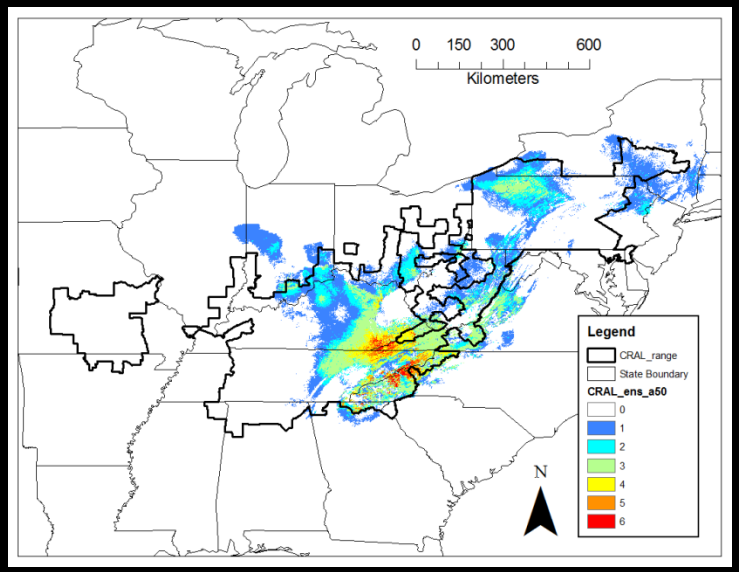
Distribution Modeling

Unit 3: Approaches to Vulnerability Assessment



A rose by any other name…

- Ecological niche modeling
- Element distribution modeling
- Predictive range mapping
- Habitat suitability modeling
- Climate envelope modeling

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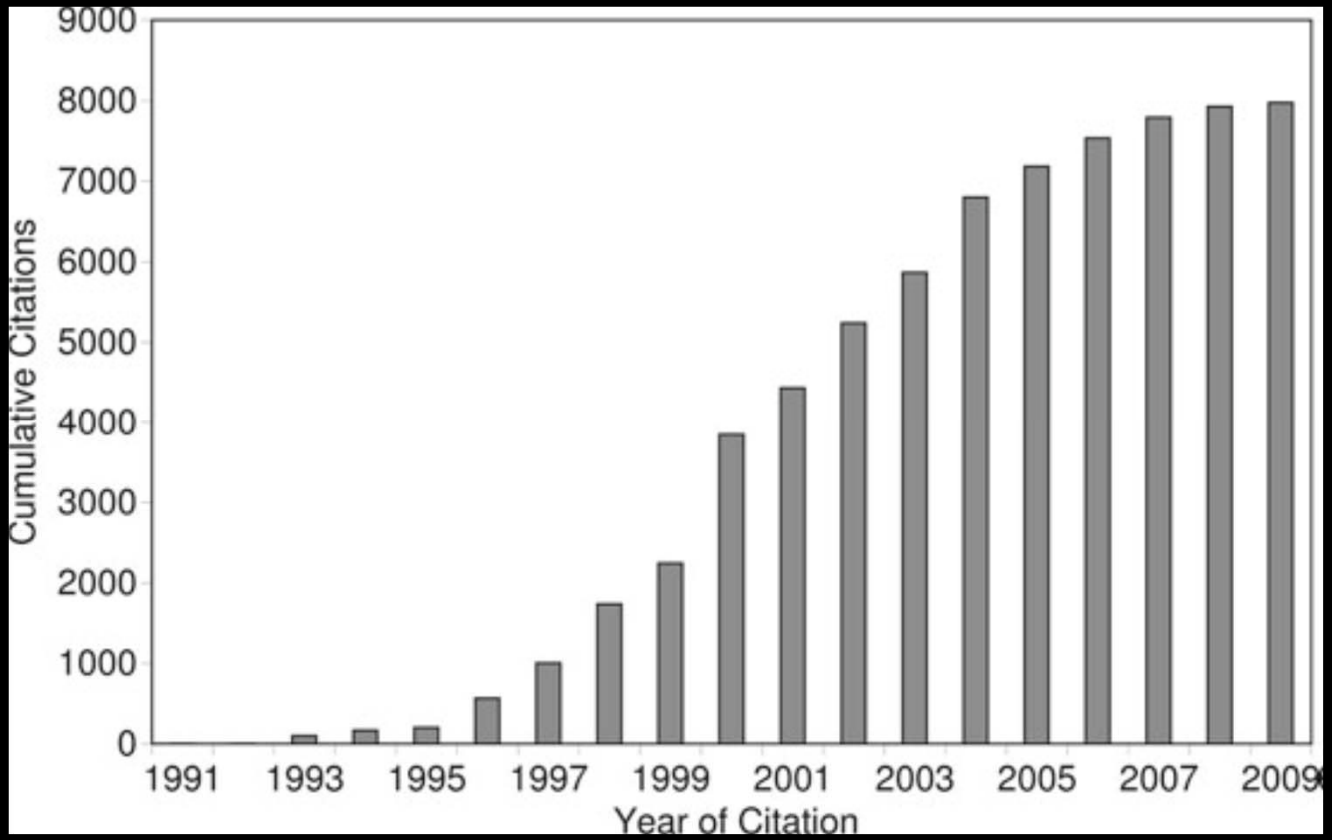
THE GOAL: capture species-environment relationships that characterize where the species can occur on the landscape

