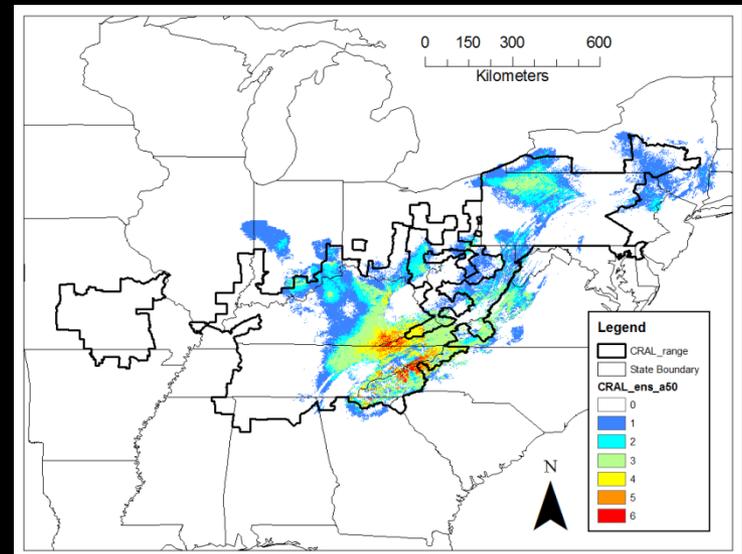


# Distribution Modeling

## 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**

# 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?**  
 James R. Butler, Mark C. Beck, Michael J. Bevelhimer, Ian S. Cohen, Todd A. Kiese, and Michael R. Rees  
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**ABSTRACT**  
 Rapid anthropogenic changes in climate conditions and land use patterns are predicted to have species well beyond their current geographic ranges. Despite the need to understand species' responses to these changes, the mechanisms that inform species' distributions are poorly understood. We review the current state of knowledge on the mechanisms that inform species' distributions and discuss the implications for species' distribution models. We argue that mechanistic models, which explicitly represent the physiological and behavioral processes that inform species' distributions, are more likely to provide accurate predictions of species' distributions under future climate conditions than correlative models, which do not explicitly represent these processes. We discuss the challenges of developing mechanistic models and the implications for species' distribution modeling under future climate conditions.

