Reducing uncertainty in species’ responses to climate change

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According to the fifth assessment report of the Intergovernmental Panel on Climate Change, warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. In the Northern Hemisphere, 1983–2012 was likely the warmest 30-year period of the last 1,400 years (IPCC 2013). Although some evidence for ecological change associated with recent warming is available from all biomes, general assessments of species’ responses to climate change remain associated with great uncertainty (Parmesan, 2006; Post et al., 2009b).

Early efforts to understand how species would respond to climate change were using historical data collected for other reasons than to study the ecological effects of climate change (Primack and Miller-Rushing, 2012; Sparks, 2007). As a consequence, geographical bias remains a pronounced feature of the literature on species responses to climate change. Studies from North America, Europe and Russia are overrepresented and high latitude ecosystems are underrepresented (Høye et al., 2007; Parmesan, 2006).

Studies of species’ responses to climate change are increasing in temporal and spatial extents (Devictor et al., 2012; Post et al., 2009a) and focus on understudied species groups (Gange et al., 2007; Hickling et al., 2006; Høye et al., 2009). Ultimately, a major aim of the study of species’ responses to climate change is to identify time periods, regions and species exhibiting particularly rapid responses. The special column of Current Zoology on species’ responses to climate change brings together studies exemplifying efforts to meet this overall aim. In this editorial, I briefly describe key research frontiers of the field placing each study in their relevant context.

1 Types of Species’ Responses to Climate Change

Three main types of species’ responses to climate change are commonly reported: changes in abundance, distribution, and phenology, although arguably these phenomena interplay with each other to determine species responses to climate change (Parmesan, 2006). Evolutionary responses albeit important are not considered here. In addition, the interactions among species can shape the effect of climate change on species and communities (Tylianakis et al., 2008; Wisz et al., 2013). A distinction is, therefore, often made between direct effects of climate change altering the behaviour, physiology or demography of species and the indirect effects where a climate response in one species has cascading effects on the food web (Roslin et al., 2013). The paper in this special column by Bêty et al. (2014) addresses such indirect effects on abundance by providing a first assessment of how various environmental parameters affect biomass removal by herbivores including greater snow geese Anser caerulescens atlanticus. In this system, the authors are able to demonstrate how the indirect effect of climate on primary production via herbivory is fading, and the direct positive effect of warming on wetland plants is becoming the key driver of variation in primary productivity.

Distributional changes were among the first reports of ecological responses to climate change. Species are moving upwards (Lenoir et al., 2008) and northwards (Parmesan et al., 1999) in response to climate change, but our ability to predict the rate of change is hampered by several constraints. Most importantly is probably our limited understanding of the role of past glaciation events on current species distributions and the capacity of species to track their environmental niches (Svenning and Skov, 2004; Wisz et al., 2013). Climate change is providing opportunities for natural experiments, where community assembly processes can be studied in new habitats appearing in front of melting glaciers. With climate change, many northern environments are rapidly transforming from inhospitable snow and ice dominated areas into suitable habitat for plants and animals.
(Ingimarsdottir et al., 2013). The paper by Franzén and Dieker (2014) in this special column presents a detailed account of the species diversity of terrestrial arthropods at sites of different age since deglaciation in the vicinity of one of the fastest melting glaciers in Sweden and provides new insights into the colonization process for arthropod communities from the regional species pool following deglaciation. The paper by Sandin et al. (2014) in this special column addresses the critical challenge of comparing the sensitivity of ecological communities to climate change between regions with different species pools. A solution to this problem is to compare traits expressed by the species in each assemblage rather than the response of individual species themselves. The authors develop an indicator of climate change sensitivity from multiple traits in freshwater invertebrates from Sweden. While the trait-based indicator is developed for freshwater habitats in Sweden, the same approach could be applied across larger geographical regions as well as for terrestrial and marine habitats.

The study of phenological responses to climate change began as reports of how first flowering dates or arrival dates of birds were becoming earlier and quickly moved on to link those changes directly to climate-related environmental predictors (Crick et al., 1997; Forchhammer et al., 1998; Menzel et al., 2006). Currently, there is much focus on the interruption of temporal synchrony between trophically linked organisms so called trophic mismatch (Miller-Rushing et al., 2010; Rafferty et al., 2013; Thackery et al., 2010). The paper in this special column by Fox et al. (2014) asks how plasticity in departure dates of Greenland white-fronted geese Anser albifrons flavirostris at wintering sites in Britain and Ireland affect the arrival and departure dates at a stopover site in Iceland. A diet shift at the stopover site is allowing this population to accumulate fat stores at a time of the year where traditional food resources are unavailable. The study points to the role of behavioural flexibility in species ability to avoid trophic mismatch by adapting to novel resources which may become available due to climate change. Trophic mismatch is also addressed in a first account of phenological responses to climate change in Arctic butterfly species presented in this special column by Hoye et al. (2014). The Greenland study area hosts two abundant butterfly species, which differ in their response to increasing temperatures. The study demonstrates that flight time duration of both species is becoming shorter possibly due to decreased overlap with floral resources.

2 Taxonomic and Geographical Bias in Studies of Species’ Responses to Climate Change

There is a strong taxonomic bias in the published results on species responses to climate change (Parmesan, 2006). Plant and bird studies predominate despite other taxonomic groups hosting most of the species richness (Mora et al., 2011). As pointed out by May (2011), the taxonomic effort is approximately divided 1:1:1 among vertebrates, plants, and invertebrates, whereas plant species are roughly 10 times, and invertebrates 100 times, more numerous than vertebrates. Yet species specific knowledge of phenology, occurrence or population dynamics is largely confined to a few charismatic groups of macro-arthropods (e.g. butterflies, dragonflies, hoverflies and bees). This special column presents three studies on arthropods and all of the studies are based on field observations in high latitude environments thus highlighting taxonomic and geographical knowledge gaps (Høye and Sikes, 2013; Post and Hoye, 2013). Clearly, five contributions to a vast research field like species’ responses to climate change will not remedy the publication biases. Hopefully this special column will, however, be a source of inspiration for the research community to take up the challenge of reducing taxonomic and geographical bias and thereby contribute to reducing uncertainty in the study of species’ responses to climate change.

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