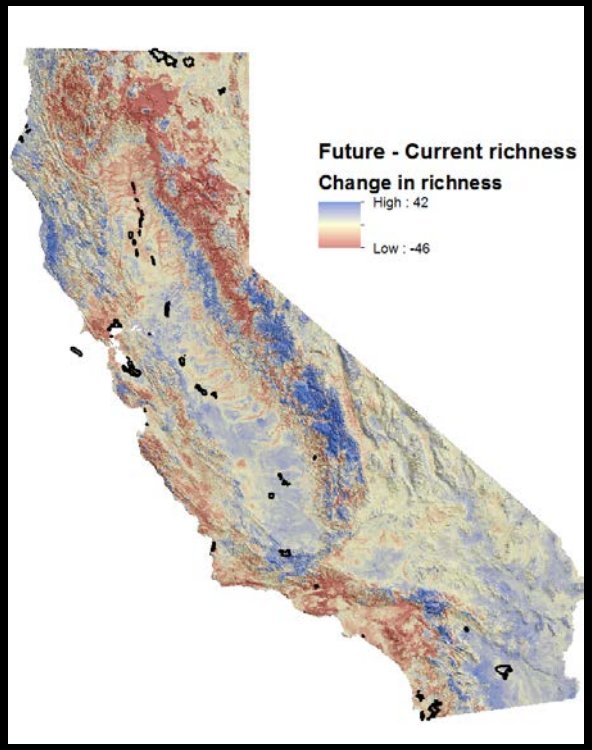
Distribution Modeling

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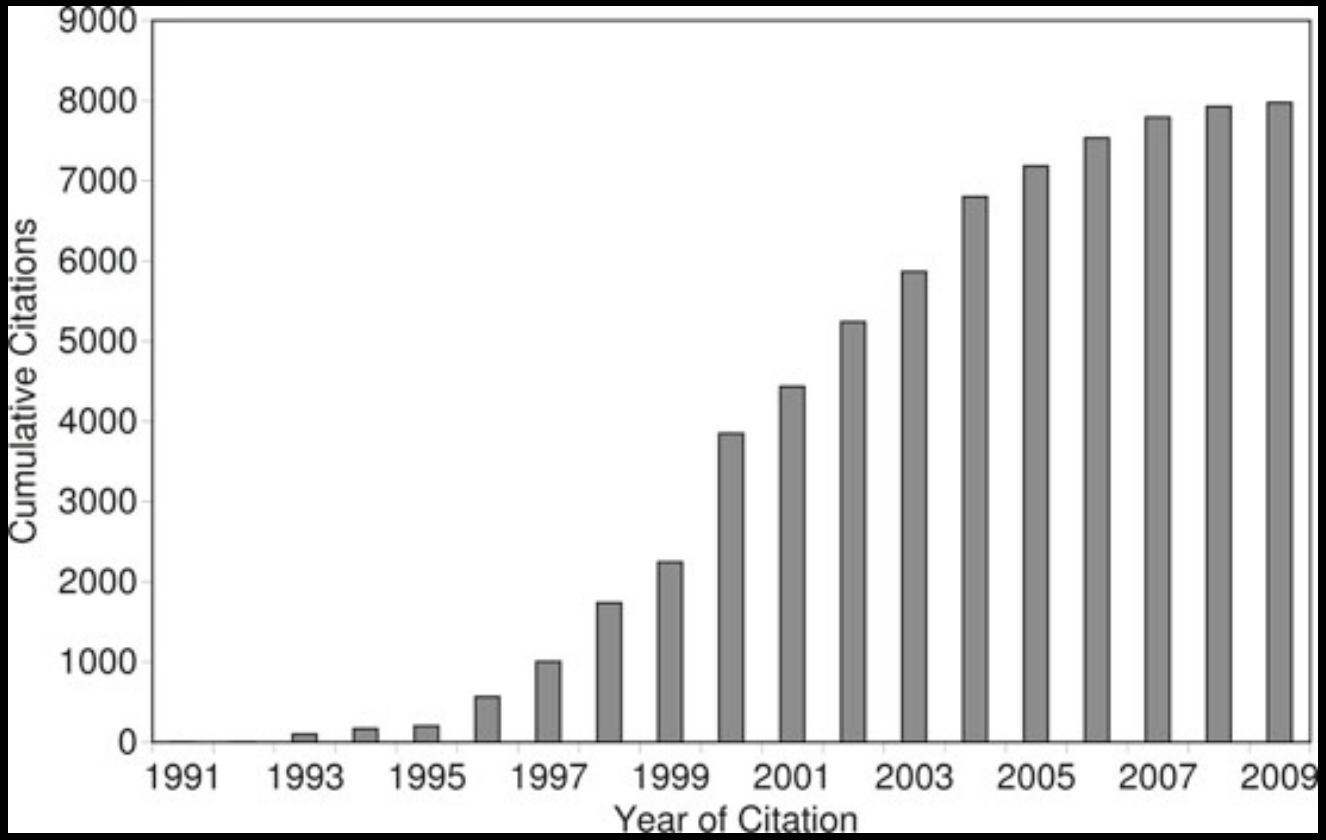
THE GOAL: capture species-environment relationships that characterize where the species can occur on the landscape

