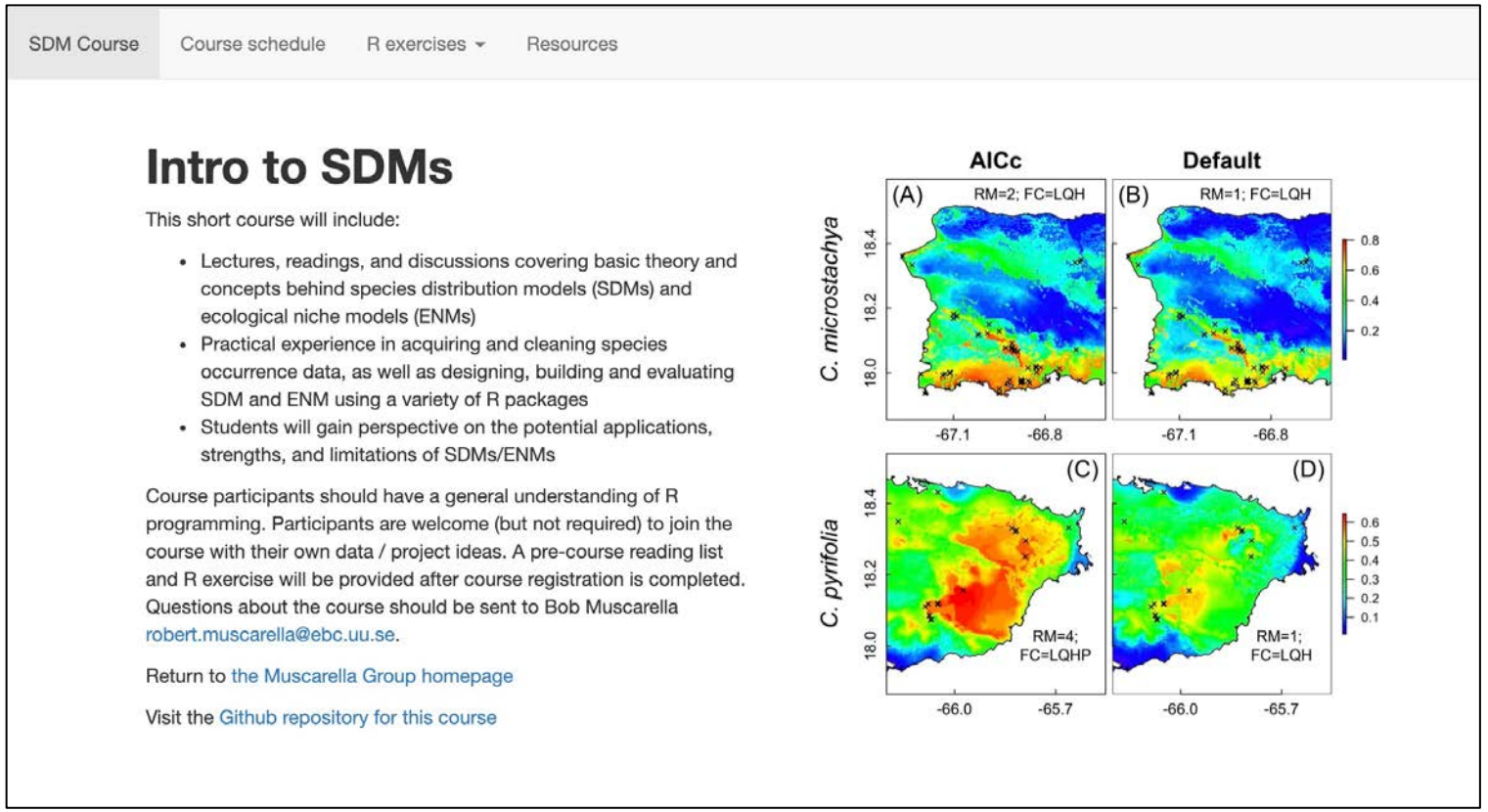
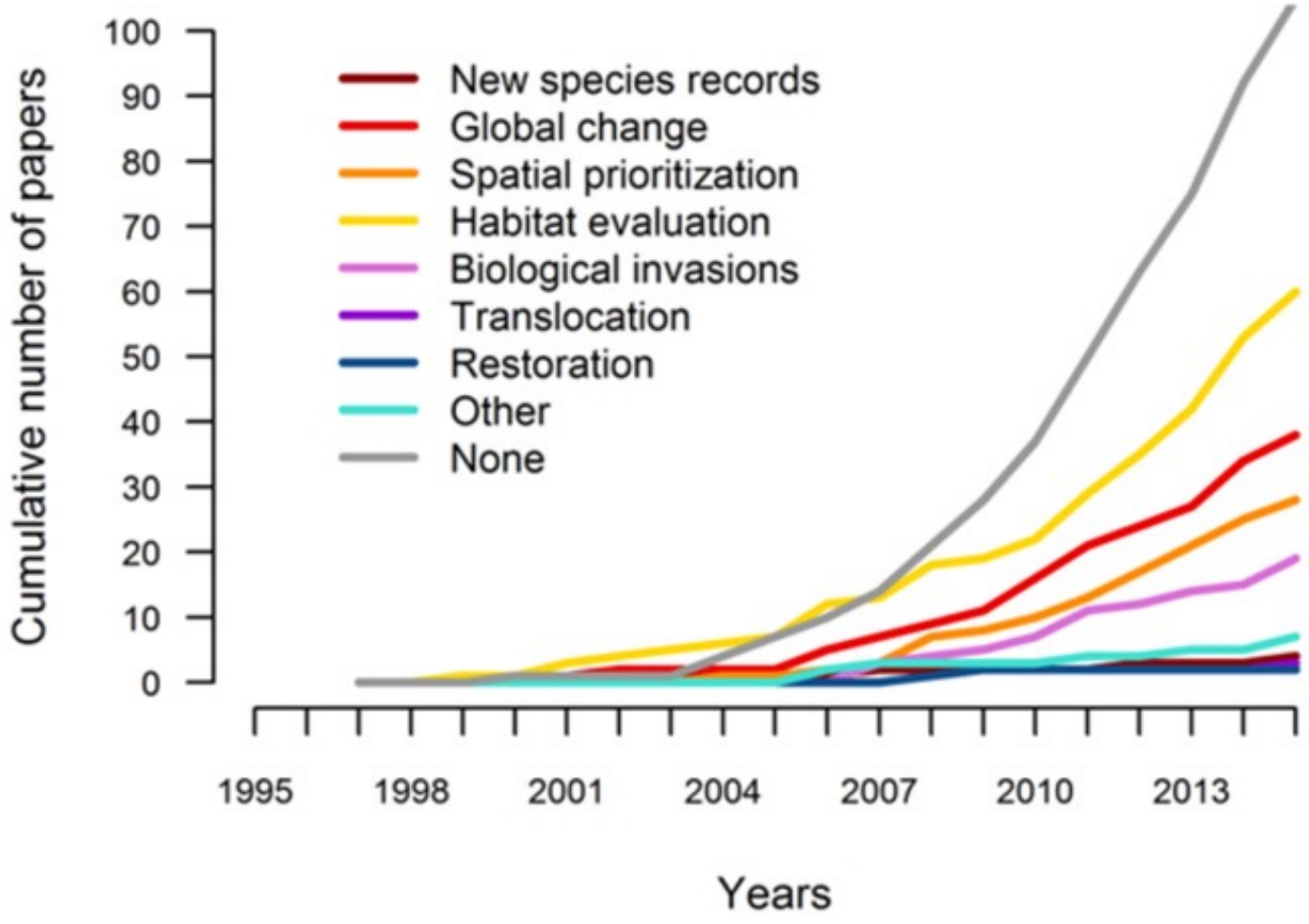
Potentials and Pitfalls

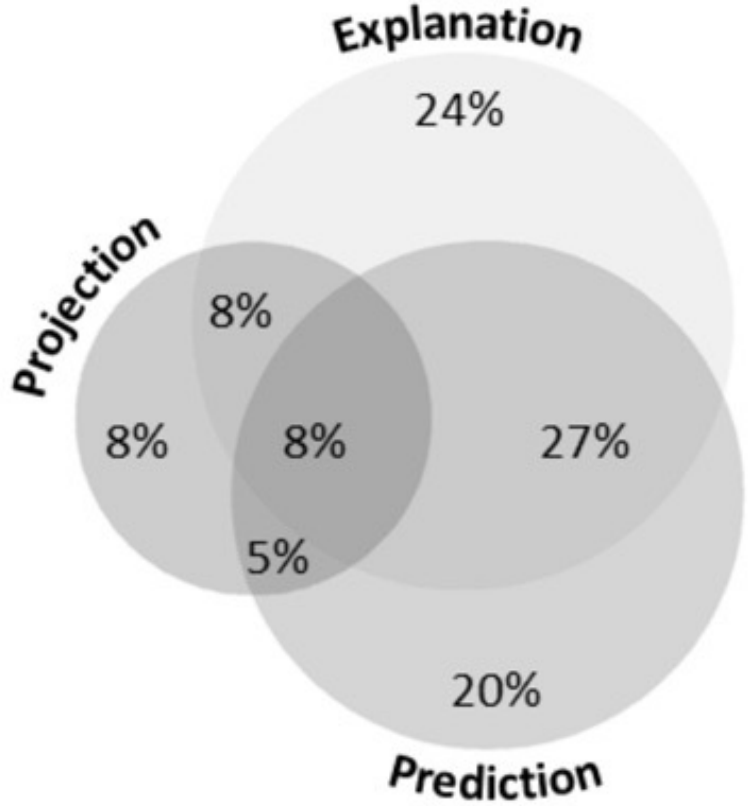
Bob Muscarella
Sapienza University, Roma
June 9-11



