Local dynamics slow the response of species ranges to climate change in eastern North American forests

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Abstract

The climate may be changing more rapidly than the rate at which tree species can migrate to track their optimal environment. Correlative species distribution models (SDMs), commonly used to predict the response of species distributions to climate change, often do not account for slow processes that might produce lags in the response to climate change. An alternative type of model based on metapopulation theory that analyzes patch-scale colonization and extinction (C-E) rates along an environmental gradient has been successful in describing species range limits in theoretical studies. Because the model is stochastic and dynamic, it is more robust to changes in the environmental gradient than static SDMs. We applied such a model to 21 of the most abundant trees in eastern North American forests, using repeated observations over a 40-year time scale to parameterize the C-E functions. We find that a model generating species ranges from C-E dynamics accurately predicts range limits for most species and that movement of current range limits has lagged behind climate change for most species. Additionally, we find that the rate of change in species distributions is more responsive to climate in the southern portion of species' ranges. Thus, as the climate warms, southern populations will likely go extinct more rapidly than northern populations will expand, leading to range contractions for many species.

Keywords: Climate Change, Forest Ecosystems, Species Distributions, Metapopulation Theory

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