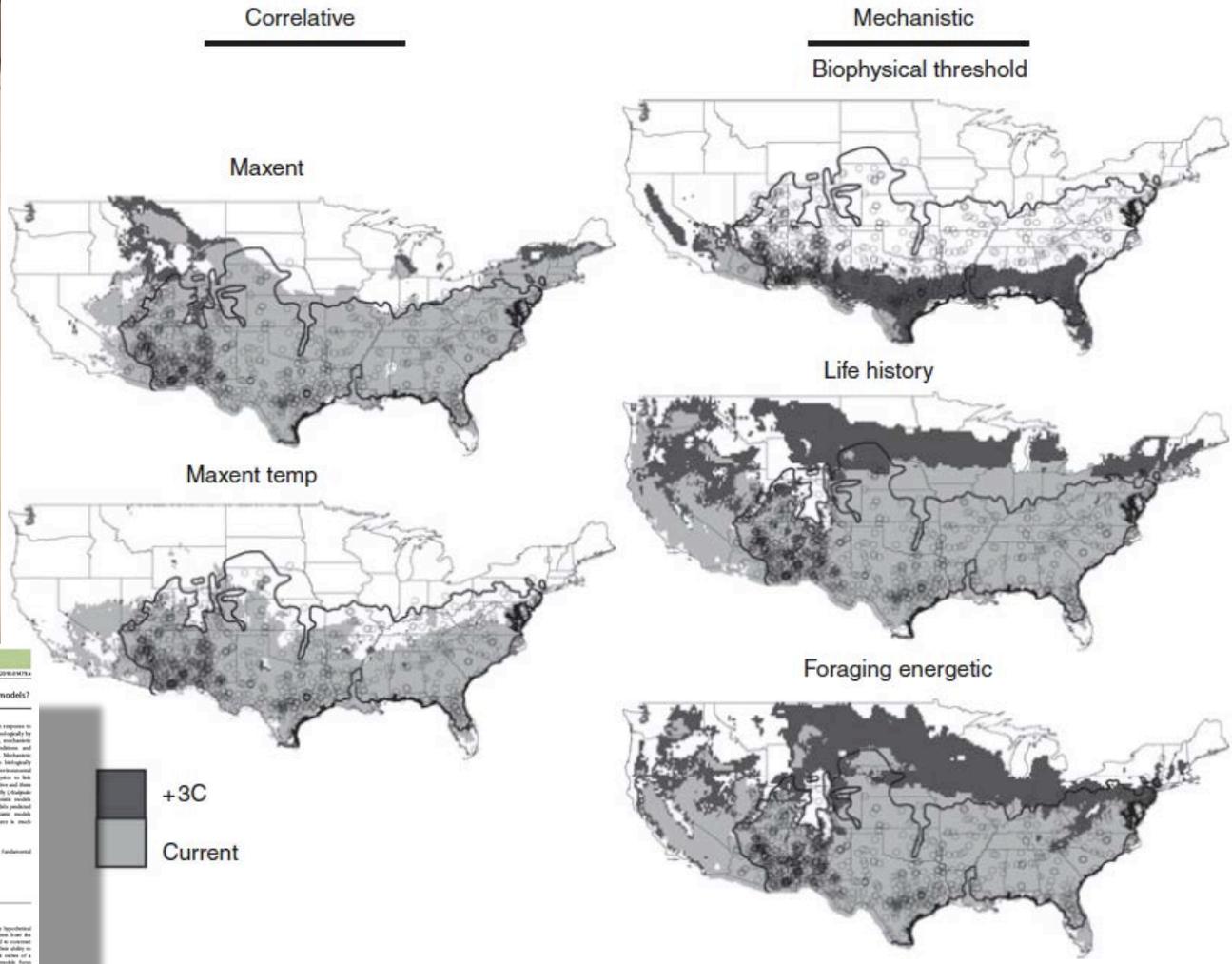
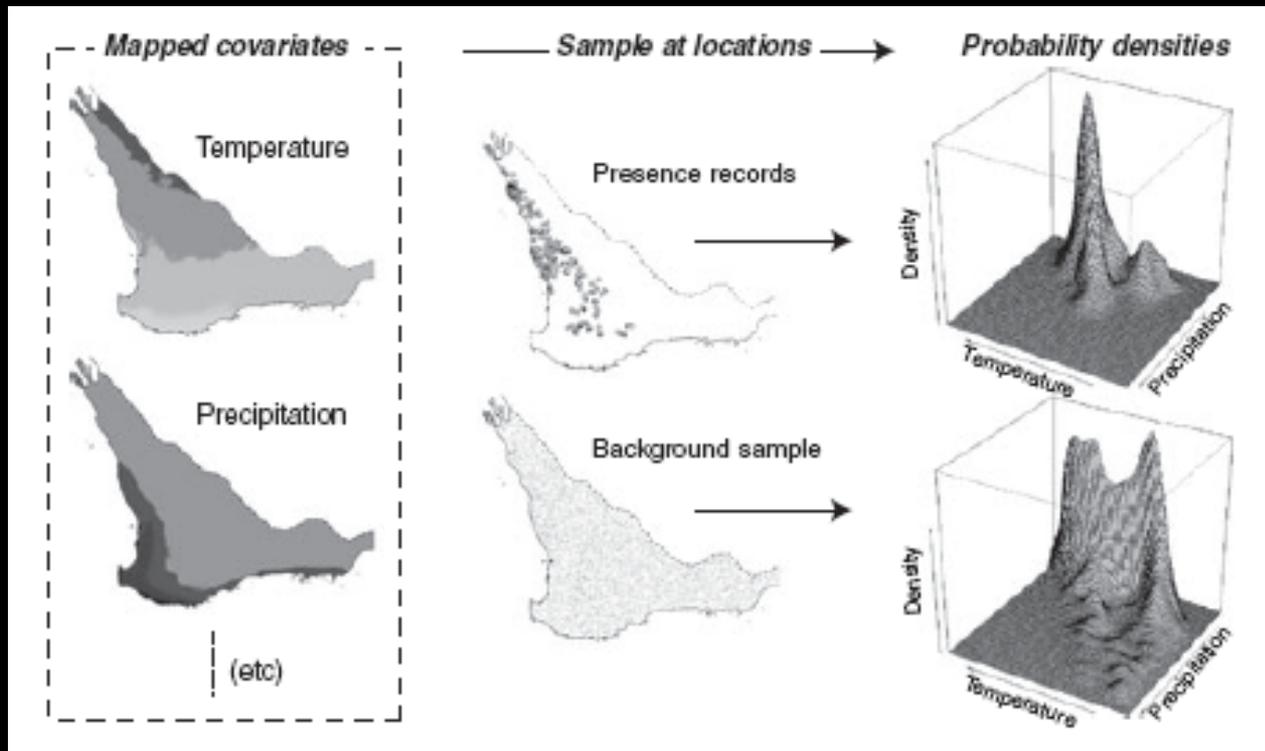