Course website: https://bobmuscarella.github.io/SDM-course/index.html

Applications of SDMs





Araújo et al. (2019) Standards for distribution models in biodiversity assessments. *Science Advances*

(Some) Potential applications of SDMs/ENMs

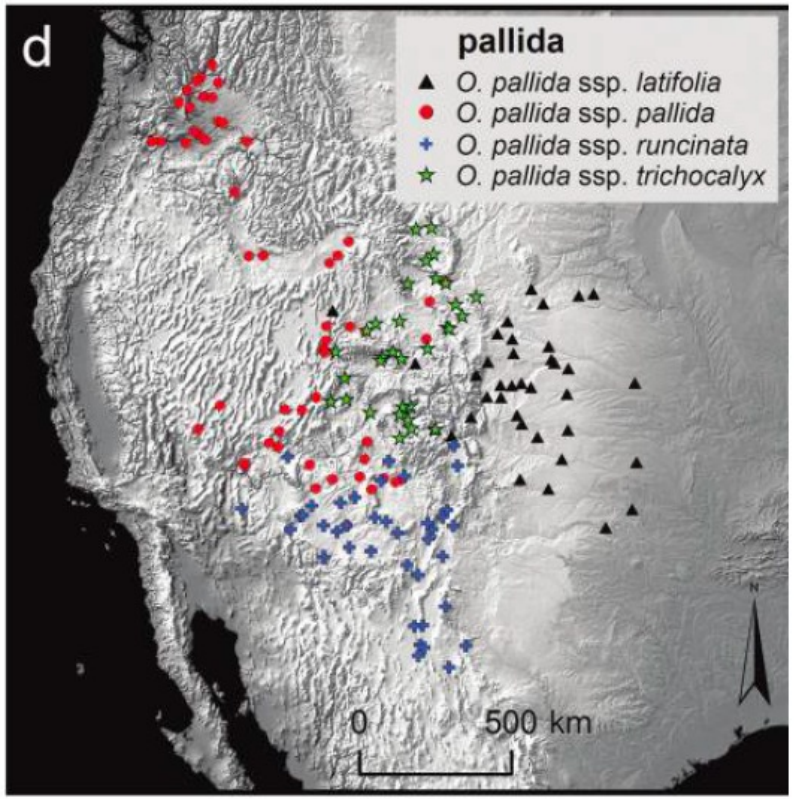
- Niche structure and limits (ecological / evolutionary application)
- Discovery of species and populations
- Consequences of climate change
- Reconstructing past distributions
- Invasive species applications
- Systematic conservation planning
- Large-scale conservation/restoration projects
- Public health

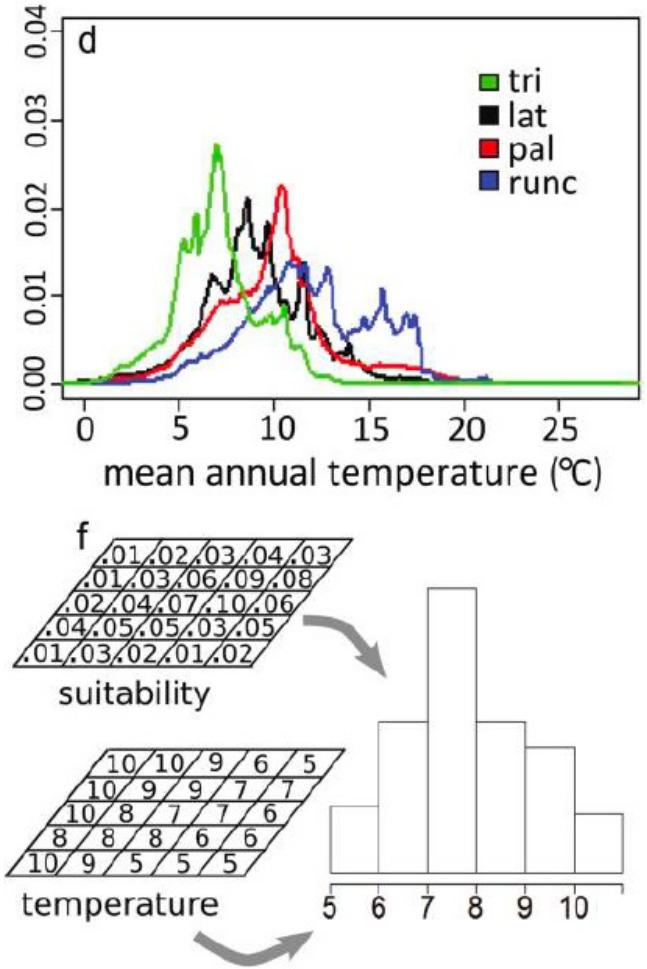
Niche structure and limits

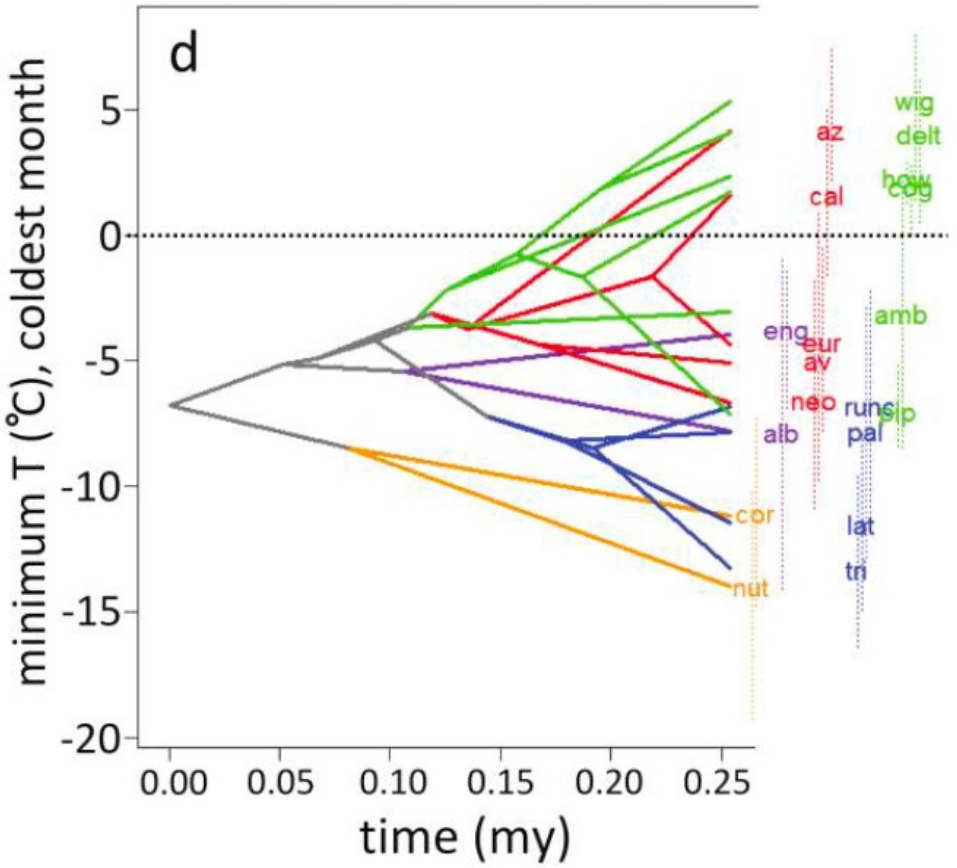
Evolutionary hypotheses

Niche conservatism?

Niche divergence?







Evans *et al.* (2009) Climate, Niche Evolution, and Diversification of the “Bird-Cage” Evening Primroses. *The American Naturalist.* 173(2): 225-240.

Niche structure and limits

Evolutionary hypotheses

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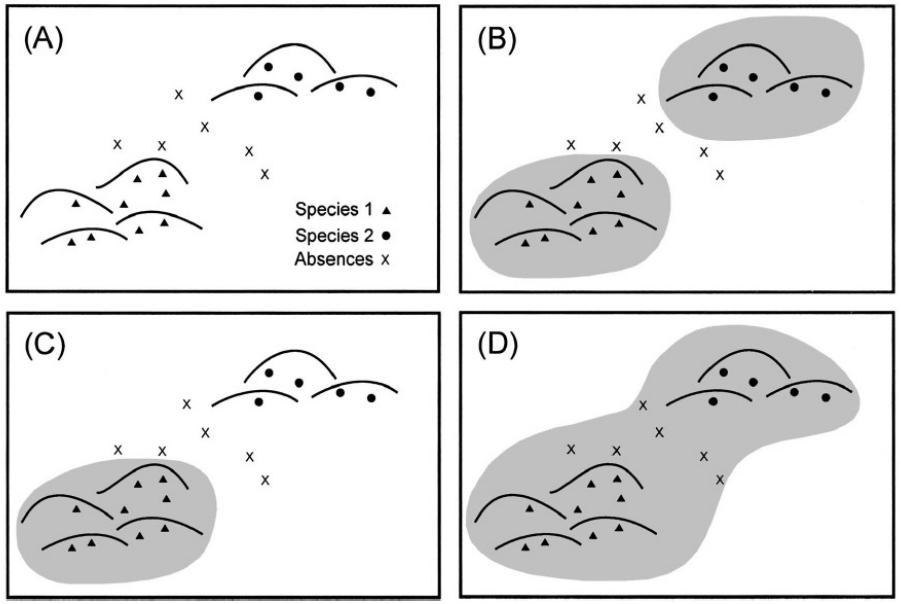

