**The UK Biodiversity Research Advisory Group**

# Research priorities: climate change and adaptation

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*on behalf of the*
*Climate Change and Adaptation Research Priorities sub-group*

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# 1. Introduction

## 1.1. Background to the report

In addition to the cross-cutting themes already addressed by UK BRAG:

- Impacts of non-native species
- The role of biodiversity in ecosystem function
- Habitat and ecosystem management
- Monitoring of biodiversity and evaluation of actions
- Conservation of genetic and native species diversity
- Socio-economic issues

the need to consider climate change and adaptation has been recognised. This theme cuts across all of these other areas of work and, given the widely acknowledged scale of the threat that climate change presents for Europe's biodiversity, is of critical importance.

In addition to UK BRAG's interest in this topic, The England Biodiversity Group (EBG) project examined impact of climate change on biodiversity. For each of the five sectors within the England Biodiversity Strategy (EBS) – (1) agriculture, (2) water and wetlands, (3) woodland and forestry, (4) towns, cities and developments, (5) coasts and seas - the EBG project aimed to :

- Review and summarise the evidence for the direct impacts of climate change on biodiversity in England
- Outline the potential changes in working practices, development policies and land use that are caused by climate change and assess the opportunities and threats to biodiversity as a result of these changes
- Assess non-climate change drivers of change and their interaction with climate change
- Identify feasible adaptation strategies in terms of policy and practice
- Identify key areas of research required to fill knowledge gaps on climate change adaptation

In order to provide a clearer UK-focus, and to refine the thinking to formulate a suite of research priorities and possible delivery mechanisms, this report has been developed by a UK BRAG sub-group of experts. The membership of this sub-group is given as an appendix to this report.

## 1.2 Our current state of knowledge

The conservation of biodiversity in the UK (and, indeed, across Europe) will have a more fluid context as a result of climate change (Brooker and Young, 2006). There will be changes in community and habitat composition, and these are likely to have important, possibly unforeseen consequences for ecosystem functioning and, in turn, provision of some goods and services on which we depend.

If species are to survive under changing conditions, then landscapes will need to be suitably permeable so as to enable them to move northwards or upwards, tracking their "climate envelopes" or the movement of other species upon which they are dependent. There is a

lack of clarity over what actions we need to take in order to create such permeability, and whether these would be the same or similar for all species.

The threat of climate change is driving adaptation responses in many sectors, most notably in agriculture (e.g. the introduction of drought tolerant varieties). It is important that we understand the impacts of adaptation activities on biodiversity, and that biodiversity considerations are incorporated at the outset of any actions.

Changes in the timing of biological processes, productivity and species distribution have already been detected in marine ecosystems in response to climate change. These responses show regional variability, with complex patterns of species movement and response to climate drivers. Climate change can be expected to result in further changes in the length of the growing season, community composition and species ranges. Trophic disruption is likely as a result of changes to timing of biological processes, and may have serious impacts throughout foodchains. Coastal ecosystems are expected to change in response to increased storminess and rises in sea levels (e.g. erosion of existing coastal habitats).

# 2. Identifying research priorities

## 2.1 Sources of ideas

This report is based on a joint workshop between UK BRAG and the Climate Change workstream of the England Biodiversity Group, in support of its report by Mitchell *et al*. (2006).

In addition, the European Platform for Biodiversity Research Strategy (EPBRS) has recently identified knowledge gaps in relation to climate change at the European level (EPBRS 2005). These knowledge gaps are generic across Europe and the majority of them apply to the UK. For details, see Appendix 1.

A systematic literature review is needed to identify knowledge gaps applicable to the UK. Once knowledge gaps have been identified, there are three possible responses:

1. Monitoring, to assess how the situation is changing, or
2. Further specified research
3. Provision for knowledge transfer

## 2.2 Workshop methodology

Before the workshop, participants were asked to suggest potential projects which they saw as important to fill knowledge gaps in relation to climate change. The projects were then assessed using six criteria. The criteria asked whether the project:

1. addresses immediate obstacles to development or implementation of adaptation policy
2. is strategic research relevant to longer term policy development or guidance
3. is cross-cutting – enables significant integration with other sectors e.g. agriculture, water, energy
4. adds value to other research initiatives e.g. European projects;
5. is tractable – what is the likelihood of producing outcomes to influence policy or management, and
6. the timescale for project work

The scoring for the criteria 1-5 were (H) high, (M) medium or (L) low.

The scoring for criterion no. 6, timescale, was assessed as (U) Urgent – within the next 3 years, (M) medium – within the next 6 years, (L) Long – long term 6-10 years.

From the discussion on the day, eleven broad areas of research (research programmes) were identified as key to advancing our understanding of climate change and its impacts. These research programmes are broader than research projects and often combine several of the suggested projects together.

The eleven broad areas were:

1. Assessing the effectiveness of landscape-scale initiatives for adaptation to climate change
2. Wetland, coastal zone and marine adaptation to climate change
3. The impact of climate change on ecosystem goods and services
4. Monitoring the impacts of climate change and atmospheric pollution on biodiversity
5. Indicator Species

6. Review of conservation targets
7. Soils, Sediments and Resilience
8. Climate Change and Phenology, distribution, population dynamics, breeding success with predictive mapping
9. Planning and implementation of adaptation strategies
10. Genetic conservation
11. Atmospheric Chemistry and Pollution

# 3. A summary of the research priorities

## 3.1 Prioritised list of research programmes and projects

The following table lists the eleven thematic programmes, with their individual component projects. Each of the projects is classified according to their level of priority (based on five criteria – see section 2.2) and the urgency with which they need to be undertaken (U – urgent, within 3 years; M – medium, within 6 years; L- low, between 6-10 years).

| Research Programme | Priority | Urgency |
|---|---|---|
| Assessing the effectiveness of landscape-scale initiatives for adaptation to climate change | | |
| 1. Impact of future weather patterns on priority habitats | M | U |
| 2. Review of effectiveness of implementation of landscape-scale initiatives | H | U |
| Wetland, coastal zone and marine adaptation to climate change | | |
| 3. Investigation to identify constraints and opportunities and provide recommendations for optimisation of adaptation to climate change in coastal zones | M/H | U |
| 4. Managing the marine environment in response to climate change - identifying the options | ? | U |
| 5. The impacts of hydrological and geomorphological change due to climate upon freshwater ecology | H | U |
| 6. Managed retreat | H | U |
| 7. Assessment of the implications of ocean acidification and climate change in respect of the impact on key habitats, species and ecosystem function | M/H | U |
| 8. Understanding changes to sub-tidal marine ecosystems that are a consequence of climate change | H | U |
| The impact of climate change on ecosystem goods and services | | |
| 9. Providing evidence for sustainable policy making in an era of climate change | L/M | L |
| Monitoring the impacts of climate change and atmospheric pollution on biodiversity | | |
| 10. Targeted Monitoring of climate change and Atmospheric Pollution Impacts on Biodiversity | H | U |
| 11. Indicators of climate change impacts and adaptation | L | L |
| Indicator Species | | |
| 12. Development of headline indicators of climate change impacts on biodiversity | M | M |

| | | |
|---|---|---|
| 13. Responses of marine biodiversity to climate change using inter-tidal indicators | H | U |
| **Review of conservation targets** | | |
| 14. Conservation Targets in UK SPAs, SACs and BAPs in light of existing climate change | M/H | U |
| **Soils, Sediments and Resilience** | | |
| 15. Climate changes and soil biodiversity | H | U |
| 16. The functional role of biota in sediments | M/H | U |
| **Climate Change and Phenology, distribution, population dynamics, breeding success with predictive mapping** | | |
| 17. Modelling impacts and testing the accuracy of predicted faunal responses to climate change | M | M |
| 18. Species' autecology and distribution in response to climate change | ? | U |
| 19. Long-range conservation of British lower plant diversity | ? | U |
| **Planning and implementation of adaptation strategies** | | |
| 20. Site / Habitat management and climate change adaptation | M/H | U |
| 21. Planning for urban biodiversity under climate change (PUB-dUCC) | M | ? |
| 22. Climate change impact on landscape permeability and wildlife corridors | H | U |
| 23. What adaptation works for biodiversity? | H | U |
| **Genetic conservation** | | |
| 24. Will local genetic adaptation within species limit adaptation to climate change? | ? | ? |
| **Atmospheric Chemistry and Pollution** | | |
| 25. Carbon dioxide: feedbacks in natural and anthropogenic systems and implications for adaptation and mitigation strategies | H | U |
| 26. Integrated projections of climate change, atmospheric pollution and terrestrial ecosystem response. | ? | ? |

