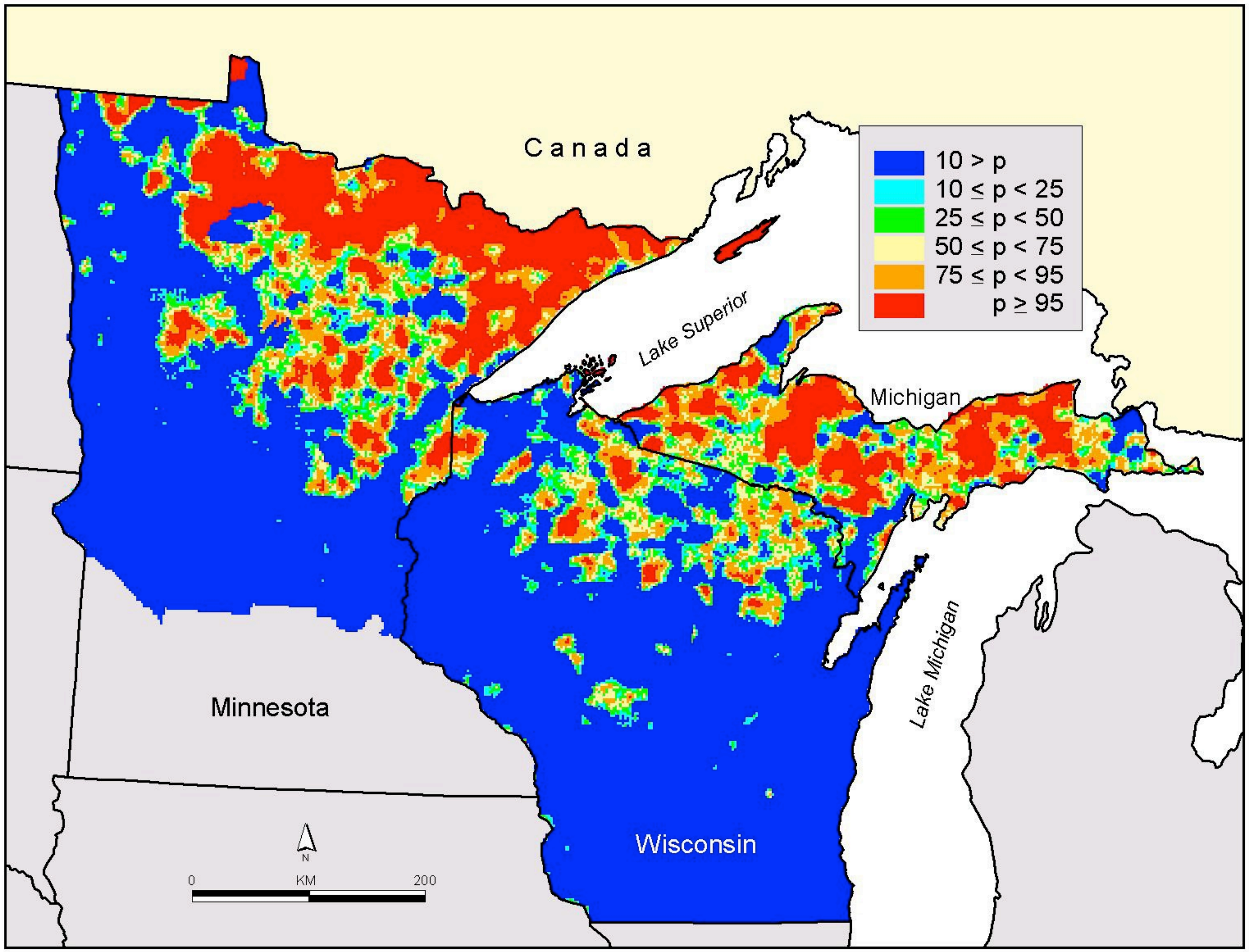
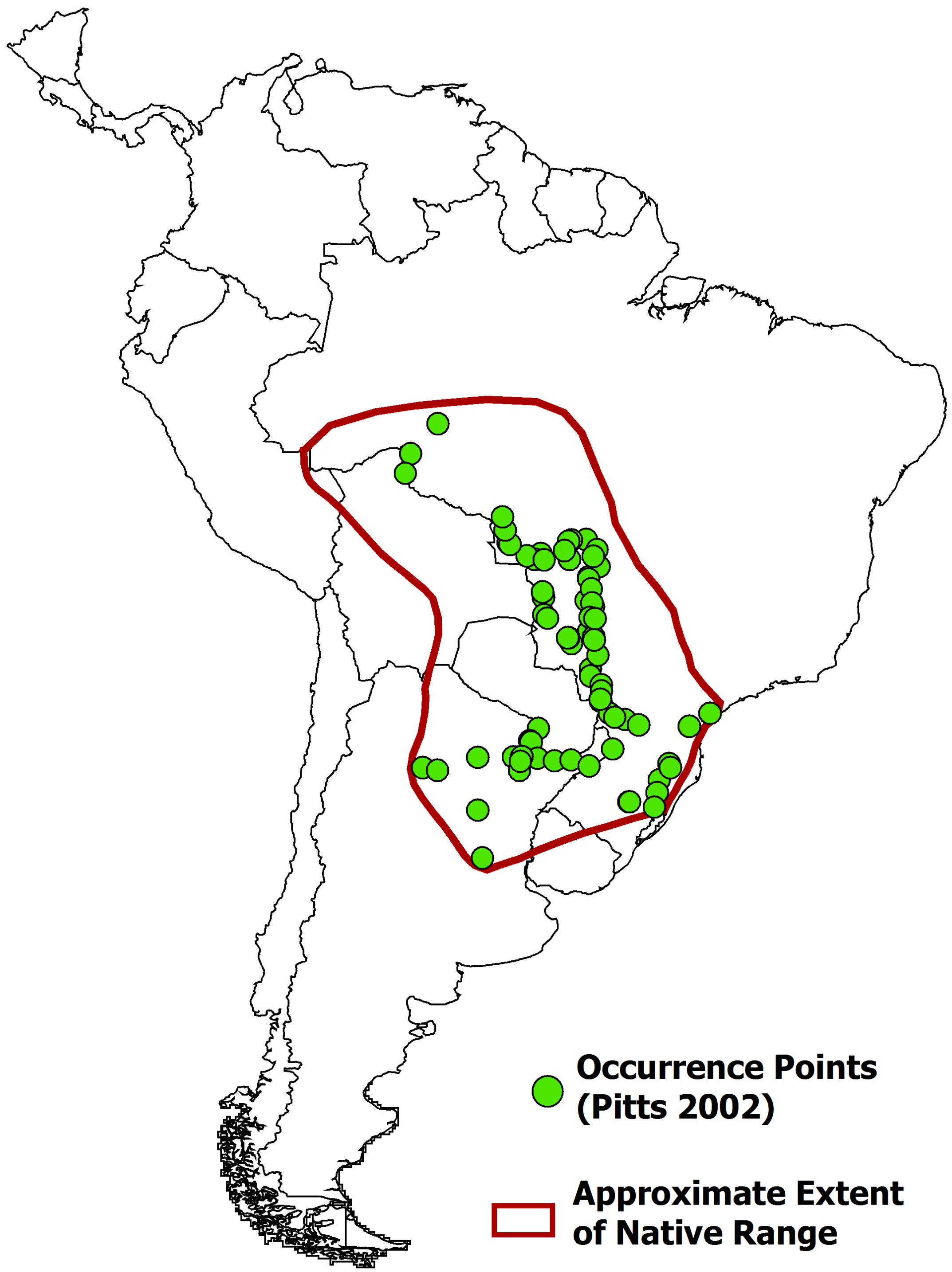
Species Distribution Modeling - Intro

Predicted habitat suitability for wolves

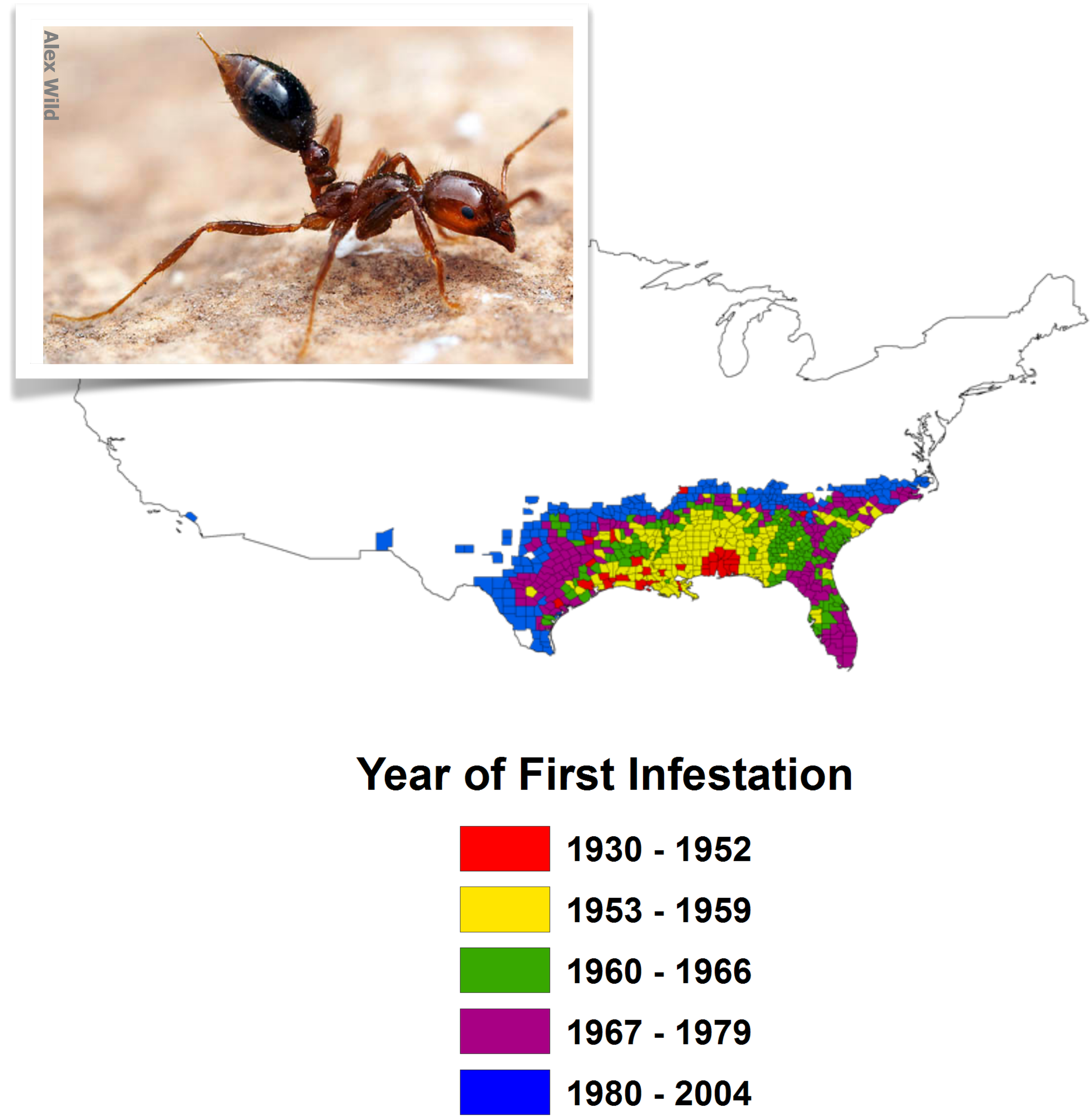


Mladenoff et al. 1999

Native range of *Solenopsis invicta*



Introduced range in US



Species Distribution Models (SDMs)