Species distribution modeling is widely used



From Johnson et al. 2012. in A.H. Perera et al. (eds.), *Expert Knowledge and Its Application in Landscape Ecology*

Methods for modeling species responses to climate change

- Forecasting distribution responses

  Correlative models:

  - Phenomenological
  - Relate current distributions to environmental variables

  Mechanistic models:

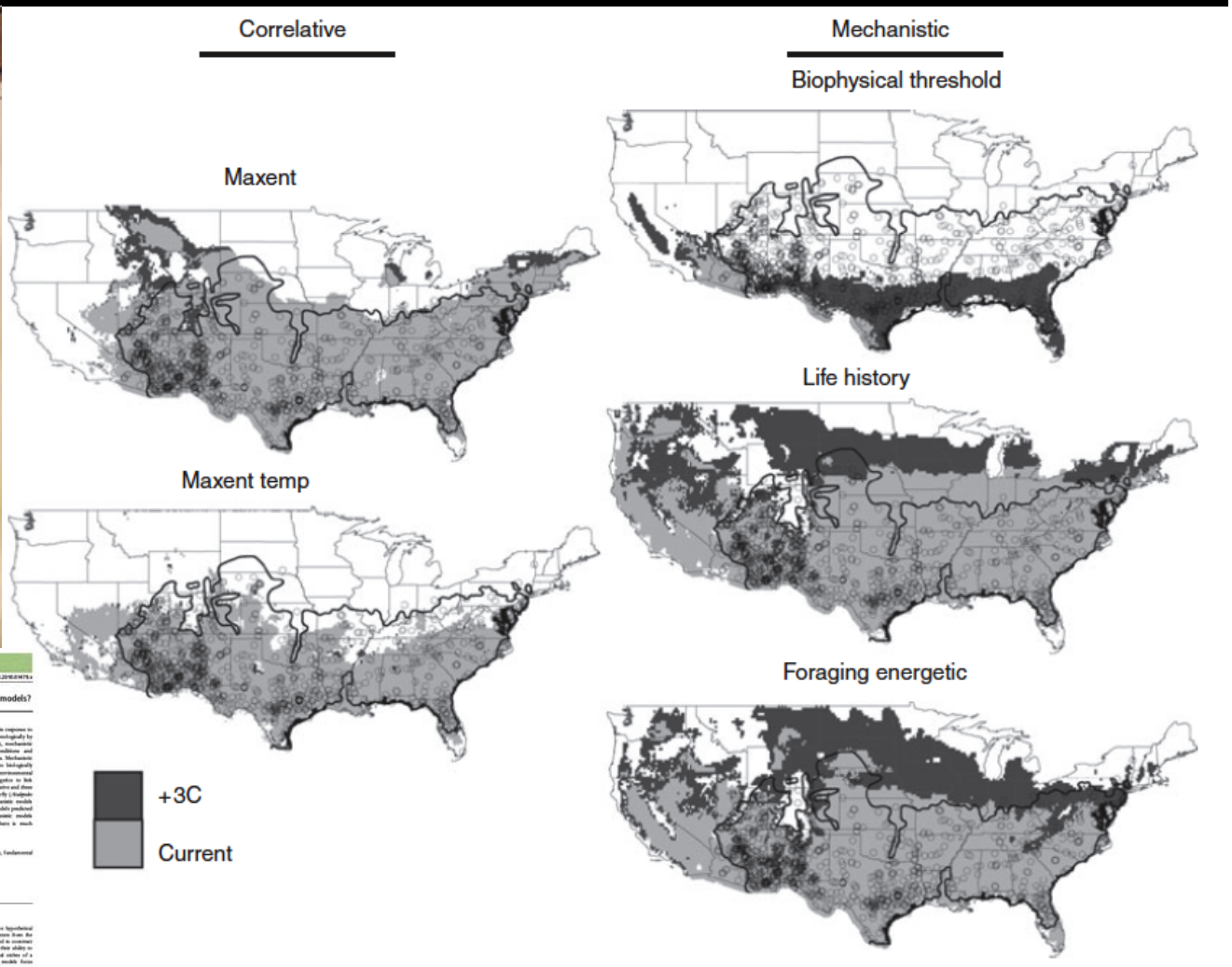
  - Use explicit relationships between environmental variables and organismal performance
  - Estimated independently of species current distribution