## 3.2 Generic research needs

While the workshop generated a number of specific project proposals (section 4), these inevitably represent the interests of the participants and their specialist skills. This may unavoidably bias the proposed projects, and there are numerous additional research areas that need to be highlighted.

### *3.2.1 What if Scenarios*

Uncertainty about climate change and responses to it still exists. We need to examine uncertainty from climate model projections through to modelled ecosystem responses and consequences for adaptation policy. Given this uncertainty, one approach is to develop "what if" scenarios as policy tools. Scenarios would be developed to represent the range of pressures upon biodiversity habitats, and consequences for adaptation considered. This could be a mixture of brain storming, scientific research and expert opinion.

### *3.2.2 Cumulative Effects*

There is recognition that climate change does not act in isolation, i.e. there are numerous pressures affecting biodiversity. The impact of climate change on other ecosystem pressures needs to be considered. Research needs to address how climate change may work with/affect other pressures impacting on ecosystems (e.g. changes to river regimes, water quality and resultant affects on species). Many proposals recognise the links between temperature and abundance shifts of species; what is lacking is an analysis of the effects on other pressures/processes and how these in turn affect biodiversity.

We need to improve our understanding of cumulative effects. Although the effect of individual factors resulting from climate change on biota is sometimes understood rarely, if ever, is it possible as yet to assess how several factors will in combination affect wildlife (or humans). This may require the development of new modelling approaches.

### *3.2.3 Long term data sets*

In order to underpin modelling and scenario work, we need to invest in the development of long term data sets. It is necessary to establish the robustness of baseline and historical data sets and maintain long term data sets in order to assess change. Long-term datasets for the marine environment are particularly rare and are presently coordinated through the MECN; more effort is required to make sure these valuable datasets are maintained (and enhanced where necessary) and utilised for modelling and testing of hypotheses.

### *3.2.4 Autoecology*

Alongside this research, there remains a need to improve our understanding of species' autecology and distribution in response to climate change. Such a programme would aim to increase our autecological knowledge of rare and/or taxonomically difficult species; to assess the impact of current climate change on these species; and to assess the impact of future climate change on these species.

For many taxa, especially rare species e.g. BAP species or taxonomically difficult groups of species, basic autecological knowledge is lacking. There is a need for basic knowledge of species distribution, population dynamics and breeding success. Secondly, these results need to be related to climate change and then used to predict future changes.

However, this requires that we have a suitable approach to selecting species to study. Unless a strategic approach is taken, this could be a very expensive and never-ending piece of research.

Related to this, climate change is likely to have an important impact on non native or invasive species and disease. How will non native or invasive species and diseases behave in conditions of climate change - what consequences will this have for human health, ecosystem goods and services? This research needs to include both terrestrial, fresh water and marine invasive species.

# 4 Knowledge transfer

There is a need to improve access to summarised scientific information for many groups of species. Although this is not really climate change specific, such background information can be used in conjunction with climatic and phenological data to give early warnings of responses to climate change. This information is crucial for the support of both policy and management, most notably in relation to the UK Biodiversity Action Plan (UK BAP), and needs to reach both Lead Partners and others associated with delivery of UK BAP targets "on the ground."

There are three stages involved:

- To review (on an annual basis) scientific literature of relevance to key taxa and climate change, with special reference to issues relating to adaptation;
- to write-up this review as a short internet-based report in a style accessible to non-scientists;
- to update this report on an annual basis.

Maintaining the knowledge base via annual review is a demanding task, and likely to require input from a number of bodies. However, central coordination is essential, and this could become the responsibility of the UK BRAG secretariat, an multi-agency group set up for the purpose (similar to a UK BRAG sub-group), or by way of a systematic review undertaken by the Centre for Evidence-Based Conservation (CEBC, http://www.cebc.bham.ac.uk/).

In addition, there is a need to relay this information to a wider audience, e.g. the general public, regional and local government, regulatory agencies, and the land-use and business sectors.

Climate change is not restricted to the UK, and it would be important to understand the effects here within the context of both European and global scales. There would be value in a research priorities workshop on "Climate change adaptation for biodiversity." This is a very broad theme, and so it would be beneficial to select a small number of ecosystems. It would need to develop predictions operating at both international and national levels. This is hugely cross-cutting, and such an event would have a high priority at a global scale, but lower priority within UK. This wider interaction aims to produce improved understanding and collaboration.

The questions to be addressed include the wider implications of losses or changes in biodiversity and ecosystem function. Are changes we are monitoring/ predicting happening elsewhere, at similar rates and scales? How important are our mitigation / adaptation strategies across a European scale, e.g Natura 2000 sites.

**Actions**

- Establish an annual review programme to provide summarised scientific information, including publication of a non-technical online report
- Ensure that this information is communicated to a wider audience
- Explore the benefits of an international research priorities workshop and, if appropriate, coordinate organisation

# 5 Conclusions

The workshop and subsequent discussions have identified a wide ranging portfolio of programmes (11) and projects (26). In addition to these, the need for a knowledge transfer mechanism has been highlighted, and requires further development.

Although there are a few projects still in need of assessment, there are at currently at least ten which are both a high priority and urgently need to deliver results, in order to inform policy and management. These are:

- Review of effectiveness of implementation of landscape-scale initiatives
- Managed retreat
- Understanding changes to sub-tidal marine ecosystems that are a consequence of climate change
- Targeted monitoring of climate change and atmospheric pollution impacts on biodiversity
- Responses of marine biodiversity to climate change using inter-tidal indicators
- Climate changes and soil biodiversity
- Climate change impact on landscape permeability and wildlife corridors
- What adaptation works for biodiversity?
- Carbon dioxide: feedbacks in natural and anthropogenic systems and implications for adaptation and mitigation strategies

Consideration needs to be given as to how these are to be addressed, i.e. how the research will be funded, by whom, and for what duration; whether the expertise exists to undertake the research, where it is located, and whether capacity is available. Champions are required to promote these topics and maintain good levels of communication between funding agencies, policymakers, researchers and practitioners. There is an important role here for UK BRAG, as the Group enters a new phase of its work, with an increased focus on promotion and delivery of research, and subsequent translation into policy. Communicating the recommendations of this report to the Environmental Research Funders' Forum (ERFF, http://www.erff.org.uk/) is one specific task.

The generic issues, highlighted in section 3.2 need to be addressed in an appropriate manner, through existing mechanisms where possible, and with new initiatives as required. For example, the development of "what if" scenarios as policy tools needs to be overseen by Defra, The Scottish Executive, the Welsh Assembly Government, and the Department of the Environment for Northern Ireland, and possibly delivered through the UKClimate Impacts Programme (UKCIP, http://www.ukcip.org.uk/).

