNRs significantly compromised. Cost of maintaining access features increased, including H&S considerations.
- Fundamental changes to affected NNRs with major losses of valuable habitats, species and geodiversity features, including the attributes for which the site was originally declared, with the implication that some sites should be de-declared.
- In many cases, no easy areas to retreat to due to abutting high value, improved agricultural land.

12) Increased survival of pathogens (Medium):

- Enhanced survival of pathogens due to milder winters leading to the spread of diseases onto NNRs such as *Phytophthora*, with consequent effects on susceptible species and ecosystems.

Medium priority threats

1) Changed hydrological regime (High):

- NNRs reliant on just surface water from rainfall will be especially vulnerable to change in hydrological regime due to changed rainfall patterns; sites with complex hydrological regimes less vulnerable (Winter 2000, Acreman *et al*. 2008).
- Loss or reduction in value of habitats and dependant species on wetland or aquatic NNRs could lead to an inability to meet current habitat and species objectives (Environment Agency 2008).
- NNRs in floodplains subject to loss of fine control of water levels, causing deterioration in habitat.

2) Increased diffuse pollution (Medium):

- Waterlogging resulting in damage to soils by machinery, livestock or access users when wet. Leading to compaction or poaching of soil, and increased runoff, carrying sediment and potentially pollutants into watercourses (DEFRA 2010).
- Increased nutrient loading of watercourses (Whitehead *et al*. 2009).

3) Decreased water quality (Medium):

- Flooding increasing the risk of eutrophication and/or pollution of semi-natural habitats (Whitehead *et al*. 2009; DEFRA 2010). Eutrophic or polluted floodwaters will adversely affect vegetation on NNRs and in turn invertebrates and other fauna.

4) Loss of climate space (Medium):

- Reduction in oceanic climate characteristics likely to affect bryophytes and ferns.
- Increased soil moisture deficit could lead to the loss or reduction of blanket bog and fen (Clark *et al*. 2010).
- Climate conditions exceed ecological niche for peat forming *Sphagnum* species and peat stops forming on major lowland raised bog and blanket bog restoration projects on NNRs (Clark *et al*. 2010, Lindsey 2010).
- Risk of significant reductions of key, often specialist, species on relevant NNRs could lead to an inability to meet current habitat and species objectives, or the loss of attributes for which the NNR was originally declared, leading to the prospect of de-declaration of sites.
- Increased risk of mortality of drought and heat sensitive species, for example, beech trees (Broadmeadow *et al*. 2005, Geßler *et al*. 2007).

5) Damage to veteran trees (Medium):

- Increased loss of veteran trees and damage to woodland, parkland and hedge habitats due to high winds in storm events (Della-Marta & Pinto 2009, Gardiner *et al*. 2010).
- Increasing tree safety management costs in honey pot zones on NNRs.

7) Increased incidence of flooding:

- Semi-natural areas in floodplains ‘sacrificed’ to absorb flood waters. Increase in area required for floodwater absorption, and consequent risk of eutrophication and/or pollution of semi-natural habitats. Will limit any expansion of NNRs on floodplains and connectivity between sites will be restricted by increased pressure on land use.
- Access areas and routes affected, and unavailable for longer periods of the year, restricting public access. Increased maintenance costs for certain NNRs and possible increase in visitor numbers and pressures on alternative NNRs during flood season.

13) Agricultural Adaptation (Medium):

- Increased inputs of lime and fertiliser as a response to waterlogging causing greater leaching of nutrients into groundwater and a decline in quality of ground water.

14) Societal Adaptation (Medium)

- In drought conditions increased competition for water between sectors. Leading to a reduction in available water to control site hydrology leading to negative impacts on habitats and species and restrictions on the expansion of existing wetland limiting connectivity between sites (Hume 2008, Spoor 2004).
- Increasing competition for land and other resources. Expansion of reserves and providing linkages becomes more expensive and politically challenging.
- 'Coastal squeeze' of coastal ecosystems between rising sea levels and hard coastal defences (Foresight 2004).

Opportunities

Table P Matrix showing the different opportunities for National Nature Reserves, according to their importance and proximity

		Proximity				
		Now	**Short**	**Medium**	**Long**	**Very Long**
Importance	**Major**	(e)	(g)			
	Moderate	a, (h)	b,(f)	c,d		
	Minor					

(purple = high; blue = medium; yellow = low). Indirect opportunities are indicated in brackets.

High priority opportunities

a) Shifts in species range (Low):

- Potential for some taxonomic groups (for example, thermophilic invertebrates) to increase range and colonise new sites this could result in an increased likelihood of reaching some Biodiversity Action Plan species targets (for example, Adonis blue, large blue, Dartford warbler) and could result in an increase in species richness for some habitats/geographical areas.
- 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.

e) Societal adaptation (Medium):

- Sea Level Rise and increased storminess is likely to increase the need for managed coastal realignment projects. Such projects could provide an opportunity for the creation of new or extended NNRs, or for linking up existing sites.

g) Agricultural adaptation (Low):

- Further intensification of English agriculture and greater pressure on land leading to increasingly value being placed in protected sites. NNRs better supported politically and by the public, and better resourced, facilitating the management, expansion and connection of sites.

- Saline incursion into soils will alter their function, reduce opportunities for agriculture and change their potential for habitat restoration.

h) Increased extent and complexity of climate change impacts (Low):

- Greater number of people environmentally aware.
- Evidence gaps in solving environmental problems become more apparent increasing the demand for solutions leads to greater support for research and monitoring activities. NNRs valued more highly for their research, monitoring and demonstration potential.

Medium priority opportunities

b) Changes to species abundance (Medium):

- Some specialist species undergo adaptive variations in response to environmental changes and become more generalist, for example, silver-spotted skipper becoming more generalist in its habitat requirements leading to population increases (Davies *et al*. 2006).

c) Changed hydrological regime (High):

- Quasi-natural, large scale changes to river flows and other aquatic processes benefiting biodiversity and geodiversity of NNRs in affected areas.

d) Increased incidence of flooding (High):

- Extreme events and changed rainfall events are likely to increase the demand for sustainable flood risk management increasing the onus on natural elements within river systems, again providing the opportunity for the creation of new or extended NNRs.

f) Alignment with mitigation (Medium):

- Semi-natural habitats play an increasingly significant role as carbon stores and sink increasing the value (perhaps including monetary) attached to NNRs acting as carbon stores.

Areas of uncertainty

The ecosystems represented on NNRs are invariably complex and responses to changing environmental variables are difficult to ascertain with a high degree of certainty. There are a great number of evidence gaps for habitats and species, including their rate of change.

NNRs contain a disproportionate number of rare and edge-of-range species, many of which are susceptible to climate change. In the case of diminishing populations of such species, there are no policies regarding when the conservation of a local population no longer justifies the resources required to maintain it.

Indirect impacts such as pollution from off-site sources or pressures from surrounding land use may be prevented or moderated by regulatory control; the degree of regulatory power may need to be enhanced if the pressures increase.

There are significant gaps in knowledge regarding the management of invasive species and diseases.

The management of damaged peatlands has improved significantly in the last decade but it is unclear whether there is sufficient knowledge and resources to address the enhanced threats caused by climate change.

Clearly, considerable uncertainty lies around the human-related responses to climate change and their consequent bearing on NNRs, such as the changes to agriculture and the values society places on the natural environment.

Our ability to address the risks

Currently, approximately two thirds of NNRs by area and number are managed directly by Natural England, often in close working partnerships with owners of the land. The remaining one third is managed by Approved Bodies: organisations such as the National Trust, RSPB and the Wildlife Trusts as well as some other environmental agencies, Local Authorities and a few commercial and private individuals.

- The majority of the on-site responses are deliverable by the organisations managing the Reserves, if resourcing is available.
- In some cases, resources are likely to be a limitation to the degree of management possible, for example in expanding Reserves, adapting access infrastructure or undertaking management of large hydrological units.
- NNRs will need significant inputs from specialist ecologists and academic institutions in order to understand the issues, develop the correct management, and to monitor the changes.
- For off-site responses, including the all-important issues of inter-site connectivity, Natural England will need to draw on its incentive schemes and regulatory powers (and call on others to use theirs).
- Natural England will require good relationships with stakeholders and strong societal support for the natural environment to achieve our objectives for NNRs.

Summary of key responses to priority risks and opportunities

Desired change: **facilitation of movement of species between reserves** by increasing reserve size and quality, maximising landscape permeability, creating 'stepping stones' and corridors; and assisting species movements where essential.

- Threats addressed: 1, 4, 6, 10, 11, [L&B: 1, 7, 8, 10, 11, 13, 16].
- Natural England's ability to influence this: low-high depending on the action required (other bodies managing NNRs also have a role; some actions would also be required outside reserves, requiring cooperation with a wider range of partners).

Action we could take: **Use and extend NNRs as stepping stones**.

- Resources: major.
- Time: medium term action; medium delay to effect.
- Additional benefits: Carbon sequestration through creation of wetlands and other semi-natural habitats; reduction in nitrous oxides for same areas.

Action we could take: Facilitate and **encourage large-scale projects** on land between reserves, to help to make the 'matrix' between them more permeable to species.

- Resources: major.
- Time: medium term action; medium delay to effect.
- Additional benefits: Carbon sequestration through conservation of agricultural soils.

Action we could take: **undertake translocations and introductions** to IUCN protocols.

- Resources: major.
- Time: medium term action; short delay to effect.

Desired change: creation of **new coastal conservation areas**, and extension of existing sites, to compensate for the projected loss of coastal reserves.

- Threats addressed: 10, 11, 14, [L&B: 1, 7, 8, 10, 11, 13, 16].
- Natural England's ability to influence this: medium.

Action we could take: **create new/extended nature reserves**.

- Resources: substantial.
- Time: medium term action; medium delay to effect.
- Additional benefits: Carbon sequestration through creation of wetlands, coastal marsh; Flood regulation; regulation of water quality; recreation provision.

Desired change: **reserves are buffered and protected** against detrimental effects arising on land surrounding the reserve.

- Threats addressed: 2, 3, 7, 13, 14.
- Natural England's ability to influence this: low (a large number of other organisations and individuals are involved, and in many cases the levers are not directly in Natural England's hands).

Action we could take: work with partners and local land managers and other businesses, and spatial planners, to **agree and establish appropriate buffer zones around reserves**. Agree and implement water use and other agricultural and industrial controls.