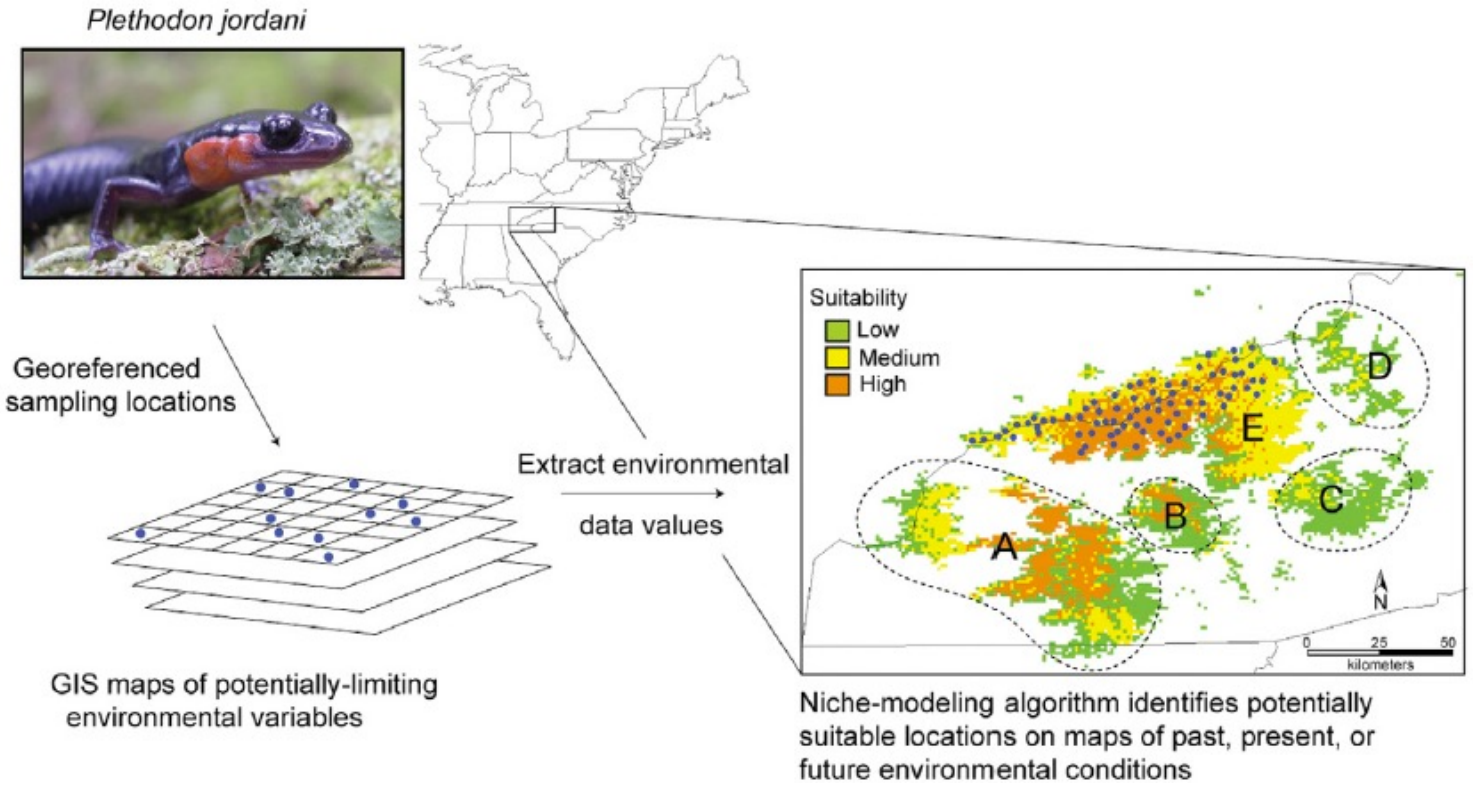

Kozak & Weins (2006) Does niche conservatism promote speciation? A case study in north American salamanders. *Evolution* 60(12): 2604–2621

Kozak *et al*. (2008) Integrating GIS-based environmental data into evolutionary biology. *Trends in Ecology & Evolution* 23(3)

Niche structure and limits

Abundance-Center Hypothesis:
Species are more abundance towards the geographic center of the range.

Vol. 124, No. 2 The American Naturalist August 1984

ON THE RELATIONSHIP BETWEEN ABUNDANCE AND DISTRIBUTION OF SPECIES

JAMES H. BROWN

Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, Arizona 85721

Submitted July 8, 1983; Accepted February 27, 1984

Brown (1984) On the Relationship between Abundance and Distribution of Species. *The American Naturalist.* 124(2) 255-279.

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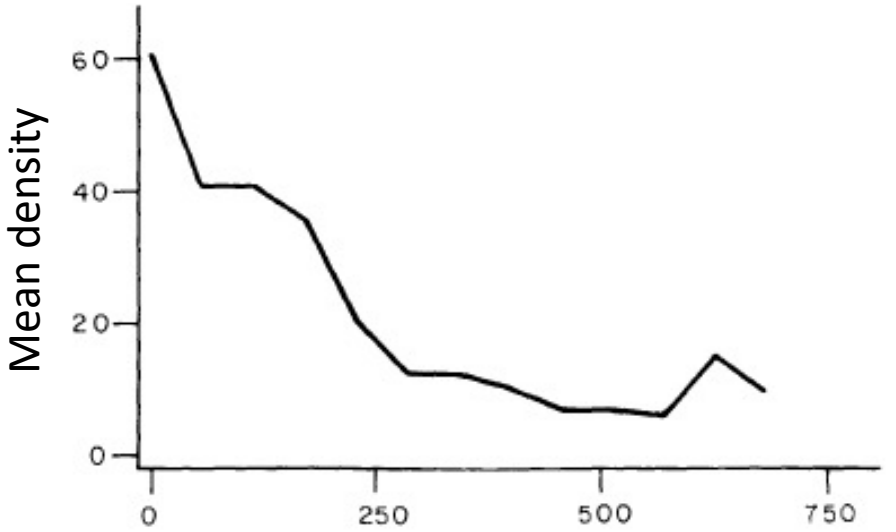