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*

Common uses

- Discovery of new populations
- Risk of species invasions
- Reserve selection and design
- Restoration, translocation, reintroductions
- Climate change impacts on biodiversity

Methods for modeling species responses to climate change

- Forecasting distribution responses

  Correlative models (PATTERNS):

  - Phenomenological
  - Relate current distributions to environmental variables

  Mechanistic models (PROCESSES):

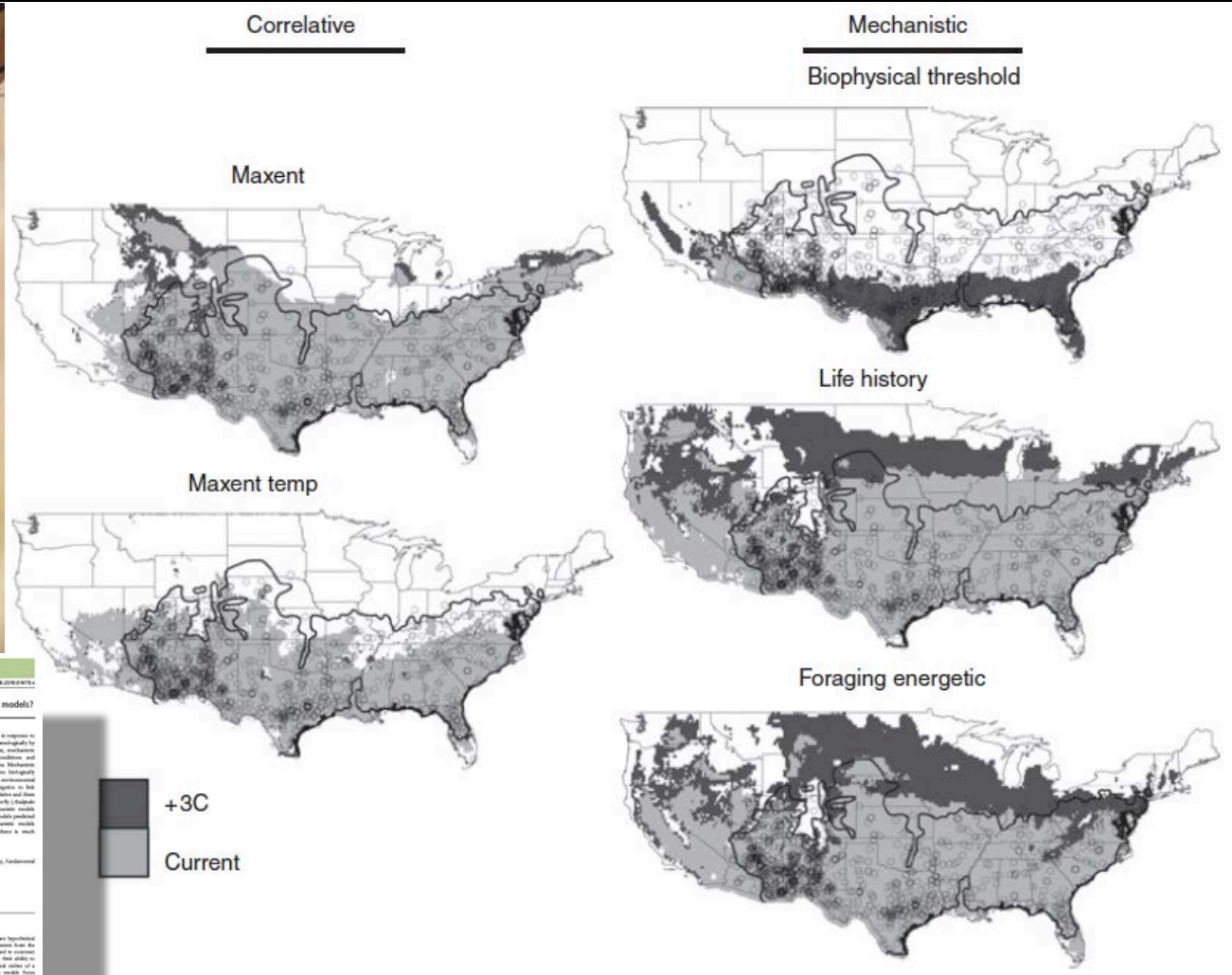
  - Use explicit relationships between environmental variables and organismal performance
  - Estimated independently of species current distribution

