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A metapopulation approach to predict species range shifts under different climate change and landscape connectivity scenarios

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ABSTRACT

Forecasting future species distributions under climate change scenarios using Ecological Niche Models (ENM) is common practice. Typically, these projections do not account for landscape connectivity and species dispersal abilities. When they do account for these factors, they are based on either rather simplistic or overly complex and data-hungry approaches. Here we apply a new approach for predicting species range shifts under different climate change and landscape connectivity scenarios that balances data requirements and output quality. The approach builds on the metapopulation concept to produce a dispersal model based on repeated simulations of stochastic extinction-colonization dynamics across multiple landscapes of variable connectivity. The model is then combined with an ENM to produce more realistic predictions of species range shifts under environmental change. Using the near-threatened Cabrera vole (*Microtus cabrerae*) as a model species and considering two contrasting climate change scenarios (B2 and A1b) and three scenarios of increasing landscape connectivity, we confirmed that model predictions based solely on ENM overestimated future range sizes (2050 and 2080) in relation to predictions incorporating both future climates and landscape connectivity constraints. This supports the idea that landscape change critically affects species range shifts in addition to climate change, and that models disregarding landscape connectivity tend to produce overly optimistic predictions, particularly for species with low dispersal abilities. We suggest that our empirically-based simulation modelling approach provides a useful framework to improve range shift predictions for a broad range of species, which is essential for the conservation planning of metapopulations under climate and landscape change.

1. Introduction

Ecological niche models (ENMs) based on climate envelopes are widely used to predict species' current geographical ranges and their potential shifts in response to climate change. These models provide useful information for assessing the overall conservation status of a species and for supporting conservation decision making (Peterson et al., 2011). However, a range of uncertainties related to the choice of the statistical model, variable selection, model range and emissions scenarios may influence the results of ENMs (Araújo and Guisan, 2006; Heikkinen et al., 2006; Pearson et al., 2006; Beaumont et al., 2008; Synes and Osborne, 2011). While increased emphasis has been given to the validation of statistical models and the development of ensemble approaches to account for such uncertainties (Araújo and New, 2007), ENM forecasts are still criticized for the assumptions made about dispersal, which range from unlimited to no dispersal (Heikkinen et al., 2006; Sinclair et al., 2010; Travis and Dytham, 2012). A further limitation of most ENM-based projections is that they generally ignore how landscape connectivity within climatically suitable areas may affect the way species modify their distribution ranges (Opdam and Wascher, 2004). It is thus likely that ENMs incorporating both dispersal limitation and landscape connectivity should provide more

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