Methods for modeling species responses to climate change

ECOLOGY LETTERS

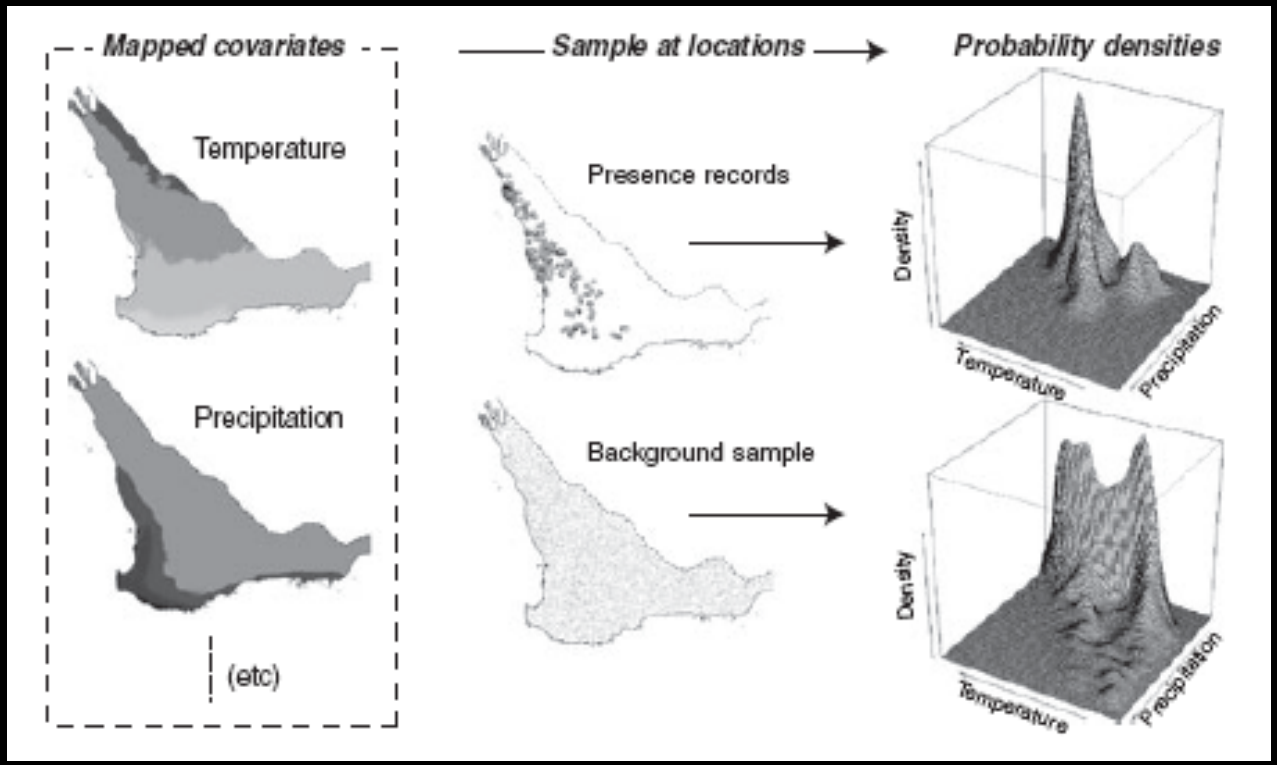
REVIEW AND SYNTHESIS

Can mechanism inform species' distribution models?



re 1 Range predictions for *Sceloporus undulatus* in current climates (light gray) and predicted range expansions following a uniform 3 °C
perature increase (dark gray). Localities (o) and the atlas range polygon are shown.