Methods for modeling species responses to climate change

ECOLOGY LETTERS

REVIEW AND SYNTHESIS

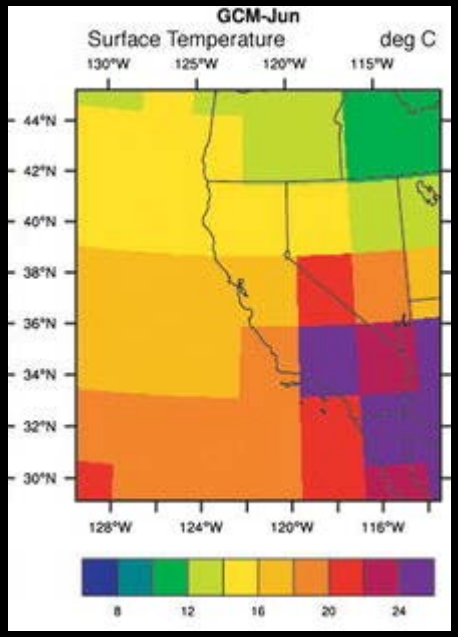
Can mechanism inform species' distribution models?



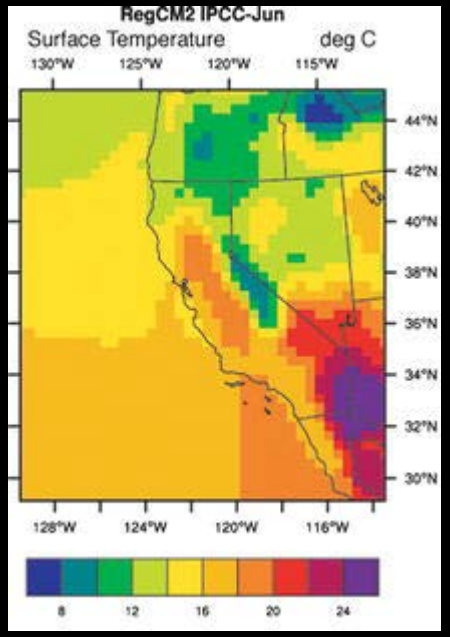
re 1 Range predictions for *Sceloporus undulatus* in current climates (light gray) and predicted range expansions following a uniform 3 °C
erature increase (dark gray). Localities (o) and the atlas range polygon are shown.

How can distribution models contribute to a vulnerability assessment?

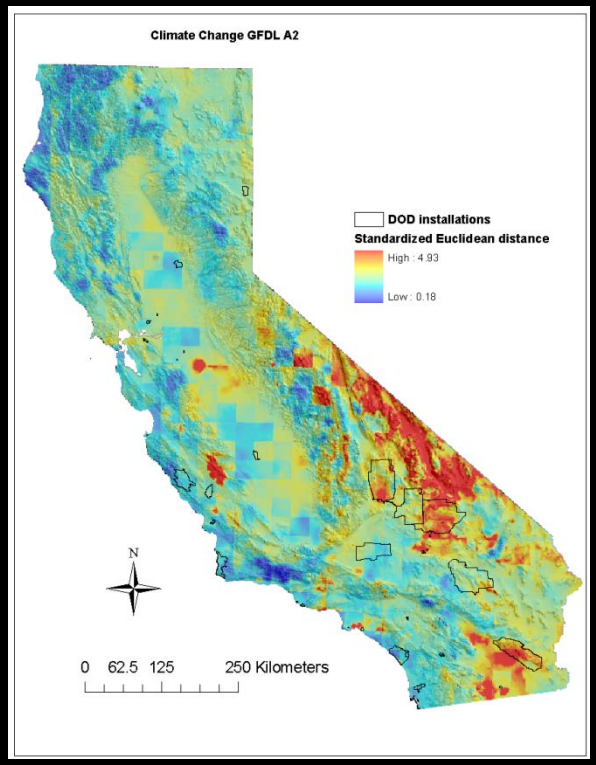
General Circulation Model GCM)



Regional Climate Model (RCM)