- Resources: major.
- Time: medium term action; short delay to effect.
- Additional benefits: Regulating service: response would help manage water quality, floods and pollution.

Desired change: all National Nature Reserves are appropriately managed, with **climate change explicitly considered in objectives and management actions**, which should be reviewed and revised on a regular basis.

- Threats addressed: 1, 4, 5, 6, 7, 8, 9, 10, 11, 12.
- Natural England's ability to influence this: medium (other bodies managing NNRs would need to be involved).

Action we could take: build **climate change adaptation into NNR management plans** and encourage managers to develop and adapt to new management techniques and invest in new equipment and infrastructure to deliver it. (Peatland NNRs in particular will require a focus on hydrological control through developing new techniques, increasing the extent of sites and creating buffer zones.)

- Resources: minor.
- Time: short term action; rapid effect.
- Additional benefits: Regulating service: response would help manage floods, water quality and wildfires on a small scale. Recreational benefits.

Desired change: wildlife conservation areas in England **fulfil their important potential role in the monitoring of the effects of climate change on the environment**, in the research into management techniques to mitigate and adapt to them, the demonstration of these techniques, and to help communicate the effects of climate change to the public. Reserves should also be used to promote and develop an adaptive management approach, including testing new management approaches.

- Risks addressed: a very large number of risks listed above in both the NNR and Landscape & Biodiversity sections.
- Natural England's ability to influence this: high.

Action we could take: **Increase the use National Nature Reserves for the monitoring, research** and public engagement roles listed above.

- Resources: minor.
- Time: rapid action; short delay to effect.
- Side-benefits: Recreational, cultural and scientific services.

Desired change: wildlife conservation areas in England are used to help **communicate the specific local effects of climate change to the public**.

- Risks addressed: raised awareness for the need to address a range of risks, particularly the indirect 'societal adaptation' risks.
- Natural England's ability to influence this: high.

Action we could take: Maximise the profile of NNRs as areas that **showcase and highlight some of the effects of climate change** and possible responses that can benefit both wildlife and people. Provide additional information to the public.

- Resources: minor.
- Time: rapid action; short delay to effect.
- Additional benefits: recreational, cultural and scientific services.

People and Partnerships and Statutory Access Team

We work with others to increase the opportunities for people to access and engage with the natural environment. This includes inspiring 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; showing the benefits of people using 'nature's health service' and helping improve the quantity and quality of greenspace.

Our objectives include delivery of statutory access duties to open access land that maximise the amount of land available for public access, ensuring the least restrictive principle underpins all casework, including the restriction regime with respect to open access land; facilitation and advice on new Coastal Access rights and work to extend the National Trail network and development of a new more sustainable management model.

We also influence the planning and design of new national, strategic and local initiatives to support access to and experience of the natural environment for as many and diverse a range of people as possible.

Threats

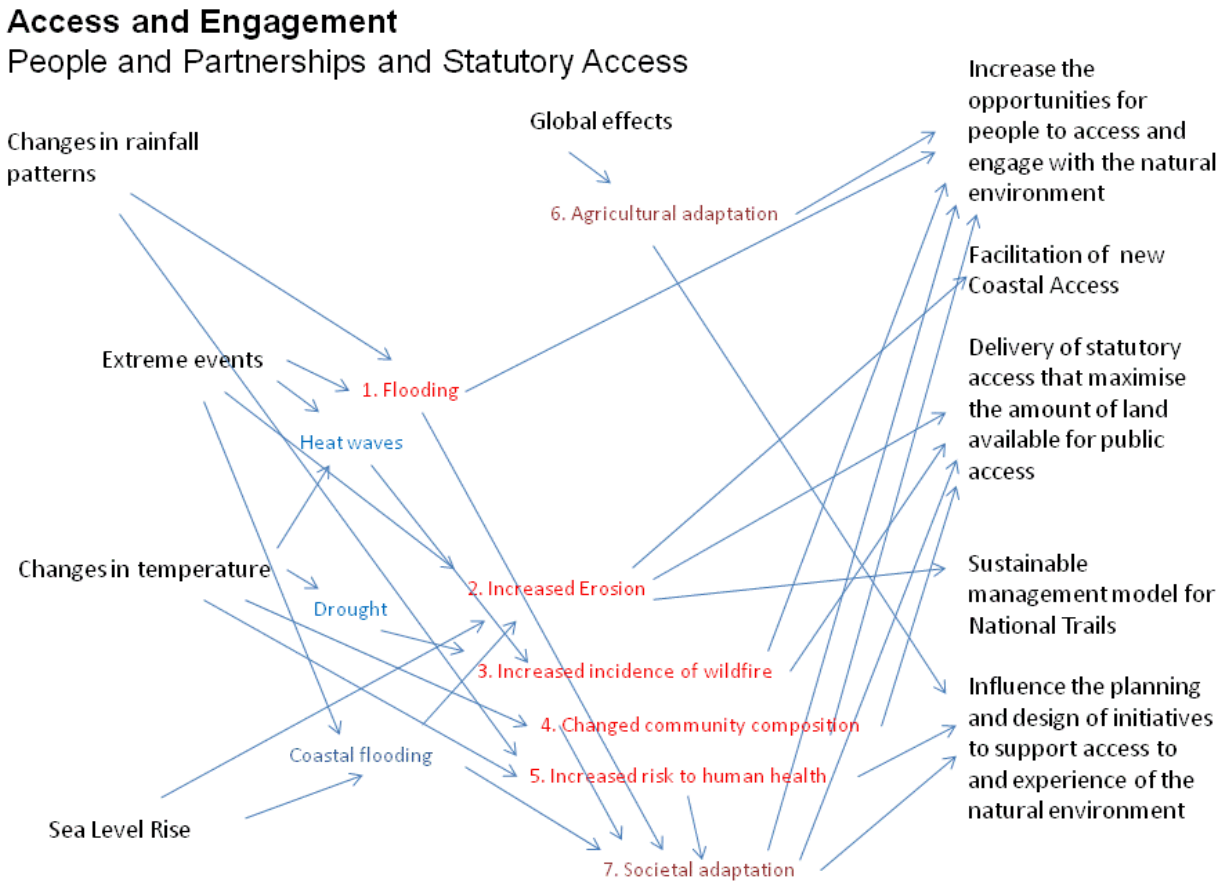

Figure C Threat Analysis - Access and Engagement: People and Partnerships and Statutory Access

Table Q Matrix showing the priority of the different threats to the People and Partnerships and Statutory Access Team objectives, according to their importance and proximity

		Proximity				
		Now	**Short**	**Medium**	**Long**	**Very Long**
Importance	**Severe**					
	Major		2			
	Moderate		1,3	(7)		
	Minor			4,5,(6)		
	Negligible					

(red = high; orange = medium; green = low). Indirect threats are indicated in brackets.

High priority threats

2) Increased Erosion:

- Extreme events and changed rainfall patterns leading to increased erosion of National Trails and NNRs, open access and other access routes (Prosser *et al*. 2010, SNH, 2011).
- Increased numbers of people in some areas as they become more popular due to warmer summers, and/or closure of other sites due to adverse weather and flooding (McEvoy, D et al 2006).
- Storm events in combination with higher tides will re-shape the coast including increasing coastal erosion and changing deposition patterns (MCCIP 2010). Flooding, erosion or managed coastal realignment result in increased maintenance costs of repairs and realignments necessary for affected routes and reduced ability to provide opportunities for people to engage with and value the natural environment if there are insufficient resources to maintain access to an appropriate standard.

Medium priority threats

1) Increase in flooding:

- Localised flooding and associated increases in flood defences could reduce the availability of local greenspace and routes, and negative impact on the coherence of local rights of way networks. More greenspaces and access routes could be unavailable for longer periods of the year, restricting people's access (SNH, 2011, Gill. S, 2007).
- Networks and routes using increasingly flooded areas could be severed, damaged by flooding or less well maintained.
- Increase in area required for floodwater absorption.
- A reduced ability to provide opportunities for people to engage with and value the natural environment. Increased maintenance costs for greenspaces, routes and certain NNRs.
- Increase in visitor numbers and pressures on alternative sites during flood season.

3) Increased incidence of wildfires:

- Drought events increase the risk of wildfire on areas of statutory open access land, resulting in prolonged closure of areas of open country to the public (McMorrow, J et al, 2009). This leads to a reduced ability to provide opportunities for people to engage with and value the natural environment and requires more staff time spent on administering temporary restrictions.

4) Changes to community composition (affecting 'open access' status of land):

- Changes to composition of vegetation (see landscape & biodiversity threat 11) could mean that areas currently classified as open access might no longer meet the criteria, or vice versa. Natural England also has statutory duty to remap areas of open country, and changes to the landscape that were not noted could result in these maps being inaccurate.

5) Increased risk to human health:

- Significant increases in heat related mortality and morbidity (DoH and HPA, 2008), changing biodiversity – impacting on pathecenosis – increasing infectious disease risk. Summer air quality will be degraded by ground level ozone and VOCs aggravating respiratory conditions (DoH and HPA, 2008); extreme rainfall events are likely to increase the chemical and pathogen load of water courses and farmland exposure to pathogens. These risks would be exacerbated by going outdoors and into the natural environment. In these circumstances, people may be discouraged from going outdoors to avoid increased UV exposure, heat effects and diseases.
- Changing patterns of vector borne disease (Kuhn et al. 2005, Costello et al. 2009) which could also discourage people from visiting the natural environment (for example, malaria near wetlands).

6) Agricultural adaptation:

- Changes to agricultural systems and practices as farmers adapt to climate change (Foresight 2010, 2011). Leading to a reduced ability to provide opportunities for Educational Access visits, meaning fewer people are able to engage with and value the natural environment within an agricultural context. A reduced interest from farmers and landowners in providing new permissive or permanent access.

