Modeling Species Distributions to Support Assessment of Extinction Risks under Climate Change

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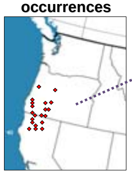
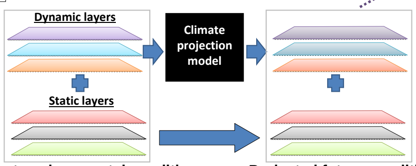
Background: Predicting Extinction Risks under Climate Change

Current occurrences



1. The geographic locations where a species is known to occur can be combined with information about the environmental conditions at those locations to create correlation-based models of the species' range. These models are then used to forecast how the range may change in the future under climate change



2. Present environmental conditions

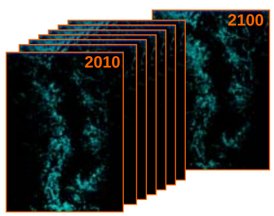
Projected future conditions

3. An important question is: what is the best way to combine dynamic variables that have been projected to future conditions with static variables.

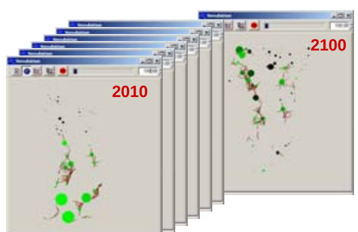
Species distributions are influenced by dynamic variables that are expected to change in the future (such as climate), as well as static variables that are either not expected to change significantly (e.g. soil type), or may change but for which future scenarios are not available (such as variables available from remote sensing).

The static variables can be (1) included directly in the model along with the dynamic variables, (2) used as a mask overtop of the distribution based only on the dynamic variables, or (3) excluded altogether. Here we compare and evaluate these different approaches for species distributions projected to future climate conditions.

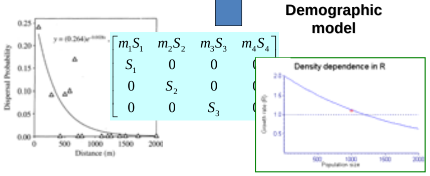
4. Future projected species habitat (time series of maps)



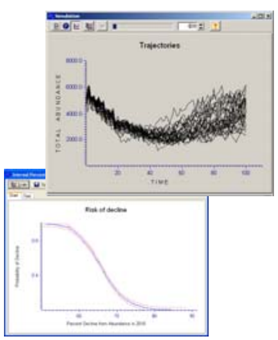
6. Metapopulation model with dynamic spatial structure



5. Demographic model



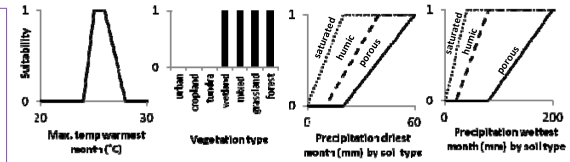
7. Extinction risk assessment



8. Synthesis across species to inform IUCN Red List process

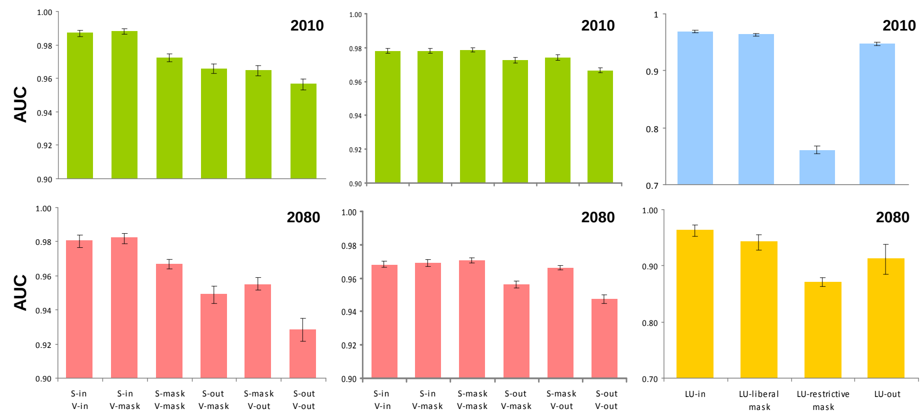
Methods

As part of the project to predict extinction risks under climate change, we tested methods of combining static and dynamic layers in modeling species distributions. We created simulated (artificial) species with different environmental requirements (see example on the right). We sampled locations from "true" distributions, and modeled present and future suitability using Maxent, with static variables included (**in** in figures below), excluded (**out**) or used as a mask (**mask**). We then compared future predictions to "true" distributions using AUC.



Habitat suitability is the product of the 4 suitability scores based on the above functions.

Results



In the above graphs, mean values for between the modeled suitability and true suitability are shown for three simulated species. The error bars show the standard deviation over the 100 model runs. Each bar shows a different fitted model, with static variables (soil, vegetation cover, and land-use) included in the model (in), excluded (out), or used as a mask. For details, see Stanton et al. (2011).

Conclusions and recommendations

For studies designed to predict future change in a species' habitat or distribution as a result of climate change, we recommend that:

- static variables that are highly correlated with climate variables, and which have only indirect influences on species distributions, such as elevation, be **excluded**;
- static variables that are known or suspected to interact with climate variables, such as soil, be **included in the model** as additional explanatory variables (i.e., as input layers);
- static variables that are not expected to interact with climate variables be either **included in the model** as additional variables, or **used as a mask** to remove areas that are not suitable;
- dynamic non-climate variables (e.g., those related to human land use) that are expected to change in the future be either **included in the model** as additional variables, or **used as a mask** to remove areas that are not suitable, even if future change in these variables cannot be predicted, and thus only the current maps can be used (if these variables are used as a mask, we recommend that the mask is not overly restrictive).

Next steps

1. Create habitat models for a set of amphibians and reptiles in North America and Madagascar, as time series of habitat maps using both dynamic maps (climate) and static maps (land cover, soil, hydrology, and other layers derived from remote sensing).
2. Add demographic models to create a dynamic metapopulation model for each species; assess extinction risks under climate change; and synthesize results across species to support the IUCN Red List process (see steps 5 through 8 in the figure on the left).

Acknowledgements

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