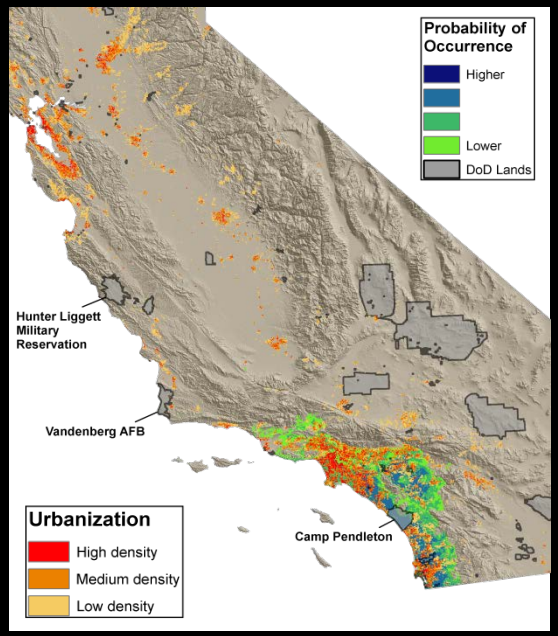
Magnitude of climate change



Qualitative assessment – estimate exposure qualitatively and piecemeal

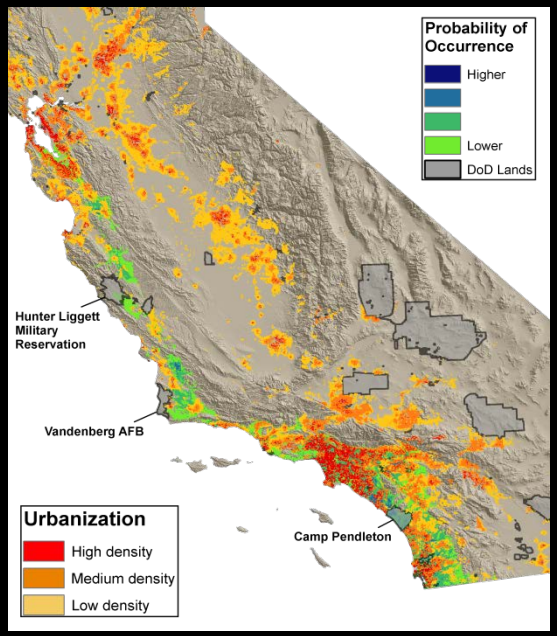
How can distribution models contribute to a vulnerability assessment?