- Arguably the most popular class of models across ecology, evolution, and conservation
- More than 1,000 published papers per year on the topic

Species Distribution Models (SDMs)

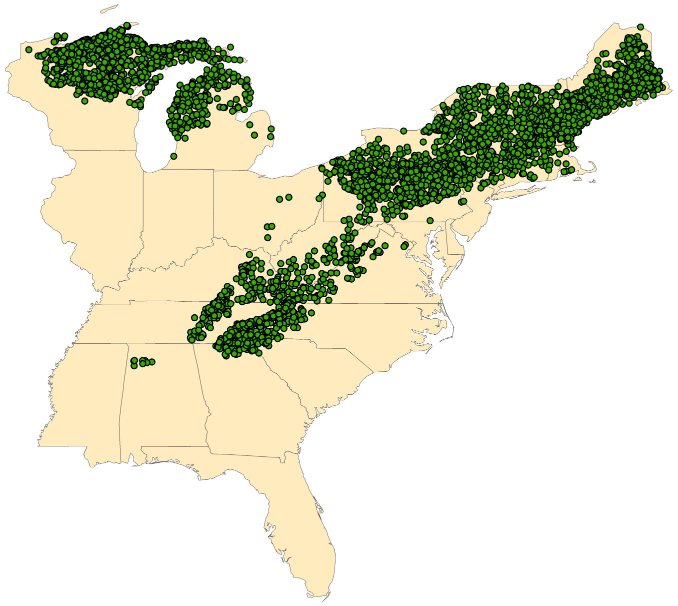
- Also known as…
  - Ecological / environmental niche models
  - Habitat suitability models
  - (Bio)climate envelope models
  - Range models

Distinguish between where the species actually is vs where they could be based on suitable conditions

- What are they?
  - Correlative / statistical models that estimate the potential spatial distribution of species by linking point-occurrence data and a set of coincident predictor variables
- How are they used?
  - Lots of ways!
  - Understanding species distributions
  - Prediction / projection of species distributions

Species distribution modeling

Tsuga canadensis



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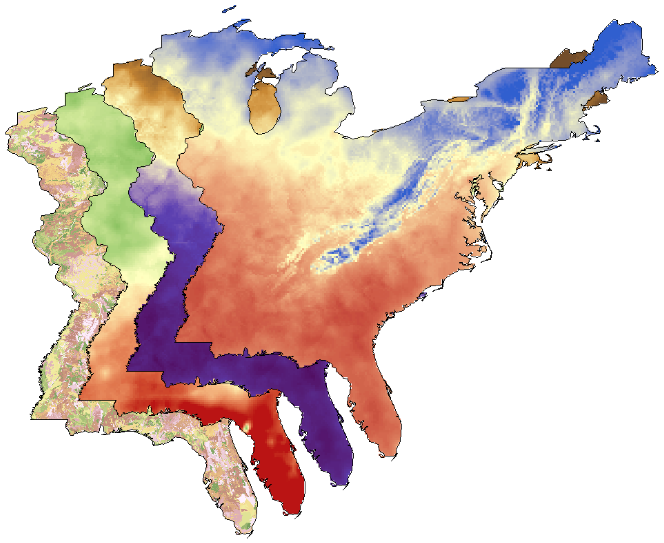
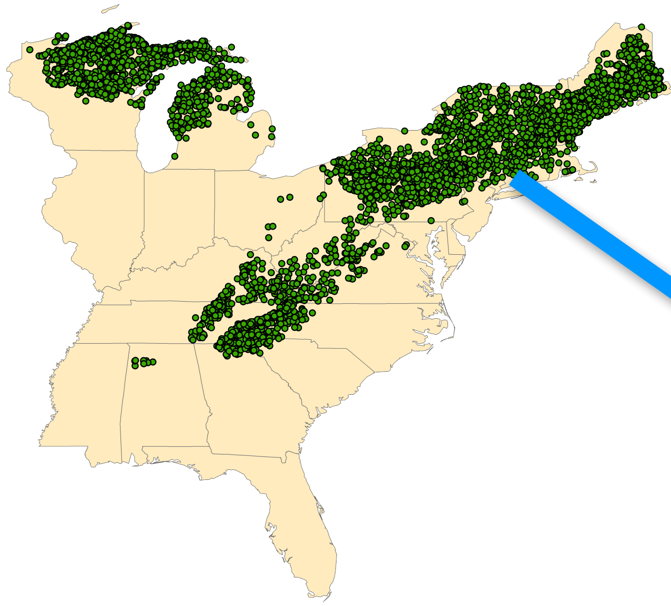


Species distribution modeling

Tsuga canadensis



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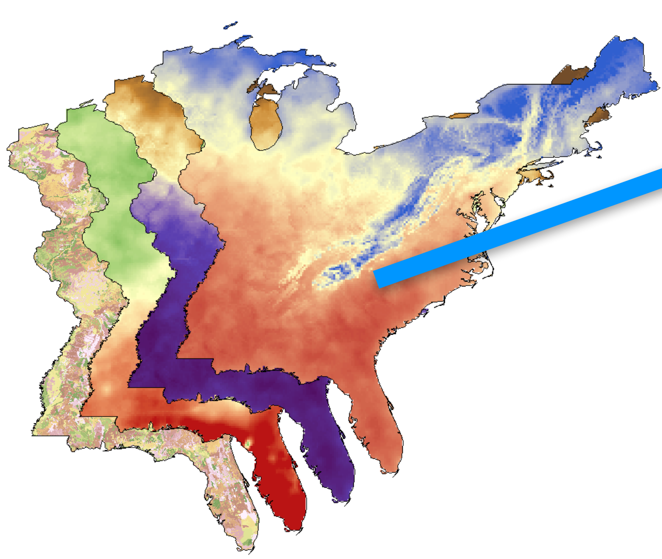


Biological survey data

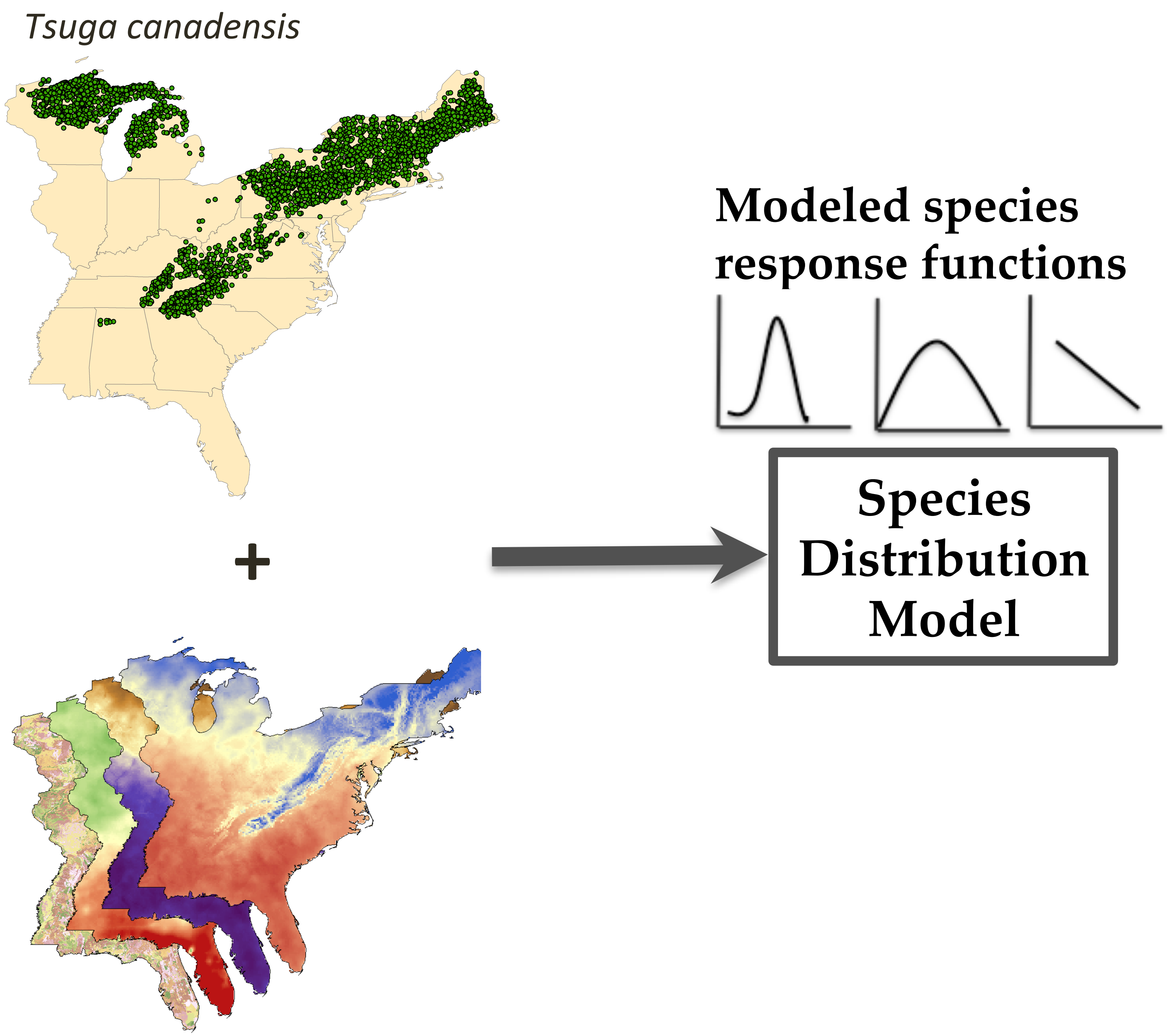
Environmental covariates

$$
\begin{array}{c} \\ Site_1 \\ Site_2 \\ Site_3 \\ \ldots \\ Site_j \end{array}
\begin{array}{c} Spp_1 \\ \left[\begin{array}{c} 0 \\ 1 \\ 1 \\ \ldots \\ 1 \end{array}\right] \end{array}
= f\left\{
\begin{array}{c} \\ Site_1 \\ Site_2 \\ Site_3 \\ \ldots \\ Site_j \end{array}
\begin{array}{c} \begin{array}{ccccc} Env_1 & Env_2 & Env_3 & \ldots & Env_k \end{array} \\ \left[\begin{array}{ccccc} 23.4 & 545.5 & 0.64 & \ldots & 4.1 \\ 22.1 & 89.0 & 0.22 & \ldots & 8.0 \\ 24.9 & 439.5 & 0.61 & \ldots & 3.4 \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ 25.3 & 321.7 & 0.88 & \ldots & 3.9 \end{array}\right] \end{array}
\right\}
$$