To address the cumulative effects of climate change and other pressures on ecosystems requires a recognition by the major research funders (e.g. the Research Councils, particularly NERC) of the need to support inter-disciplinary, multi-agency research. Before embarking on new research, existing datasets and modelling approaches need to be better integrated. UK BRAG needs to engage the ERFF on this issue, in order to gain support for this as a priority action.

The establishment and maintenance of long term datasets (e.g. the Environmental change Network (ECN), http://www.ecn.ac.uk/; and the Marine Environmental Change Network (MECN), http://www.mba.ac.uk/MECN/about.htm) needs to be underpinned with a commitment from a number of key funders. Again, the ERFF is a crucial body in this respect, in order to secure support for the coordination efforts of the Centre for Ecology and Hydrology (CEH) and the Marine Biological Association (MBA), respectively. To ensure that full use is made of these datasets, they need to be available via the National Biodiversity Network (NBN, http://www.nbn.org.uk/).

In order to improve our understanding of species' autecology and distribution in response to climate change, there needs to be a well-considered strategy for selecting species for study. This should aim to address generic questions of wider applicability, to avoid a species-by-species focus for which insufficient funds are available. UK BRAG needs to work with projects such as MONARCH (http://www.eci.ox.ac.uk/research/biodiversity/monarch.php) and MARCLIM (http://www.mba.ac.uk/marclim/) in order to identify the key cross-cutting issues. The specific question of climate change interactions with non native or invasive species and diseases needs to be addressed in consultation with the GB Non Native Species Forum.

Brooker and Young (2006), focusing at a pan-European level, have highlighted "…a need for interdisciplinary research to address the development of policies that can deliver conservation goals on a broad geographical scale and for the development of an institutional framework capable of delivering appropriate incentives for stakeholders to conserve biodiversity."

It must be recognised that the research identified in this report has strong links to that identified by other UK BRAG sub-groups, addressing a range of cross-cutting issues. For full details, readers are referred to the Report of UK BRAG Activities, 2003-2006 (Ferris, in prep.). Interdisciplinary research approaches underpin all of UK BRAG's thinking, as outlined by Perrings and Ferris (2004).

**Actions**

- identify "champions" to promote research priorities
- communicate the main messages of this report to ERFF
- establish an action plan to identify and engage funding agencies and research providers

# 6 References

Brooker, R. and Young, J. (2006), eds. *Climate change and biodiversity in Europe: a review of impacts, policy responses, gaps in knowledge and barriers to the exchange of information between scientists and policy makers*. Final Report for Defra Research Contract CRO326. Defra, London.

EPBRS (2005). *Climate change and biodiversity conservation: knowledge needed to support development of integrated adaptation strategies.* Recommendations of the meeting of the European Platform for Biodiversity Research Strategy, held under the UK Presidency of the EU, Aviemore, Scotland 2nd – 5th October 2005

Mitchell, R.J., Morecroft, M., Mountford, O., Acreman, M., Ross, L.C., Maclean, I.M.D., Crick, H.Q.P., Rehfisch, M.M., Piper, J. and Wilson, E. (2006). *England biodiversity strategy – towards adaptation to climate change*. Draft report to Defra for contract CRO327. May 2006

Perrings, C. and Ferris, R. (2004), eds. *Socio-economic biodiversity research perspectives relevant to the delivery of the UK Biodiversity Action Plan*. A report to the UK Biodiversity Research Advisory Group. August 2004.

# 7 Appendices

# Appendix 1

## Key programmes of research

### 1 Assessing the effectiveness of landscape-scale initiatives for adaptation to climate change

This programme should be based around two linked projects (1 and 2):

**Project number:** **1**

**Project title:** Impact of future weather patterns on priority habitats

**Objectives:**

- To identify how climate change will change weather-derived resources and impacts at key habitats.
- To assess the impact of these changes on habitat integrity, resilience and key species.
- To identity practical management and conservation responses to adapt to these change.

**Costs:** £10-100K

**Overview:** To understand how direct impact of future weather conditions, brought on by climate change, will affect specific habitats of conservation importance: Caledonian pine forest, lowland heath, and coastal, flood plain and grazing marsh. This will enable suitable management responses to be developed.

**Assessment scores:** 1 (H), 2 (H), 3 (L/M), 4 (M), 5 (L), 6 (U) MEDIUM PRIORITY

**Comments:**

**Project number:** **2**

**Project title:** Review of effectiveness of implementation of landscape-scale initiatives

**Objectives:**

- To review the effectiveness of landscape scale initiatives as an adaptation to climate change in the UK and elsewhere in Europe.
- To assess outcomes with regard to conservation objectives, administration, socio-economic costs and benefits.
- To develop best practice guidance on implementation of landscape scale approaches, including governance arrangements, participatory approaches, adaptive management.

**Costs:** £10-100K

**Overview:** A better understanding is needed of effective spatial planning measures to enable biodiversity to survive and thrive in changed climates and perhaps in changed locations. What measures are most effective in permitting species to move in response to climate change (e.g. along corridors, across the wider landscape), habitats to increase their resilience and the quality of the wider landscape to improve for biodiversity. (The BRANCH project has made some progress on this).

Review the success and failures of "landscape scale" initiatives including the strengthening and enhancement of protected area networks, reversal of habitat fragmentation, re-creation of large scale natural ecosystems and application of CBD Ecosystem Approach. Develop practical guidance on how to improve effectiveness of such approaches.

**Assessment scores:** 1 (H), 2 (H), 3 (H), 4 (H), 5 (H), 6 (U) HIGH PRIORITY

**Comments:** Timely, as the project coincides with major European developments in landscape work, such as that currently being carried out by the BRANCH project http://branchproject.org/about/ "**B**iodiversity **R**equires **A**daptation in **N**orthwest under a **CH**anging climate."

Defra has already put forward a research proposal *The ecological basis for landscape permeability as a means of facilitating the species response to climate change*. This will be addressed in two stages. Part 1 is an investigation of the ecological basis for landscape permeability as a means of facilitating the response of species to climate change. It will provide the background and evidence for subsequent development, in Part 2, of policy tools and best practice advice to deliver a landscape approach to facilitating the response of biodiversity to climate change.

The aims and objectives of Part 1 are to:

- examine and provide a summary of the evidence demonstrating the significance of landscape permeability or connectivity for dispersal of wide range of different species, including migratory species and selected non native species;
- identify characteristics of the landscape that facilitate movement of native species or hinder movement of a non native species,
- identify species, or groups of species, that are most likely to benefit from a more permeable landscape and be able to use it to respond favourably to the effects of climate change;
- review of the time scales involved for dispersal patterns and distances travelled by a range of species, including common species as well as those on the BAP species list (this is important, since creation of habitat links and dispersal takes time, and the species of concern may become extinct before the link or re-location is complete); and
- recommend any further investigations needed to increase our understanding of landscape permeability.

## 2 Wetland, coastal zone and marine adaptation to climate change

This programme should be based on five projects (3, 4, 5, 6, 7 and 8):

**Project number:** 3

**Project title:** Investigation to identify constraints and opportunities and provide recommendations for optimisation of adaptation to climate change in coastal zones

**Objectives:**

- To develop tools and methods of recognising opportunities and optimising adaptation to climate change along coastal zones;
- To investigate large scale opportunities presented by whole coastal systems, including bathymetry, currents, sediment transport, potential erosion and accretion, and requirements for defences based on current literature, models, field observations, and current locations of habitat of conservation value and protected sites;
- To increase understanding of climate change adaptation requirements of coastal biodiversity and provide advice for changes in policy.

