Unexplained limits on species distributions. What do they mean for conservation?

Supervisors

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Project description

A major tool for planning conservation in response to climate change and biological invasions is to make climatic Species Distribution Models (SDMs). SDMs predict range contractions or expansions based on the principle that species distributions are predominantly determined by climate. Recent research by Dr Early suggests a fundamental flaw in this approach, as non-climatic factors appear to limit distributions more strongly than climate. This could render conservation based on climatic SDMs useless[1,2]. The studentship will address this flaw by measuring the importance of non-climatic range limitations such as competition, herbivory/predation, and habitat condition, and the propensity for evolution of climatic range limitations.

The project employs two key innovations. The first is a novel dataset: the comparison of plant species distributions between their native and human-introduced distributions[2]. The second innovation is an interdisciplinary approach that evaluates the importance of biotic interactions and evolution in determining distributions - factors that cannot normally be studied using SDMs. Growth and physiology experiments will be used to precisely measure range-limiting factors for a few exemplar species, and the wider generality of the results will be evaluated using computational analyses for hundreds of species globally.

Experiments will use several plant species introduced from Europe to the USA. In the USA these species have undergone niche shifts into climatic conditions that are very different to their native ranges. Thus, either these species' native ranges are not limited by climate, or rapid evolution of climate tolerances is much more likely than anticipated. The student will sample the European and USA ranges, and grow individuals in a variety of experimental climate conditions to ask whether niche shifts were caused by: (i) rapid evolution, or (ii) release from enemies or competitors present in the native range.

Computational analyses will employ SDMs and meta-analyses of climate-niche shifts across plant, mammal, and bird taxa globally. The student will ask whether such niche shifts (i) correlate with a decrease in pathogen or parasite loads or changes in phenological characteristics, (ii) occur disproportionately in species with traits that could make them particularly susceptible to range-limitation by biotic interactions, or (iii) could be caused by release from non-climatic environmental limitations, such as land cover, soil properties, and human habitat transformation.

The results of this project will be used to provide practical guidance for conservation following climate change

and biological invasions, improve the accuracy and interpretation of SDM predictions, and generate fundamental insights into biodiversity patterns.

1. Sax, D. F., Early, R. & Bellemare, J. Niche syndromes, species extinction risks, and management under climate change. *Trends in Ecology & Evolution* **28**, 517-523 (2013).

2. Early, R. & Sax, D. F. Climatic niche shifts between species' native and naturalized ranges raise concern for ecological forecasts during invasions and climate change. *Global Ecology and Biogeography*, online early doi:10.1111/geb.12208 (2014).