Current suitability



California Gnatcatcher

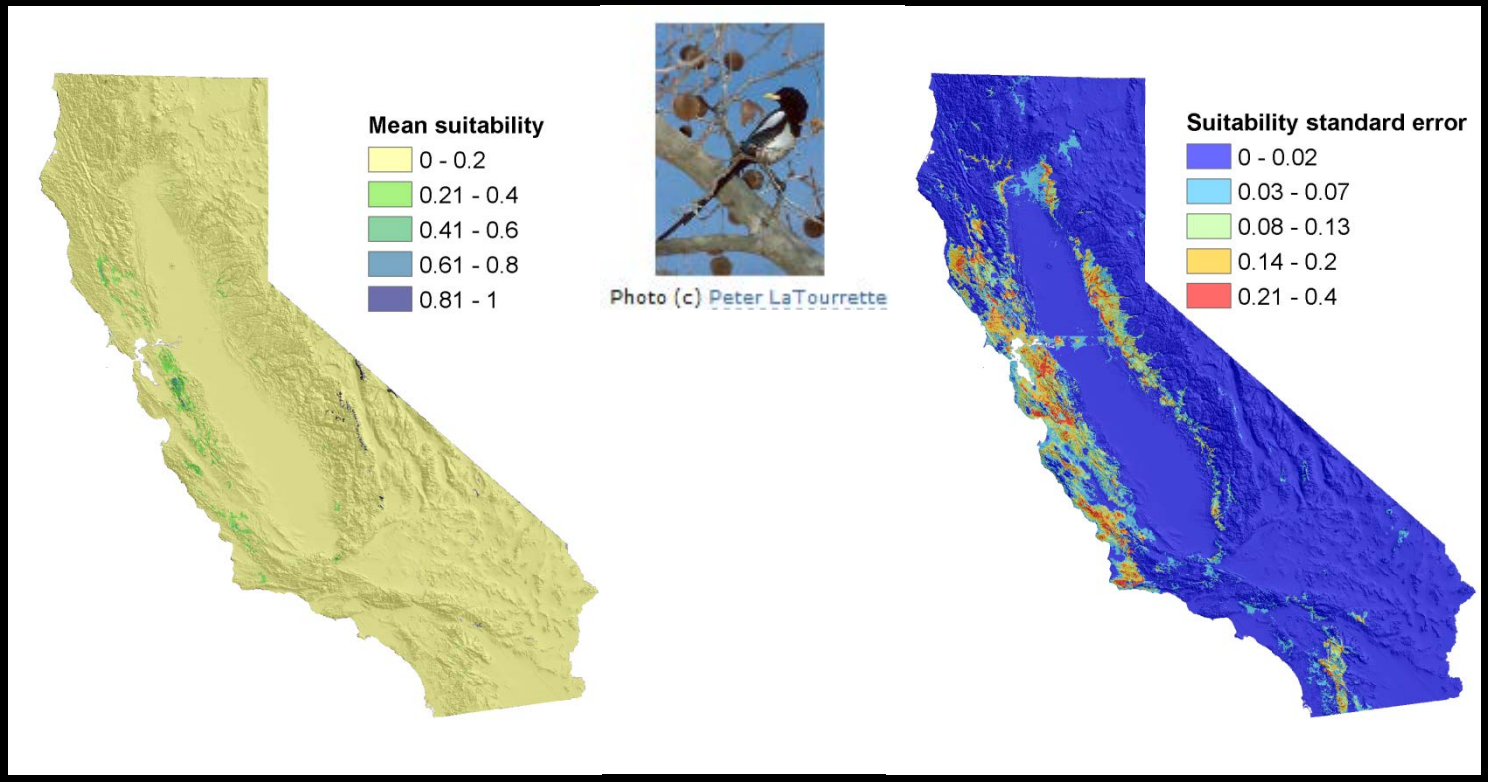
Suitability in 2070



Sensitivity can be assessed in a quantitative and spatially explicit manner

How can distribution models contribute to a vulnerability assessment?

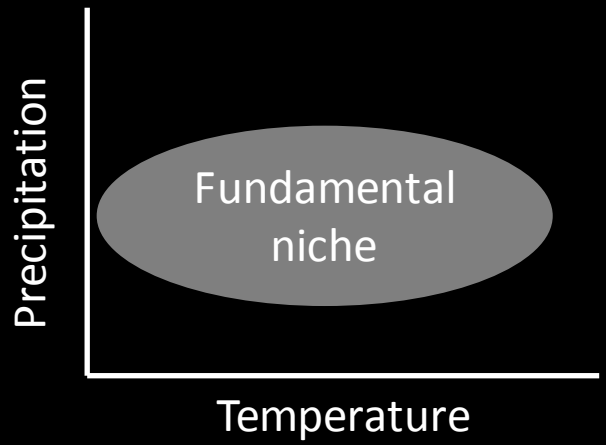
Yellow-billed Magpie



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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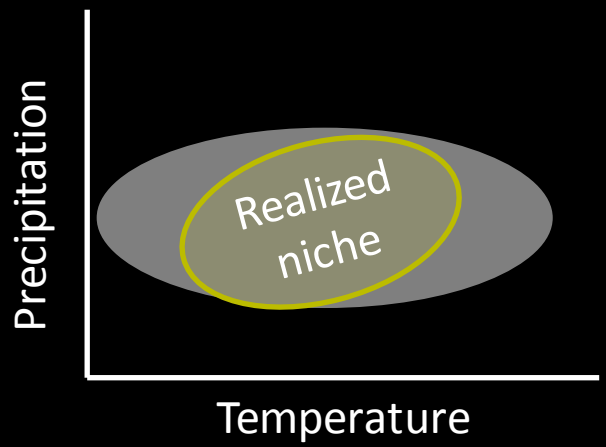

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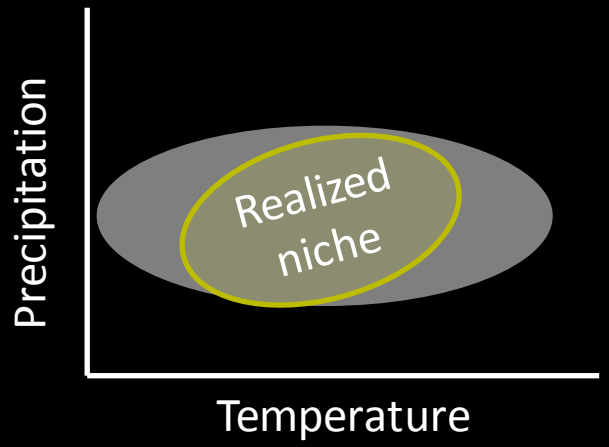
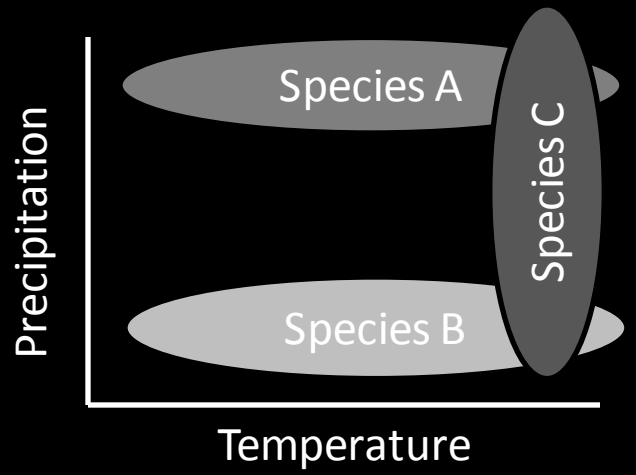