**Costs:** **>£500K**

**Overview:** The projects aim to identify and develop the tools that make it possible to manage wetland and coastal ecosystems in the face of climate change. In combination the suite of projects are assessed as being particularly valuable, in part because of the international importance of the UK's wetland and coastal biodiversity, but also because there has been little work carried out on many of the issues contained within this research programme.

**Assessment scores:** 1 (H), 2 (H), 3 (H), 4 (H), 5 (L), 6 (U) MEDIUM/HIGH PRIORITY

**Comments:** Projects that aim to identify constraints and opportunities and provide recommendations for the optimisation of adaptation to climate change in coastal zones. The projects aim to identify and develop the tools that make it possible to manage wetland and coastal ecosystems in the face of climate change.

**Project number:** **4**

**Project title:** Managing the marine environment in response to climate change - identifying the options

**Objectives:**

- To identify policy areas, especially in respect of objectives and targets, where consideration of climate change may be important to the outcome and to develop mechanisms to ensure that appropriate consideration of climate change is made(e.g. MPA network);
- To provide guidance on appropriate approaches, or actions that will ensure provision for possible impacts of climate change on the outcomes in each policy area.

**Costs:** **£**10-100K

**Overview:** To identify mechanisms to integrate consideration for climate change with our management of human activities, identification of conservation sites, and how we monitor, assess and report on the status of habitats, species and ecosystems.

**Assessment scores:** 1 (H), 2 (H), 3 (H), 4 (H), 5 (L), 6 (U) **?PRIORITY**

**Comments:** See above.

**Project number:** **5**

**Project title:** The impacts of hydrological and geomorphological change due to climate upon freshwater ecology

**Objectives:**

- To utilise the database of water temperature currently being developed by EA and CCW along with flow data to detect long-term climate change impacts in freshwaters and differences regionally within the UK (including distinguishing the contribution of the positve NAO);
- To develop a risk assessment of sensitivity to the range of climate change impacts within selected river catchments and at a national scale between them;
- To use data from well monitored sites to empirically model the impacts identified and the potential interactions with other key freshwaters stressors such as acidification;
- To utilise the modelling outputs and data from well monitored sites to explore the potential for a risk management strategy to reduce the impacts of extreme fluvial events and other stressors on the ecosystem.

**Costs:** £100-500K

**Overview:** There has been limited consideration of the impacts of climate change on freshwaters and their ecology compared to terrestrial and marine ecosystems. The PRINCE and Eurolimpacs projects have provided a review of knowledge for this topic but it is clear that the impacts of (summer) low flow and more frequent flood events as well as changes in water temperature require further consideration in order to develop an appropriate management strategy to counteract climate change in streams, rivers and lakes.

**Assessment scores:** 1 (H), 2 (H), 3 (H), 4 (H), 5 (H), 6 (U) HIGH PRIORITY

**Comments:** This is the only project in the portfolio which is concerned specifically with freshwater ecology.

**Project number:** **6**

**Project title:** Managed retreat

**Objectives:**

- To quantify the ecological and landscape characteristics of managed and unmanaged retreat sites;
- To determine the temporal, physical, sedimentological and geomorphological characteristics that explain why managed retreat sites frequently have very different landscape and ecological characteristics to equivalent tidal elevation natural areas;
- To develop a framework to allow the prediction of the temporal development of landscape and biodiversity characteristics of retreat sites under different sea level rise scenarios, and the consequences of these for economic costs and engineering stability of flood protection measures;
- To inform decisions about the location of managed retreat sites and to inform best practice so that future managed retreat achieves more desirable outcomes than previous schemes and is integrated into an overall framework of adaptive coastal management.

**Costs:** Costs needed

**Overview:** To understand the mechanisms that lead to the creation of suitable managed retreat sites to make it possible to accurately predict the value of proposed managed retreat sites to biodiversity.

**Assessment scores:** 1 (H), 2 (H), 3 (H), 4 (H), 5 (H), 6 (U) HIGH PRIORITY

**Comments:** **See above**

**Project number:** 7

**Project title:** Assessment of the implications of ocean acidification and climate change in respect of the impact on key habitats, species and ecosystem function

**Objectives:**

- To investigate impacts of ocean acidification on marine organisms and ecosystems (including structure and composition) - in particular calcifying organisms;
- to assess the effects of increasing ocean CO2 and associated environmental changes on non-calcifying organisms, considering the interactions between variables;
- to assess the magnitude of the rate of change in the carbonate equilibrium and its effects and to develop a composite index that will allow easy assessment of changes in ocean acidity levels and the consequence to calcium calcite regulation?

**Costs:** **£10-100K**

**Overview:** To assess the effects of ocean acidification in combination with climate change on marine habitats, species and system functioning and develop a composite index to track change.

**Assessment scores:** 1 (M), 2 (H), 3 (H), 4 (M), 5 (M), 6 (U) MEDIUM/HIGH PRIORITY

**Comments:** **This is a v**ery important topic. American research is in progress on similar topic.

Project number: 8

Project title: Understanding changes to sub-tidal marine ecosystems that are a consequence of climate change

Objectives:

- To identify key impacts of climate change in the marine environment and isolate those resulting directly from anthropogenic activities.
- To predict the likely impact of climate change on trophic pyramids, species and habitat range and ecosystem processes in the marine environment.
- To provide recommendations for mitigation or management of these changes.

Costs: £100-500K

Overview: To understand the impact that climate change is having on the marine environment, in isolation from anthropogenic impacts, and attempting to predict the consequences of climate change for key habitats and species of nature conservation and economic importance.

Assessment scores: 1 (H), 2 (H), 3 (H), 4 (H), 5(M/H), 6 (U) HIGH PRIORITY

Comments: This is a generic programme containing a lot of important potential areas. The challenge is to separate climate change from other impacts. Elements of this are a high priority; it could encompass 5 – 10 projects, and it is important to disentangle the elements and develop a programme. It has high relevance, especially with Marine Bill due.

## 3 The impact of climate change on ecosystem goods and services

This programme is based on a single project (9):

**Project number:** **9**

**Project title:** Providing evidence for sustainable policy making in an era of climate change

**Objectives:**

- Link changes in species to change in ecosystem function;
- Understand how the demand for ecosystem goods and services will be affected by climate change;
- Develop better understanding of the threats and benefits of climate change to ecosystem functioning and the goods and services provided;
- Develop better links betweens the social economic impacts of climate change and the impacts on biodiversity;
- Provide advice to policy makers across government in the UK and internationally.

**Costs:** **£**10-100K plus

**Overview:** There is mounting evidence of climate change and the potential impacts it will have on biodiversity. While it is accepted that climate change is happening, mechanisms must be found for communicating the impacts to those sectors whose actions and reactions will affect biodiversity, but that are attempting to move towards sustainability. We need to improve our understanding of the impact of climate change on ecosystem functioning. In the same way as experiments were carried out on the impacts of pollution on biodiversity, similar experiments need to be carried out on the impacts of climate change. This work needs to be carried out in terrestrial, fresh water, marine and inter-tidal ecosystems. The socio-economic changes associated with climate change must be included within this work.

**Assessment scores:** 1 (L), 2 (M), 3 (M), 4 (M), 5 (L), 6 (L) LOW/MEDIUM PRIORITY

**Comments:** This programme should focus on how climate change will impact on the provision of ecosystem goods and services directly and indirectly via human adaptation to climate change. Further thought is required to develop the methodology behind this research programme before it is taken forward.