7) Societal Adaptation:

- Changes to climate in different parts of the country result in an increased appeal of certain areas of the country at certain times of the year (Coombes & Jones 2010) (Swanwick, C. 2009), posing a threat of overcrowding, potential disturbance to wildlife (for example, ground nesting birds) and damage to habitats and access routes.
- Hotter, drier summers may put increased pressure on certain areas which are already very popular in the summer (for example, the Cornish coast or the Lake District). Alternatively, the appeal of some currently popular areas may be reduced due to changes in landscape character or weather conditions, putting increasing pressure on other areas around the country which currently have limited access opportunities (Coombes & Jones 2010).
- A reduced ability to inspire people to use and value the natural environment as climate change alters landscape character and therefore what people perceive to be the 'special qualities' of those places, potentially resulting in negative perceptions of the landscape change (Swanwick, C. 2009). People demanding that change is resisted and slowing process of adaptive management.
- There is a risk that our current evidence on patterns of recreation in the natural environment will not 'keep pace' with changes to the environment and how people engage with it.

Opportunities

Table R Matrix showing the different opportunities to the People and Partnerships and Statutory Access Team objectives, according to their importance and proximity

		Proximity				
		Now	**Short**	**Medium**	**Long**	**Very Long**
Importance	**Major**	c	b			
	Moderate		a			
	Minor					

(purple = high; blue = medium; yellow = low). Indirect opportunities are indicated in brackets.

High priority opportunities

a) Opportunities for new recreational land (Medium):

- Increasing areas of land could be allocated for flood attenuation, with greater use of sustainable urban drainage systems (Gill. S et al. 2007). This land could be available for informal greenspace and access so Access to Natural Greenspace Standards (ANGSt) would be more likely to be achieved.

c) Opportunities to provide increased tourism and recreation opportunities (medium):

- Warmer drier summers, and changes to habitats and landscapes will result in an increased appeal of certain areas of the country at certain times of the year (Coombes & Jones 2010) (Swanwick, C. 2009). This will encourage more people to visit and use the outdoors and more people to holiday in England as opposed to abroad providing greater opportunities to increase the number of people inspired to engage with and take action for the natural environment.
- Opportunities to promote health benefits of taking part in outdoor recreation activities. Opportunity (though also a cost) to improve access infrastructure in places more frequently visited as a result of climate change, but wider leisure and tourism economic benefits to the local economy of these more popular locations.

b) Greater awareness of and engagement with the natural environment (low):

- Increasing global and local impacts of climate change could lead to greater recognition of the ability of the natural world to deliver benefits to society could support Govt's and NE's objectives to foster greater engagement with nature, more community involvement and increased use of greenspace with associated human health and wellbeing benefits (Natural England, 2011).
- Increased awareness and interest in the natural environment and in climate change impacts as a local, tangible issue leading to an increased demand and opportunity for community involvement to take action to protect and enhance the natural environment (for example, 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).
- Easier to engage people with the natural environment and to take action, easier to recruit volunteers and increased demand for volunteering opportunities, though this would demand more staff time to administer.
- Increasing opportunities to inspire people to use, value and conserve the natural environment by increasing the opportunities for new audiences to encounter nature and support National Nature Reserves, Local Sites, National Trails etc.

Areas of uncertainty

In the past, Natural England has highlighted a lack of data on human responses to climate change, however NE commissioned new ongoing research on attitudes as an addition to the Monitoring Engagement in the Natural Environment research programme (Natural England (2011), MENE, Attitudes to the natural environment 2009-10) which addresses some of the evidence gaps.

The following extracts summarise some of the findings:

'*In general, the English adult population regard the state of the natural environment as being in a fair condition or better, but some believe that it has degraded over the last ten years and most expect it to deteriorate over the next 50 years. However, most people expect changes over this period to be 'slight' and most expect the environmental scenarios to be 'fairly' rather than 'extremely' likely to occur*'.

'*Respondents were presented with a list of issues related to living in England today and then asked to identify their 'single main concern', along with any other issues of concern. In terms of issues related to the natural environment, climate change was selected by 38 per cent of respondents as one of the issues that concerned them. It is notable that this was a significantly higher percentage than obtained for any of the other issues relating to the natural environment. This was similar to the proportion of the population that selected the war in Afghanistan or the economic recession. Eight per cent selected climate change as the single issue of most concern to them*'.

The results also show that, '*levels of concern for a number of environmental issues such as climate change, carbon emissions and extinction of animals and plants was higher amongst those people who had visited the natural environment in the previous seven days*'.

Our ability to address the risks

Levers

Natural England has duties and powers to publish the Countryside Code, propose and consult on National Trails, implement a new coastal walking route around England's coast and to manage any restrictions and carry our periodic reviews of the existing conclusive maps of open country and registered common land.

In most areas of our access and engagement work (other than those where we have specific statutory duties), we are shifting from direct delivery to:

- proposing strategic direction and standards, and co-ordinating and sharing the evidence base (for example, MENE) that underpins them.
- working in partnership with stakeholders at an appropriate scale - usually some form of landscape scale - to support communities and integrate access and engagement with wider environmental, social and economic interests, including the business sector.

Our Strategic Standards will set out the principles of what our role is in engagement and access, and what it means. The gathering, collation and sharing of evidence and the development of proposed standards based on that evidence, will be important parts of our future delivery model. Priorities in this area are likely to include:

- monitoring the state of access facilities (including routes and spaces).
- monitoring their use by people (through a long-term commitment to MENE).
- demonstrating their economic value.
- collating and sharing good practice from around the country.

Production of advice with NE's Land Use Function on the climate change adaptation potential of multi-functional green and blue space is an important lever in promoting and encouraging use of green infrastructure and ecosystems approach to climate change.

The Access and Engagement function also leads for Natural England on the principles of working with local communities and civil society organisations. Providing advice and guidance, standards and good practice on the ways to engage communities, we also facilitate, support and encourage civil society partnerships. We increase opportunities for local community engagement to empower communities to make informed decisions and take practical action to deliver multiple benefits for people and nature.

Barriers

- Staff time and resource, including availability of staff with sufficient knowledge and expertise.
- It may be difficult to get buy in from partners including communities and land owners for measures to combat climate change threats, which many perceive are a long time in the future or not their responsibility.
- The difficulty in predicting attitudes, behaviour and human responses to climate change, either individually or collectively, and the comparative lack of current evidence to help make these predictions.

Our partners and stakeholders

We are working with partners and stakeholders - including NGOs, Defra and other bodies within the Defra network - to help develop a shared strategy and common language for engaging people with the natural environment, based on the concept of benefits to society from ecosystem services.

We work in partnership at an appropriate scale to engage communities and integrate access and engagement with wider environmental, social and economic interests. Natural England is committed to enabling and facilitating communities (of both locality and interest) to identify and meet their own priorities for safeguarding and improving access opportunities and the natural environment in their locality.

Delivery of the actions required to mitigate the threats and opportunities identified requires the coordinated action of Natural England's functions and a wide range of external organisations. Key stakeholders, such as communities, NGOs, farmers and developers also play a significant part in helping Natural England deliver its objectives with the challenges of climate change.

Summary of key responses to priority risks and opportunities

Desired change: operation of the **Coastal Access Scheme** (including identification of route, spreading room, alternative routes and 'roll back') **fully considers possible future sea level rise and coastal change** scenarios and plans for these at early stage in the implementation of each stretch.

- Risks addressed: 1, 2.
- Natural England's ability to influence this: medium.

Action we can take: We should work closely with local and national experts to **plan the delivery of the Coastal Access Scheme with climate change in mind**, and to engage with human communities at the coast to share information on the implications of climate change for their locality. The scheme is already designed to allow 'roll back' due to coastal erosion, but it might be necessary to identify further 'spreading room' if appropriate (for example, if managed realignment of coastlines is required to meet other objectives), or to identify alternative routes at the outset.

- Resources: Moderate.
- Time: short term action; short delay to effect.

Desired change: a system is in place to **restrict access by people, when necessary, to areas at high risk of wildfire**.

- Risks addressed: 3.
- Natural England's ability to influence this: medium.

Action we could take: The increased likelihood of wildfires on areas of open country should continue to be **managed through the restrictions process**, though as this was planned to be activated only in exceptional circumstances, it will need reassessing and the fire restrictions legislation placed on open access land and associated are likely to need to be reviewed. We will need to share our understanding of the effects of climate change with upland land managers, communities and interest groups.

- Resources: Minor.
- Time: short term action; immediate effect.

Desired change: maps of **open access land remain up to date and take into account changes** in vegetation cover as a result of climate change.

- Risks addressed: 4.
- Natural England's ability to influence this: high.

Action we could take: Ensure that any **review of maps of areas of open country takes changes in vegetation into consideration** in the revised methods. A robust evidence base will be needed of the effects of climate change on designated access land, and of the patterns in how people use the natural environment.

- Resources: Moderate.
- Time: short term action; medium delay to effect.

Desired change: An **improved evidence base** containing detailed information from across the country on changes to visitor patterns, number and timing of visits to different sites and areas, and attitudes to the natural environment. Appropriate monitoring mechanisms should also be in place to capture total or seasonal losses or gains in local greenspace, access routes and infrastructure (for example, from flooding).

- Risks addressed: 7, c.
- Natural England's ability to influence this: medium.

Action we could take: **develop and strengthen our collection and analysis of evidence** as above. Work with partners to ensure that we understand changing management costs and the impacts that changing patterns of visits to the natural environment have on local economies that are reliant on particular types of outdoor tourism and leisure. In the longer term, we might need to develop evidence on the real or perceived health barriers to people enjoying the natural environment under the changed conditions that are projected.

- Resources: Moderate.
- Time: medium term action; short delay to effect.

Desired change: Local communities, decision-makers, land managers, and developers have **access to information about the full range of benefits to human health and wellbeing that can be provided by the natural environment and outdoor recreation**; encouraging greater use of 'green infrastructure' and resultant cost-effective benefits to society.

- Risks addressed: a, b, c, 7, [threats in other functions, for example, land use].
- Natural England's ability to influence this: medium (other organisations also have a role in providing and communicating information).

Action we could take: We can work with partners to **develop consistent, locally-specific advice and examples of good practice**, highlighting the benefits of planning for multifunctional green infrastructure and the role of the environment in providing benefits to society.

- Resources: Moderate.
- Time: medium term action; short delay to effect.

Desired change: Increased interest in and appreciation of the natural environment and **awareness of the role nature-based solutions** have in adapting to climate change. Greater number of tangible and accessible opportunities to take action.

- Risks addressed: b.
- Natural England's ability to influence this: high.

Action we could take: provide **increased opportunities for people to experience and engage with the natural environment**, and to make a practical contribution to conservation. This could be done, for example, through providing increased volunteering opportunities and other activities on National Nature Reserves and other areas such as National Trails, Country Parks, Local Nature Reserves and other green spaces. In many cases this would need to be done with partner organisations.