- There may not be current analogs of future climate or future communities



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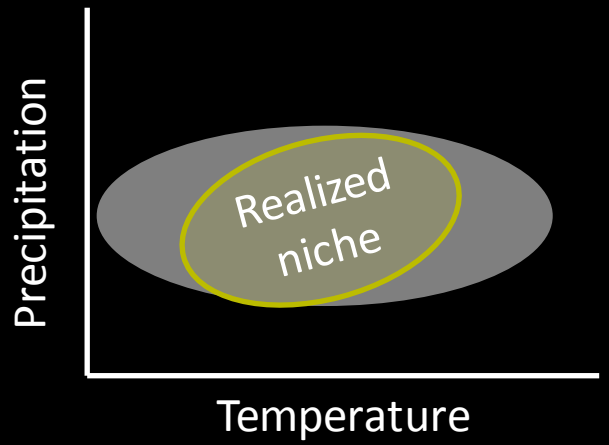

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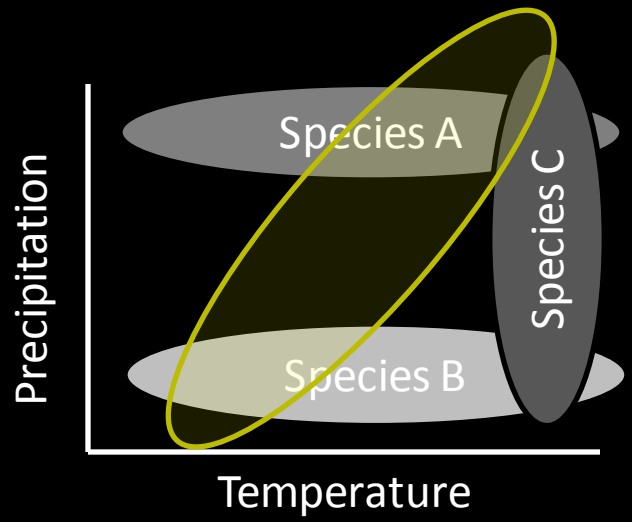

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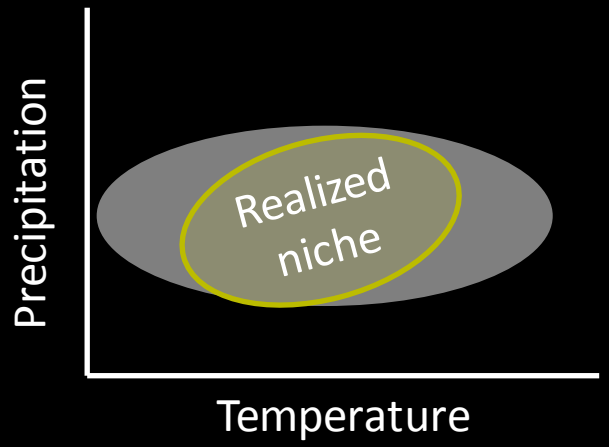

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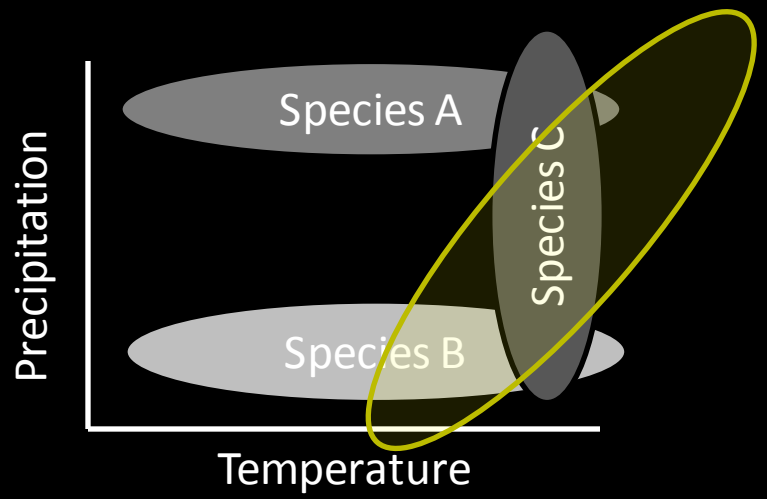