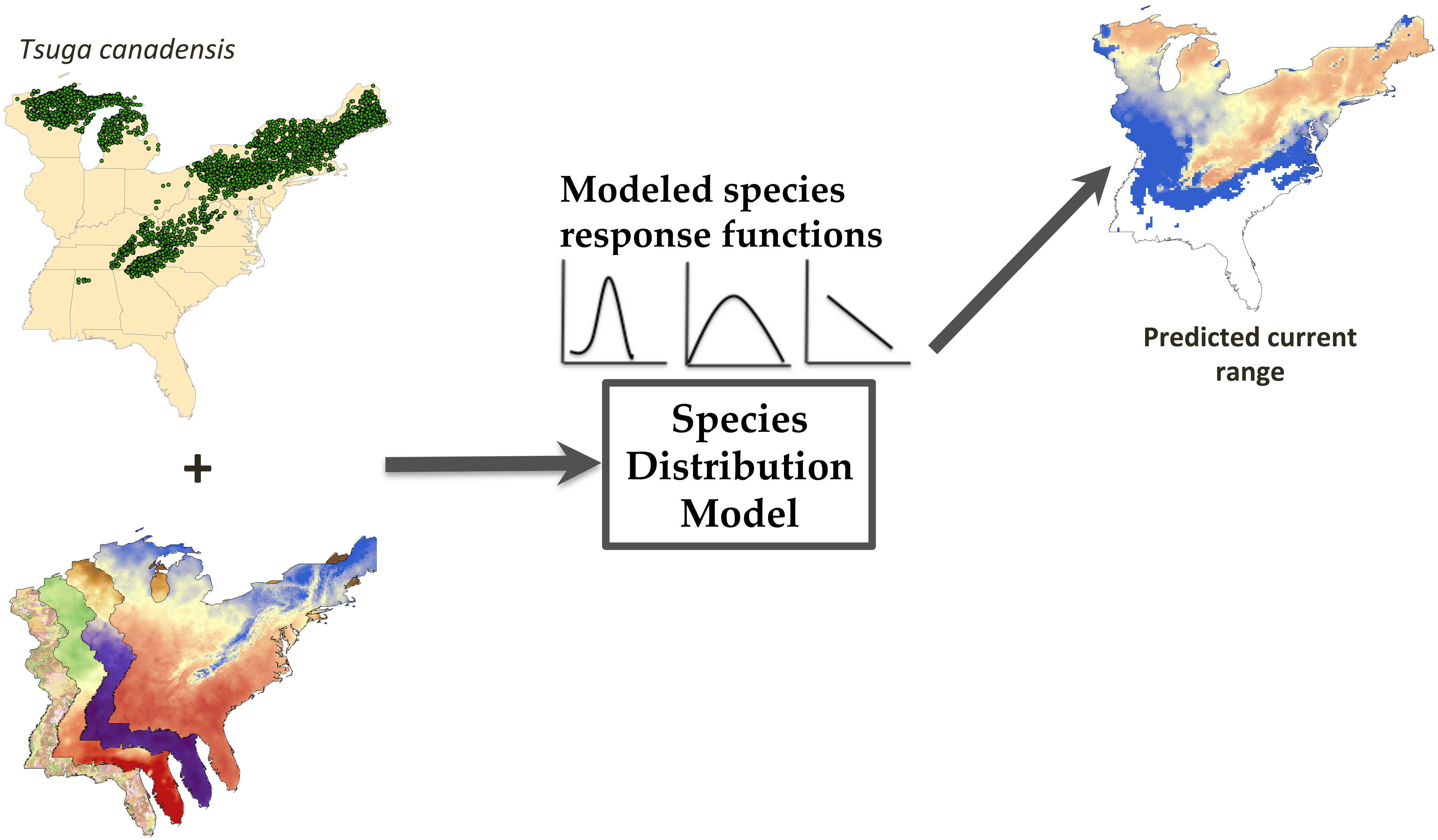
0 for absence
1 for presence (can be presence only)
or could actually have counts