How can correlative distribution models contribute to a vulnerability assessment?



Current species - environment relationships are projected onto forecasted climate scenarios

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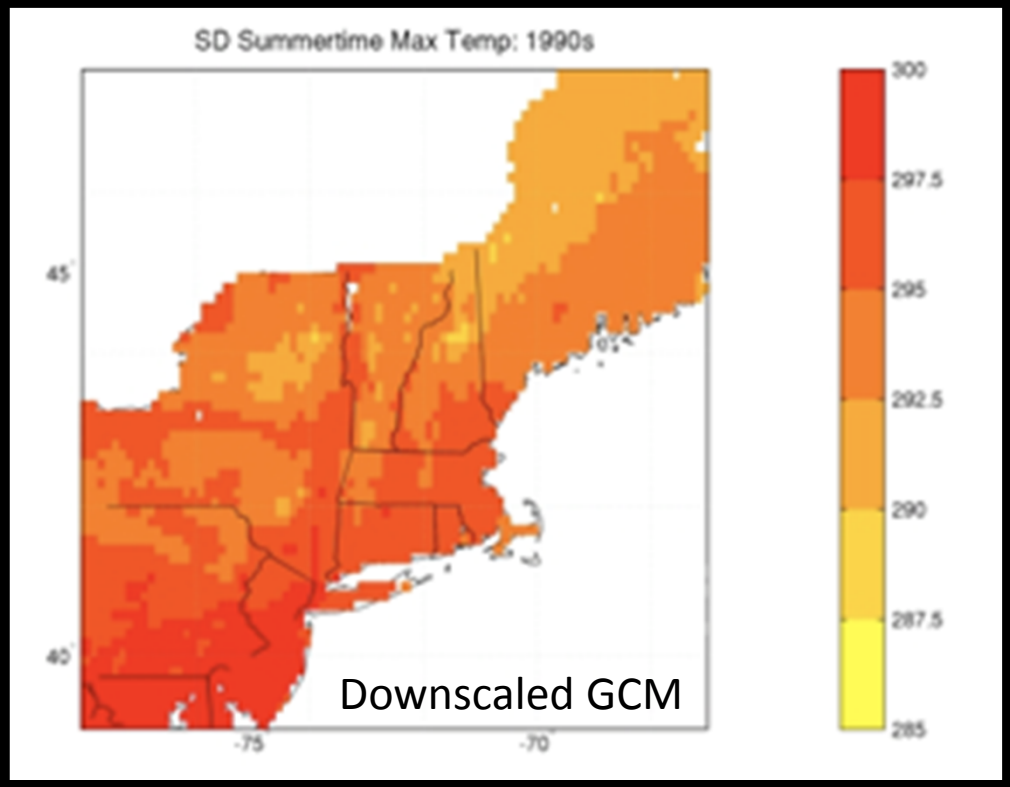
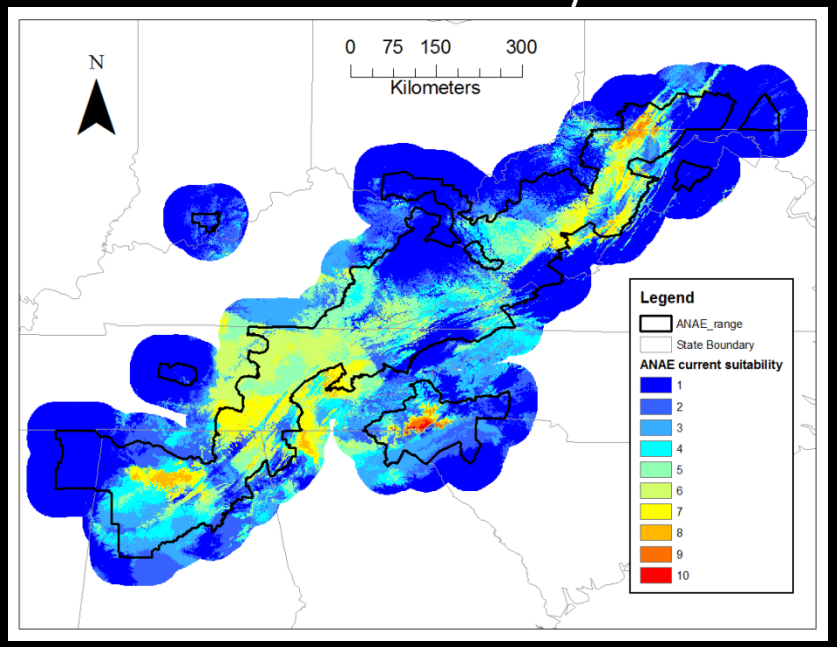


