Phenotypic plasticity and extinction risk in South African plants: A reaction norm approach to species distribution modeling

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INTRODUCTION

- Phenotypic plasticity, the ability of organisms to change genetic expression patterns in response to the environment, is believed to be a potential source of adaptability for plants facing novel environments due to climate change.
- Ultimately, plasticity’s role as a source of adaptability is controversial, as it may incur fitness costs on plants.
- Here, a novel modeling approach is presented which incorporates plasticity into species distribution models as an improvement over typical ecological niche models (ENMs).

MATERIALS AND METHODS

To test the models developed for this study, we chose to use Pelargonium elongatum (Geraniaceae), a species of perennial sub-shrubs endemic to South Africa, and classified as “Least Concern” to conservation.

Leaves from wild P. elongatum plants in the sun and shade were sampled on August 15, 2010. Plants were also grown in the UConn research greenhouses from 2011-2012 in water-stressed/unstressed and sun/shade conditions, to measure the full range of plasticity displayed by the species. Plastic traits measured included specific leaf area (area/dry mass), and dissection index (area/perimeter)0.5.

RESULTS

- While the ENM climate envelope generally encompassed the ranges projected by the CA model, those ranges were consistently more constrained.
- Despite plasticity, extinction was projected in 8/27 of the CA scenarios (all by 2020).
- Overall species survival was most influenced by germination rate and adult survivorship, relative to the minimum habitat suitability cutoffs.
- The Cape Point area will be the most significant for protecting the species: eastern population did not persist in any of the 27 scenarios.

MODEL DESIGN

- Climate data for 2011-2080 was taken from WorldClim[2], and was also used to estimate the percent of plants in shade conditions (canopy gap %) [3].
- A general bioclimatic envelope ENM was created using general linear models (GLMs), which only explained 54.4% of the present species distribution.
- The alternative models were run as a spatially-discrete cellular automaton (CA) simulation incorporating phenotypes responding plastically to shade and climate, with seed production taken as a function of these phenotypes.

DISCUSSION

- Overall, 17 of the 27 models met the criteria for re-classification as Critically Endangered [5].
- Risk classification depended primarily on adult and seed survivorship, indicating more data is needed for those parameters.

CONCLUSIONS

- In this system, both climate envelopes and raw plasticity data underestimated species vulnerability; plasticity is unlikely to be able to overcome high mortality, nor is it likely to compensate for low landscape and metapopulation connectivity.
- Better demographic data on P. elongatum will be critical to the revision of its current risk status.
- Current data used to determine species’ conservation priority may dramatically underestimate extinction risk for species with similar ecological and demographic limitations.

LITERATURE CITED


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