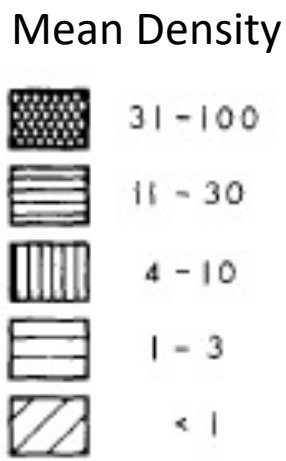

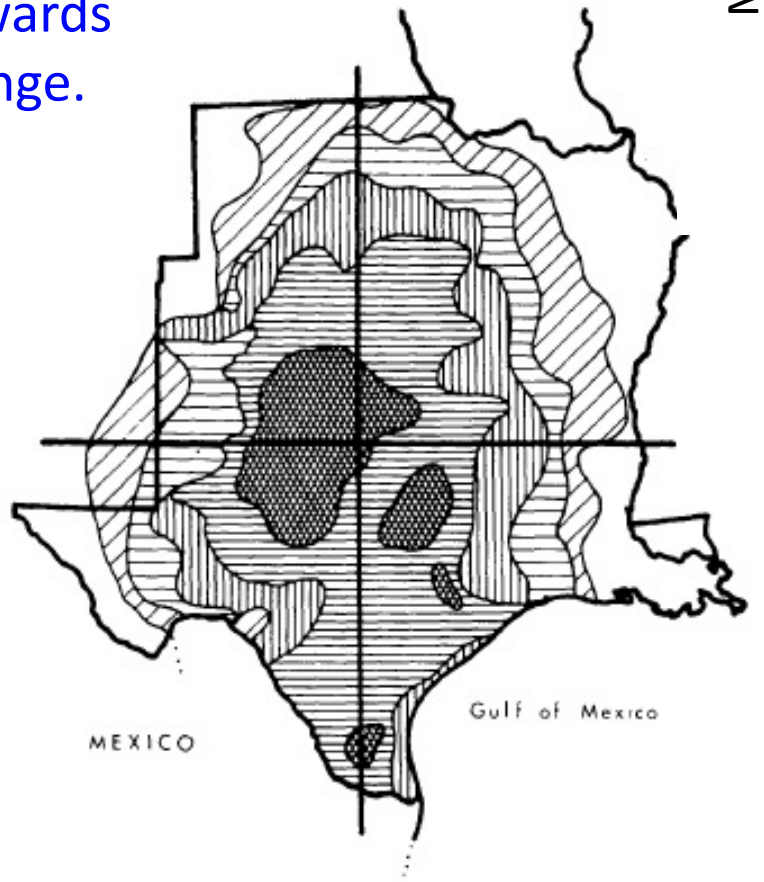

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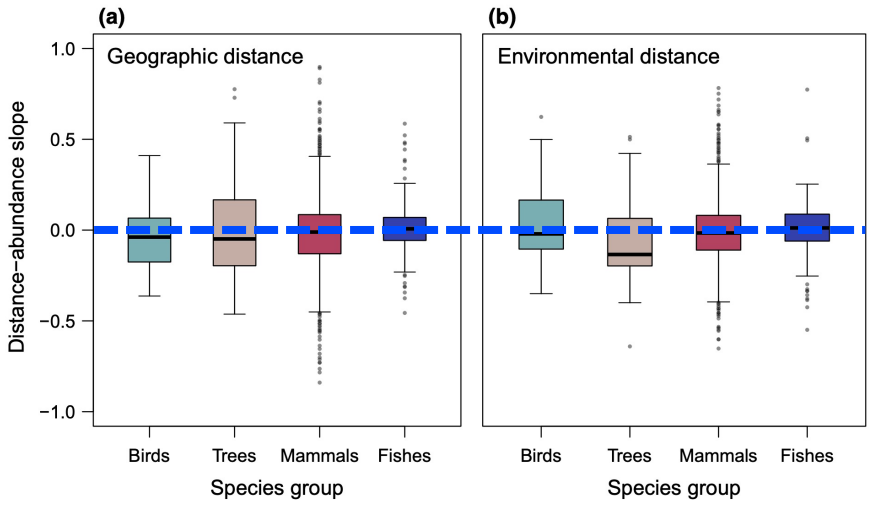
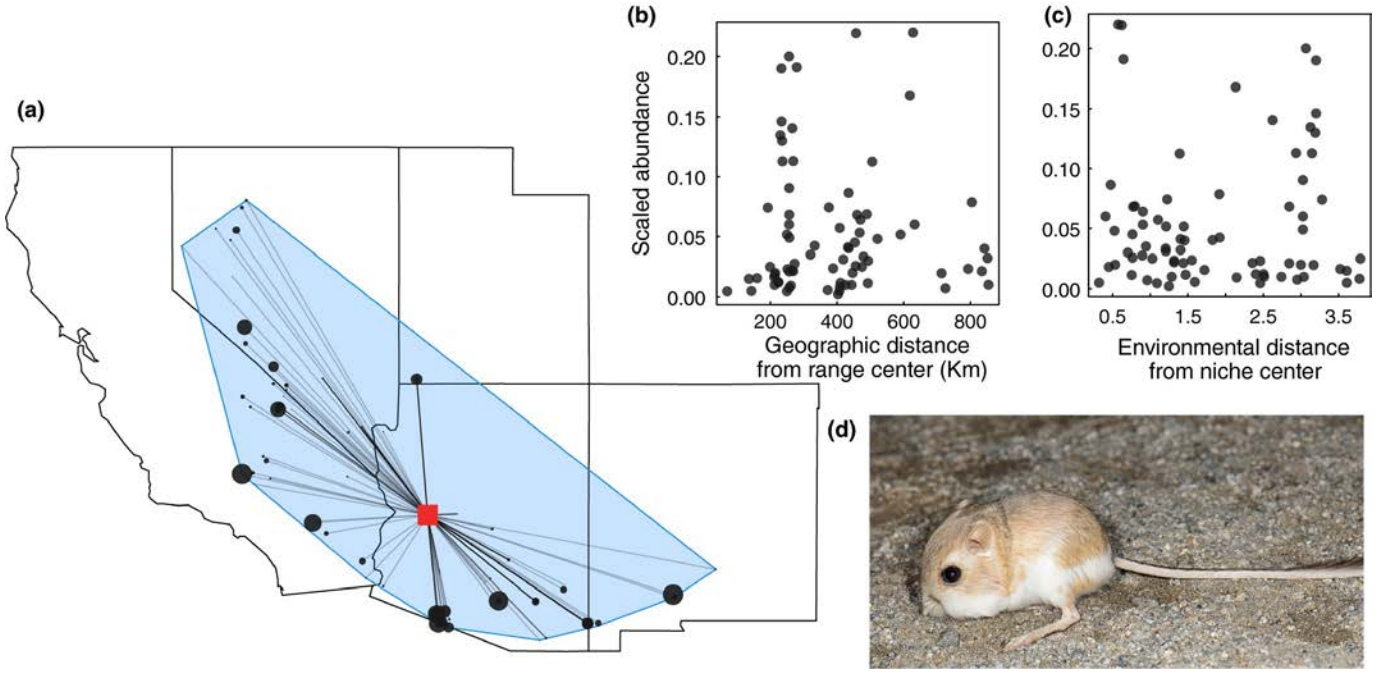


For >1,400 species of birds, trees, mammals, fishes:



Dallas et al. (2017) Species are not most abundant in the centre of their geographic range or climatic niche. *Ecology Letters*. 10.1111/ele.12860

Niche structure and limits

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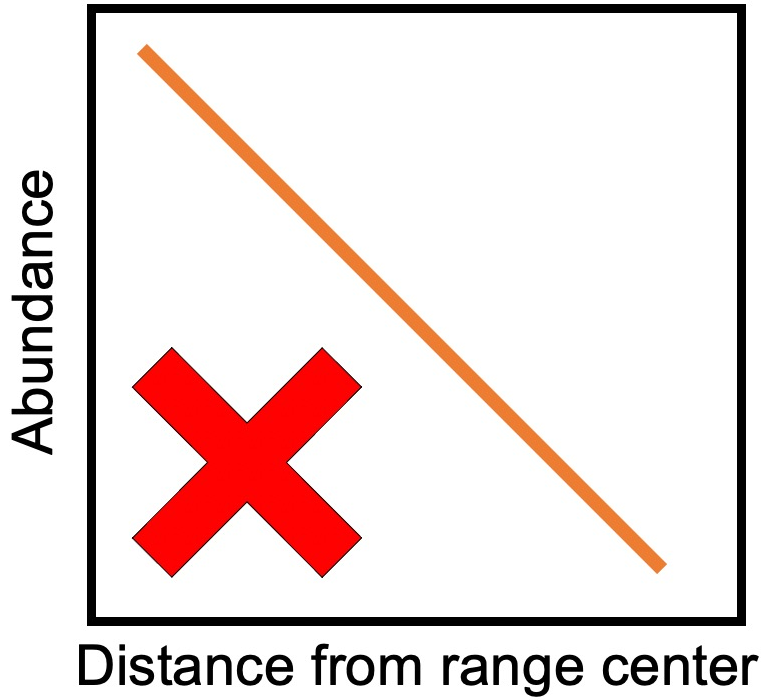

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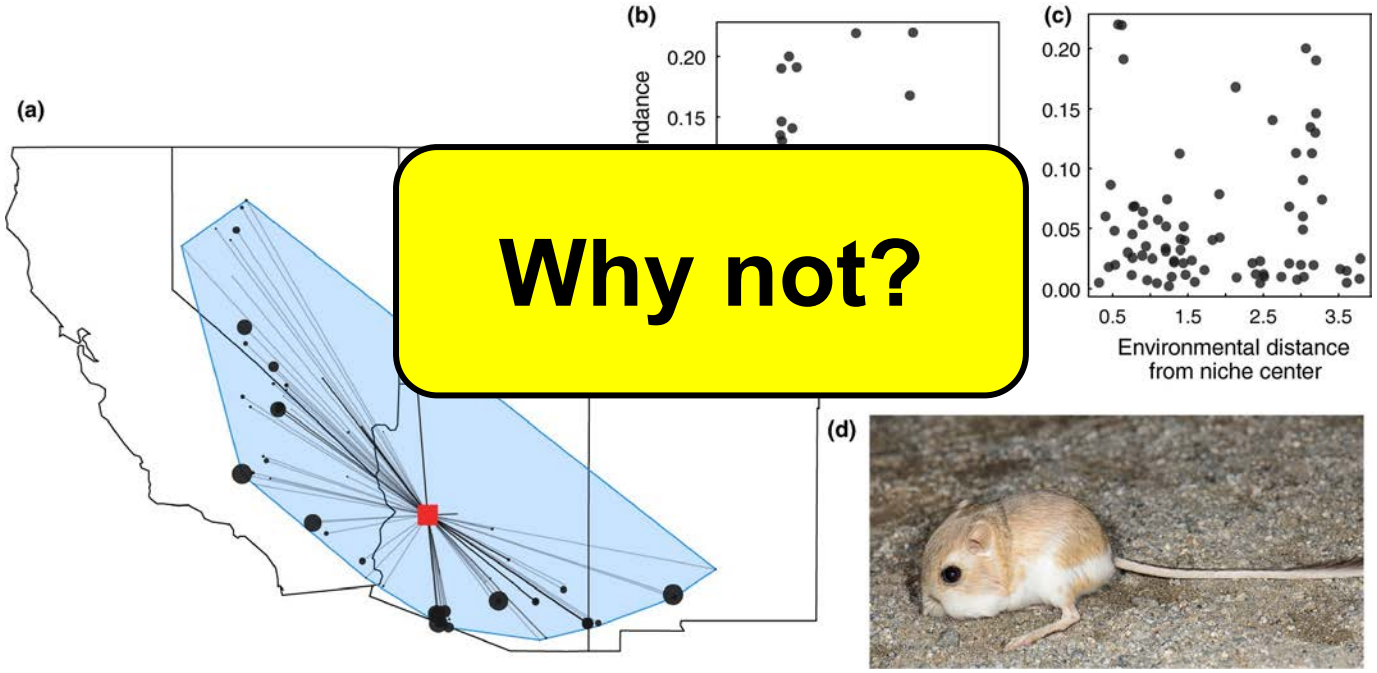


Why not?