## 4 Monitoring the impacts of climate change and atmospheric pollution on biodiversity

This programme should be based on two closely related projects (10 and 11):

**Project number:** **10**

**Project title:** Targeted Monitoring of climate change and Atmospheric Pollution Impacts on Biodiversity

**Objectives:**

- To compile a body of evidence by monitoring the effects of climate change and atmospheric pollution on biodiversity on sites with high conservation value across the UK over a long term and to develop partnerships, progressively extend the network across the UK and form links with existing networks.
- To increase understanding and differentiate between effects of climate change and atmospheric pollution on biodiversity.
- To provide access to data, data analysis and interpretation and information dissemination and to promote discussion and participation through implementation of an effective communications plan.
- Establish a new network of sites linked to the existing Environmental Change Network but using a smaller number of measurements across a wider range of sites, of high biodiversity interest, particularly focussed on National Nature Reserves.
- Analyse results to detect trends and test attribution of cause.
- Make data and interpretation information available to guide future policy and management development and inform public debate.
- Establish a new network of sites linked to the existing Environmental Change Network but using a smaller number of measurements across a wider range of sites, of high biodiversity interest, particularly focussed on National Nature Reserves;
- Analyse results to detect trends and test attribution of cause;
- Make data and interpretation information available to guide future policy and management development and inform public debate.

**Costs:** **>£500K**

**Overview:** To detect the impacts of climate change on biodiversity and allow them to be distinguished from the effects of air pollution and land management change. To expand and develop the ECN so that it links in with recording on national nature reserves and that done by the UK Phenology Network (UKPN), and provides additional data on the impact of climate change and atmospheric pollution that will inform management on sites of high conservation value. There is a need to link monitoring of biodiversity to socio-economics e.g. link ECN and MECN monitoring to social economic monitoring. The monitoring of the marine environment is linked to fisheries in a better way than the monitoring of the terrestrial environment is linked to farming. The research will provide long term surveillance and data analysis of atmospheric pollution, climate change and aspects of biodiversity on a series of sites across the UK, which have been targeted to isolate possible effects of climate change or atmospheric pollution, and to achieve a representative sample of habitats . The new network will link with existing ECN sites and modelling programmes, and possibly link to other EU initiatives. It is intended to inform on appropriate management in response to climate change, especially on sites of high conservation value.

**Assessment scores:** 1 (H), 2 (H), 3 (H), 4 (H), 5 (M/H), 6 (U) HIGH PRIORITY

**Comments:** H priority for science, M for funding. A rethink of ECN is needed, to assess whether it addresses the key issues in an effective way. If stakeholders wish for the ECN to tackle additional issues, an increase in resources will be required.

**Project number:** **11**

**Project title:** Indicators of climate change impacts and adaptation

**Objectives:**

- Develop C1 indicators of climate sensitive species at ECN sites to show changes in community structure.
- Develop indicators of range change to include butterflies, dragonflies, marine molluscs etc.;
- Develop indicators for adaptation response e.g. reversal of fragmentation?
- To identify relationships between variables (climatic, abiotic and biotic) and responses (e.g. phenology, abundance, range change) established at ECN sites.
- Extrapolate such relationships nationwide through use of complimentary national recording scheme.

**Costs:** **£10-100K**

**Overview:** To develop indicators of climate change impacts and adaptation to support the Country biodiversity strategies and the UK Biodiversity Action Plan. This work will underpin the development of more effective climate-biodiversity indicators.

**Assessment scores:** **1 (L), 2 (L), 3 (L), 4 (M), 5 (L), 6 (L)** **LOW PRIORITY**

**Comments:** Indicators for climate change have already been developed, but new indicators for specific purposes are required e.g. monitoring the impact of adaptations or to cover groups of species for which indicators are not available. The research aims to develop indicators that include a range of taxa, migratory and non-migratory species, terrestrial and marine species. Indicators should include things such as breeding success, abundance and timing of biological events and changes in distributions.

## 5 Indicator species

This programme should be based on two projects (12 and 13), with links to 11, above:

**Project number:** **12**

**Project title:** Development of headline indicators of climate change impacts on biodiversity

**Objectives:**

- To develop multi-species indicators for monitoring responses of breeding, wintering and migrating birds to climate change.
- To monitor changes in the distribution and abundance of breeding and wintering birds in the UK in response to climate change.
- To monitor changes in the timing of breeding of widespread bird populations in the UK in relation to climate change.

**Costs:** **£10-100K**

**Overview:**

**Assessment scores:** 1(M), 2(M), 3(M), 4(M), 5(M), 6(M) MEDIUM PRIORITY

**Comments:** To develop multi-species indicators that allow us to monitor the response of breeding, wintering and migrating birds to climate change. While it is a good idea, it does need to focus beyond birds alone. Indices are needed, but the major question is whether birds are the correct indicator? This should be considered before further work on this project.

**Project number:** **13**

**Project title:** Responses of marine biodiversity to climate change using inter-tidal indicators

**Objectives:**

- To quantify the relative abundance of northern and southern suites of species;
- To map extensions of southern species and retreats of northern species, including the role of artificial habitat created by sea defences;
- To validate predictive models of biodiversity responses to climate change using UKCIP scenarios.

**Costs:** **£100-500K**

**Overview:** To establish a monitoring network to continue long-term quantitative time series and broad-scale quantitative and semi-quantitative surveys of intertidal indicator species to measure climate change responses in the British Isles to inform policy including SACs, SPAs and future Marine Protected Area Networks and provide general headline indicators.

**Assessment scores:** 1 (H), 2 (H), 3 (H), 4 (H), 5 (M/H), 6 (U) HIGH PRIORITY

**Comments:** Policy drivers need to be teased out. For criterion 4 it is a high priority for science but medium for funding

## 6 Review of conservation targets

This project is based on a single project (14):

**Project number:** 14

**Project title:** Conservation Targets in UK SPAs, SACs and BAPs in light of existing climate change

**Objectives:**

- To determine how the distribution and abundance of biota is already changing as a result of climate change;
- To produce realistic scenarios of future changes in distribution and abundance of biota with climate change on designated sites;
- To review conservation targets in the light of climate change and assess if and how they need adjusting, while, if possible meeting current conservation targets;
- Are BAP targets going to be achievable in view of the climate change, and are any amendments needed?
- To ensure that conservation resources are used to best effect in the light of climate change e.g. habitats restored and species introduced/reintroduced where they have the best chance of establishing in the light of climate change;
- To determine whether the observed changes in the number of UK's internationally important water birds on designated sites can be explained by climate change;
- To assess whether it is possible to determine whether the observed changes in the abundance of terrestrial birds on SPAs can be explained at least in part by climate change.

**Costs:** **£10-100K**

**Overview:** To review conservation targets in SPAs, SACs and BAPs in relation to climate change and then to develop tools for setting and helping to meet climate change-proofed conservation targets. To assess whether recent temperature increases have affected the abundance of species that are designated features of protected sites

**Assessment scores:** **1 (H), 2 (H), 3 (M), 4 (M), 5 (H), 6 (U)** MEDIUM/HIGH PRIORITY

**Comments:** This project needs to focus on a subset of sites and adopt a case study approach. It would also benefit from being broadened out from water birds. Defra has already initiated a project proposal titled BAP Targets in a Changing Climate. This project will assess the risk posed by climate change to the achievement of BAP targets for priority habitats and species, based on available evidence. The project will identify sources of uncertainty and identify general issues concerning application and future development of biodiversity targets. Identification of future evidence needs will be undertaken in conjunction with BRAG.