- Resources: Minor (in addition to work in this area that is already being done).
- Time: short term action; short delay to effect.

Land Management

The Land Management function provides the ownership, accountability and expertise within Natural England for the delivery of sustainable land management. This is delivered through the targeted delivery of incentive payments to land managers to secure integrated environmental objectives and the provision of advice, directly and through others, to land managers and other bodies in support of their delivery of integrated environmental objectives.

Functional objectives threatened by climate change include targets for; the uptake of incentive schemes; the area of priority habitat within schemes and the contribution that schemes make to protected site management and to wider environmental benefits to biodiversity, landscape and the historic environment; how schemes are monitored and; ensuring that schemes, and advice work to improve resource protection and water quality.

Threats

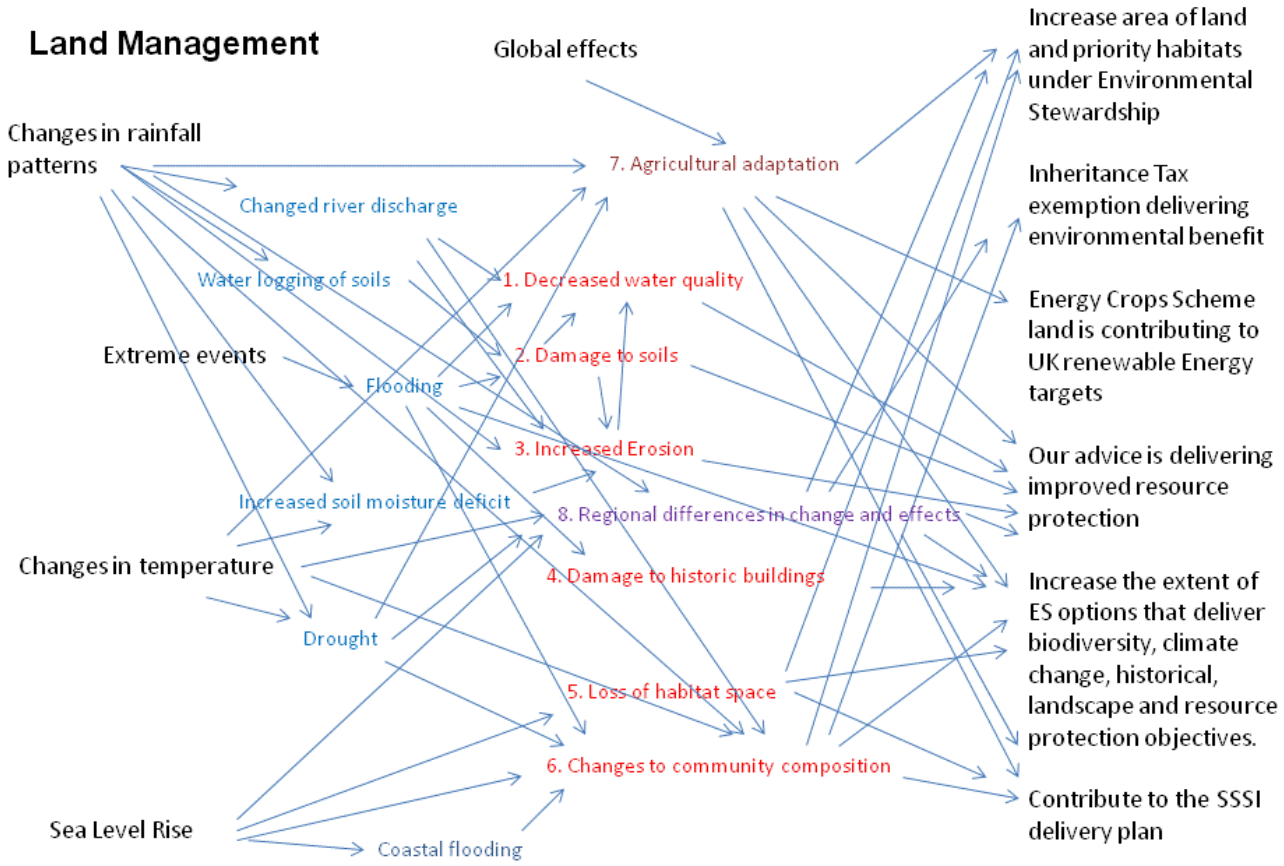

Figure D Threat Analysis - Land Management

Table S Matrix showing the priority of the different threats to Land Management, according to their importance and proximity

		Proximity				
		Now	**Short**	**Medium**	**Long**	**Very Long**
Importance	**Severe**					
	Major		6,(7)	5		
	Moderate	3		8		
	Minor	1,2	4			
	Negligible					

(red = high; orange = medium; green = low). Indirect threats are indicated in brackets.

High priority threats

3) Increased erosion (Medium):

- Increased coastal and riverine erosion (Prosser *et al*. 2010).
- Drier soils at increasing risk of erosion by wind.
- Peat soils vulnerable to increased drying (Bain *et al*. 2011, Fenner & Freeman 2011).
- Increased susceptibility to run-off.

6) Changes to community composition (Medium):

- Seawater intrusion to freshwater coastal priority habitats.
- Incremental change to the presence and abundance of key species in response to changes in temperature and rainfall (Morecroft *et al*. 2009; Bain *et al*. 2011).

Scheme advice and targets become irrelevant and out of date.

7) Agricultural adaptation (High) (Foresight 2010, 2011):

- Changing farming practices in response to climatic changes leading to decreased water water quality (Dunn & Brown 2010).
- Increasing area under production/intensity of production.
- Increased competition on land management - due to loss of productive capacity overseas or lower productivity potential of UK soils.

Scheme uptake, priority habitat, resource protection and wider contribution to environmental outcomes increasingly difficult to meet.

Medium priority threats

1) Decreased water quality (Medium):

- Increased likelihood of erosion and diffuse pollution due to heavy rainfall events, and/or increased soil moisture deficit severe drying, drought (Charlton *et al*. 2010).
- Intensification of agriculture leading to increased diffuse and acute pollution (Jeppesen *et al*. 2009; Dunn & Brown 2010).

Targets for resource protection and water quality increasingly hard to meet.

2) Damage to soils (Medium):

- Increased likelihood of damage to soils and water resources from waterlogging and flooding (DEFRA 2009).

Targets for resource protection increasingly hard to meet.

4) Damage to historic buildings (Medium):

- Historic building guttering and drainage unable to cope with increased rainfall intensity (English Heritage 2008).
- Coastal erosion threatening historic archaeological sites (Murphy, Thackray & Wilson (2009).

Incentive scheme objectives for historic environment increasingly hard to meet.

5) Loss of habitat space (Medium):

- Gradual loss of inter-tidal habitat due to sea level rise and increased incidence of storms (Lee 2001).
- Changed rainfall leading to reduced river flows and saline intrusion on floodplain coastal grazing marsh.

Loss of priority habitat within schemes and increasingly difficult to meet contribution to protected site objectives.

8) Regional differences in change and effects (Medium):

- Differential nature of climatic changes from one area to another, combined with differential vulnerability of environmental assets, means that our identification of priority or target areas may no longer be appropriate.

Opportunities

Table T Matrix showing the different opportunities for Land Management, according to their importance and proximity

		Proximity				
		Now	**Short**	**Medium**	**Long**	**Very Long**
Importance	**Major**	a	(c),(d)			
	Moderate	b				
	Minor					

(purple = high; blue = medium; yellow = low). Indirect opportunities are indicated in brackets.

High priority opportunities

a) Increased water stress (High):

- Increased soil moisture deficit due to increased temperatures and changed rainfall patterns resulting in loss productive capacity provide the opportunity to promote soil management, both as a carbon store and as a farming resource.
- Increased incidence of drought increasing the demand for actions that promote soil moisture retention and water storage.

b) Changes to community composition (Medium):

- Increased sea-level rise driven coastal flooding and/or saline intrusion resulting in changes to coastal habitats could provide increased opportunities to create new inter-tidal areas.

c) Alignment with mitigation (medium):

- Increased focus on protecting (Fenner & Freeman 2011) and restoring peat leading to an increased interest in the use of HLS to restore peat soils (Alonso, Weston & Gregg 2011).
- Increased focus on tree planting leading to an increased interest in use of HLS tree planting/woodland creation options (Nisbet *et al*. 2011).
- Increased demand for wood as fuel leading to a greater interest in woodland management resulting the restoration of derelict woodland (Forestry Commission 2011).
- Increased demand for biomass energy crops such as Miscanthus, short rotation coppice (SRC) SRC resulting in greater uptake of the Energy Crops Scheme.
- Increased awareness and market driven interest in mitigation through land management, leading to the need for appropriate advice for land managers on reducing emissions. Provides the opportunity to integrate mitigation advice with existing advice programmes.

d) Agricultural adaptation (High):

- Increased incidence and severity of climate change impacts resulting in greater interest in adaptation of land management, which in turn generates greater interest in use of ES to address climate change mitigation and adaptation.
- Opportunities to promote adaptation solutions that can benefit both farming and wildlife, such as planting of trees and use of temporary water bodies.

Areas of uncertainty

Areas of uncertainty in which further research and analysis are needed include:

- Uncertainties about the impact of climate change on habitats and species mean that we cannot be sure our land management programmes will provide the conditions required to support effective adaptation.
- Whilst increasing temperatures and atmospheric CO_2 concentrations may increase plant growth (both crops and wild plants), lower levels of soil water availability may limit plant growth (Met Office 2011). We shall need to understand these changes and their impact on land management to ensure that our programmes remain relevant to changing conditions and to ensure that we can continue to provide a valuable advice service to land managers.
- Existing evidence identifies how the agri-environment programmes reduce greenhouse gas emissions (Defra, 2008, Warner 2011). However, this can sometimes be associated with a loss of agricultural production (for instance where land is reverted from arable production to low input grassland). As the Foresight Report (2011) shows, food production will need to increase to feed a growing population, and this may be exacerbated if climate change makes farming more difficult in other countries from which we currently import food products. We shall need to better understand the impact of agri-environment management on production whilst developing support for protection of environmental features that underpin successful agricultural production.
- We cannot be certain now how individuals and societies will respond to future climate change and how this will impact on land management. Developments in agricultural policy and practice, forestry and energy production, both in the UK and overseas will all impact on the pressures affecting environmental land management in England.
- Peatland restoration by re-wetting drained soils protects carbon stored in the peat soil and helps provide the conditions for further carbon sequestration. However, it also leads, in the short term at least, to an increase in methane production. Whilst the evidence to date

suggests that the overall impact is in favour of peatland restoration, there are uncertainties about the significance of the methane issue. (Lindsay, 2010).