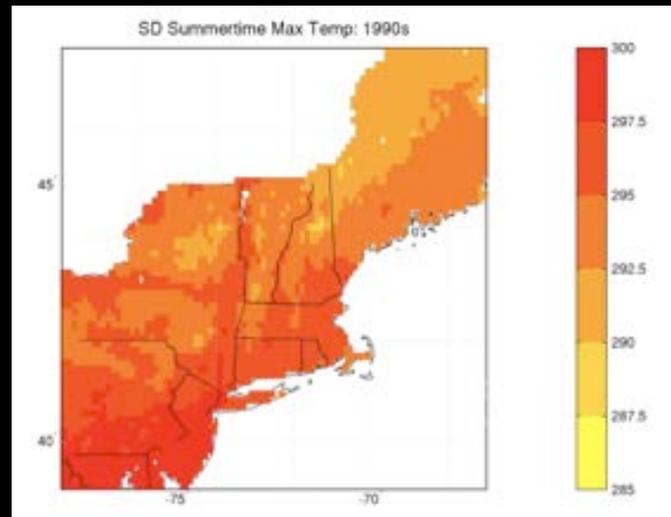
Figure 1 Range predictions for *Sceloporus undulatus* in current climates (light gray) and predicted range expansions following a uniform 3 °C temperature increase (dark gray). Localities (o) and the atlas range polygon are shown.

# How can correlative distribution models contribute to a vulnerability assessment?



Current species - environment relationships are projected onto forecasted climate scenarios

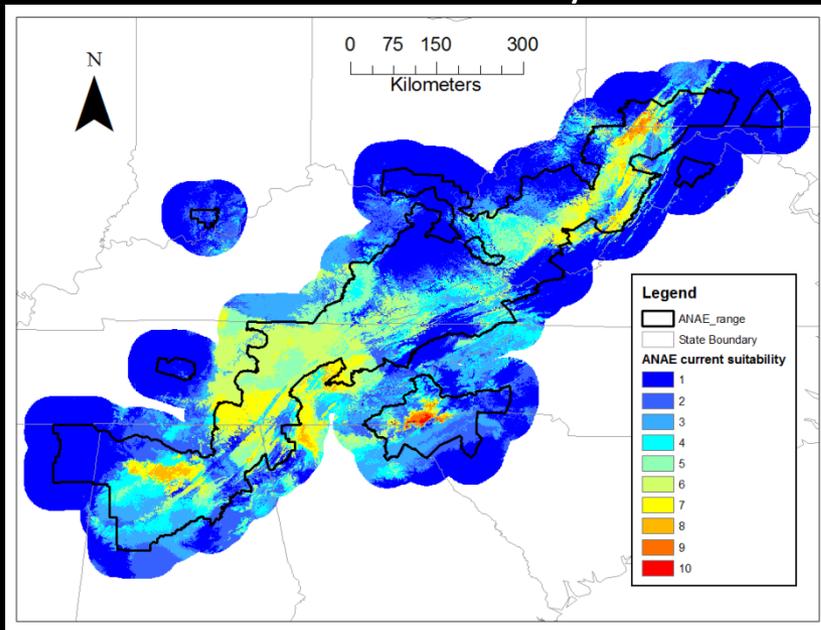
# How can distribution models contribute to a vulnerability assessment?



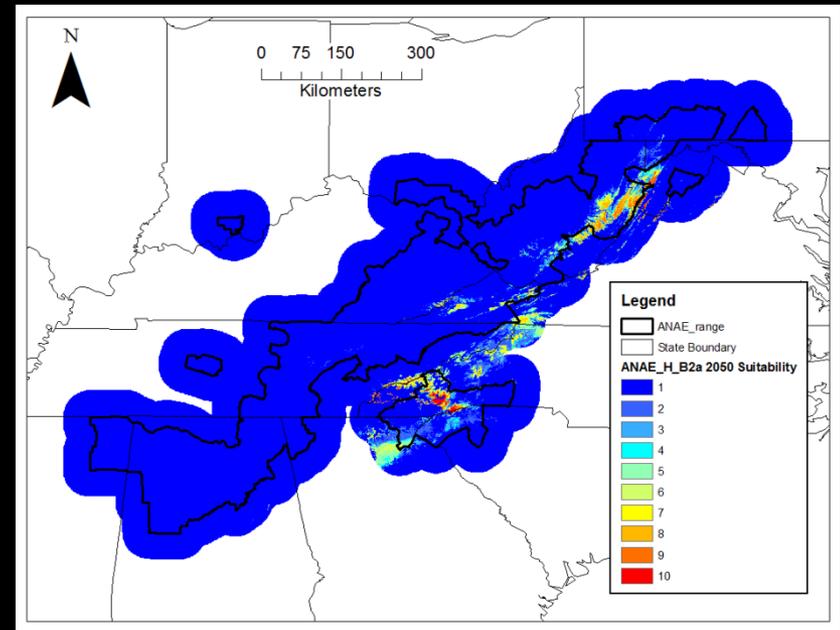
Exposure can be assessed in a quantitative and spatially explicit manner