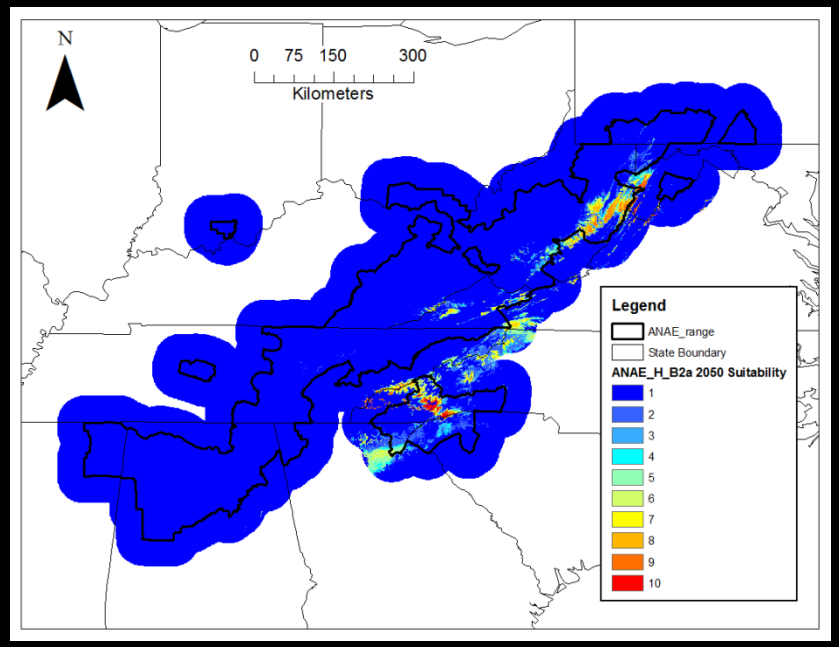
Qualitative assessment – estimate exposure qualitatively and piecemeal

How can distribution models contribute to a vulnerability assessment?