Our ability to adapt/mitigate the threats

Levers

- Our incentives programmes provide an opportunity to influence the actions of land managers over a wide area. Environmental Stewardship agreements currently cover nearly 70% of utilisable agricultural area in England. Higher Level Stewardship agreements provide scope for encouraging actions to help priority habitats adapt.
- Advice programmes such as Catchment Sensitive Farming encourage good management of soil and water resources.
- Our delivery of the Energy Crops Scheme includes an assessment of the environmental impact of energy crop production in any given location. This enables us to consider climate change adaptation when assessing these mitigation initiatives.

Barriers

- Our Environmental Land Management programmes, such as ES, are voluntary schemes: land managers are under no obligation to participate and, in the case of Entry Level Stewardship and Organic ELS, farmers are free to select the land management options to implement on their farms. This limits our ability to influence land management actions on the ground.
- Environmental Stewardship agreements operate in the short to medium term (5 years (Entry Level Stewardship) or 10 years (Higher Level Stewardship)). This is particularly significant when considering management for long term carbon sequestration or long term adaptation.
- The uncertainties in the evidence base (for example, in how species and habitats will respond to the interactions between different climatic changes), are complicating factors, but we shall need to manage this uncertainty in the development of future land management programmes.
- The first opportunity for significant changes to the agri-environment programmes is presented by the forthcoming CAP reform, but this will be subject to many drivers, of which our intention to address climate change is just one. The current economic climate makes it very unlikely that there will be increasing amounts of funding available to implement land management adaptations, yet our ES budgets are already under significant demand to address our existing environmental priorities for biodiversity, resource protection, access, landscape and the historic environment. We shall work constructively with Defra, partners and stakeholders, to make the case for land management programmes, increasingly focused on climate change adaptation and mitigation and sufficiently responsive to adapt as our understanding of the interplay between climatic changes, natural environment and land management increases.

Our partners and stakeholders

As the main lever of the function is our incentive schemes the success of our work to address climate change will depend on working with others.

As well as land managers who ultimately make the decision to join or not to join the schemes we will work with our Arms Length Body (ALB) partners, the Environment Agency (EA) and the Forestry Commission (FC) to ensure comprehensive and joined up advice on schemes and regulation. We will also work in close partnership with farming and land manager bodies such as the National Farmers Union and Country Land & Business Association to ensure the relevance of our advice to farmers and land managers. We shall also work with non-governmental organisations such as The Farming and Wildlife Advisory Group and the Wildlife Trusts to ensure that climate change adaptation measures for the natural environment are clearly understood and articulated.

In addition we will work with Defra to ensure that the schemes remain relevant and able to deliver the flexibility needed to help land owners and the natural environment adapt to climate change.

Summary of key responses to priority risks and opportunities

Desired change: **Restoration and conservation of upland and lowland peatlands**.

- Risks addressed: 2, 3, c, [L&B: 3, 4, 15, 16, 19, f].
- Natural England's ability to influence this: medium (through agri-environment schemes and working with National Parks and AONBs).

Action we could take: continue to use agri-environment programmes to **support peatland restoration**. At the same time, to protect peat soils as long term carbon stores we shall need to consider longer term management arrangements than the 10 year duration of Higher Level Scheme Environmental Stewardship agreements.

- Resources: Substantial.
- Time: short term action; medium delay to effect.
- Additional benefits: mitigation through carbon storage and sequestration; water purification and supply; flood alleviation in lowland areas; landscape.

Desired change on ground: Habitat creation and restoration to **enhance ecological networks and buffer high value sites**, to promote the 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.

- Risks addressed: 1, 7, 8, 10, 13, a, b [L&B: 7, 8, 10, 11, 12, 13],[A&E-NNR: 8, 9, 10, 11].
- Natural England's ability to influence this: high.

Action we could take: Targeting of Environmental Stewardship options that **secure appropriate management adjacent to priority sites**.

- Resources: Substantial.
- Time: medium term action, medium term delay to impact.
- Additional benefits: mitigation through carbon storage, improved landscape character.

Action we could take: Targeting of Environmental Stewardship options to **enhance ecological networks through habitat creation and restoration** in appropriate locations.

- Resources: Substantial.
- Time: medium term action, medium term delay to impact.
- Additional benefits:mitigation through carbon storage.

Desired change: protection **of soils from drying, wind erosion and loss of carbon** during projected dry conditions, and from water erosion during wet conditions. Appropriate management of water resources to avoid over-use during drought and runoff and diffuse pollution from agriculture during heavy rainfall.

- Risks addressed: 1, 2, 3, 7, 8, c, d, [L&B: 1, 3, 4, 15, 20], [Marine: 8].
- Natural England's ability to influence this: medium.

Action we could take: we need to **develop advice and incentives focused on the ecosystem services** provided by the natural environment and hence promote land management that supports both the natural environment and the environmental resources that underpin agricultural

production. For water, management and coordination will be needed across catchments, involving multiple land managers. We shall promote the value of agri-environment measures to support soil and water protection and management of ecosystem services in our advice to Defra on the development of future land management programmes.

- Resources: Moderate.
- Time: short term action; short delay to effect.
- Additional benefits: mitigation through maintenance of soil carbon; Reduced green house gas emissions from land under scheme options; improved water supply and quality.

Desired change: land management programmes such as **incentive schemes remain appropriate and relevant to local conditions**, and are informed by an understanding of both changes in the natural environment and likely agricultural responses.

- Risks addressed: 6, 7, 8, c, d, [L&B: 1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 20, a, b, d, f, g].
- Natural England's ability to influence this: high.

Action we could take: We shall ensure that future reviews of our land management **programmes are informed by an understanding of environmental change** and agricultural responses. As part of this, we need to improve our knowledge and understanding of the varying vulnerabilities of different areas and natural resources to climate change, and different pressures and opportunities that are present in different places, to ensure that we can focus our interventions most effectively.

- Resources: Minor.
- Time: short term action; rapid effect.
- Additional benefits: Reduced green house gas emissions from land under scheme options.

Action we could take: We will need to work with others to understand **farmers' information and support needs as they seek to adapt their businesses** to changing climatic conditions.

- Resources: Minor.
- Time: short term action; short delay for effect.
- Additional benefits: Greater uptake of appropriate scheme options; reduced green house gas emissions; mitigation through increases in soil carbon.

Desired change: Flood risk management **actions taken across catchments where flood risk is anticipated to increase**, including using soils and river floodplains to store floodwater and increase infiltration into groundwater.

- Risks addressed: 1, 2, 4, 7, a, d, [L&B: 1, 3, 4, 5, 16, 20, d, e],[Marine: 8].
- Natural England's ability to influence this: low.

Action we could take: We can increase the use of agri-environment targeting in **promoting coordinated action across vulnerable catchments and coastal zones**.

- Resources: Substantial.
- Time: short term action; medium delay to effect.

Desired change: **increased woodland and tree cover** in agricultural areas, in order to protect and expand woodland ecosystems and species they support and as a means for protecting soils and water in targeted locations.

- Risks addressed: 1, 2, 3, c, d [L&B:1, 2, 3, 4, 7, 9, 10, 12, 19, f].
- Natural England's ability to influence this: low (Forestry Commission has the major responsibility; also need to work with land managers and Defra).

Action we could take: Promote use of Environmental Stewardship **woodland creation and tree planting options**.

- Resources: Minor.
- Time: short term action; medium delay to effect.
- Additional benefits: mitigation through sequestration and storage of carbon in soils and vegetation and substitution of timber for GHG-intensive building materials or fossil fuels; water quality; alleviation of erosion and flooding.

Action we could take: Consider **alignment and integration of Environmental Stewardship and England Woodland Grant Scheme** in future Rural Development Programme for England. We need to ensure that our land management programmes contribute to wider initiatives such as those led by the Forestry Commission, to help implement these responses and hence to address threats to woodland habitats and to soil protection.

- Resources: Substantial.
- Time: short term action; medium delay to effect.
- Additional benefits: mitigation through sequestration and storage of carbon in soils and vegetation and substitution of timber for GHG-intensive building materials or fossil fuels; water quality; alleviation of erosion and flooding.

Land Use

The Land Use Function leads on the delivery of Natural England's work with the planning system.

We advise on the sustainable use of land and water to support communities and local government in their planning decisions to protect and enhance local environments. We also aim to secure new priority habitat and green infrastructure which deliver ecosystem services for both people and wildlife.