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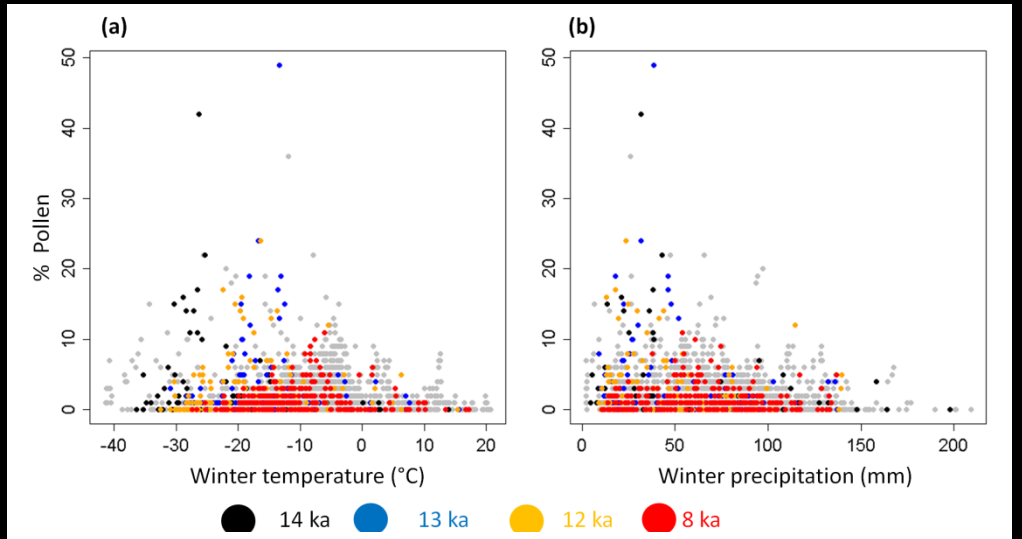
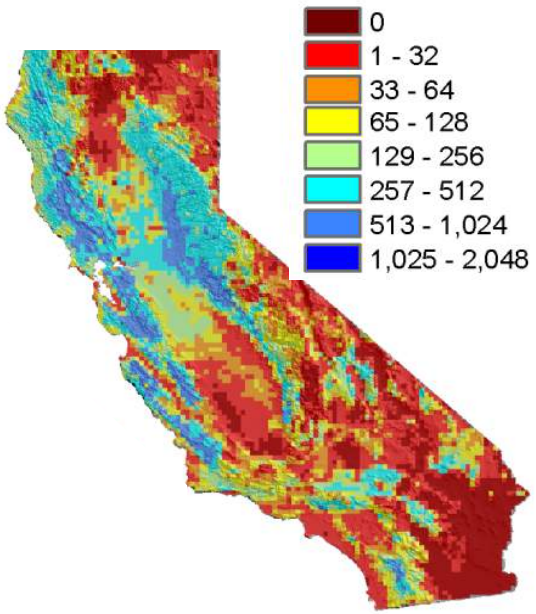


Future Bird Communities: Number of Modern Analogs



Red = novel communities

Categories of correlative distribution modeling

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

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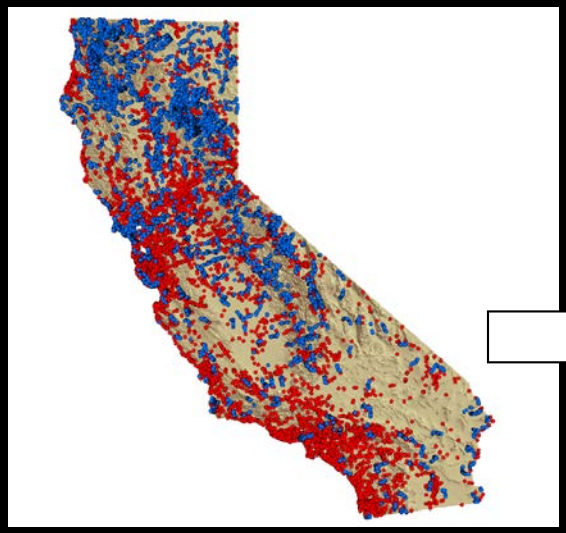
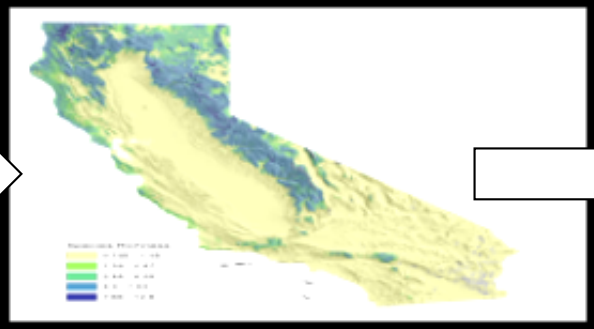
- Deductive
  - Typically based on expert knowledge
  - Identify key habitat/environmental requirements and map them
  - National GAP program
- Inductive
  - Requires knowledge of species occurrence data
  - Uses an algorithm to identify species-environment relationship