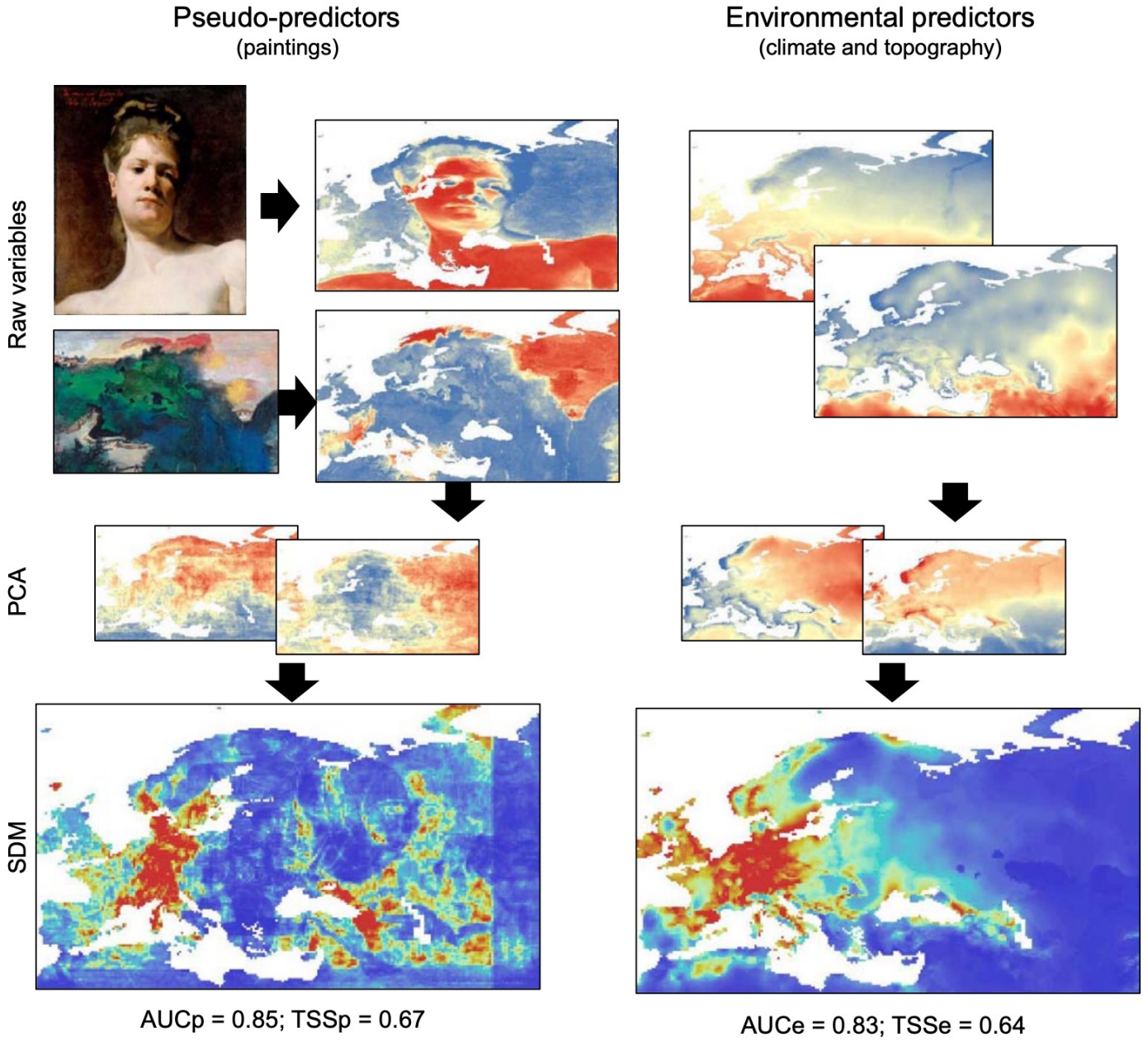
Dallas et al. (2017) Species are not most abundant in the centre of their geographic range or climatic niche. *Ecology Letters*. 10.1111/ele.12860

Pitfalls

- Other (Unmeasured? Unknown?) variables may be most important determinants of a species distributions

Pitfalls

- “Environmental” variables derived from paintings did as good (or better) at predicting species distributions as commonly used bioclimatic variables.
- Metrics of “model performance” do not assess the *biological significance* of SDMs.
- Variable selection *needs* to be hypothesis-driven, connected to the ecology of the study species.



Fourcade *et al.* (2018) *Global Ecology and Biogeography,* **27,** 245-256.

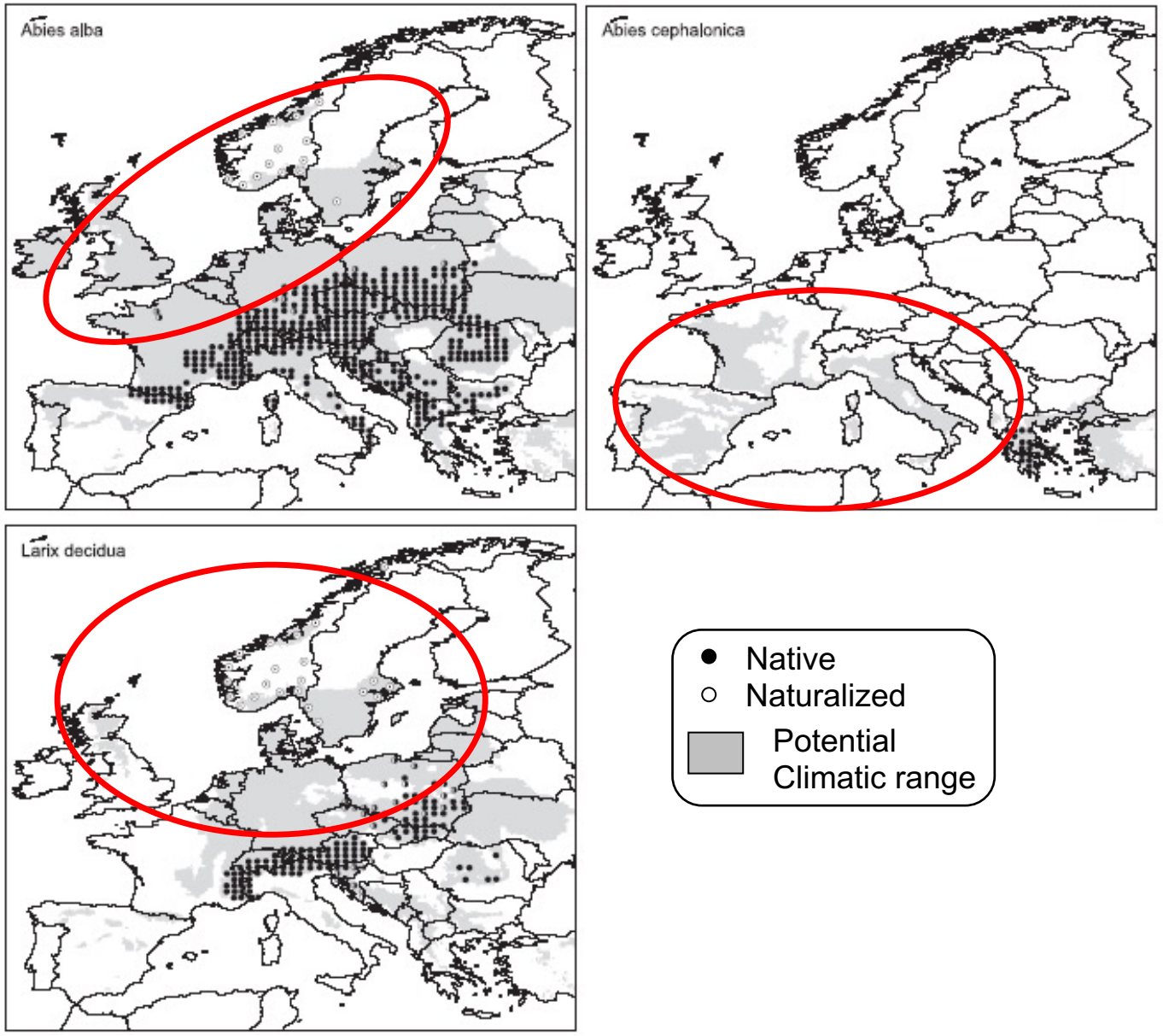
Pitfalls

- Other (unmeasured) variables may be most important determinants of a species distribution

- A species may not be in *equilibrium* with the environment
  - Abundance (presence) is not highest where fitness is highest