model survey data as a function of covariates to get the response function

Species distribution modeling

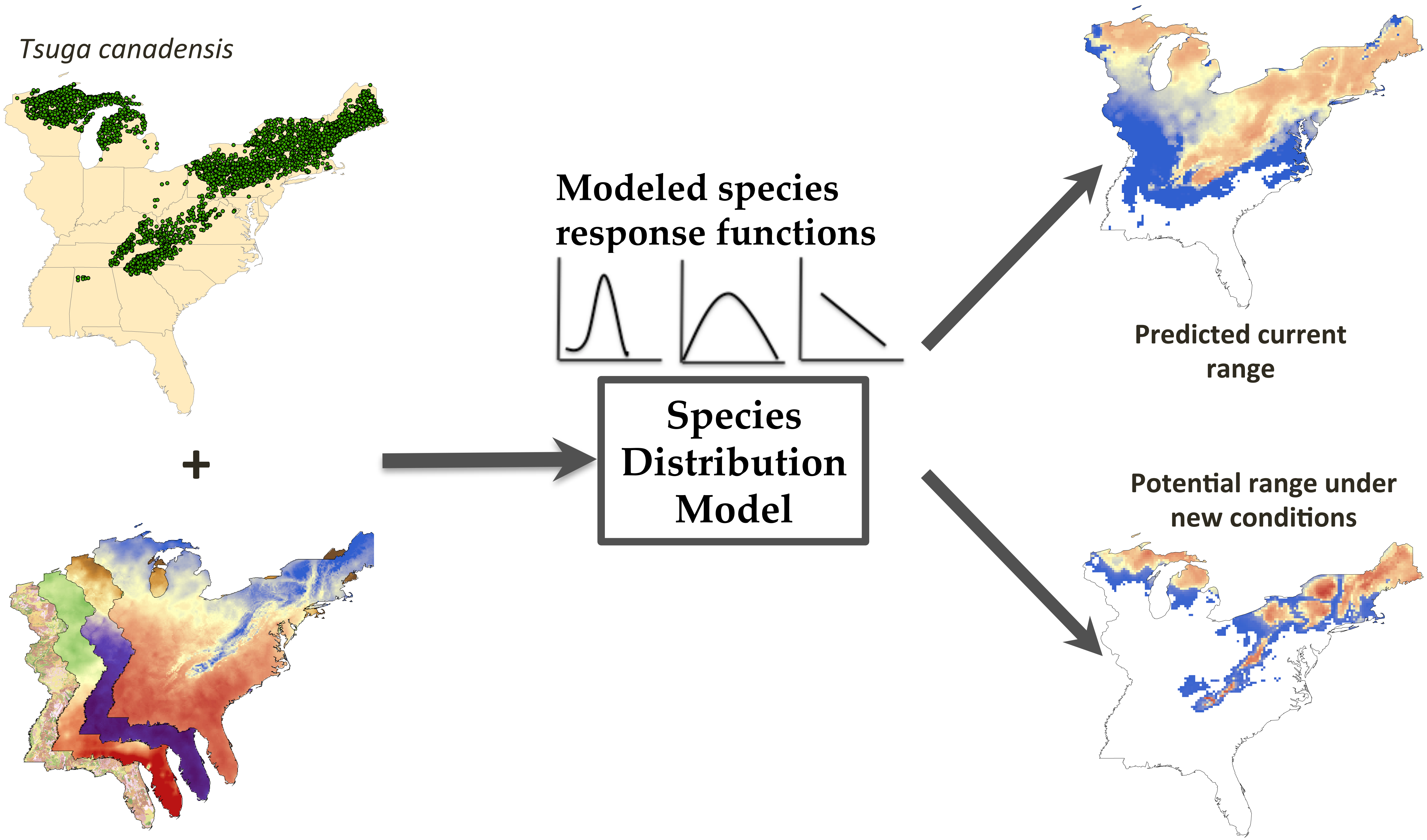


Species distribution modeling

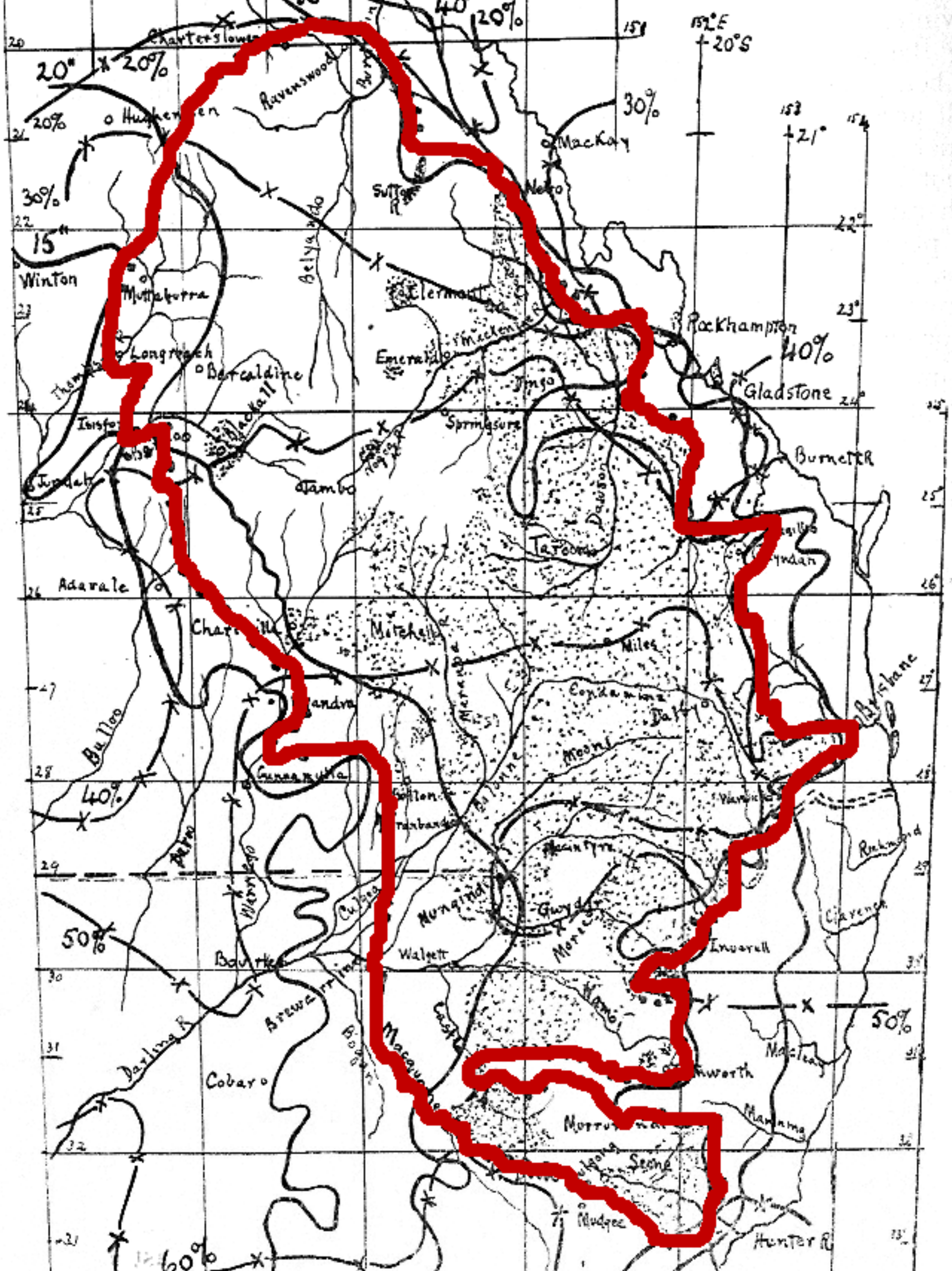


Species distribution modeling

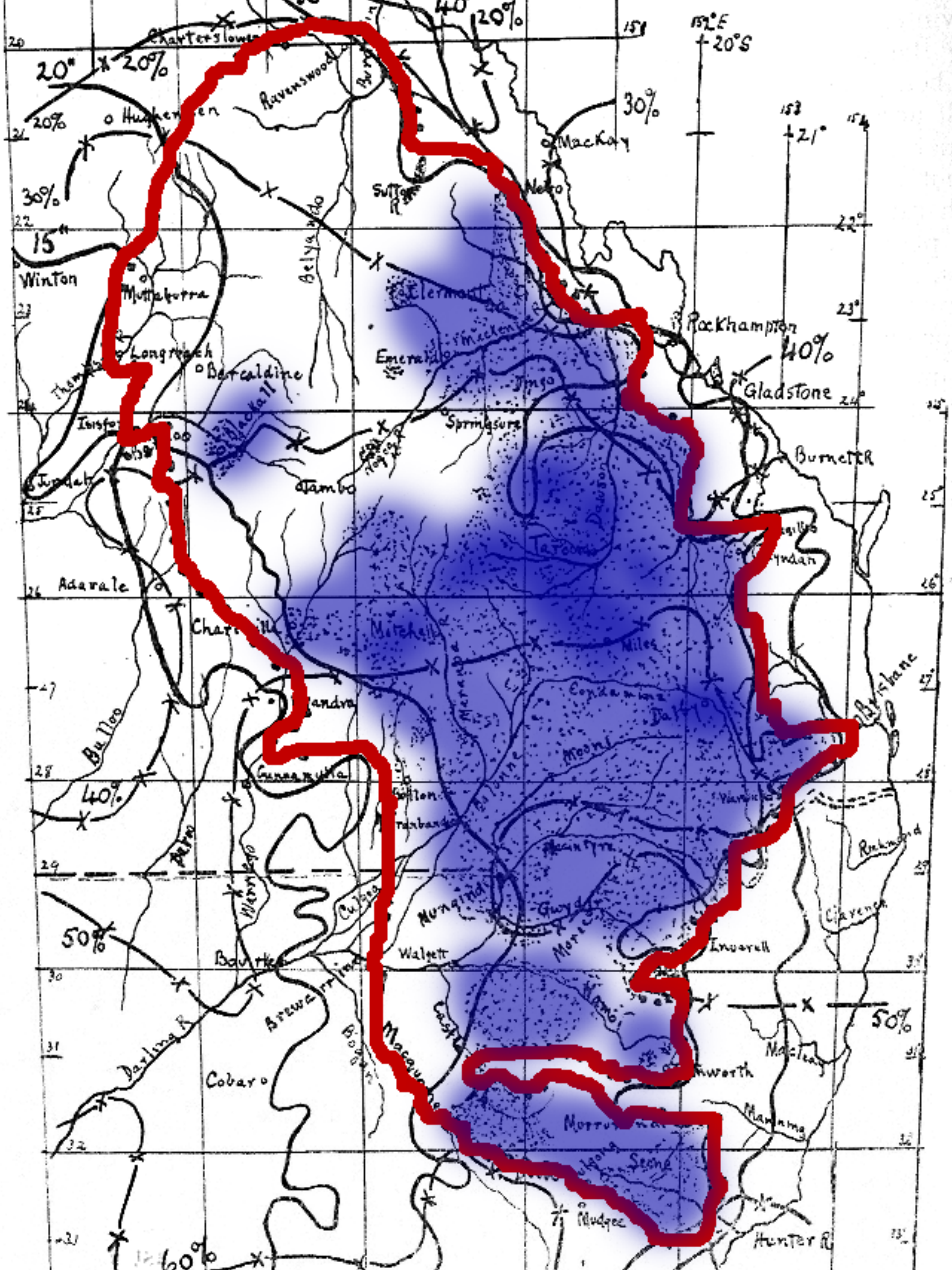
forecast under new conditions
ensure that the underlying model
assumptions are not violated!



Johnston was interested inw



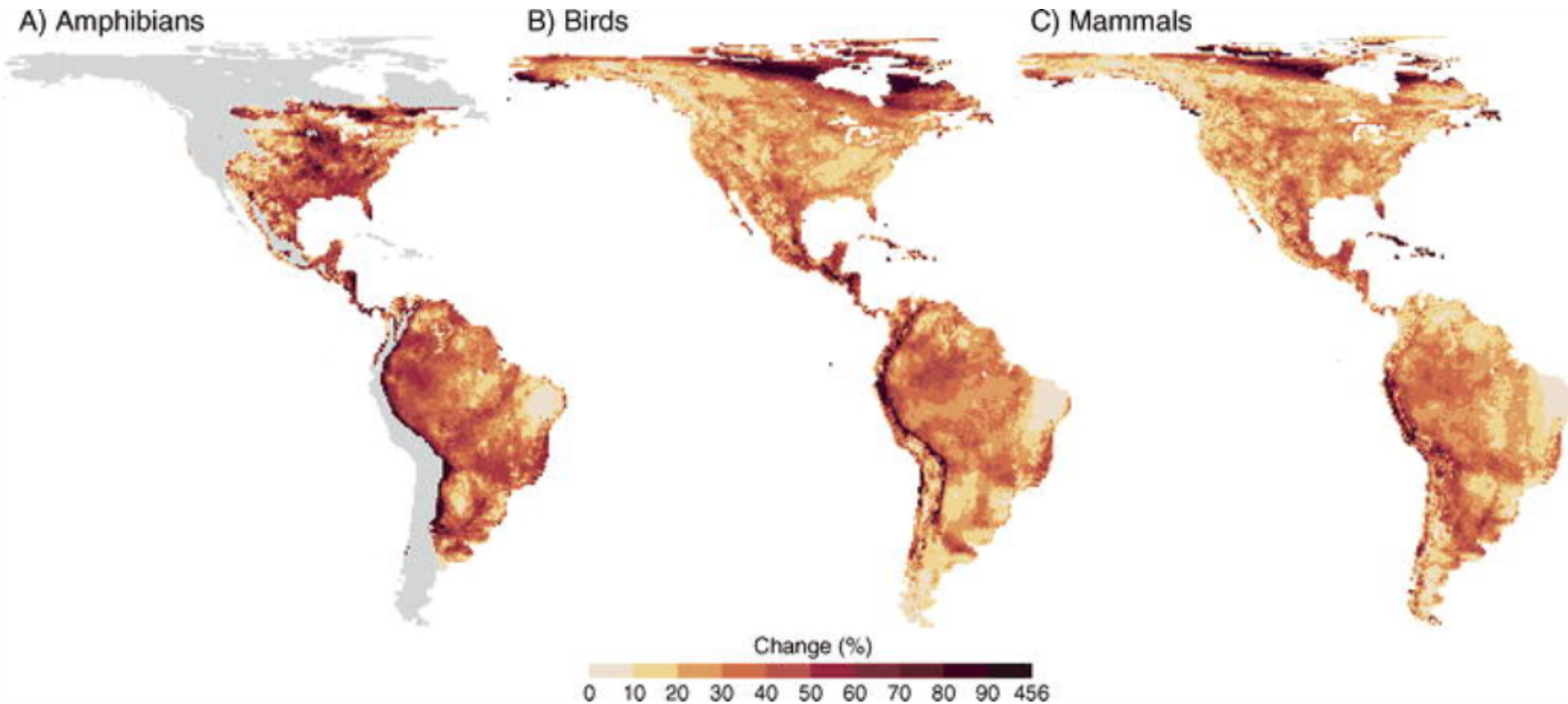
Johnston 1924



Johnston 1924

blue = known distribution of prickly pear

red= where prickly pear is likely to invade



Group modelled climate change impacts on 100s of species to determine possible change in species composition. High latitudes and high elevatic

