Summary for policy makers

Introduction

- Climate change is having an increasing impact upon biodiversity. Species ranges have shifted in response to warming, whilst the timing of biological events has also changed\(^1\). There has, however, been less synthesis of the response of species’ populations to climate change.
- The first BICCO-Net project assessed the impact of climate change on UK biodiversity, by analysing long-term monitoring data on terrestrial taxa to 2008.
- In this second phase of the project we have extended this analysis to 2011, and also examine changes in the freshwater environment.
- Analysis linked population changes to variation in temperature and precipitation, to identify species most likely to be affected by climate change.
- The results were used to identify the impact of climate change upon long-term population trends.
- A number of potential climate change indicators were developed from these results and are reported.

Policy context

- Species monitoring across habitats and taxa should be coordinated (English Biodiversity Strategy, UK Biodiversity Partnership).
- Thorough analyses of causes of change are required to identify climate change impacts and inform adaptation (Hopkins et al. 2007, Smithers et al. 2008).
- The UK Government needs to develop a system to monitor the effects of climate change on the abundance of vulnerable taxa (www.ccra.defra.gov.uk).
- The recently published climate change report cards (www.lwec.org.uk/resources/report-cards) partly fill this gap, and reported many of the first BICCO-Net project results.
- The National Adaptation Programme also requires evidence on climate change impacts to inform the Natural Environment theme.

Terrestrial environment

Models indicate that climate change may largely be responsible for large-scale reductions in the abundance of many moth populations. The garden tiger moth is one species particularly sensitive to the warm, wet winters particularly linked to population declines.

- Climate change appears to have significantly contributed to national declines in moth populations and to increases in aphid populations. General changes in the abundance of birds, butterflies, and mammals were not strongly related to climate change.
- Warmer winter temperatures enhance resident and short-distance migrant bird populations, but warm, wet winters have negative effects on butterflies and moths.
- Warmer spring and summer temperatures may boost aphid, butterfly and moth populations. The sensitivity of these species to climatic variables at different periods differs with life-history, overwintering strategy and flight period.
- Individual populations at sites towards the cooler north of the UK showed greater sensitivity to climatic conditions.

\(^1\) http://www.lwec.org.uk/resources/report-cards/biodiversity
Plots indicating how the response of aphid, bird, butterfly, mammal and moth populations to temperature and precipitation varies through the year, relative to surveys in year $t$. Solid lines show the mean positive (above the line) and negative (below the line) response of populations to each climate variable. Shading shows a greater proportion of species showed a particular response than expected by chance.

**Freshwater environment**

- Trends in the occurrence of aquatic invertebrates can be largely explained by improving water quality, rather than climate change, which have allowed pollution sensitive upland species also associated with cooler temperatures, to expand into lowland waterways.
- Shorter-term fluctuations in the occurrence of these groups vary with discharge and temperature, suggesting that the macroinvertebrates remain sensitive to climatic impacts.
- Analysis of annual fluctuations in the abundance of upland aquatic invertebrates showed they tend to be negatively affected by warm temperature, particularly in the summer and autumn. Variation in precipitation had less consistent effects across taxa.
- Similar analysis of aquatic invertebrates from more lowland contexts, indicate species responses to temperature and precipitation vary with ecological traits, such as tolerance to temperature, water flow and pollution. Significant contrasts in response with respect to feeding group also suggests that predatory species may be most sensitive to warming.
Indicators

- Computer simulations suggest that a range of potential climate change indicators show similar sensitivity to climate change, but may also be affected by changes in non-climatic environmental change.
- When applied to the UK, indicator trends were largely positive for birds (broadly matching expectation) but negative for butterflies (opposite to expectation). Indicators for aphids and moths showed strong fluctuations and non-significant positive trends.
- Cold-associated bird species tend to be located in northern and upland areas in the UK. Relative increases in the abundance of these species, as measured by changes in the community-temperature index (CTI), have been greatest across the Highlands and west coast of Scotland.

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Achievements

- This project has developed new statistical methods to provide the most comprehensive single assessment of the impacts of climate change on UK biodiversity population trends that has been conducted to date.
- Long-term population trends of terrestrial species were related to climate change, emphasising the potential contribution of climate change to moth population declines and to aphid population increases.
- A tendency towards bird population declines and mammal population increases were largely unrelated to climate change, as found previously for farmland birds.
- The importance of non-climatic changes was highlighted by analysis in the freshwater environment, which showed how changes in water quality have exceeded climate change in driving long-term trends in occurrence.
- Shorter-term fluctuations in occurrence, and annual population changes in both upland and lowland contexts, were more closely linked to temperature in particular, and precipitation. Cold-associated upland species of fast-flowing waters, and predatory species, appeared those most sensitive to warming.
- The simple reporting of climate change indicators is possible, but indicators require careful interpretation given the additional influences of non-climatic factors on species’ populations. A non-significant indicator trend may mean that populations are insensitive to climate change, or that the impacts of climate change are being masked by other changes.

Conclusions

There is growing evidence that climate change is affecting UK biodiversity populations. BICCO-Net has used long-term monitoring data to quantify this impact. Continued maintenance and development of long-term ecological monitoring programmes, coupled with a rolling programme of rigorous statistical assessment, especially in relation to climate change, is essential for the reliable recording and attribution of biodiversity change to climate change. The ecological understanding this provides is key for the development of appropriate priorities within adaptation strategies.

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