Pitfalls

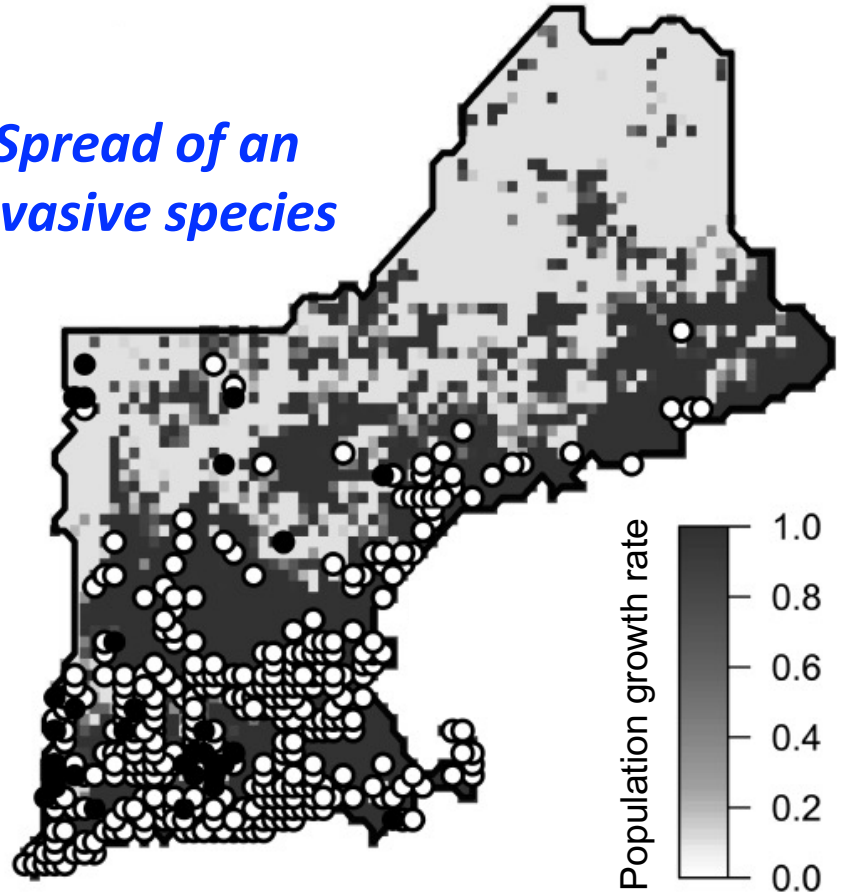
Limited filling of the potential range in European tree species



Svenning & Skov (2004) *Ecology Letters*

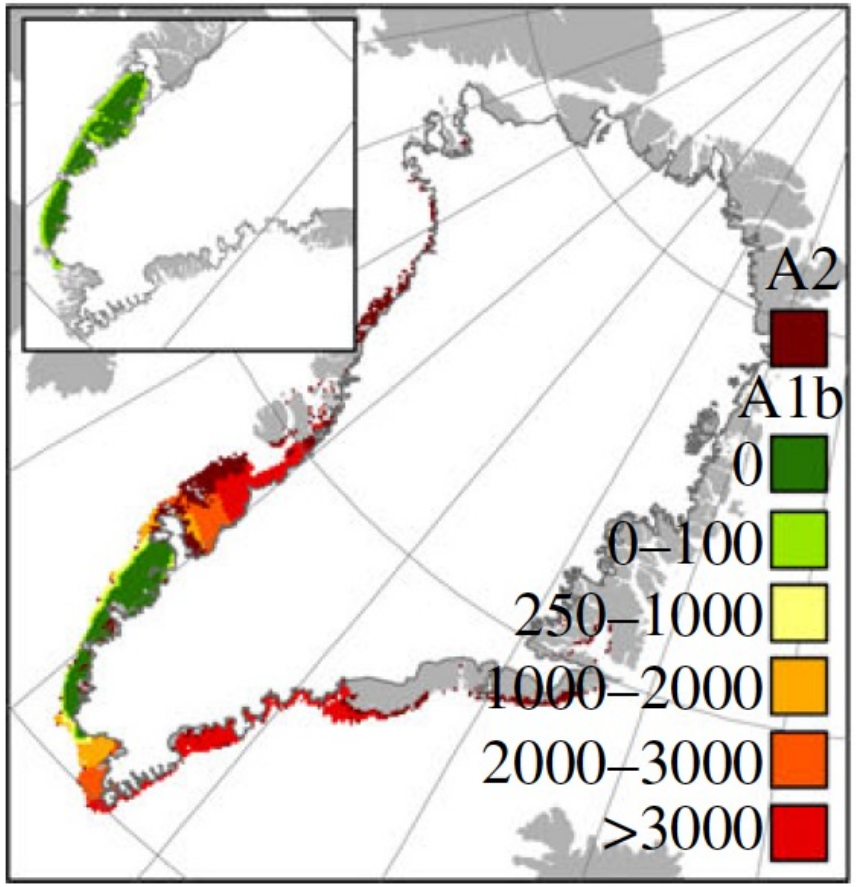
Potential?

Spread of an invasive species



Celastrus orbiculatus in Maine

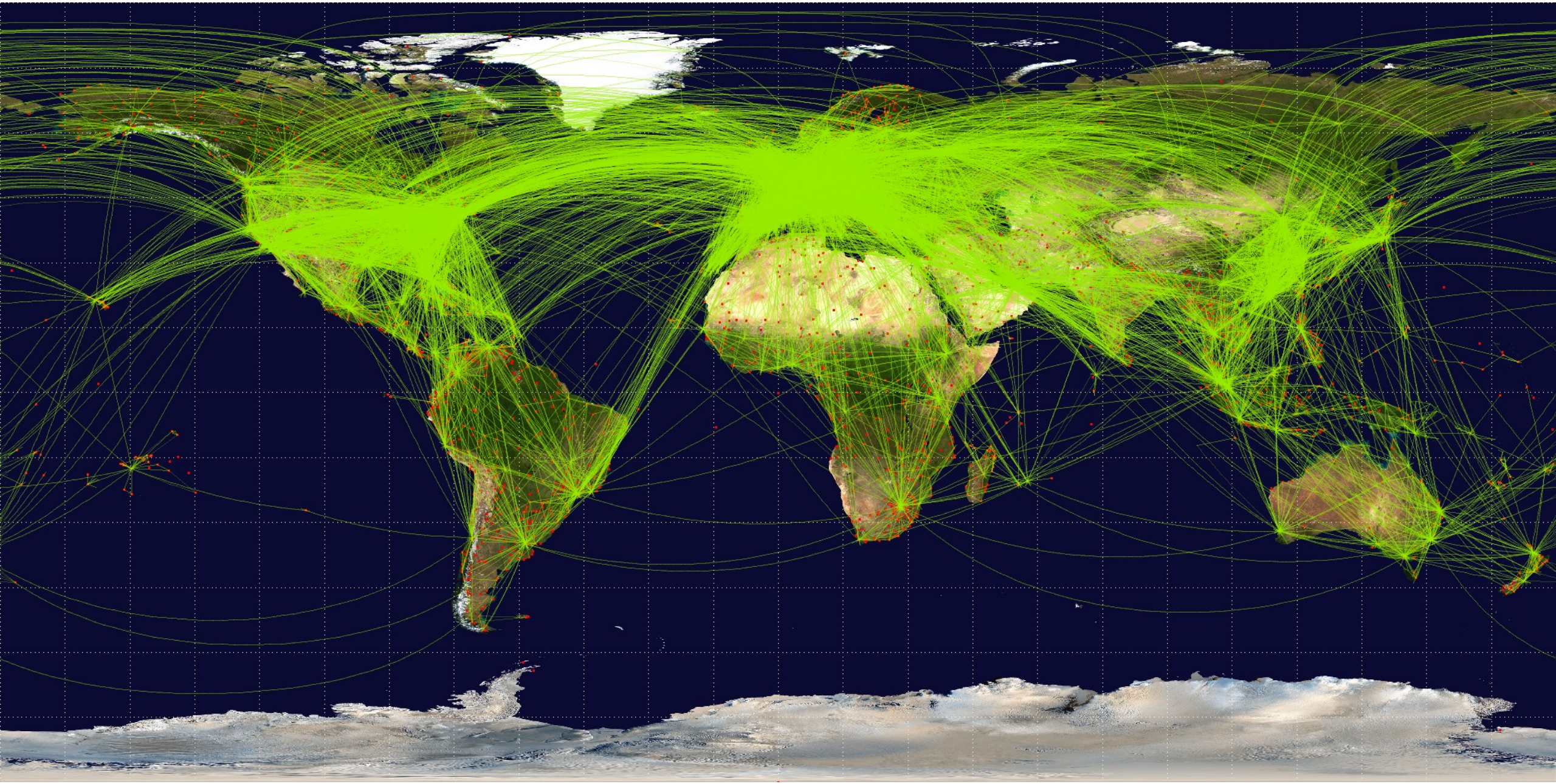
Predicting suitable areas under climate change