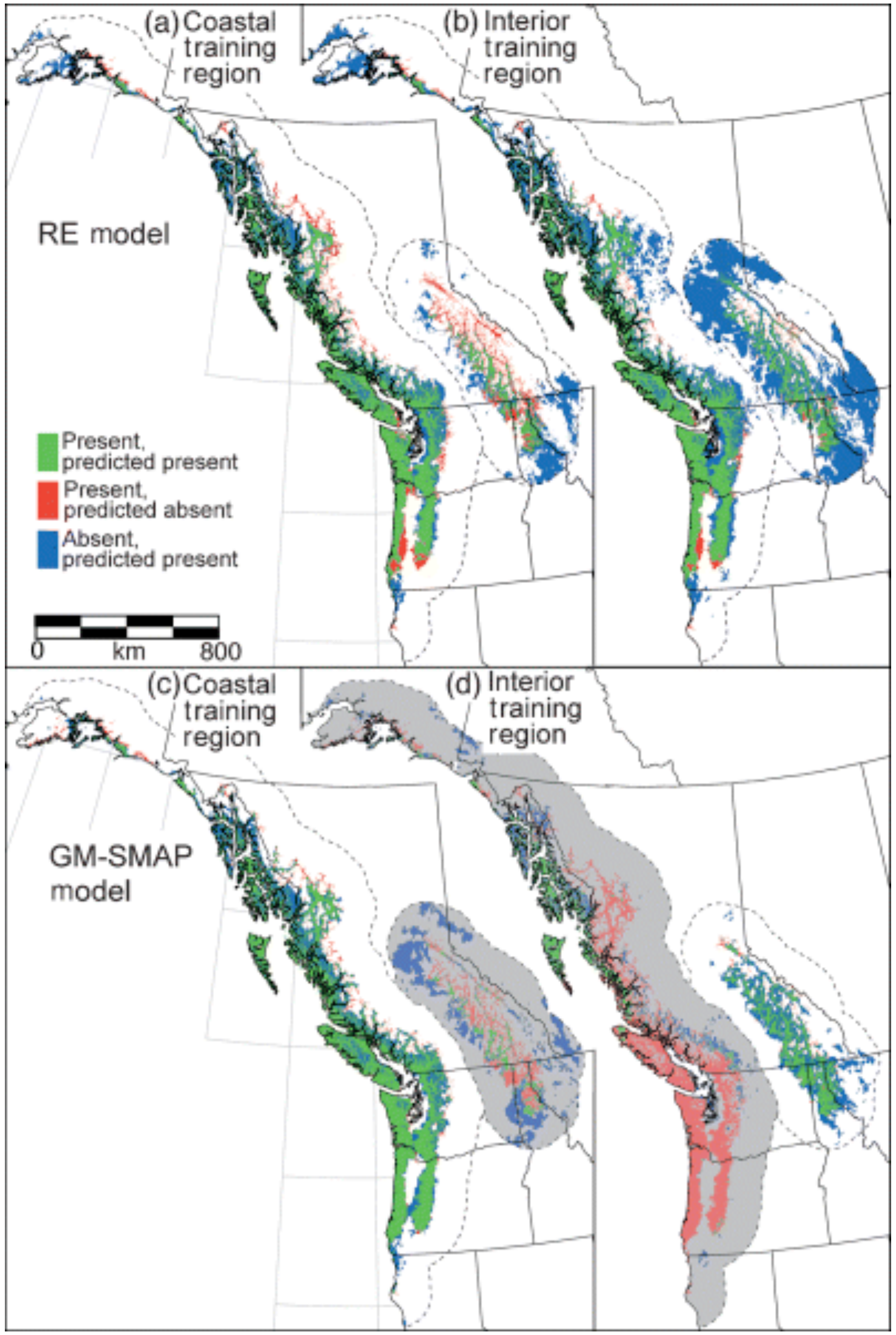
Ecology
Volume 90, Issue 3, pages 588-597, 1 MAR 2009 DOI: 10.1890/08-0823.1
http://onlinelibrary.wiley.com/doi/10.1890/08-0823.1/full#i0012-9658-90-3-588-f03

Applications

Biogeography:
Understand and explain distributions

differences in drivers of coastal and inland distribution

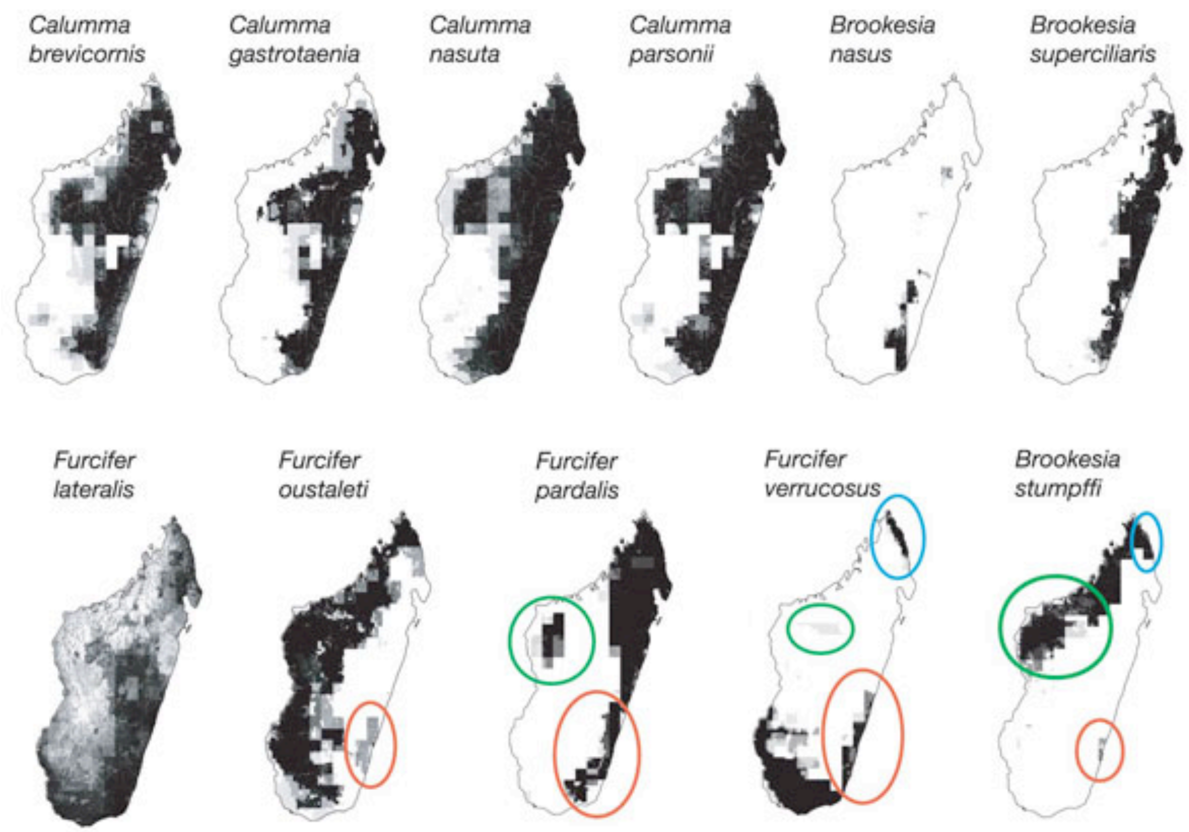
Bioclimatic model predictions of the *Tsuga heterophylla* distribution. Predictions from the rectilinear envelope model using (a) coastal-region thresholds and (b) interior-region thresholds, and from the Gaussian mixture-sequential maximum *a posteriori* model trained on (c) the coastal region and (d) the interior region.



Gavin and Hu. 2006. Journal of Biogeography.

Applications

Discovery…



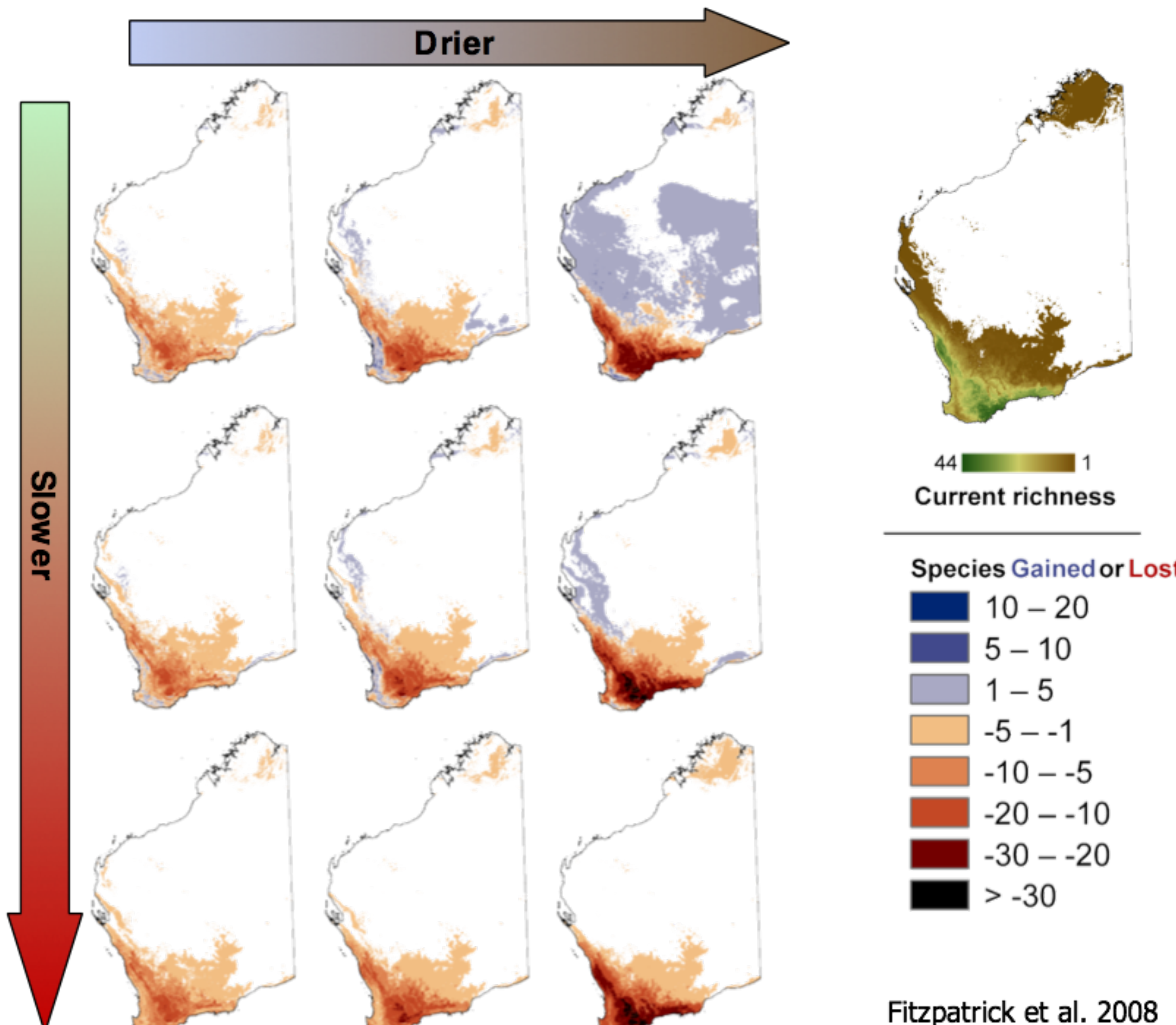
modelled distributions of chameleon species and then asked model for suitable habitats (circled) then surveyed to see if the chameleons were actually there. They were.

