Testing the effectiveness of climate change adaptation principles for biodiversity conservation

Natural England's summary and perspective on the project

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Introduction

Climate Change is a threat to the conservation of ecosystems, the biodiversity they support and the benefits they provide to people. This much has been widely recognised and the evidence continues to grow, with impacts such as changes in species distributions and community composition starting to emerge (DEFRA, 2012; Natural England 2012). The questions is how to respond to this threat, how to take advantage of any opportunities that climate change presents for conservation; in other words how, to adapt to climate change?

Adaptation is defined by the Intergovernmental Panel on Climate Change as *adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.* (IPCC 4th Assessment report Working Group 2 Glossary www.ipcc.ch/pdf/glossary/ar4-wg2.pdf. Over the last decade, various sets of principles have been identified to guide climate change adaptation for conservation. Heller and Zaveleta (2009) reviewed 113 scientific papers which made recommendations of this sort, and the number has continued to grow since then. Conservation agencies, NGOs and government departments have also been active in developing adaptation strategies in many countries (Mawdsley *et al.*, 2009) including the UK and England specifically (Mitchell *et al.*, 2007).

Within the UK conservation community, the most widely quoted sets of adaptation principles are those produced for the UK Biodiversity Partnership (Hopkins *et al.*, 2007; Table 1) and the England Biodiversity Strategy (EBS) (Smithers *et al.*, 2008; Table 2). The UKBP principles focus on guidance for conservation practice; the EBS incorporate these into a wider context. At the present time in England there is a considerable emphasis on developing coherent and resilient ecological networks, following the recommendations of the Making Space for Nature Review (Lawton *et al.*, 2010). These recommendations, which have been picked up in the white paper 'The Natural Choice' (HM Government 2011) and the new England Biodiversity Strategy 'Biodiversity 2020' (DEFRA 2011), focus on the concept that protected sites need to be 'bigger, better, more and joined'. This message is consistent with recent thinking on climate change adaptation and presents a good opportunity to accelerate progress towards climate change adaptation.

The various sets of adaptation principles are based on sound ecological theory, but there has been little practical testing or assessment of which approaches work best in particular, real - life circumstances. Without stronger empirical evidence of this sort it is difficult to translate high level principles into practical initiatives on the ground and to prioritise scarce resources. We established this project to start the process of testing and evaluating climate change adaptation principles.

The UK is fortunate to have a number of long term monitoring datasets which allow changes in populations to be identified and relationships to a range of habitat and landscape variables identified. Two of the best datasets are for birds and butterflies with wide geographical coverage, long time series and annual data. The long time series allow us to test the responsiveness of species to year-to-year variations in the weather, long-term climatic trends and one-off climatic extremes, all elements of sensitivity to climate change.

On the basis of ecological theory encapsulated in the adaptation principles we would expect this sensitivity to be moderated - and thus resilience increased - by increasing size of habitat patches, site and landscape heterogeneity and connectivity of habitat patches. Spatial data from a variety of sources, including the Land Cover Map 2000, Habitat Inventory datasets and a grid based national hydrological model are available to test these hypotheses.

We contracted a consortium of the Centre for Ecology and Hydrology (CEH), British Trust for Ornithology (BTO) and AEA Ltd. to investigate relationships of population resilience and community composition with spatial and climate variables, working closely with specialists in Natural England. The following chapters in this report provide a full account of the analyses and their results.

Headline results

Perhaps the most striking result in this study was that the community composition of birds and butterfly species has been changing over recent decades consistent with impacts of a changing climate. Both groups show a shift towards species typical of warmer climates, but there is a contrast between birds and butterflies in the underlying cause. In birds there has been a significant decrease in the abundance of birds adapted to cool climates, whilst for butterflies, the change has been an increase in warm adapted species. These findings add to the weight of evidence that climate change is having important ecological impacts and illustrates how the impacts can be both positive and negative.

Turning to relationships between species and site and landscape characteristics, there are more significant relationships than you would expect by chance indicating the potential for land use and management decisions to influence climate change resilience. This is encouraging in that it shows the potential for adaptation by manipulating land use and management to reduce the adverse impacts of climate change. The results are however complex and in some cases the signals are mixed. This is not unexpected given the number of potential relationships between driving and response variables and the wide range of species, habitats and landscapes encompassed by the analysis. Further analysis will be necessary to get a better understanding, including a detailed assessment of differences between different species as most of the analyses here deal with species groupings. Nevertheless, the present study has delivered some potentially important results.

The clearest result was that species typical of relatively cool climates have declined less where there is a large area of semi-natural habitat. This was true of both butterflies and birds and indicates that maintaining a sufficient area of habitat is a necessary starting point for climate change adaptation. It emphasises the ongoing importance of protecting and creating semi-natural habitat – the mainstay of conservation over many decades: climate change makes this more, not less important.