Suitable tree habitat in Greenland

Merow *et al*. 2011 *Am. Nat.*

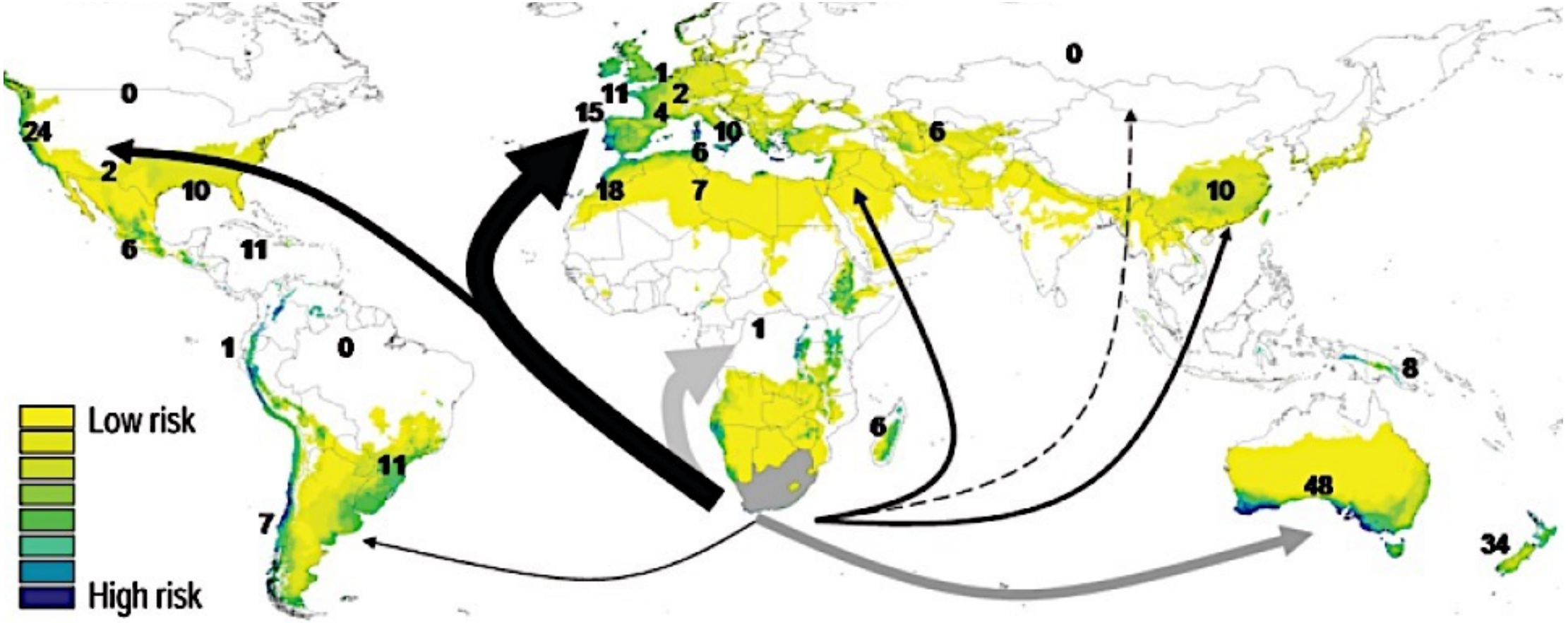
Normand *et al*. 2013 *Phil. Trans. Royal. Soc.*



Potential?

e.g., Carpobrotus edulis

Suitable habitat for South African ornamental plants predicts invasion success



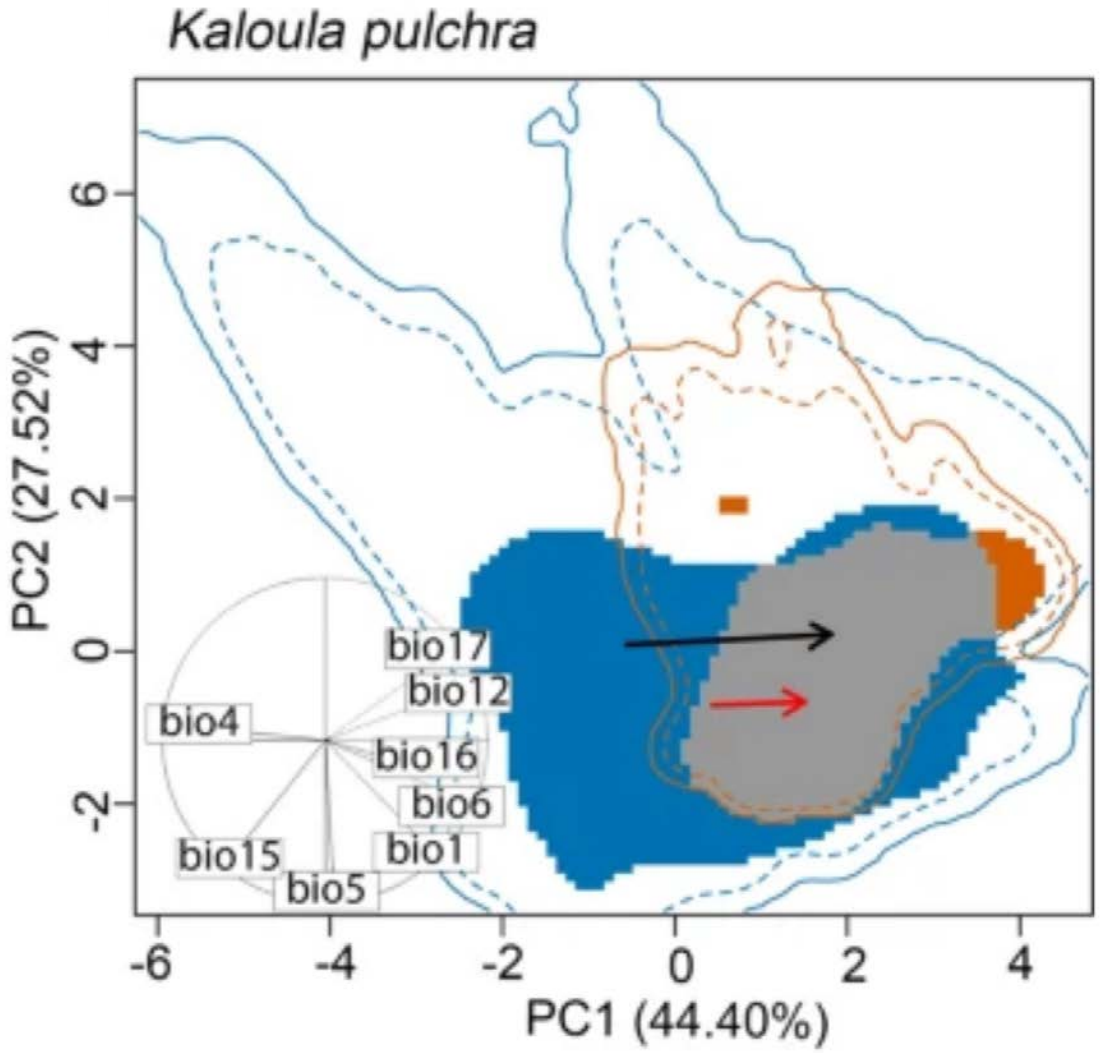
Thuiller *et al*. 2005 *Glob. Change Biol.*

Invasive species

OPEN

Niche shifts and environmental non-equilibrium undermine the usefulness of ecological niche models for invasion risk assessments

Arman N. Pili[1,2,3] ✉, Reid Tingley[3], Emerson Y. Sy[2,4], Mae Lowe L. Diesmos[2,5,6] & Arvin C. Diesmos[1,2,7]



Centroid shift from native to Philippine-invaded niche

Centroid shift from native to Philippine range climate

Climate niche in native range

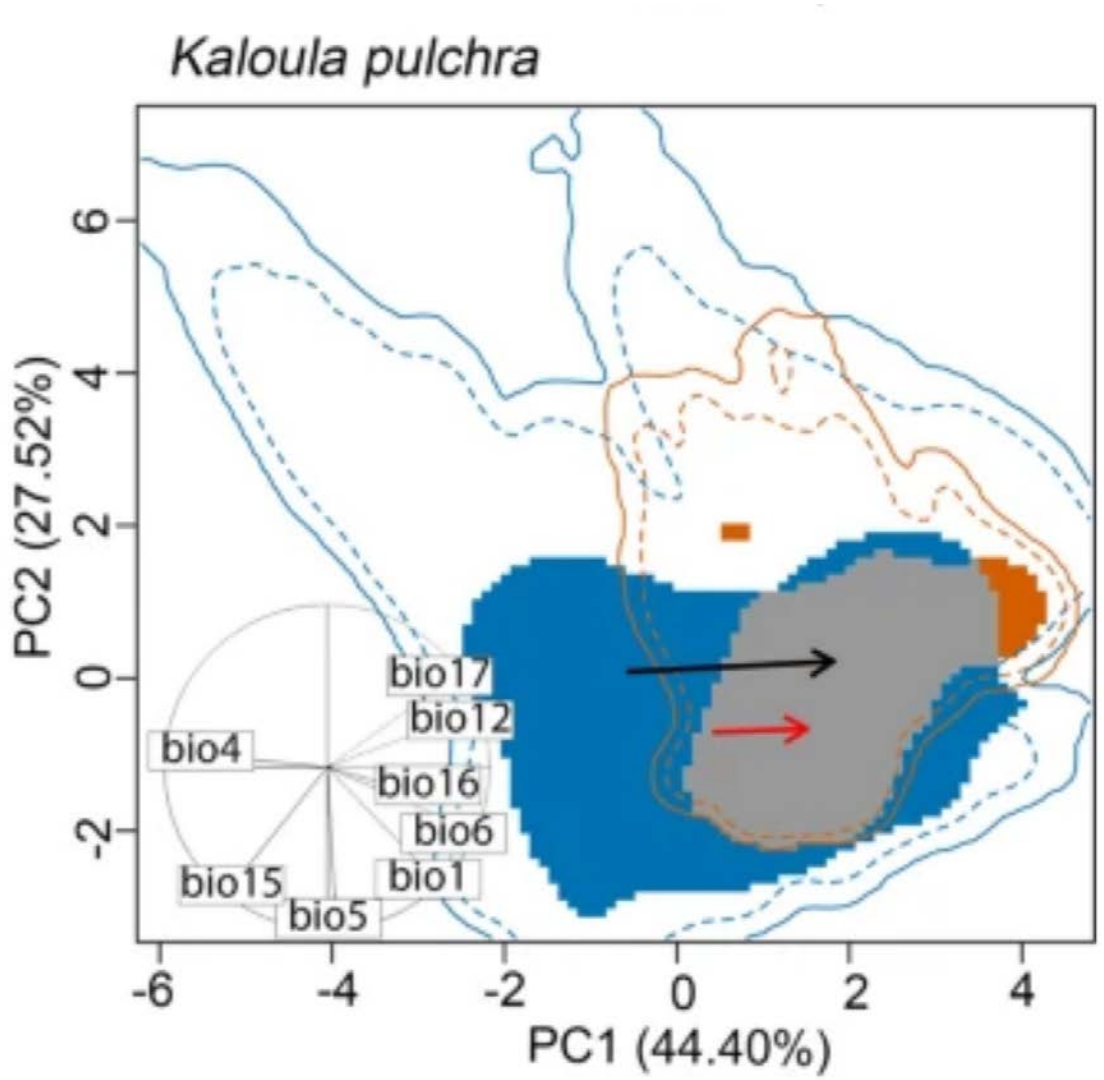
Climate niche in Philippine invaded-range

Climate niche overlap

Pili *et* al. (2020) *Scientific Reports*

Invasive species

- Niche shifts and environmental non-equilibrium challenge our ability to predict potential distributions



Pili *et* al. (2020) *Scientific Reports*

Pitfalls

- Other (unmeasured) variables may be most important determinants of a species distribution

- A species may not be in *equilibrium* with the environment
  - Abundance (presence) is not highest where fitness is highest

- Are we using best practices?