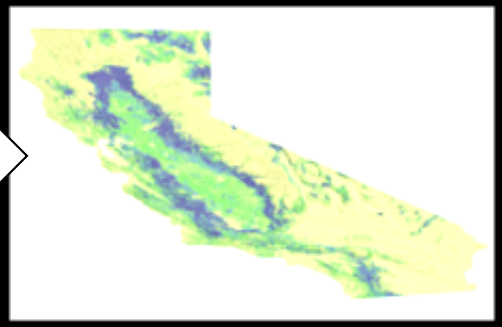
How can correlative distribution models contribute to a vulnerability assessment?

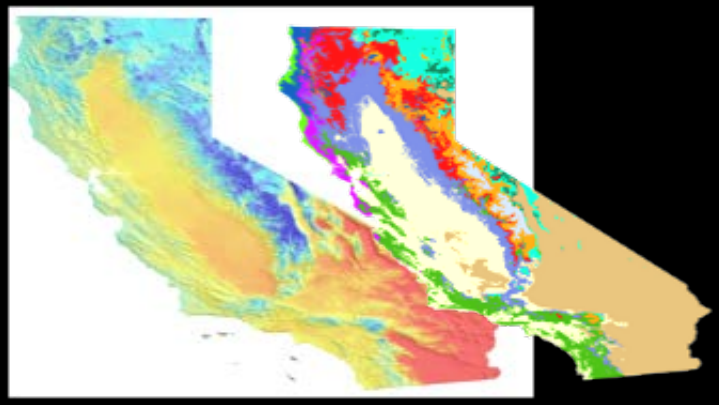


Current distributions



Future distributions

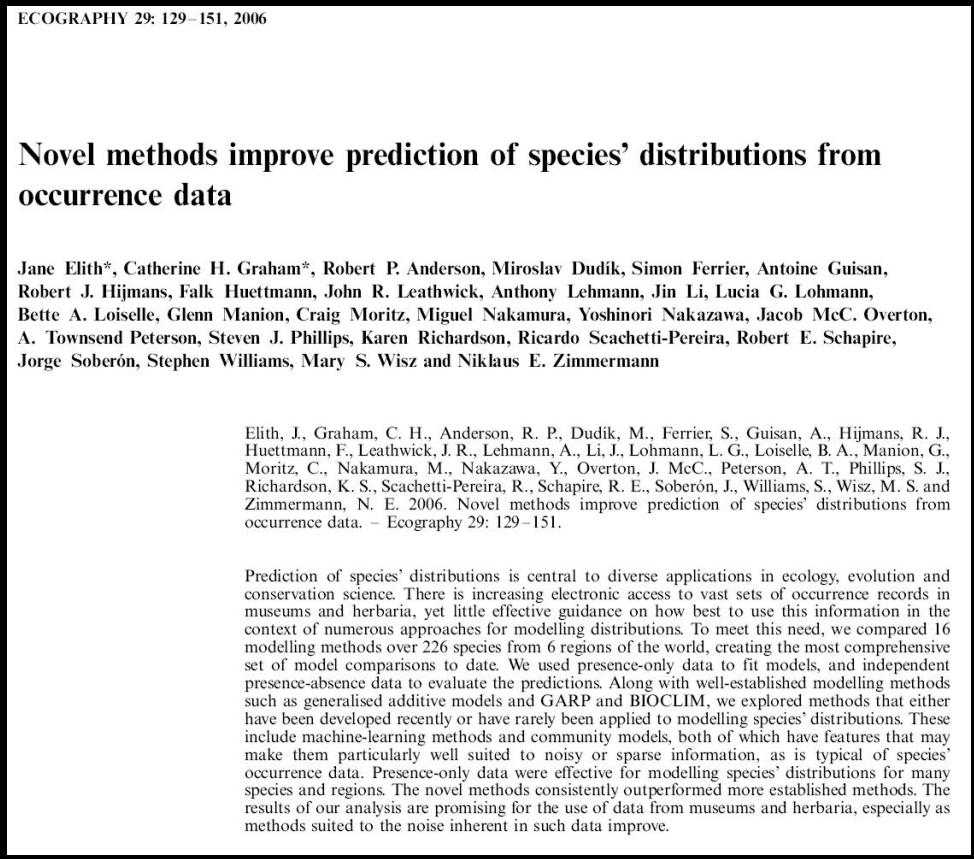




Current species - environment relationships are projected onto forecasted climate scenarios

Selecting a tool for correlative modeling

DOMAIN
Logistic regression
MaxEnt
~~GARP~~
Random Forests
Boosted regression trees
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.