Threats

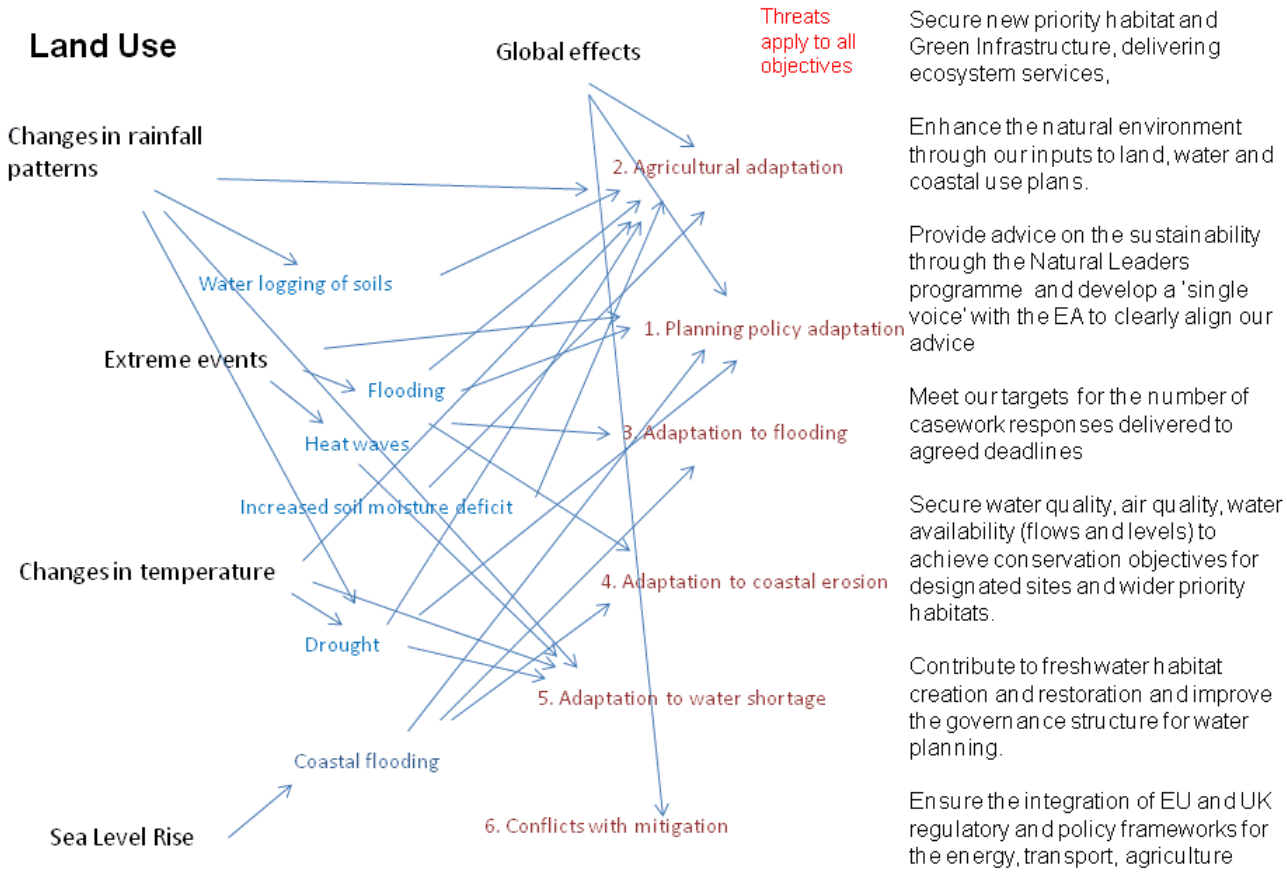

Figure E Threat Analysis - Land Use

Table U Matrix showing the priority of the different threats to Land Use, according to their importance and proximity

		Proximity				
		Now	**Short**	**Medium**	**Long**	**Very Long**
Importance	**Severe**					
	Major	(3),(6)	(2),(4),(5)			
	Moderate					
	Minor	(1)				
	Negligible					

(red = high; orange = medium; green = low). Indirect threats are indicated in brackets.

High priority threats

2) Agricultural adaptation (Medium):

- Land use change in response to climate-related issues, food security concerns, increased water supply from reservoirs and expanding markets for biofuels) (Foresight 2010, 2011).
- Changes to cropping patterns requiring increased abstraction (Environment Agency 2010, 2011).
- The potential for 'pollution swapping' (Stevens & Quinton 2008) in agricultural practices lead to air pollution effects on designated sites and BAP habitats.
- Unsustainable use of land (incl soil) and water lead to adverse effects on designated sites and BAP habitats.
- Reduced ability to successfully influence land and water use plans to achieve SSSI objectives, secure BAP habitat creation, benefits for BAP species, green infrastructure, new access, soil protection and landscape character benefits.

3) Adaptation to flooding (High):

- Greater demand for hard engineered solutions to flooding (Harries & Penning-Rowsell, 2011).
- Increasing number of applications with environmentally unsustainable climate change measures, such as major 'hard' flood defence schemes in response to riverine and coastal flooding and erosion.
- Demand for bigger engineered solutions in response to greater risk of coastal and flooding.

4) Adaptation to coastal erosion (High):

- On coastal soft cliffs, more demand for coast protection due to greater risk of coastal flooding landslips. Engineered solutions given more prominence, potential loss of sediment sources, decline in relations with LAs/communities threatened by change (Hosking & McInnes 2002).
- Hard defences seen as solution rather than working with natural coastal processes and making use of risk reduction from sedimentary systems. NE has less influence on securing sustainable coastal/estuary form (Foresight 2004, DCLG 2010).
- Coastal changes resisted at all levels of society, from individual to political, poor understanding of benefits of enabling change to build resilience. Limited adaptation responses available, Shoreline Management Plan policies disregarded (Jones 2011).

5) Adaptation to water shortage (Medium):

- 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 (Defra 2011).

6) Conflicts with mitigation (High):

- Impacts of some renewable energy initiatives on natural systems and biodiversity, for example, tidal barrages, wind turbines on peat or hydro-electric dams (Drewitt & Langston 2006).
- An increase in climate and energy-related casework overwhelming our capacity to provide specific advice on each case.
- Increasing applications for wind/hydro/biomass plants.
- Local Authorities focus solely on climate mitigation and management of climate hazards, to the detriment of other environmental concerns.
- Drive to reduce carbon reduces our opportunities to influence development design. Policies/schemes implemented that that tackle climate change but damage air quality (and

vice versa), for example, gas fired combined heat and power plants and biomass plants in the wrong places/large scale uptake (reduced CO_2 emissions but increased NOx and particulate emissions) lead to air pollution effects on designated sites and BAP habitats.

Medium priority threats

1) Planning policy responses (Medium):

- Changes in forward planning practice which prioritise certain geographical areas for development, for example a focus on areas of low flood risk. This constrains our ability to deliver environmental benefits to more limited geographical areas.
- Short-term solutions to immediate and locally specific land use issues.
- Multiple pressures of climate change lead to separate policy frameworks for environmental impacts leading to trade-offs. Conflicting policies reduce our ability to provide holistic and integrated responses at the individual scheme/plan level.
- Change in focus of planning system to prioritise climate change without a consistent approach to climate change adaptation and mitigation. Natural England loses influence with Spatial Planners. Risk of disassociation between climate change and eco-system services. Reduced ability to meet objectives to encourage use that protects and enhances the value of the natural environment in a strategic way.

Opportunities

Table V Matrix showing the different opportunities for Sustainable Land Use, according to their importance and proximity

		Proximity				
		Now	**Short**	**Medium**	**Long**	**Very Long**
Importance	**Major**	(a),(b)				
	Moderate					
	Minor					

(purple = high; blue = medium; yellow = low). Indirect opportunities are indicated in brackets.

High priority opportunities

a) Societal adaptation - opportunities for more 'green infrastructure' (High):

- Increased incidence and severity of climate change impacts, locally and globally leading to:
  - 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 (Gill *et al*. 2007, Natural England 2009a).
  - Increasing focus on natural solutions and eco-system services to deliver socio-economic benefits. Greater focus on ecosystem service delivery should also provide a more holistic and joined up approach rather than the environment being treated as a series of separate silos (Natural England 2009a).
  - The incorporation of natural features of adaptive value into new built development, including built structures themselves (for example, urban green spaces and green roofs which reduce flood risk, and wooded areas which provide local direct cooling) (Natural England 2009b). Development which is adapted or resilient to climate change from the start - fewer implications for natural resources, for example, water.
  - NE engaging with more applications and casework with a climate change offers opportunities for better habitat networks and to link new habitat creation schemes with those for statutory habitat replacement in response to coastal sea level rise.

- Innovative community-led development responding to local climate change impacts facilitated through the planning system reforms.

- Climate change creates a strong impetus for the delivery of multi-functional green infrastructure (Natural England 2009b) to counter:
  - the effects of flooding, for example, providing multi-functional flood storage areas, green spaces that slow the flow of flood waters.
  - the effects of heat waves and heat island impacts, for example, shade and cooling provided by green spaces and green travel corridors (Gill *et al*. 2007).
  - the effects of drought, for example, retaining water in wetlands and drought tolerant planting and management practices.

- Better adapted and resilient Green Infrastructure providing ecosystem services (Natural England 2009b).
- Increased opportunities to engage with local planning authorities and developers to advise on the design of proposed development at an earlier stage, resulting in a better set of economic, social and environmental outcomes.
- Increasing focus on multi-modal transport solutions that incorporate 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 (for example, Tameside Metropolitan Borough 2010).

b) Alignment with Mitigation (Low):

- Increase in the number of, and size of renewable energy generation projects providing opportunities to influence design and location through engagement with industry.
- Concerns about action on climate change mitigation combined with food, biofuel and water security and focuses attention on soils as a component of the natural environment leading to greater focus on soil in the planning process.

Areas of uncertainty

Due to the nature of the indirect threats and opportunities identified in the land use climate change risk assessment, ie they are behavioural and policy responses, there are areas of uncertainty beyond those associated with the uncertainty associated with the climate change projections. These include the following:

- Assumed changes in the focus of the planning system on climate change either in geographical location or increased focus on mitigation measures have low confidence levels due to a lack of current evidence that Local Authorities are becoming overly focused on climate change and is also strongly reliant on local forward planning decisions. Therefore implications likely to be highly variable depending on risk and location.
- There is uncertainty about the policy context, resource issues and infrastructure regarding the future changes in agricultural and energy practices that would affect sustainable land use. These are particularly around water supply and cropping capability.
- The expected increase in the number of applications with environmentally unsustainable climate change measures are likely to range from very small-scale and local, to large-scale and significant, so there are uncertainties about the locations and scale of these applications.
- The opportunities highlighted on the potential increase in innovative and environmentally beneficial development depends hugely on uptake of community-led development proposals.

There are a number of areas where further work could increase our understanding of the dynamics between indirect climate change impacts and sustainable land use. These include:

- Development of systems-based approaches that can improve understanding of the multitude of interactions within the natural environment, and their links to the human environment.
- Development of better assessments of medium to long term climate change impacts on ecosystem function (for example soil functions and effects of CO_2).
- Although pollution swapping is widely understood it has received relatively little research attention and receives little consideration in agri-environmental policy.
- The planning system in England is undergoing a major re-structuring with the proposed National Planning Policy Framework and supporting legislation with its emphasis on local plans, which is not due to be presented to Parliament until December 2011. Until the proposals and any supporting guidance have been published, it is uncertain how this might impact on Natural England's role in the planning system. Guidelines to assist what is a step-change in the way planning works in England will be needed and Natural England should be proactive in seeking to influence such guidance which is likely to be produced by others.