The abundance and interannual variability of populations of butterflies and birds was influenced by the area of particular habitats. Some of these results are not surprising, for example bird density is higher, and interannual variability lower, in areas with high woodland cover and the opposite where arable land predominates. Others are more interesting. The observed beneficial effects of arable land on butterfly populations for example presumably reflects the importance of hedgerows and other field margin habitats and is a reminder of the importance of the agricultural environment for some aspects of biodiversity. Areas with a relatively high proportion of urban land cover had relatively low interannual variability in populations of both groups, implying greater resilience to climatic fluctuations. We do not know the reason for this, although we may speculate on factors which may be important such as the supplementary feeding of garden birds and watering of gardens in dry summers or it could simply be that more climate sensitive species have already been lost from these places. The role of urban and suburban habitats needs to be looked at more closely in the context of climate change adaptation.

Habitat and landscape heterogeneity is an issue which is of considerable current interest for climate change adaptation of conservation. Heterogeneity has a number of aspects. Variation in topography provides a greater variety of microclimates (e.g. north facing slopes are cooler than south facing slopes) and increases the chances of suitable conditions being maintained at a small scale, despite climate change. Heterogeneity in vegetation structures similar provides a diversity of microclimates and potential niches. Different habitats can have a similar effect, for example woodland edge may provide shade to grassland species and also increases the chances of alternative food sources. Different soils and catchment characteristics will create a diversity of soil moisture conditions which may buffer species from the effects of drier summers and wetter winters, which are expected from climate change projections for the UK. The results show some evidence of the beneficial effects of heterogeneity: a diversity of habitats at both site and landscape scale was associated with greater stability of butterfly populations. There was however little evidence of heterogeneity effects on bird populations and few topographical effects on butterflies, contrary to some earlier research. Much may depend on individual species' habitat requirements and more detailed study may reveal clearer signals.

The role of ecological networks and particularly connectivity between sites, is a high priority issue at the moment. Greater connectivity of habitat patches should allow mobile species to redistribute to cooler places during warm conditions. It should also allow the functioning of metapopulations in which populations in adjoining patches can interchange individuals. This project did find significant effects of habitat configuration on population density and stability, although results were mixed and highly contingent on the configuration metric tested. Greater connectivity might be expected to aid recovery from an extreme event such as a drought. However, this project did not find consistent relationships across species for the sensitivity or recovery of populations from drought events. More detailed investigation may well reveal strong relationships between some species populations and some aspects of connectivity of habitats. It is does however sound a cautionary note about making generalisations about the benefits of connectivity.

Application and next steps

This work is part of a process of developing the evidence base to make sure that ecological networks are developed in ways that promote their resilience to climate change and thereby ensure their long-term value.

Ecological networks and the relationship between protected sites and the wider landscape are important issues for conservation and land management and are a priority in England at the present time with the establishment of Nature Improvement Areas (NIA). Climate change is also high on the agenda with a National Adaptation Programme (NAP) being developed for publication in 2013. Another important dimension to this is the support for agrienvironment schemes provided by the Rural Development Programme for England under the Common Agriculture Policy, of which climate change adaptation is an objective. In recent years, the largest source of funding for environmental management and habitat creation over much of England has been the Environmental Stewardship Schemes. Under the Higher Level Scheme in particular there is considerable scope to target resources to the places and options which are likely to deliver most benefit and we are working to factor climate change adaptation into the decision making process of farmers and land management advisors.

The finding that species typical of cooler climates have survived better in areas where semi-natural habitat predominates, reinforces the ongoing importance of protected areas and support for maintaining extensive land management systems. One of the basic tenets of climate change adaptation has been to reduce other pressures on species and this supports that principle.

Another implication of this finding is that the creation of semi-natural habitat will be beneficial to maintaining biodiversity in future climates – assuming the habitat produced is of the necessary quality. But where is it best to target habitat creation? Should existing areas of semi-natural habitat be expanded (larger patches) or should new patches be created to increase the heterogeneity of the landscape or connectivity between patches be maximised? This study provides evidence that these decisions do matter, but does not provide easy generalisations. Local knowledge, expertise and a clear understanding of the objectives for habitat creation in a particular place will be essential to making the best decision. Further research is, however, important to develop a better understanding to guide decision making.

There are a number of immediate priorities for follow-up research on these datasets. In particular species- specific analyses will help to identify more clearly which factors matter most to which species and to allow contrasts between different functional types. This will in turn allow more habitat-specific understanding. We expect that this will allow a better understanding of the relative merits of patch size, heterogeneity and connectivity in different contexts. There are also good opportunities to use a similar approach to investigate whether agri-environment scheme options have increased aspects of population resilience. Another area which requires more work is the role that condition of sites plays in determining population resilience to climate variables, we would expect a site in ‘favourable’ condition to support larger and therefore more resilient populations, but this is as yet untested.

A fundamental limitation of the present study is its focus on birds and butterflies. They were selected for analysis because of the quality of the data sets available, however, caution needs to be exercised in extrapolating the results from these groups more widely. In particular both birds and butterflies are relatively mobile groups of species. Future work will need to investigate the relevance of the findings to other groups.

Another issue which will require a different approach, is that large scale analyses of the sort reported here, do not lend themselves to testing the importance of small scale variation, for example in sward height and soil moisture. Much site scale heterogeneity cannot be adequately assessed by national scale datasets and will require a more targeted follow up in specific locations.

The establishment of the NIAs provides an opportunity to test whether the enhancements they bring have an impact on the resilience of populations. Building in appropriate monitoring from the start and identifying appropriate control areas would allow the opportunity to test some of these ideas in a rigorous experimental way.

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