REVIEW | ECOLOGY

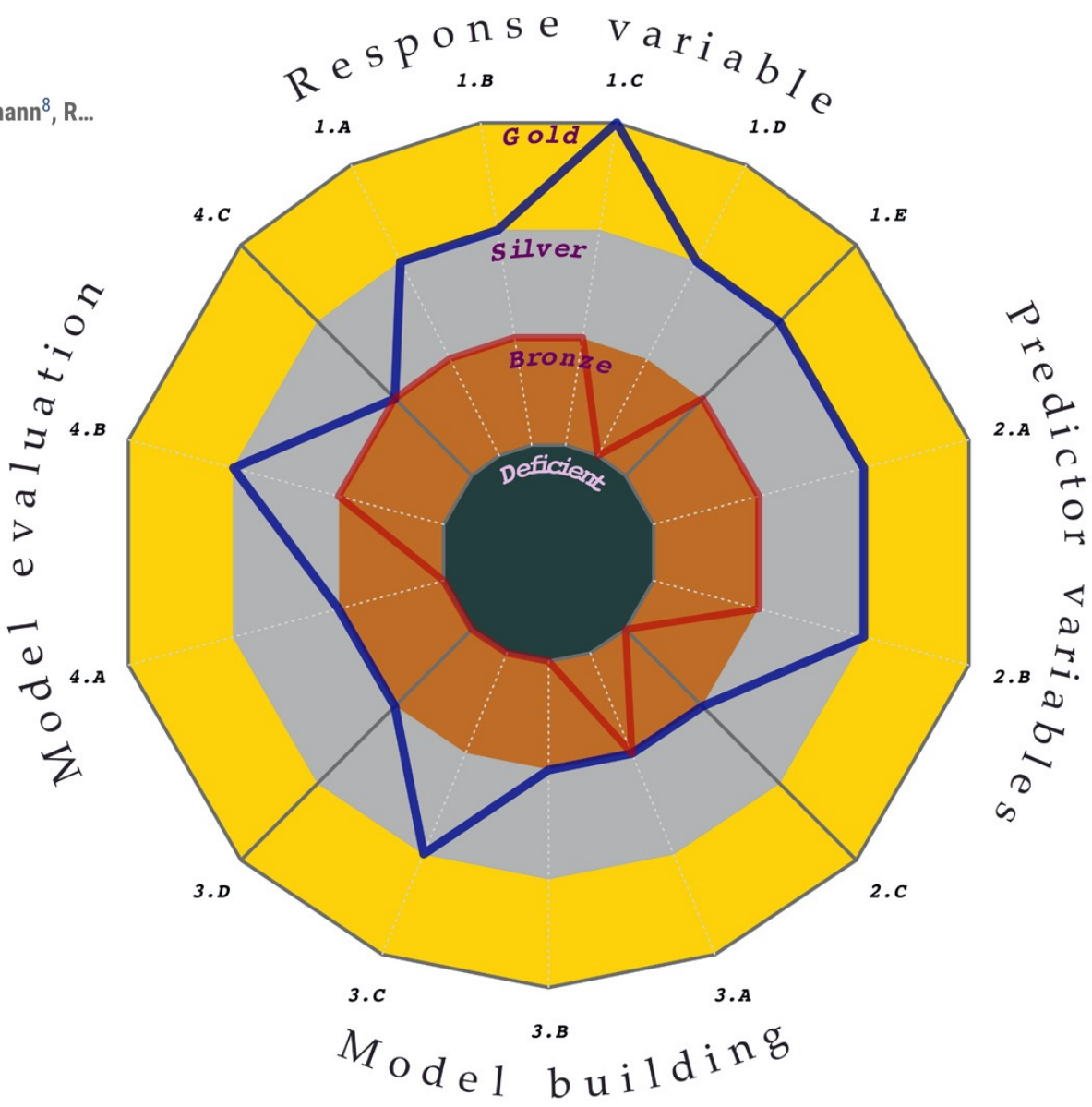
Standards for distribution models in biodiversity assessments

Miguel B. Araújo[1,2,3,*], Robert P. Anderson[4,5,6], A. Márcia Barbosa[3], Colin M. Beale[7], Carsten F. Dormann[8], R...
+ See all authors and affiliations

Science Advances 16 Jan 2019:
Vol. 5, no. 1, eaat4858
DOI: 10.1126/sciadv.aat4858

Top 90%

Top 50%



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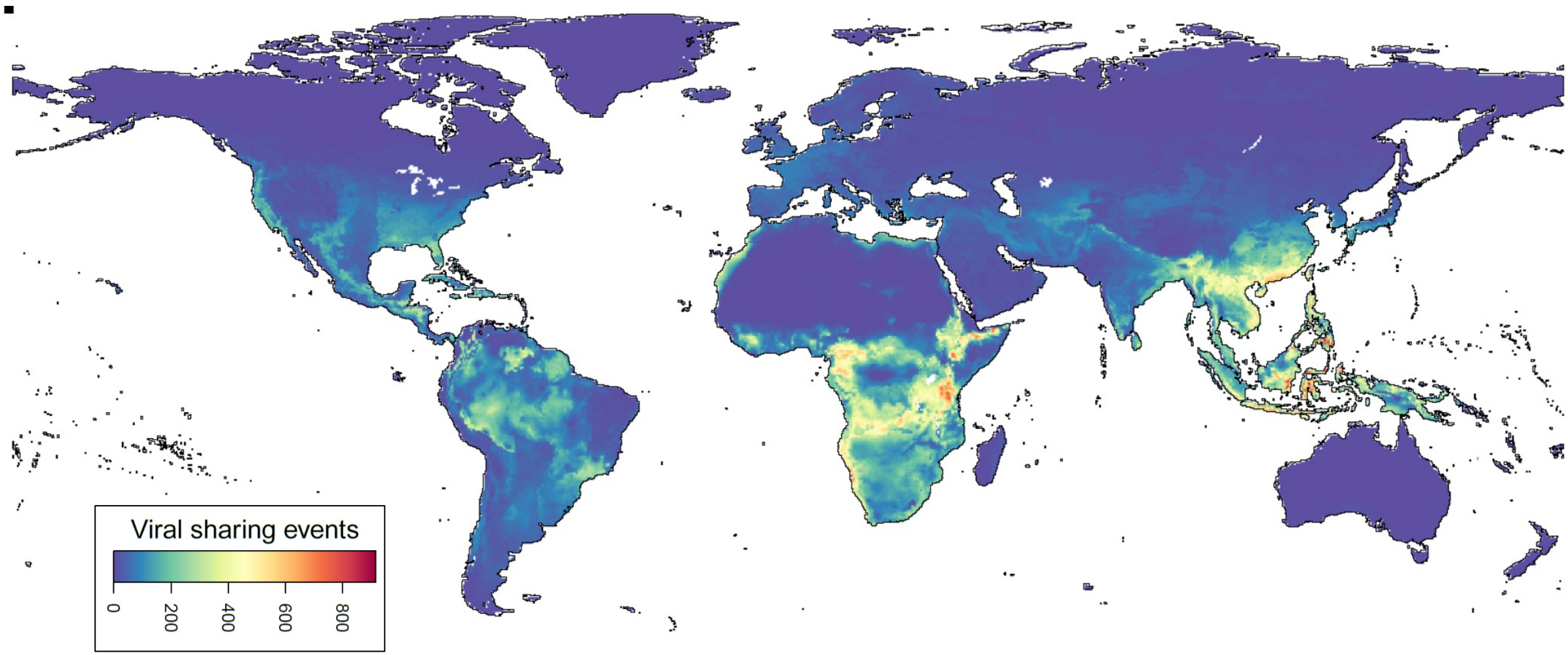
Emerging infectious disease



Carlson *et* al. (2020) Climate change will drive novel cross-species viral transmission. *bioRxiv:2020.2001.2024.918755.*

Summary

- SDMs/ENMs are relevant for an *extremely broad range of applications*
- Some key assumptions are rarely met (e.g., environmental equilibrium)
- Best practices are … not always … used
- Yet, these types of models can be extremely useful (understanding, prediction, *communication*)