The sum of ten best-subset models is shown, with darker shading representing greater model agreement. Areas of over-prediction are circled. The intersecting over-prediction regions in the west (green) and northeast (blue) have recently yielded seven new locally endemic chameleon species; the other area in the southeast (red) remains poorly studied.

Raxworthy et al. 2003 Nature.

Applications

Climate change impacts



Fitzpatrick et al. 2008
Global Change Biology

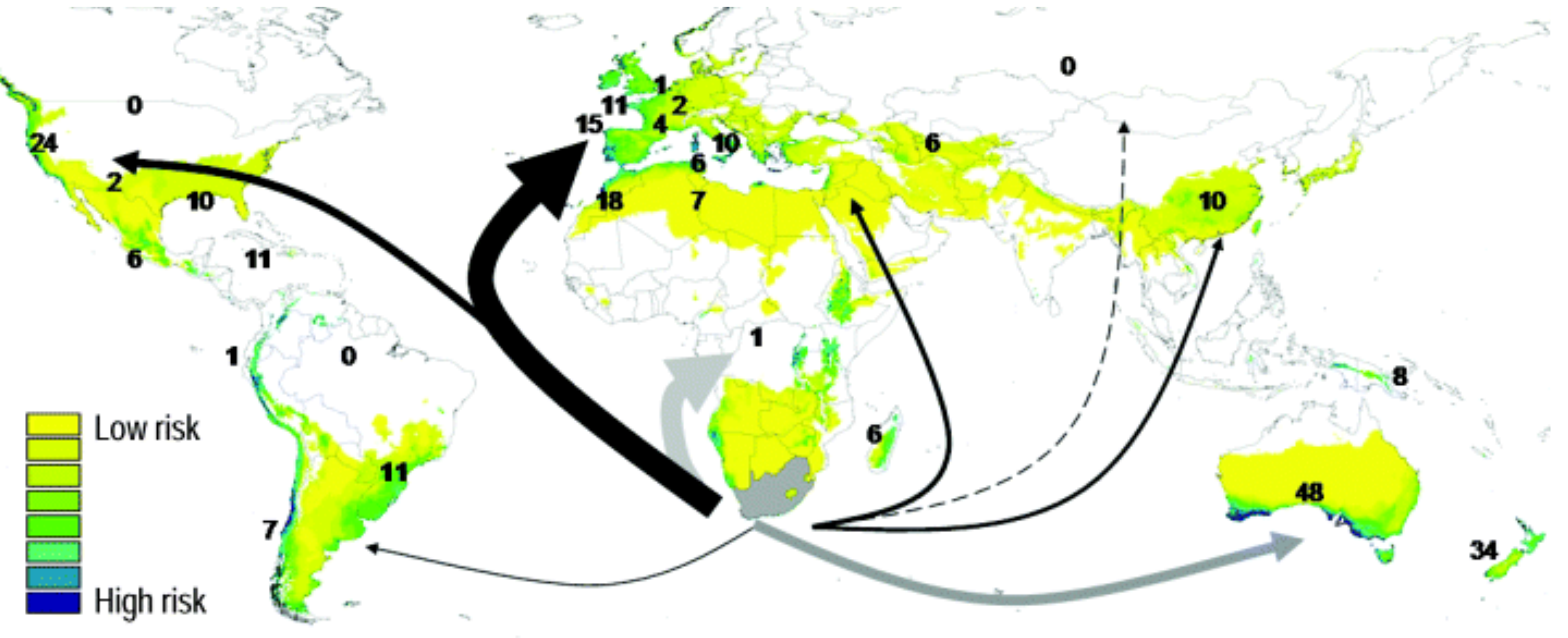
dispersal in response to
different climate scenarios

Applications

some papers model the likelihood of archaeological sites to yield findings

Invasion risk

this paper models the entire biome, finds similar climate, and combines with commerce info. Highest suitability and highest commerce were most likely to become invaded.



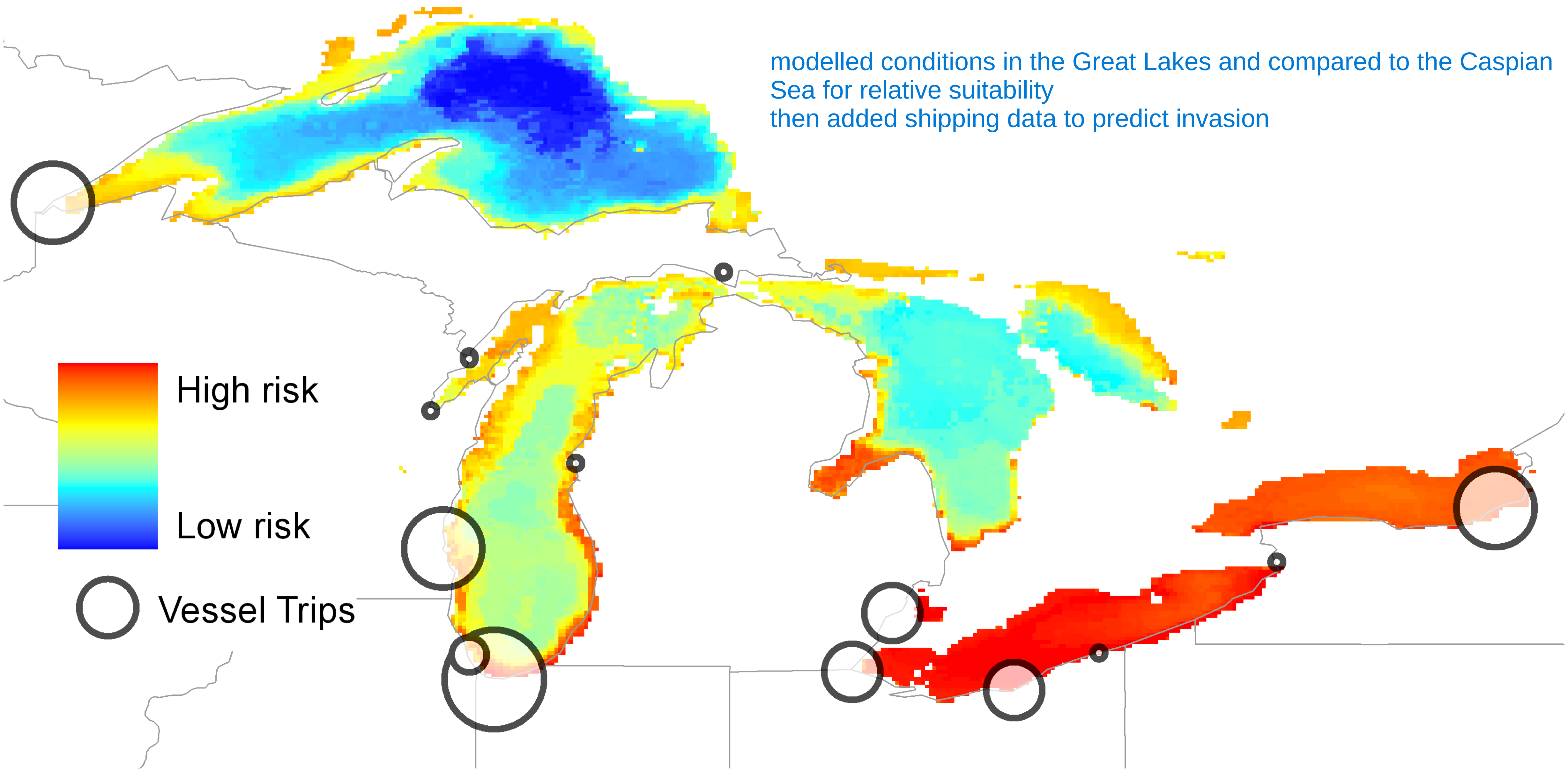
Thuiller et al. (2005)

Applications

Risk of invasion in the Great Lakes

Habitat suitability + propagule pressure

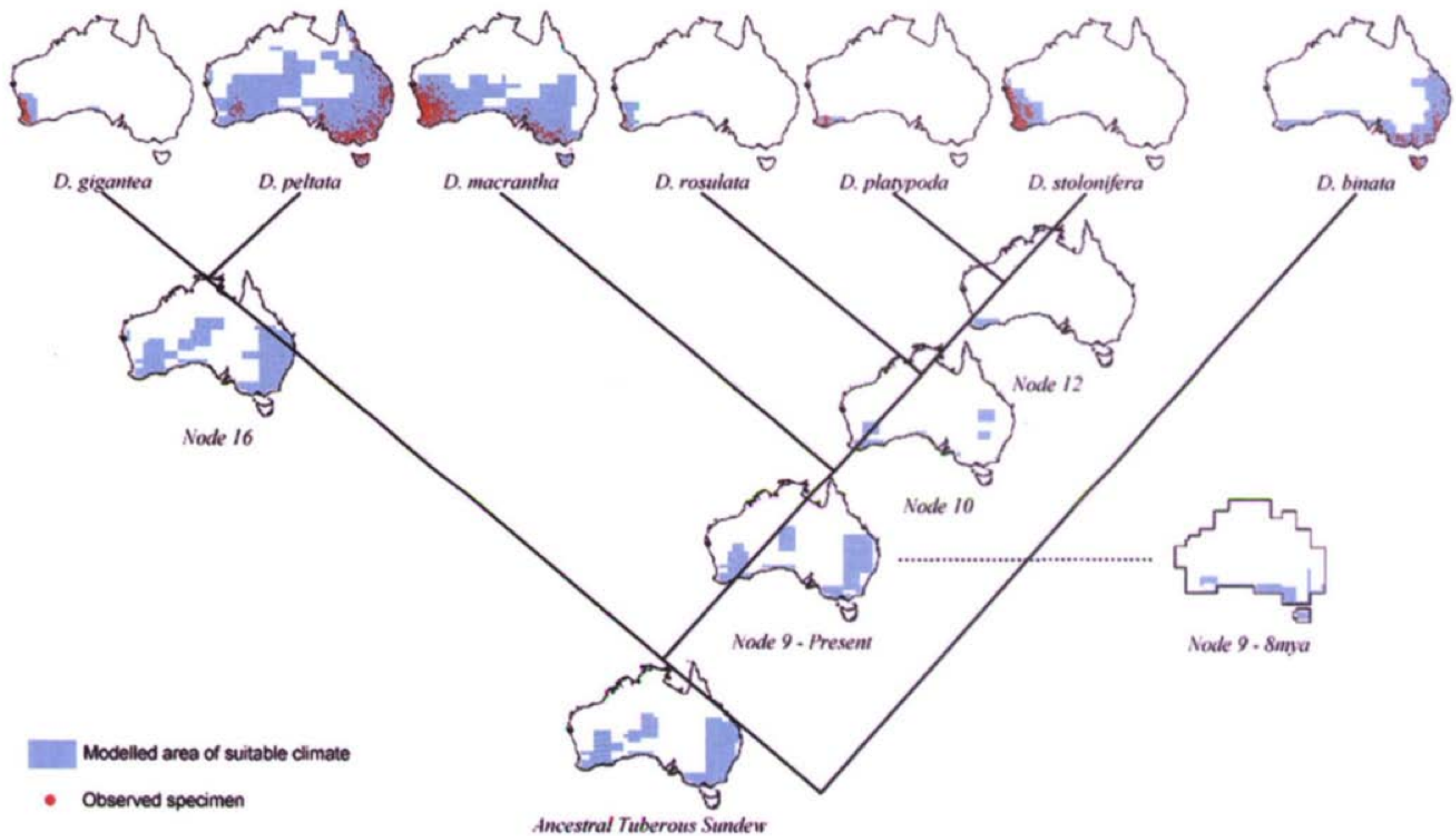
modelled conditions in the Great Lakes and compared to the Caspian Sea for relative suitability
then added shipping data to predict invasion



