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Species response to climate change – can the past inform the future?

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Background

Species response to historical climate change

Facilitating adaptation of species to the effects of climate change is a focus of conservation programs. Climatic variations through historical time have driven changes in biotic distributions, and understanding how species have responded to past climate change can help inform how they will respond to current and future change.

When climatic conditions become unsuitable for species they have several options for response. They can move to track their ecological requirements, they can persist in pockets of favourable habitat, or they may adapt to the changed conditions. If they are unable to respond in these ways they go extinct. Migration and persistence in refugia (areas of suitable habitat where organisms are able to persist during a period in which their wider geographic range becomes uninhabitable) are the most likely responses of species to climatic change.

Persistence in refugia

Western Australia is an ancient landscape with generally low geological relief. This means that if species had to move to keep track of their suitable habitat they would have to move large distances compared to areas with high topography where movement short distances up or down altitudinal gradients would allow them to maintain suitable conditions. The flat landscape provides few obvious areas that would have acted as major refugial areas where many species would have persisted. Ranges, and other geological features such as granite rocks, may have acted as major refugia during periods of inhospitable climatic conditions. But where did species in flat landscapes persist during arid conditions?

Granite rocks and ranges may have provided refugia under climate change. Photos C. Yates, D. Coates

Findings from phylogeography

The fossil record provides a visual demonstration of the change in biotic distributions over time, but is incomplete for most species. Range contractions and expansions, and repeated isolation through time also leave signatures in the genetic composition of current populations and species. These signatures can be visualised with modern molecular genetic technologies that analyse the spatial distribution of genealogical lineages (phylogeography). Phylogeographic patterns in many plant and animal species reveal that some species did contract to and expand from major refugia in the early part of the Pleistocene era (1.8–0.7 million years bp) when significant aridity developed. However, in the past 700 000 years when climatic changes became more extreme, most species show patterns of high levels of genetic divergence between local populations, indicating that they have persisted in patchy, localised refugia rather than moving long distances to major refugia. A few highly mobile species, such as birds, show patterns of recent expansion that would occur by tracking suitable habitat. Species that have persisted in localised refugia through historical climate change are not likely to respond to future climate change by migration. Persistence through changing climatic conditions also implies that species may have broader climatic tolerances than indicated by their current climatic envelope.

Heterogeneous landscapes provide a mosaic of habitats for persistence of species through climate change. Photos S. Van Leeuwen, D. Coates

Management implications

Persistence in localised refugia as the major response to climate change provides information on key mechanisms for facilitating future persistence. It highlights the significance of identifying areas that are likely to act as refugia under future changing climate. It also indicates the importance of maintaining a mosaic of habitats in heterogenous landscapes so that species can persist through changing conditions. Identification of refugia as priority areas for conservation is a key aspect of climate change adaptation strategies, and will be equally as important as establishing connectivity and ecological linkages. Persistence and resilience of species will be enhanced by facilitating continued action of dynamic evolutionary processes. Ensuring biodiversity conservation strategies capture the genetic diversity that may represent the adaptive capacity of species to respond to changing climates will be a key component of maintaining ongoing evolutionary processes.

Further reading:

Byrne M (2008) Evidence for multiple refugia at different time scales during Pleistocene climatic oscillations in southern Australia inferred from phylogeography. Quaternary Science Reviews 27: 2576-2585.
Byrne M. (2007) Phylogeography provides an evolutionary context for the conservation of a diverse and ancient flora. Australian Journal of Botany 55: 316-325.

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