Current suitability

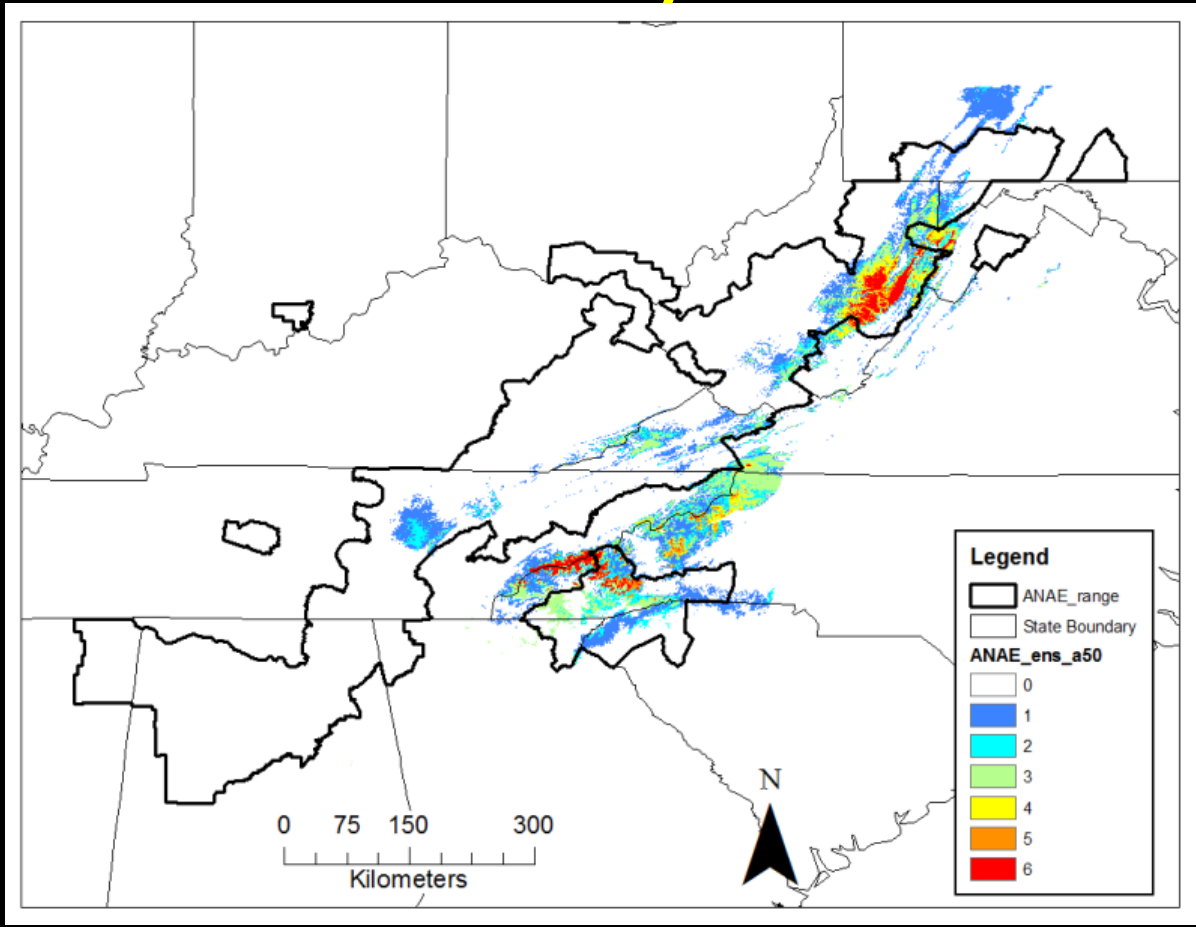


Suitability in 2050



Exposure can be assessed in a quantitative and spatially explicit manner

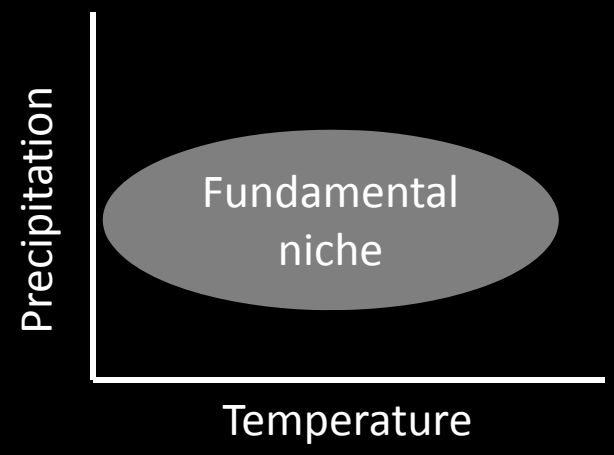
How can distribution models contribute to a vulnerability assessment?



Uncertainty also addressed and conveyed to stakeholders in a clear and spatially explicit way

Issues to consider

- In many cases we only know the realized niche of a species



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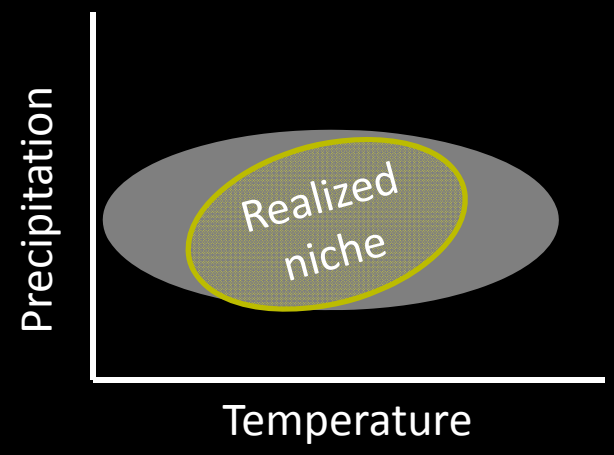