Applications

Niche dynamics & evolution

mapped species geographic niches to phylogenic trees as a species trait and then saw how they changed over time

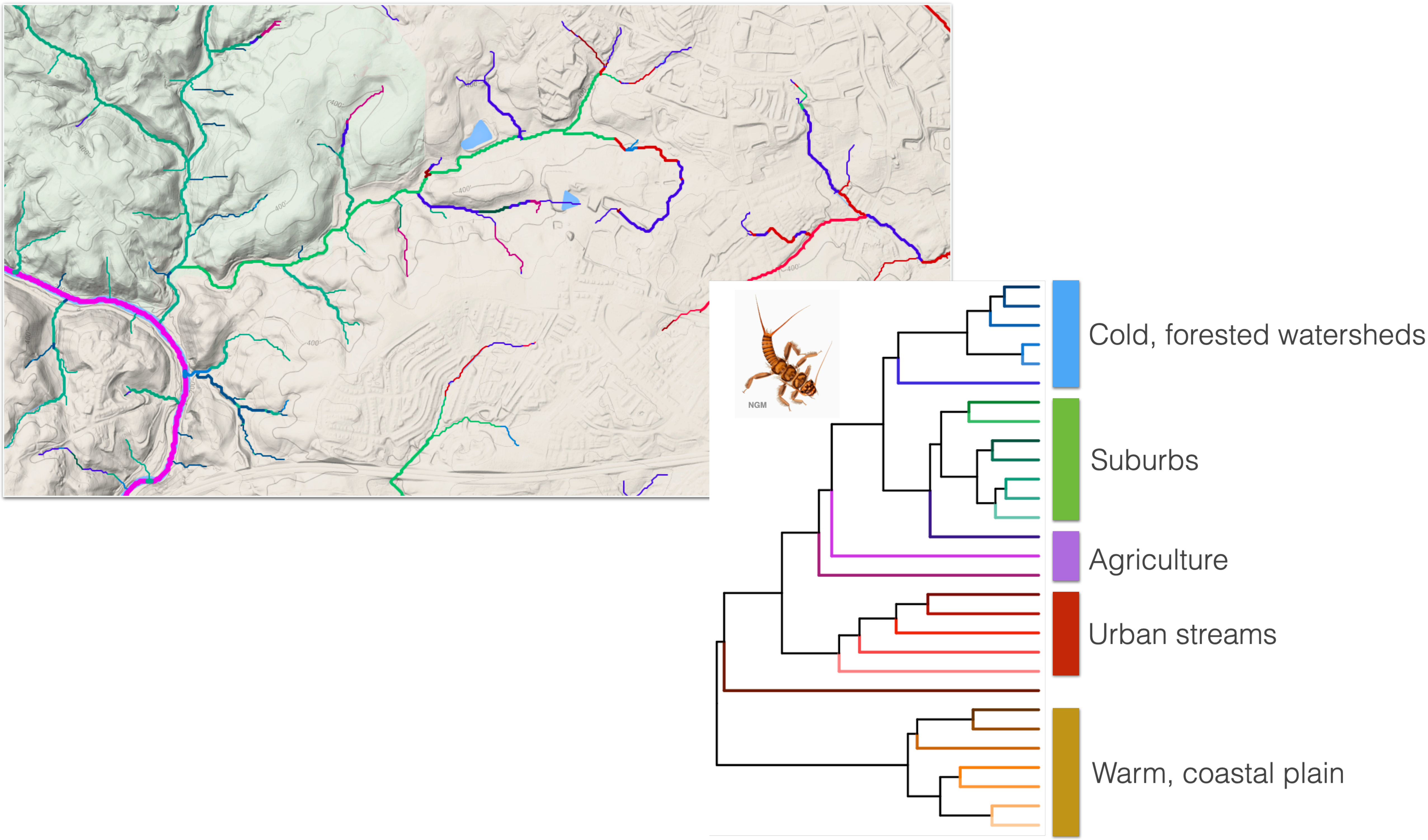


Yesson & Culham 2006

Applications

Community-level modeling

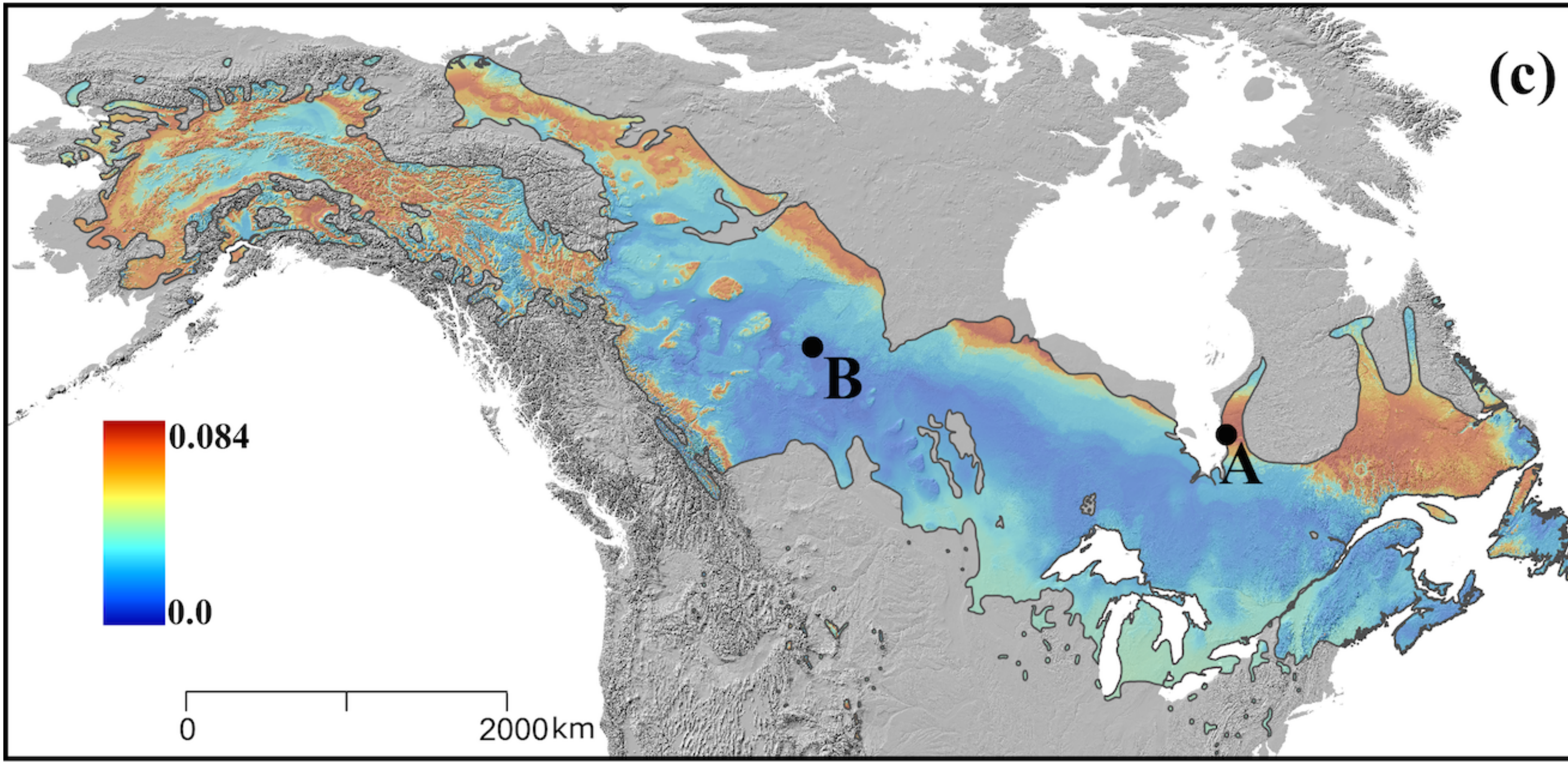
mapped stream macroinvertebrate communities in MD
community types clustered together (ie. urban all together)