# How can distribution models contribute to a vulnerability assessment?

Current suitability



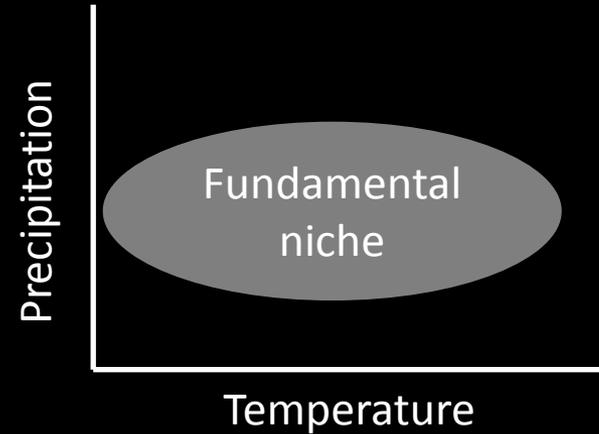
Suitability in 2050



Exposure can be assessed in a quantitative and spatially explicit manner

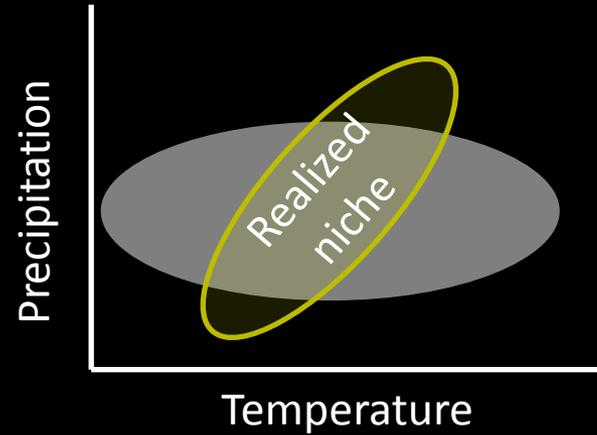
# Issues to consider

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



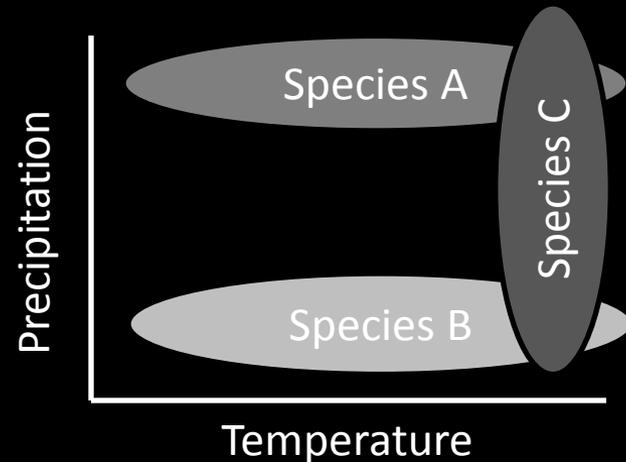
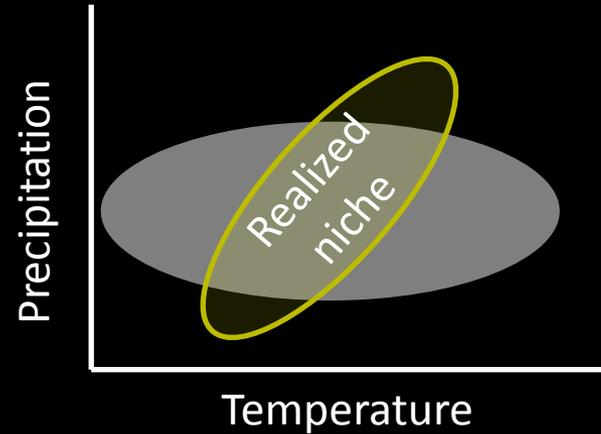