## 7 Soils and sediments and resilience

This programme should be based on two projects (15 and 16):

**Project number:** **15**

**Project title:** Climate changes and soil biodiversity

**Objectives:**

- How do the majority of soils react to environmental changes - i.e. what is their resilience?

**Costs:** **>£500K**

**Overview:** The majority of terrestrial ecosystems depend upon processes in the soil. There is a detailed study of only one soil in the UK (probably in the world) and that is the upland grassland soil at Sourhope (NERC's £6m research programme, and c. £2.5m from SEERAD).

**Assessment scores:** **1 (H), 2 (H), 3 (H), 4 (H), 5 (M), 6 (U)** **HIGH PRIORITY**

**Comments:** This is a particularly important area of research, as we know so little about resilience. We need to improve techniques for the valuation of biodiversity in terms of goods and services provided.

**Project number:** **16**

**Project title:** The functional role of biota in sediments

**Objectives:**

- Assess the impact, if any, that climate change has had on sediments, marine and fresh water, and the biodiversity contained within the sediments;
- Predict the impact of future climate change on sediments, marine and fresh water, and the biodiversity contained within the sediments using both experimental and modelling approaches;
- Assess the resilience of a range of sediments, marine and fresh water to climate change.

**Costs:** Need an estimate here

**Overview:** This proposal would parallel project 3. The role of sediments, their biodiversity, and the functions of the hundreds or thousands of organisms in sediments in the function of freshwater and marine ecosystems is poorly understood.

**Assessment scores:** **1 (M/H), 2 (M/H), 3 (H), 4 (H), 5 (M/H), 6 (U)** **MEDIUM/HIGH PRIORITY**

**Comments:** Higher priority for freshwater, estuaries and coastal sediments (rather than marine). Fragmentation of competent authorities involved here. A more focussed project would be a high priority. Coastal realignment will impact on sedimentation (but, offshore, fishing more important than CC). Need to develop a more specific proposal.

## 8 Climate change and phenology, distribution, population dynamics, and breeding success for a variety of taxa, with predictive mapping

This programme is based on two broad projects (17 and 18), linked to a more specific project (19):

**Project number:** **17**

**Project title:** Modelling impacts and testing the accuracy of predicted faunal responses to climate change

**Objectives:**

- To use historic distribution and abundance data to predict the current distribution and abundance of selected species and then to test the accuracy of these predictions;
- To test whether areas predicted to have suitable climate for species in the future differ when abundance as opposed to occurrence data are used to make the predictions;
- To establish why predictions differ from observations.
- To determine how climate affects the components of breeding performance of terrestrial birds at national and regional spatial scales and to identify those components most sensitive to climate change;
- to determine whether there are species differences in response to climate that result in some being more vulnerable to climate change and to identify the potential causes of these vulnerabilities;
- to develop and use population dynamics models that integrate national datasets of census and survival rates of birds to explore how climate change impacts on breeding performance and affects the abundance of birds.
- To produce models from annual bird monitoring data that predict bird abundance from habitat cover;
- to quantify likely changes in habitat extent under different scenarios of climate change;
- to predict future changes in bird populations based on spatial bird models and land use change scenarios.

**Costs:** £100-500K

**Overview:** To test the accuracy of predicted changes in the distribution and abundance of birds and to identify ways in which predictions can be improved

**Assessment scores:** 1 (M), 2 (M), 3 (L/M), 4 (H), 5 (H), 6 (M) MEDIUM PRIORITY

**Comments:** To understand the mechanisms by which large scale changes in abundance are influenced and determined by climate change impacts on a species' biology. This project could be used to predict changes in bird populations caused by broad-scale habitat change arising as a result of climate change. However, the approach should be applied to other taxa, perhaps comparing birds and butterflies. Coastal birds and mapping could be introduced in order to make the project more generic. The project needs to focus on abundance data, rather than presence/absence. This will add value to existing climate envelope modelling work. However, it requires at least one parallel study with another taxon, for it to be really useful.

**Project number:** **18**

**Project title:** Species' autecology and distribution in response to climate change

**Objectives:**

- To increase our autecological knowledge of rare and/or taxonomically difficult species.
- To assess the impact of current climate change on these species.
- To assess the impact of future climate change on these species.

**Costs:** **Need cost estimate**

**Overview:** For many taxa, especially rare species e.g. BAP species or taxonomically difficult groups of species, basic autecological knowledge is lacking. There is a need for basic knowledge of species distribution, population dynamics and breeding success. Secondly, these results need to be related to climate change and then used to predict future changes.

**Assessment scores:** 1 (H), 2 (H), 3 (M), 4 (?), 5 (M), 6 (U) ?PRIORITY

**Comments:** How do we select appropriate species to study? Unless a strategic approach is taken, this could be a very expensive and never-ending piece of research.

**Project number:** **19**

**Project title:** Long-range conservation of British lower plant diversity

**Objectives:**

- Use existing data-sets to model the response of British lower plant species to expected future climate change, integrating (i) the climate response of species, (ii) spatial structure of habitat, (iii) dispersal limitation and (iv) species interactions;
- to compare projected changes in the pattern of lower plant diversity to the current reserve network, with special emphasis on the protection of species of high conservation priority;
- in the light of this evidence, to promote the development of an integrated and flexible system for biodiversity protection, based on species monitoring, and, if necessary, adaptation of the current UK reserve network.

**Costs:** £10-100K

**Overview:** The project is estimated to cost ca £80,000 (equivalent to 2.5 yr employment at a post-doc level, with limited additional fieldwork and computing facilities). The project will represent a return on past investment through the application of previous compiled and publicly available electronic datasets, e.g. electronic mapping schemes.

**Assessment scores:** 1 (H), 2 (H), 3 (M), 4 (?), 5 (M), 6 (U) ?PRIORITY

**Comments:** **Thought needs to be given to the** relative abundance of lower plants in Scotland, which is a hotspot at the European level. Should this project focus on terrestrial plants? This project could usefully be applied to other taxa. This topic may have been overlooked so far. There are data issues to be resolved, since it is unlikely that data are generally available. However, it will be very difficult to model climate responses, habitat structure, dispersal and species interactions for lower plants, given the experience with higher plants in the MONARCH project.

## 9 Planning and implementation of adaptation strategies

This programme is based on five related projects (20, 21, 22 and 23), with links to project 14, above:

**Project number:** **20**

**Project title:** **Site /** Habitat management and climate change adaptation

**Objectives:**

- Identify impacts of climate change in protected areas and other places of biodiversity importance;
- identify management techniques to improve resilience against these impacts;
- shortlist adaptation measures for trial application on a series of sites of nature conservation interest;
- to implement a series of adaptation approaches across sites, and monitor the costs and effectiveness of measures;
- identify key areas for habitat creation/expansion/relocation, required to mitigate the impact of climate change on key habitats.

**Costs:** **£>500K**

**Overview:** To develop practical habitat management to make habitats more resilient to the impacts of climate change; and determine methods for on-the-ground implementation of adaptation and their effectiveness.

**Assessment scores:** 1 (H), 2 (H), 3 (M), 4 (L), 5 (H), 6 (U) MEDIUM/HIGH PRIORITY

**Comments:** This project aims to develop the practical habitat management skills that make habitats more resilient to the impacts of climate change. The work required goes beyond knowledge gathering, needing research and experimentation, to establish best practice. It is ambitious in scope, but could be tested on a few habitats initially.