Our ability to address the risks

Below are some levers for and barriers to our ability to deliver the suggested on the ground responses listed above to the threats and opportunities highlighted by the land use climate change risk assessment.

Levers

- Natural England is a statutory consultee in the spatial planning process. Natural England's views carry significant weight if presented appropriately. The use of advice and guidance around climate change adaptation is likely to be high, so it will be important that this contains the latest thinking on climate change adaptation.
- Production of climate change training products for local planning authorities and developers on climate change adaptation and the role of multi-functional green and blue space is an important lever in promoting and encouraging use of green infrastructure and ecosystems approach to climate change.
- The Natural Leaders programme and partnerships Natural England continue to be part of, such as coastal groups, provide significant communication opportunities with our partners.

Barriers

- The uncertainty on the new planning system and Natural England's role within it needs to be clarified, before we can seek to identify how best to engage with customers of the system. This is also limiting our ability to develop joint approaches with other agencies including the Environment Agency and Forestry Commission.
- Commenting on large scale proposals and providing greater levels of up-front advice, particularly at the coast requires a range of expertise and skills, which may cause resource implications for Natural England. Better skilled, more efficient and confident advisers will to some extent reduce these pressures.
- The perceived cost of multi-functional green space as a climate change adaptation tool by some developers can be a major barrier to the enhancement of some schemes. Better communication of the existing evidence of the benefits of green infrastructure supported by case studies is an important tool to overcome these concerns.

Our partners and stakeholders

The delivery of sustainable land use actions to address climate change adaptation will require close working with our partners in order to maximise benefits and ensure success.

Local Authorities will be key partners for Natural England in delivering climate change adaptation through the planning system and the delivery of green and blue infrastructure that provides vital ecosystem services to society. Our Natural Leaders programme will ensure a joined up and comprehensive approach to partnership working with Local Authorities.

We will work closely with our Arms Length Body (ALB) partners, the Environment Agency (EA) and the Forestry Commission (FC) and to ensure comprehensive and joined up advice on planning issues and regulation, especially around spatial planning and water and coastal issues. Our 'Single Voice' approach will provide greater clarity on ALB responses on land use planning to Local Authorities.

We will also work in close partnership with Protected Landscapes and NGOs on sustainable land use climate change adaptation issues to ensure that climate change adaptation measures for the natural environment are clearly understood and articulated.

In addition we will work with Defra to ensure our work on climate change adaptation remains relevant and able to deliver the flexibility needed to help the natural environment adapt to climate change. This is particularly important at the coast.

Summary of key responses to priority risks and opportunities

Desired change: Land use planners and developers, and local communities, have information - based on the **best available evidence - on how to create 'green infrastructure' most effectively in different places and situations** that can contribute both to ecological networks and the conservation of biodiversity and ecosystems, and to increasing human health, prosperity and well-being, including providing adaptation benefits to human society and helping to mitigate climate change.

- Risks addressed: 3, 4, 5, a, b.
- Natural England's ability to influence this: medium-high.
- Additional benefits:
  - Well designed green infrastructure can deliver multiple benefits including 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 also can store carbon and/or emit fewer greenhouse gases.

Action we could take: Develop a **strong evidence base and use it to develop advice and best-practice examples** for the public and industry. This advice should be tailored as far as possible to local circumstances.

- Resources: Moderate.
- Time: rapid action; rapid effect.

Action we could take: **Include climate change as part of the training and resources for our advisers**, to help them identify opportunities for action that would have adaptation benefits.

- Resources: Moderate.
- Time: rapid action; immediate effect.

Action we could take: **Build effective partnerships** with industry through a shared understanding of the way in which the natural environment underpins our economy. Some sectors will be particularly important to work with. An example is our already increasing work with the water industry to secure water supplies that are of a higher quality and quantity.

- Resources: Substantial.
- Time: short term action; medium delay to effect.
- Additional benefits: Renewable energy applications directed to the most environmentally appropriate areas.

Action we could take: Produce **training materials for planners on climate change** adaptation and eco-system services benefits. This could be done in collaboration with the Royal Town Planning Institute.

- Resources: Moderate.
- Time: rapid action; immediate effect.

Desired change: **Local Planning Authorities recognise the role that the environment contributes to their social and economic aspirations** and take this into consideration in decisions.

- Risks addressed: all.
- Natural England's ability to influence this: medium.

Action we could take: as a statutory consultee we have a role in commenting on spatial plans, and can provide information on ecosystem -based solutions to climate change adaptation (for example, rethinking the role of floodplains and coastal change) in planning policies, to **ensure Local Planning Authorities take a sustainable view of climate change adaptation**.

- Resources: Minor.
- Time: rapid action; immediate effect.

Marine

Natural England's marine function 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.

To achieve these goals the function has specific objectives covering; the substantial completion of the designation of a Marine Protected Area (MPA) network in English territorial waters and the delivery of conservation advice to enable relevant authorities to implement MPA management measures; the delivery of an integrated monitoring programme and plans are in place for baseline monitoring of Marine Conservation Zones (MCZ).

The function aims to work with the fishing industry and fisheries managers in an open and positive manner to protect and enhance the marine environment in English waters to promote sustainable use and management of the marine environment through engagement with government, industries, stakeholders and partners.

Threats

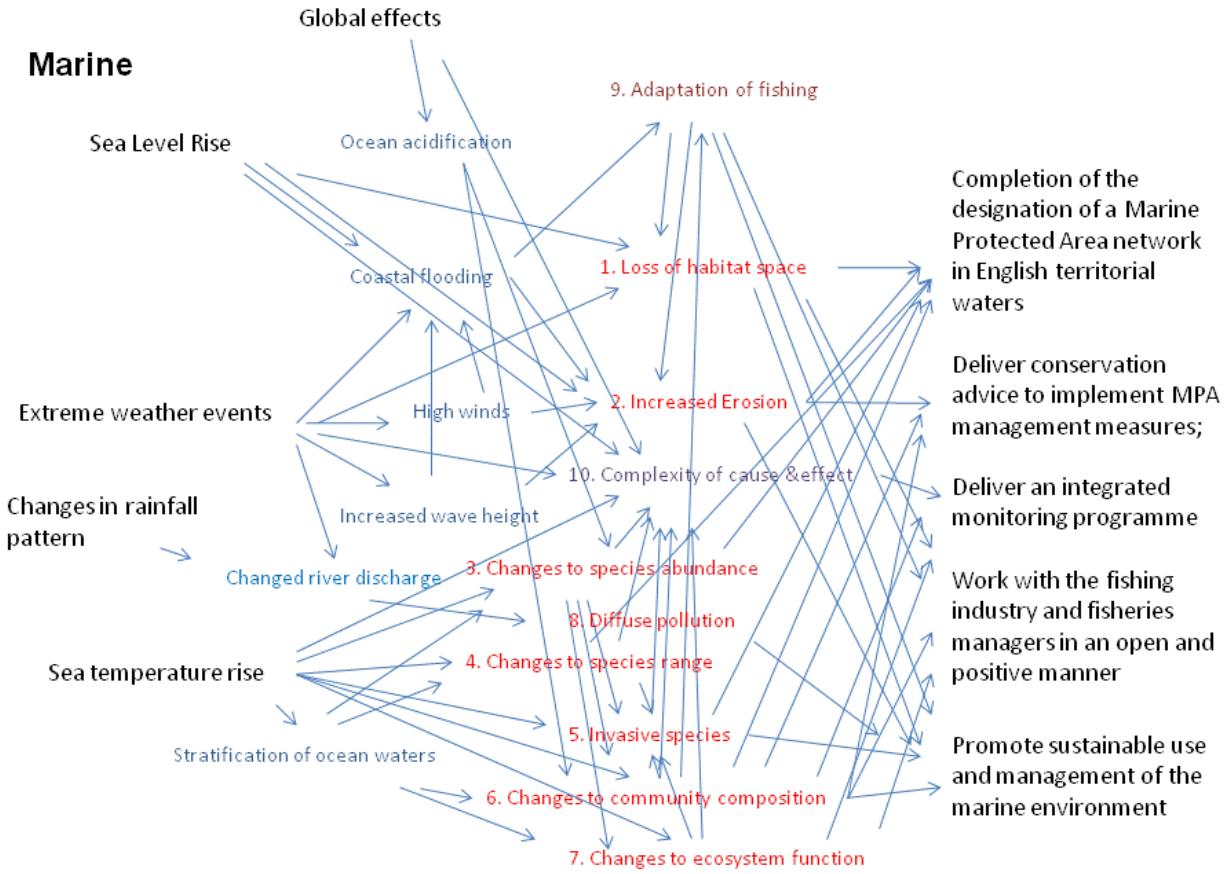

Figure F Threat Analysis - Marine

Table W Matrix showing the priority of the different threats to Marine objectives, according to their importance and proximity

		Proximity				
		Now	**Short**	**Medium**	**Long**	**Very Long**
Importance	**Severe**					
	Major		1,2,(9)	3,4,8	6	
	Moderate		5,7			
	Minor		10			
	Negligible					

(red = high; orange = medium; green = low). Indirect threats are indicated in brackets.

High priority threats

1) Loss of habitat space (Low):

- Loss and damage of coastal habitats and species (Lee 2001) and change of remaining habitat and species in location.
- Changes in type and quality of coastal habitat, damage to near shore habitats and steepening of the intertidal beach profiles. This has the potential to put pressure on some coastal wetland/terrestrial habitats that act as valuable carbon sinks (Foresight 2004).
- Northward shift of the southern limit of species ranges (Tasker *et al*. 2008).

2) Increased erosion (High):

- An increase in coastal erosion, particularly on shorelines with hard defences which are less able to respond to rising sea levels, resulting in changes in coastal habitat type and quality, damage to near shore habitats and steepening of the intertidal beach profiles (Foresight 2004, MCCIP 2010; Prosser *et al*. 2010).
- An increase in storm events, resulting in damage to habitats due to erosion and loss.
- Increased erosion of saltmarsh, especially on shorelines with hard defences, likely to lead to increased sedimentation around ports, with implications for dredging and navigation channels. Indirect effects will include changes relating to offshore renewable such as growth in wave/tidal power generation; windfarms in deeper water; greater overall sea area footprint; more cabling and more and different infrastructure. Implications and consequential management requirements of each of these changes will need to be assessed individually and in combination.