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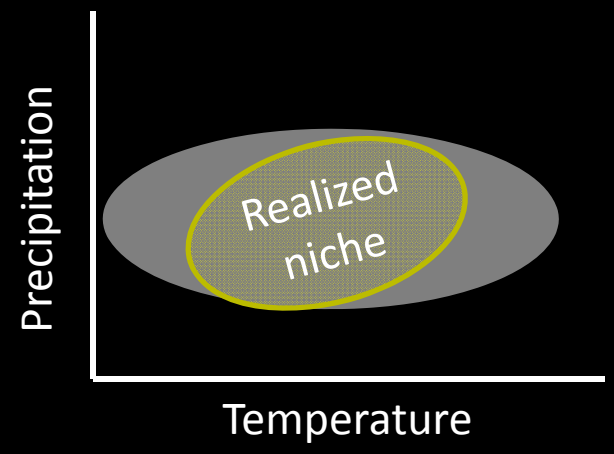
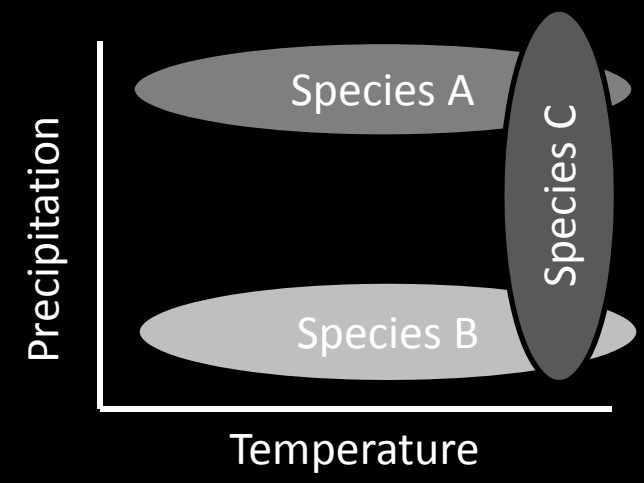


- There may not be current analogs of future climate or future communities



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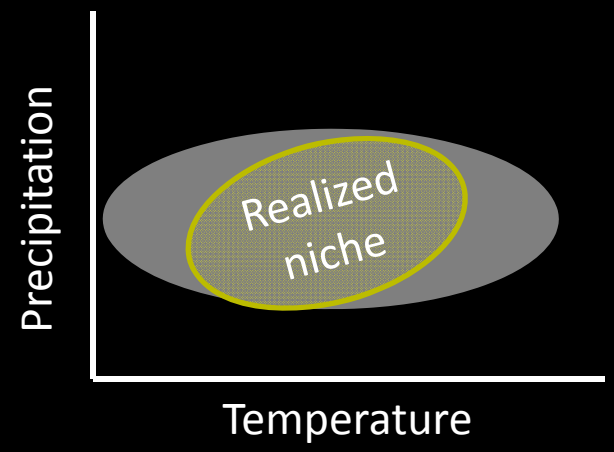

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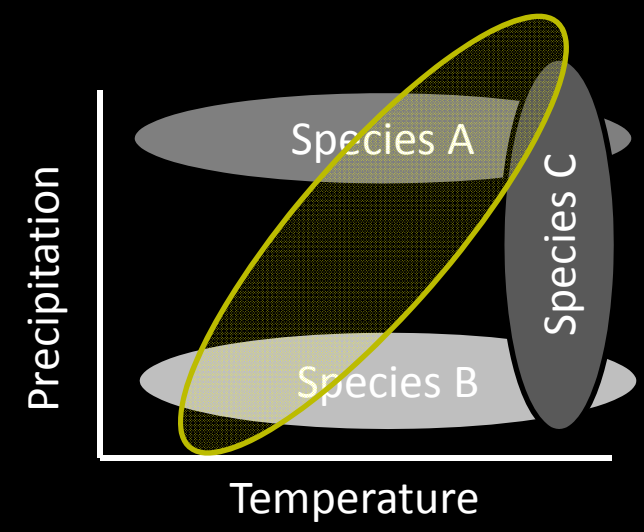

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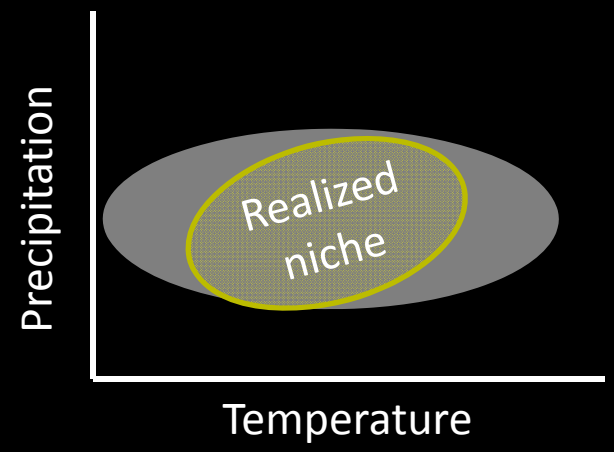