**Project number:** 21

**Project title:** Planning for urban biodiversity under climate change (PUB-dUCC)

**Objectives:**

- To investigate the availability, value and spatial location of potential biodiversity networks within urban areas and over the period to 2050;
- to identify obstacles, within the development process, to the enhancement of existing and new biodiversity “infrastructure” within urban areas (such as brownfield sites and green roofs) and to linking these up in networks;
- to explore appropriate planning mechanisms and policies to ensure the long term flexibility of networks and other green infrastructure within urban areas to facilitate adaptation to climate change.

**Costs:** **<£350K**

**Overview:** Biodiversity within urban areas (parks, gardens, brownfield sites, green roofs, river corridors, SuDS etc.) fulfils a range of functions which improve quality of life and are important for ecosystem functioning. Such areas may be lost or eroded under climate change and by development. Biodiversity protection and the creation of more opportunities for biodiversity would increase benefits, but this is at risk under an urban intensification agenda and climate change.

**Assessment scores:** **1 (M), 2 (M), 3 (H), 4 (L), 5 (M), 6 (M)** **?PRIORITY**

**Comments:** Research intended to establish the potential value of biodiversity at protected and non-protected (e.g. green roofs) sites for economic, social and environmental purposes. A project that is valuable for its specific urban focus. The assessment team identified serious political issues that would need to be resolved before the project could be considered for funding.

**Project number:** 22

**Project title:** Climate change impact on landscape permeability and wildlife corridors

**Objectives:**

- What characteristics make the landscape permeable for various groups of organisms?
- What biodiversity types and species are likely to be most in need of, and will most benefit by, more permeable landscapes to reduce the impacts of limate change on their UK populations?
- What is the best way to ensure wildlife corridors in view of climate change?
- Do wildlife corridors work?
- Over what timescales is implementation required to facilitate wildlife movement caused by climate change?

**Costs:** **£100-500K**

**Overview:** This could be a series of case studies (e.g., dormouse range shift, arable field margins, woodlands, wetlands etc.) to illustrate the impact of climate change on various species and/or ecosystems. The results of the research would feed into the adaptation strategy for those particular species/ecosystems and act as a model for other species/ecosystems.

**Assessment scores:** **1 (H), 2 (H), 3 (H), 4 (H), 5 (L), 6 (U)** **HIGH PRIORITY**

**Comments:** A project composed of case studies to illustrate the impact of climate change on various species and ecosystems. The results would feed into adaptation strategies used for the selected species / ecosystems and could act as a model for other species / ecosystems.

**Project number:** 23

**Project title:** What adaptation works for biodiversity?

**Objectives:**

- What aspects of landscape porosity are achievable in pursuit of other land-use goals?
- What are the limits to adaptation by manipulation of a protected area?
- What do people value about biodiversity?

**Costs:** Need some costs to be added

**Overview:**

How good are the possible adaptation actions and what guidance can we give to those responsible for adapting the practice of conservation of biodiversity? e.g, provision of wildlife corridors or the creation of a more "permeable" landscape has a good theoretical potential to make populations more resilient and to provide a poleward migration route, but, do they work, and for what species? What aspects are useful? What lessons can be learned from existing examples? What are the the costs, and are there any dual use benefits? Other tools of which we are pretty ignorant include: interference with existing protected sites to increase utility to key species; suppression of alien invaders; translocation of whole habitats; creation of shadow sites; facilitation of genetic flow; introduction of more southerly genotypes; acceptance and valuation of alien biodiversity.

**Assessment scores:** **1 (H), 2 (H), 3 (H), 4 (M), 5 (H), 6 (U)** **HIGH PRIORITY**

**Comments:** A project aiming to bring together stakeholders to assess how practical theoretical suggestions for adaptation really are. There is much ecological theory about the value of permeable landscapes and corridors allowing species to move as a result of climate change. However corridors and permeable landscapes may also increase the risk of invasion by aliens and non-native species which may damage native biodiversity. While the value of permeable landscapes and corridors has been assessed via models there has been little experimental work on this topic. This programme should include literature reviews, mathematical modelling, field studies and experiments.

## 10 Genetic conservation

This programme comprises a single project (24):

| | |
|---|---|
| **Project number:** | **24** |
| **Project name:** | Will local genetic adaptation within species limit adaptation to climate change? |
| **Objectives:** | • To test whether the eggs and chicks of cold-climate individuals survive and grow as well as locally adapted individuals;<br>• to test whether post-fledging juvenile survival cold-adapted individuals are affected by living in a warm climate zone (with different food supplies and habitats);<br>• to test whether recruitment rates of cold-adapted individuals is affected by living in a warm climate zone (with different food supplies and habitats);<br>• to test whether recruitment rates of cold-adapted young are lower in warmer climate zones because of poorer survival and poorer mating success, due to poorer body condition as a result of different environment and food supplies. |
| **Costs:** | £100-500K |
| **Overview:** | **It is likely that further** molecular research will be needed, to establish which genotypes are better able to adapt to climate change, e.g. in forestry, southerly species are better able to adapt than northerly ones. One aim is to experimentally test whether populations in currently colder parts of a species' range will be able to cope with climate change towards that found in the warmer parts of its range. |
| **Assessment scores:** | Need assessment scores to be added |
| **Comments:** | While this is acknowledged as being a good project, it could equally be applied to invertebrates, since these have shorter generation times. Following this, it would be possible to build up to addressing other taxa (e.g. this research could use annual plants, although transplant experiments have been done for many decades now). Overall, there are real concerns about the tractability of this project as it stands. |

## 11 Atmospheric chemistry and pollution

This programme is made up of two projects (25 and 26):

**Project number:** 25

**Project title:** Carbon dioxide: feedbacks in natural and anthropogenic systems and implications for adaptation and mitigation strategies

**Objectives:**

- What is the current state of knowledge about the storage, cycling and release of carbon dioxide in natural (biological and physiographic) systems and anthropogenic (land and water management) systems? (compiled and publicly available electronic datasets, e.g. electronic mapping schemes);
- In the context of $CO_2$ feedbacks, what complementarities and conflicts exist between the management of land and water for biodiversity benefit and for human benefit (e.g. food and energy production; water storage)?
- What knowledge gaps are preventing the development of fully integrated climate adaptation and mitigation strategies based on climate-sensitive land and water management principles (biodiversity, ecosystems, agri-environment, water resources etc)?

**Costs:** Costs need to be estimated

**Overview:** To review the existing evidence base and identify knowledge gaps to be filled through new research.

**Assessment scores:** 1 (H), 2 (H), 3 (H), 4 (M), 5 (H), 6 (U) HIGH PRIORITY

**Comments:** This project links to the Defra Soil and Defra Natural Resource Strategies. Valuable, but in part already carried out by IPCC and NERC work.

**Project number:** **26**

**Project title:** Integrated projections of climate change, atmospheric pollution and terrestrial ecosystem response.

**Objectives:**

- To perform simulations of the Hadley Centre Global Environment Model (HadGEM) including interactive atmospheric chemistry, aerosols and vegetation, driven emissions of greenhouse gases and aerosols, and also emissions and transport of atmospheric pollutants which do not directly affect the climate but which do affect ecosystem directly (e.g. N compounds). All emissions would be consistent with the SRES scenarios as used by IPCC for future climate change projections;
- To assess the combined, synergistic impact of changes in climate and atmospheric pollutants on UK vegetation using the Met Office vegetation model MOSES and/or the community land surface model JULES ("joint UK Land Environment Simulator"), to inform assessments of impacts on biodiversity;
- To provide self-consistent projections of climate and atmospheric pollutant concentrations for additional work by others in this and other sectors, as part of a strategy to facilitate future policy-relevant work.