9) Adaptation by the fishing industry and coastal communities (High):

- Climate induced changes to population sizes and ranges of fish stocks altering the location of fishing activities and therefore the interaction with the natural environment.
- Flood defence implications for key urban areas likely to include demand for offshore submerged breakwaters.

Medium priority threats

3) Changes to species range (Low):

- Progressive warming of the seas, resulting in changes to designated features including changes to species extent and range (Perry *et al*. 2005, Edwards *et al*. 2008; Perry 2010).

- Deepening of species assemblages range in response to warming seas (Dulvy *et al*. 2008, MCCIP 2010) meaning they now reside outside protected areas (van Keeken *et al*. 2007).

4) Changes to species abundance (Low):

- Progressive warming of the seas, resulting in changes to designated features including changes to habitats and species extent, ranges and population densities (Perry *et al*. 2005)
- Increased abundance of fishes as the northern parts of their range, and reductions at the southern margins (Tasker *et al*. 2008).
- 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 leading to a decline in populations. (Ocean Acidification Reference User Group (2009, 2010).

5) Increased prevalence of invasive species (High):

- Warmer seas may also mean it is easier for invasive non-native species to become established, potentially having a deleterious impact on designated sites (Ruiz *et al*. 1997; 2000).

6) Changes to community composition (Low):

- Invasions of non-native species into new range areas.
- An increase in stress on species with calcium carbonate shells and internal skeletons which are susceptible to acidification of seawater, with a possible long-term impact on the well-being of species groups and composition of habitats (Ocean Acidification Reference User Group (2009, 2010).

7) Changes to ecosystem function (Medium):

- Seasonal shifts in primary and secondary productivity, leading to a loss of synchrony between predator/prey species (Thackeray *et al*. 2010).
- Invasions of non-native species into new range areas (Ruiz *et al*. 1997; 2000).
- 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 (MCCIP 2010).

8) Diffuse pollution (Low):

- Possibility for increased run off of agricultural land (Whitehead *et al*. 2009) and sewage into estuaries causing physical-chemical properties change. This causes eutrophication that alters the ecosystem within the estuary, its habitats and species. Leads to a reduced ability to maintain Marine Protected Area (MPA) objectives and threatens the sustainability of the system.
- Periods of drought followed by heavy rain events may cause the instability of vegetation around coasts and may cause instability of habitats such as cliffs and sand dunes. Drought can also cause contamination issues due to lack of mixing within estuaries.

10) Increased complexity of causal relationships (High):

- Increased challenge of distinguishing cause and effect given additional variables as consequence of climate change will drive a requirement to ensure that monitoring programmes include suitable indicator species & habitats.

Opportunities

Table X Matrix showing the different opportunities for Marine objectives according to their importance and proximity

		Proximity				
		Now	**Short**	**Medium**	**Long**	**Very Long**
Importance	**Major**			a		
	Moderate			b		
	Minor				(c)	

(purple = high; blue = medium; yellow = low). Indirect opportunities are indicated in brackets.

High priority opportunities

a) Coastal changes (Medium):

- Sea level rise causing increased coastal squeeze of protected intertidal habitats leading to an increased requirement for habitat compensation (Foresight 2004). This could result in more widespread managed realignment, linked in with more sustainable shoreline management practices that recognise and promote the ecosystem service of intertidal habitats in flood risk management.

Medium priority opportunities

b) Shifts in species range (Low):

- An increase in warm water species of interest either ecologically and/or economically in the southern waters off England, 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. Changes provide the opportunity to encourage responsible fishing practises in emerging fisheries which reduce impact on species and habitats of conservation interest.

c) Alignment with mitigation (Low):

- Possible opportunities to protect valuable 'carbon sink' areas (for example, Seagrass).

Areas of uncertainty

There are large data gaps on many aspects of the effects of climate change on the marine environment; these include:

- Understanding the implications of increased ocean acidification. It is recognised that a tipping point is reached when ocean waters change from over saturated with calcium carbonate to under-saturated. The speed of ocean acidification varies across the globe, and it is anticipated that parts of the Arctic will reach tipping point by 2018. Areas of uncertainty around acidification include a better understanding of the role of upwelling events when deeper ocean waters circulate on to continental shelves or near shore areas.
- The extent and timescale of projected sea level rise on the UK related to a better understanding of the rate and role of sea ice melt.
- Changes in salinity levels and the relationship to climate change; salinity levels in both the North Sea and North Atlantic have fluctuated in recent decades, and it is not yet understood whether there is a relationship to wider circulation patterns within the ocean, or changes in evaporation and precipitation.

- Better understanding of the role of the Atlantic Heat Conveyor which keeps the North Atlantic warmer than other oceans at similar latitudes is required and in particular how this may be impacted by global warming with increased rainfall, melting of sea ice, glaciers and the Greenland ice sheet reducing North Atlantic surface salinity which may to slow down or even stop the formation of deep water affecting thermohaline circulation.
- Understanding the impacts of climate change on inter-tidal habitats including sea-grass beds, mud flats and other soft sediment communities.
- Gaps in research to understand options for management of invasive species and possible effects on biodiversity.

Our ability to respond to the risks

A significant amount of our work on addressing climate change threats to the marine environment will need to be undertaken through close partnership working. We have a key role in providing advice to government and local authorities, and in our ongoing role in monitoring marine protection areas and other designated sites.

Levers

- Natural England together with JNCC has a statutory role to advise Defra on possible locations for Marine Conservation Zones and European Marine Sites - Special Areas of Conservation and Special Protection Areas.
- Natural England has a (non-statutory) remit to report on condition of SSSIs, MCZs and feed into FCS reporting to the EC. Natural England is involved in monitoring the MPAs and is engaged in a 6-year MPA monitoring programme linked with JNCC-led Marine Biodiversity Monitoring and Surveillance Programme.
- Natural England provides advice to public authorities on how to meet the conservation objectives of MPAs to ensure that management measures are appropriate for features to reach favourable or reference condition.
- Natural England sits on the UK Marine Monitoring and Assessment Strategy group involved in setting Marine Strategy Framework Directive targets for the UK, advising Defra throughout the target setting process.
- Natural England advises on plans and projects including aquaculture of non-native species, through the England INNS working group.
- Natural England is a statutory consultee and appointee to the IFCA and will advise on the development of byelaws and measures required to manage new fisheries in MPAs within 0-6nm and MMO out to 12nm.
- Natural England is a statutory adviser to Shoreline Management Plan groups and provides advice on applications including beach nourishment and marine aggregate dredging to ensuring that SSSI features are not damaged and coastal processes are maintained. Natural England also ensures that linkages are made between marine plans and shoreline management plans.
- Natural England is a co-funder of the Marine Climate Change Impact Partnership.

Barriers

- Understanding and ensuring good management will require resources for monitoring. However, funding for direct observations may be limited, with the focus likely to be more risk based and pressure based monitoring.
- Targets will be agreed at UK level across government departments and so may not be sufficiently specific to address local issues in English waters.
- One in one out rules relating to the introduction of new byelaws to manage new fisheries may limit the MMO's ability to put in place required measures.

- Coastal development pressures are likely to limit the opportunities for managed realignment.
- A major response to reducing climate effects on the marine environment is reduction of other (often human) pressures. However, Natural England, as an advisory body, often has limited influence on other sectors that use marine areas.

Our partners and stakeholders

Delivery of the actions required to mitigate the threats and opportunities identified requires the coordinated action of Natural England's functions and a wide range of external organisations.

Natural England's role is as an advisory body and therefore we work closely with other organisations in order to deliver the actions to mitigate climate change. A coordinated approach with JNCC, DEFRA and its agencies, such as the Marine Management Organisation and the Environment Agency, and the regional IFCAs will ensure coordinated advice and guidance.

Key stakeholders, such as NGOs, fishermen and developers also play a significant part in helping Natural England deliver its objectives with the challenges of climate change.

Summary of key responses to priority risks and opportunities

Desired change: existing **marine biodiversity is conserved to the greatest extent possible through appropriate management measures**. 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 (MPA), 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. This should include consideration of coastal and estuarine areas, and ensuring the action is taken to limit the negative effects of land use on the marine environment.

- Risks addressed: 1, 2, 3, 4, 5, 6, 7, 8, a, c.
- Natural England's ability to influence this: low (in general) to medium (MPAs and some aspects of Shoreline Management Plans).

Action we could take: **Complete the MPA network and ensure it is ecologically coherent** and ensure that the **MPA network is well-managed and addresses climate change**. This will include recommending MCZs, SACs and SPAs to Defra and advising if ecological coherence criteria are not met. Ensure that advice given to public authorities take account of climate change. Provide advice to ensure that management measures are appropriate for features to reach favourable or reference condition. Ensure integration of Water Framework Directive and MPA objectives to ensure water quality does not affect reaching favourable condition.

- Resources: Moderate.
- Time: short action; medium delay to effect.

Action we could take: **Ensure Marine Strategy Framework Directive targets will result in an overall improvement of the state of the marine environment** by encouraging site based measures which complement wider sea measures. Advise Defra throughout target setting process and work closely with the Joint Nature Conservation Council Committee and other statutory nature conservation bodies.

- Resources: Moderate.
- Time: short action; medium delay to effect.

Action we could take: **Contribute to shoreline management plans** and ensure marine plans take account of sea level rise. Provide advice on applications for beach nourishment and ensure that SSSI features are not damaged and coastal processes are maintained. Contribute to long

term strategic planning of marine aggregate dredging. Ensure linkages between marine plans and shoreline management plans.

- Resources: Moderate.
- Time: medium term action; medium delay to effect.
- Additional benefits: mitigation, through improved protection and management of coastal carbon sinks 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.

Desired change: A **stronger body of evidence on marine ecosystem processes** and how they are affected by climate change, informed by a comprehensive programme of monitoring.

- Risks addressed: most/all.
- Natural England's ability to influence this: low-medium.

Action we could take: Our **evidence and monitoring** work should include the following, in all cases working closely with the range of other organisations with an interest and specialist scientific expertise in these topics:

  - Ensure marine monitoring programmes can detect change in ecosystems and differentiate between natural and anthropogenic causes in the change.
  - Identify options for pathway management for invasive non-native species.
  - Study range shifts and monitor the emergence of new fish species.
  - Monitor possible effects of acidification.
  - Monitoring the state of our MPAs.

- Resources: Minor.
- Time: medium term action; medium delay to effect.

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