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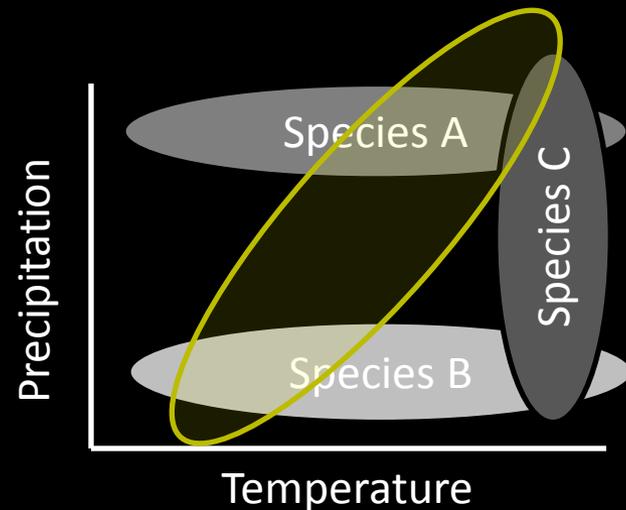
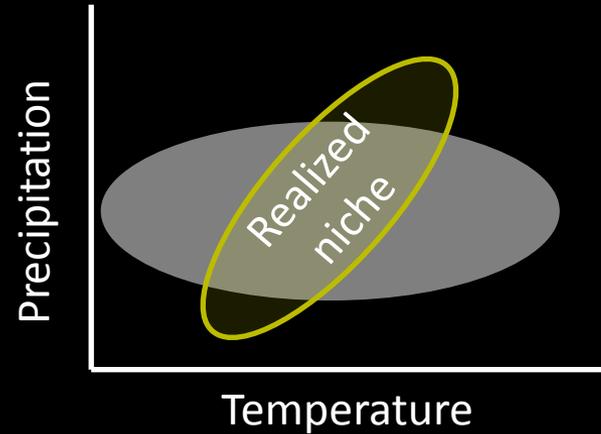
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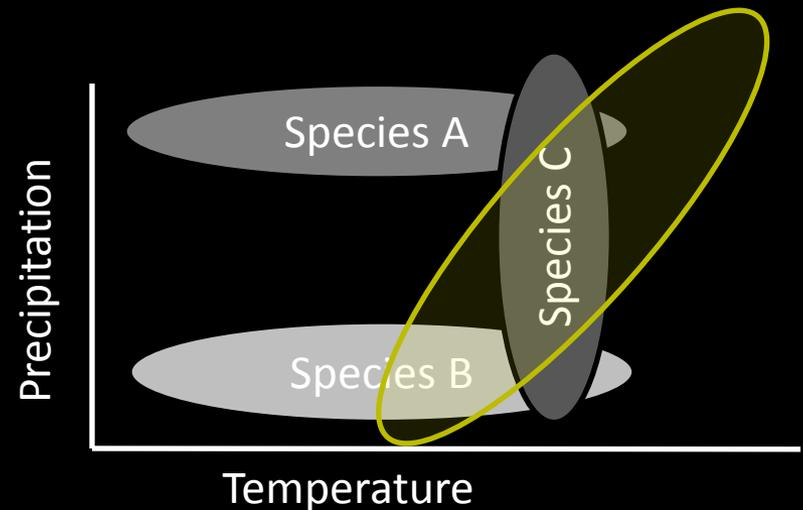
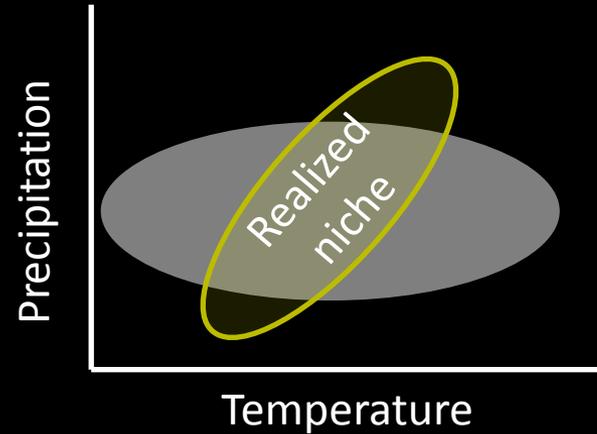
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# Categories of correlative distribution modeling

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



# 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.