**Costs:** Costs need to be estimated

**Overview:** This is a cross-sectoral project, and it can be argued that it is not strictly biodiversity-focused.

**Assessment scores:** Need scores adding here

**Comments:** Add comments

# Appendix 2

## Recommendations of the meeting of the European Platform for Biodiversity Research Strategy, held under the UK Presidency of the EU, Aviemore, Scotland 2nd – 5th October 2005

CLIMATE CHANGE AND BIODIVERSITY CONSERVATION: KNOWLEDGE NEEDED TO SUPPORT DEVELOPMENT OF INTEGRATED ADAPTATION STRATEGIES

### I – Knowledge and action

**Climate change is being driven by human activities, and will accelerate despite current mitigation efforts.** ***Having reviewed the available scientific evidence, the participants at this meeting conclude that:***

***(a) climate change poses an immediate challenge to the target of halting biodiversity loss in Europe, and to the successful implementation of Natura 2000, for the following reasons:***

- there is firm evidence of biological responses to climate change: changes in flowering dates, arrival of migrating birds and fish; these and other phenological mismatches may disrupt ecosystems.
- there is strong evidence that the distribution of many species has responded to climate change. Very many species, however, are unable to disperse sufficiently rapidly to adapt to climate change in this way, especially in systems with low connectivity.
- there is evidence of changes in the composition and structure of communities and habitats, and in the habitat requirements of some species, including some protected species, pests and disease vectors.
- ecosystem processes and services are probably also altering as a direct result of climate change. Other drivers of biodiversity loss may exacerbate the rate and extent of these alterations and their reduction would offer the possibility of adaptation strategies.
- climate change may therefore stop us reaching site, regional, national and international conservation objectives. Furthermore, ecosystem goods and services, and their socio-economic benefits, will be put increasingly at risk.

***(b) actions should be taken to:***

- raise awareness of the impact of climate change on biodiversity and the need for adaptation policies and programmes in Europe. Monitoring of phenological phenomena can help to raise public awareness while providing early warning of the capacity of species to adapt to climate change.
- exploit existing knowledge to facilitate the natural dispersal of species, including habitat connectivity and ecological networks.
- review conservation targets in protected areas in the light of likely climate change impacts and the role of ecological networks for adaptation.
- implement the CBD Ecosystem Approach in developing large-scale, long-term adaptation and mitigation strategies to climate change.
- develop, and when available implement, dynamic adaptive conservation strategies integrating site and landscape/seascape-based approaches.

**II – Knowledge Gaps**

***To support the above actions for adaptation, the participants at this meeting recommend that immediate steps are taken by relevant funding bodies, institutions and researchers to address the following gaps in knowledge:***

*Quantifying climate change impacts on species, habitats and ecosystems*

- **improve our understanding of the effects of climate change on biodiversity as it acts through changes in the physical and chemical environments.** This requires monitoring of abiotic factors and interactions with other drivers, at a range of spatial and temporal scales. Key features in terrestrial environments include $CO_2$, land use and nitrogen; and in marine environments, temperature, salinity, stratification, pH, currents, upwelling, stability and wave regime events.
- **quantify and forecast the responses of genotypes, species, habitats, ecosystems, landscapes and seascapes at all relevant spatial and temporal scales.** This requires: (1) enhanced understanding of the underlying mechanisms driving, and being driven by, these processes, (2) greater knowledge of the interactions among climate change and ecosystem components, structure, function and services; (3) improved quantitative comparison of observational, experimental and modelling approaches; (4) extended open access to data.
- **improve understanding of the capacity of species and ecosystems to adapt to climate change.** This should include assessment of the sensitivity and vulnerability of species and habitats, and consequences for ecosystem functions.
- **increase research efforts to develop methods to restore, maintain or improve the ecological functioning of protected areas, landscapes and seascapes** for biodiversity conservation, and increase the coherence of Natura 2000 and other protected area networks. Develop strategies to increase ecosystem resistance and resilience.

*Understanding socio-economic aspects of adaptation strategies*

- **further develop methodologies for evaluating adaptation and conservation policies**. Refine methods for taking into account the socio-economic aspects of ecosystem goods and services, including consideration of the ethical, epistemological and methodological issues inherent in valuation of the natural world, and the ways in which valuations differ across stakeholder groups, cultures, space and time.
- **improve understanding of the ways in which human factors influence the effectiveness of adaptation policies.** Research is needed to understand how governance structures and human perceptions, values and attitudes impact on policy effectiveness, and to support development of improved systems of governance, including for seas and coasts, taking into account ecosystem goods and services.

*Understanding interactions between biodiversity and sectoral adaptation*

- **quantify the impacts on biodiversity of existing and proposed adaptation policies** at relevant local, national and regional levels and temporal scales, through interdisciplinary and cross-sectoral research.
- **better understand and utilise the potential for biodiversity to contribute to successful adaptation to climate change across all sectors**. This includes consideration of less intensive and more natural management of land and sea in providing opportunities for adaptation.
- **improve understanding of the impacts of climate change and biodiversity loss on human health and well-being.**

*Providing adaptation policy advice*

- **develop and test robust headline indicators** of climate change impacts on biodiversity;
- **develop and implement means to incorporate learning from experience** through systematic, iterative evidence-based, experimental and visionary processes to review legislation, policies and practices;
- **develop methodologies to reassess and define appropriate management units** matching scales of ecological processes, in particular in the context of rapidly changing seas and coasts;
- **and further develop principles, legislation, guidelines, and practical techniques** for management of land and sea, sectoral adaptation, and spatial planning**.**

**III – Knowledge Transfer**

***The participants at this meeting are concerned that ineffective transfer of scientific knowledge is limiting the implementation of the adaptation strategies that are needed urgently to conserve biodiversity in the face of rapid climate change and therefore recommend actions are taken to:***

- improve access to scientific data and information, ensuring that data is transformed into useful products for policy makers and other target audiences; using and further developing existing facilities, e.g. the CBD Clearing House Mechanism, GBIF, CORDIS, EIONET[1].
- Promote, acknowledge and implement interdisciplinary global change research agendas involving a wide range of research and stakeholder communities, to stimulate exchange of ideas at the planning and delivery stages.
- develop tools to facilitate communication within and between sectors, ministries and institutions, and especially between climate change and biodiversity research and policy communities.
- establish mechanisms for effective communication to multiple stakeholders of the impacts of climate change, including the clear presentation of risk and uncertainties, and corresponding adaptations.
- engage stakeholders by raising awareness, understanding attitudes and sharing information, including participatory approaches to data collection and the shaping of adaptation strategies.
- encourage, support and train scientists to communicate with different audiences, including through participatory approaches.
- further increase the impact of scientific research by using communications and media specialists from outside the scientific community.
- improve the processes used to identify and overcome barriers to knowledge transfer within and between all sectors and between developed and developing nations, develop effective mechanisms for knowledge transfer, and review the effectiveness of existing science-policy interfaces.

[1] Global Biodiversity Information Facility, Community Research and Development Information System, European Information and Observation Network

## Appendix 3

## Membership of the UK BRAG Climate Change Adaptation Research Priorities sub-group

| | |
|---|---|
| Richard Ferris | JNCC/BRAG Secretariat |
| Andrew Stott / Helen Pontier | Defra |
| Michael Usher | University of Stirling |
| John Hopkins | Natural England |
| Clive Walmsley | The Countryside Council for Wales |
| Joanna Drewitt | SEERAD |
| Matt Frost / Steve Hawkins | The Marine Biological Association |
| Allan Watt / Ruth Mitchell | CEH, Banchory |