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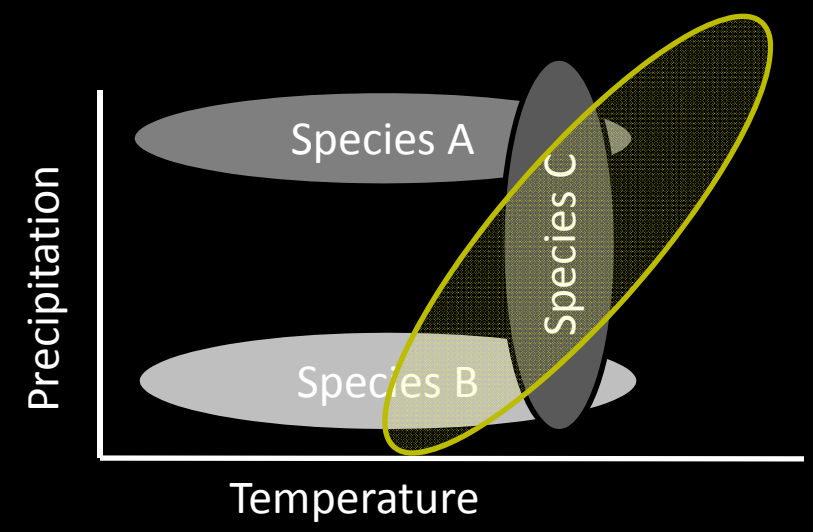

Categories of correlative distribution modeling

- Deductive
  - Typically based on expert knowledge
  - Identify key habitat/environmental requirements and map them
  - National GAP program

GAP
Keeping Common Species Common
USGS GAP ANALYSIS PROGRAM

Categories of correlative distribution modeling

- Deductive
  - Typically based on expert knowledge
  - Identify key habitat/environmental requirements and map them
  - National GAP program
- Inductive
  - Requires knowledge of species occurrence data
  - Uses an algorithm to identify species-environment relationship

Selecting a tool for correlative modeling

DOMAIN
Logistic regression
MaxEnt
GARP
Random Forests
Mahalanobis Distance

ECOGRAPHY 29: 129–151, 2006

Novel methods improve prediction of species' distributions from occurrence data

Jane Elith*, Catherine H. Graham*, Robert P. Anderson, Miroslav Dudík, Simon Ferrier, Antoine Guisan, Robert J. Hijmans, Falk Huettmann, John R. Leathwick, Anthony Lehmann, Jin Li, Lucia G. Lohmann, Bette A. Loiselle, Glenn Manion, Craig Moritz, Miguel Nakamura, Yoshinori Nakazawa, Jacob McC. Overton, A. Townsend Peterson, Steven J. Phillips, Karen Richardson, Ricardo Scachetti-Pereira, Robert E. Schapire, Jorge Soberón, Stephen Williams, Mary S. Wisz and Niklaus E. Zimmermann

Elith, J., Graham, C. H., Anderson, R. P., Dudík, M., Ferrier, S., Guisan, A., Hijmans, R. J., Huettmann, F., Leathwick, J. R., Lehmann, A., Li, J., Lohmann, L. G., Loiselle, B. A., Manion, G., Moritz, C., Nakamura, M., Nakazawa, Y., Overton, J. McC., Peterson, A. T., Phillips, S. J., Richardson, K. S., Scachetti-Pereira, R., Schapire, R. E., Soberón, J., Williams, S., Wisz, M. S. and Zimmermann, N. E. 2006. Novel methods improve prediction of species' distributions from occurrence data. – Ecography 29: 129–151.

Prediction of species' distributions is central to diverse applications in ecology, evolution and conservation science. There is increasing electronic access to vast sets of occurrence records in museums and herbaria, yet little effective guidance on how best to use this information in the context of numerous approaches for modelling distributions. To meet this need, we compared 16 modelling methods over 226 species from 6 regions of the world, creating the most comprehensive set of model comparisons to date. We used presence-only data to fit models, and independent presence-absence data to evaluate the predictions. Along with well-established modelling methods such as generalised additive models and GARP and BIOCLIM, we explored methods that either have been developed recently or have rarely been applied to modelling species' distributions. These include machine-learning methods and community models, both of which have features that may make them particularly well suited to noisy or sparse information, as is typical of species' occurrence data. Presence-only data were effective for modelling species' distributions for many species and regions. The novel methods consistently outperformed more established methods. The results of our analysis are promising for the use of data from museums and herbaria, especially as methods suited to the noise inherent in such data improve.