Applications

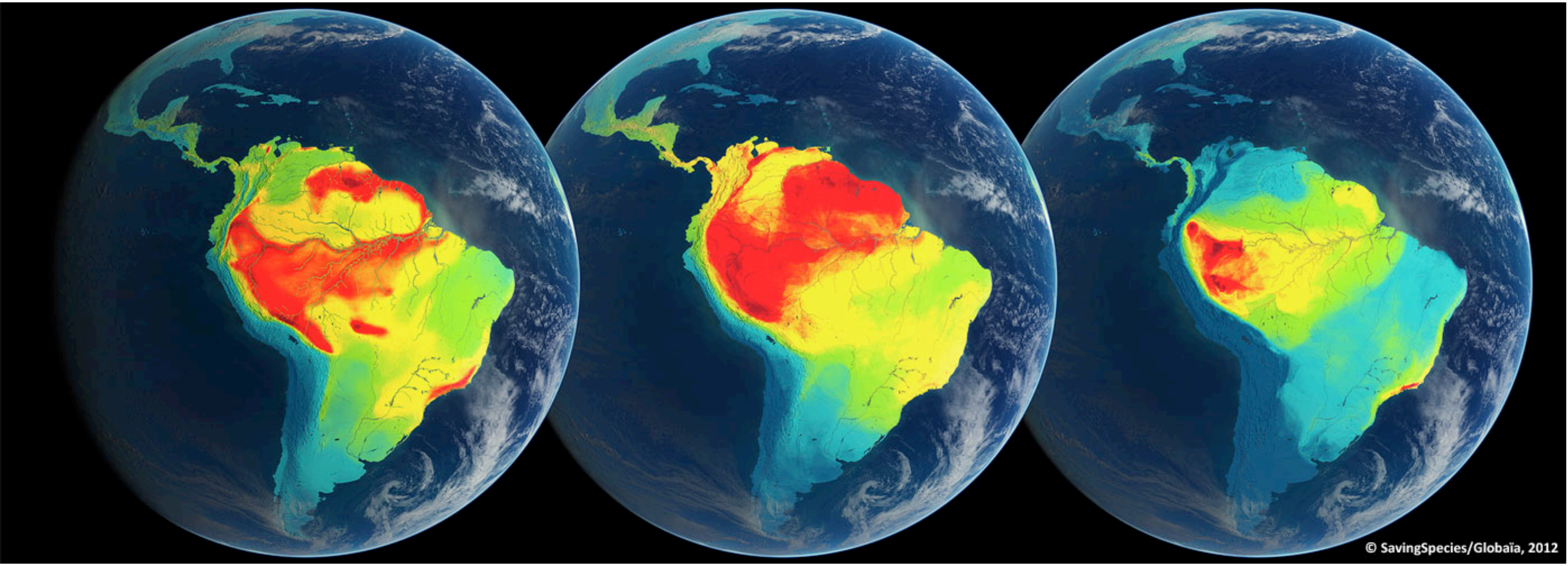
inference from genomic data to see how maladapted species are to changing climate

Genomic landscapes



Filling in unsampled ares

where else will species find suitable habitats?



Map of part of Eastern Australia to indicate relationship of prickly pear infestation to rainfall. The probable limit of the infestation, if left unchecked except by climatic control, is shown by a dotted line. 15, 20, 30, and 40 inch isohyets; also 20, 30, 40, 50, and 60 per cent. winter rainfall (April-October) isopleths (from Hunt) are indicated. Infested area dotted.

only variable looked at was rainfall

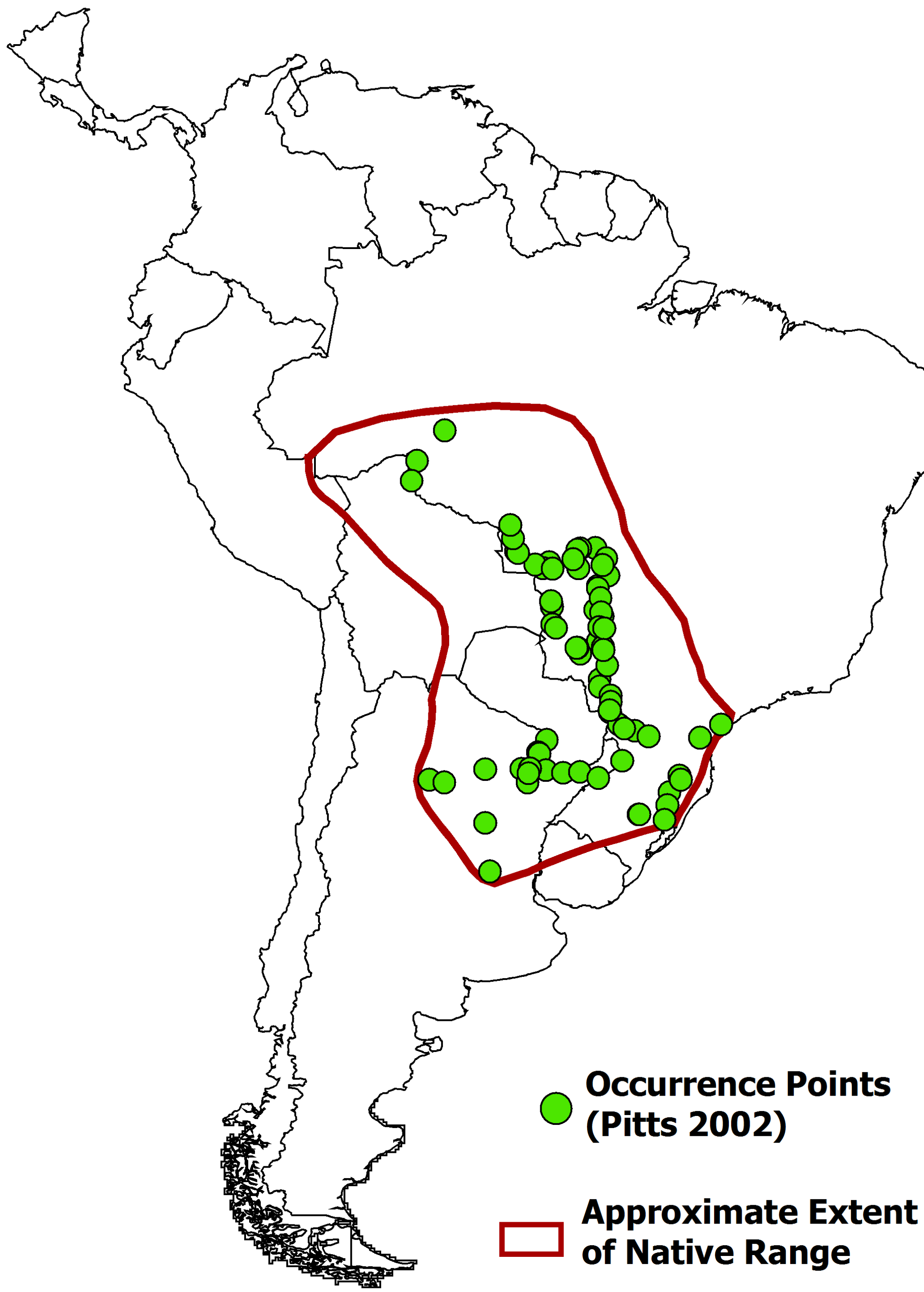
points out that climate constrains distributions

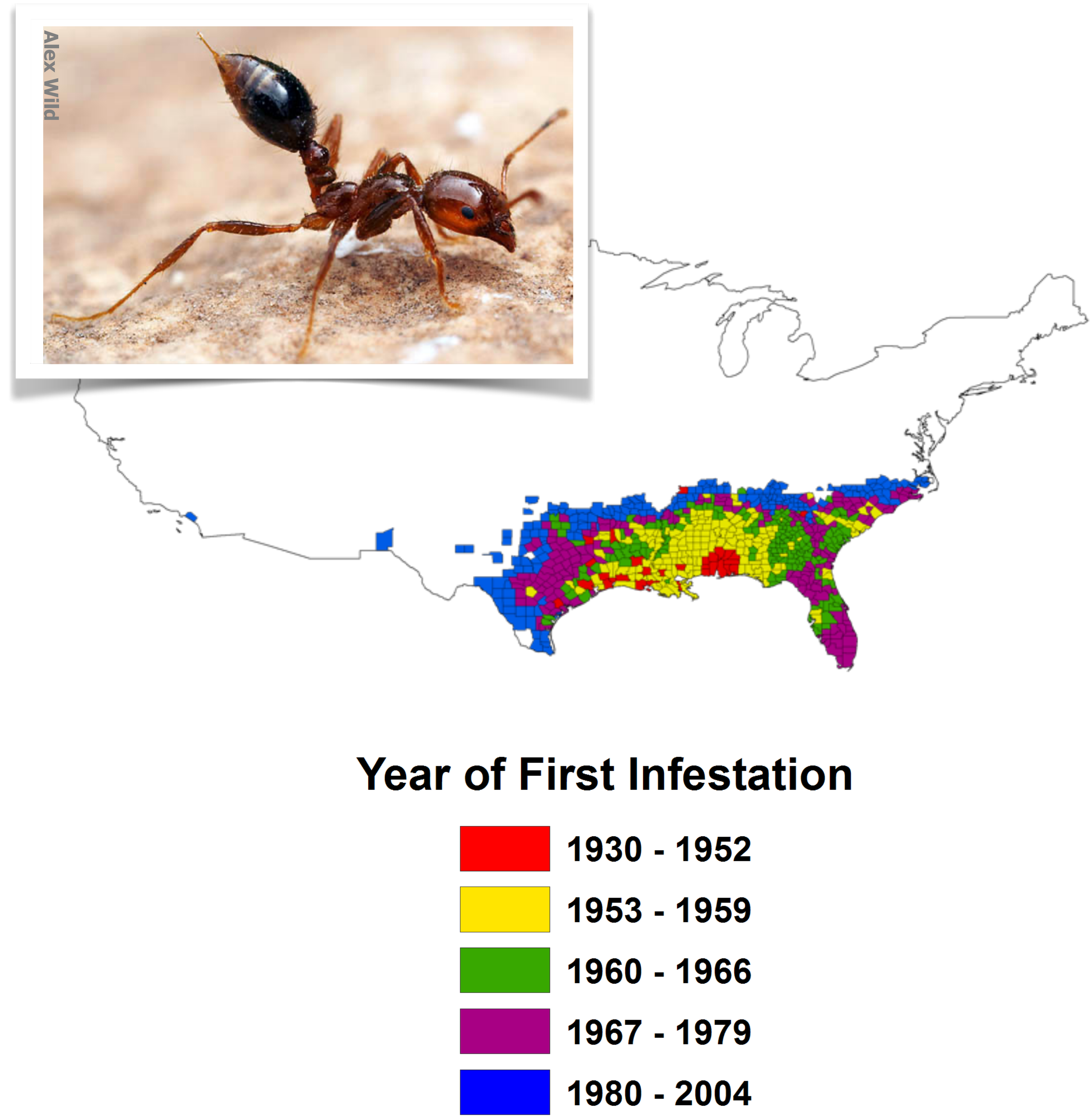
major assumption-- climate only constrains not biotic

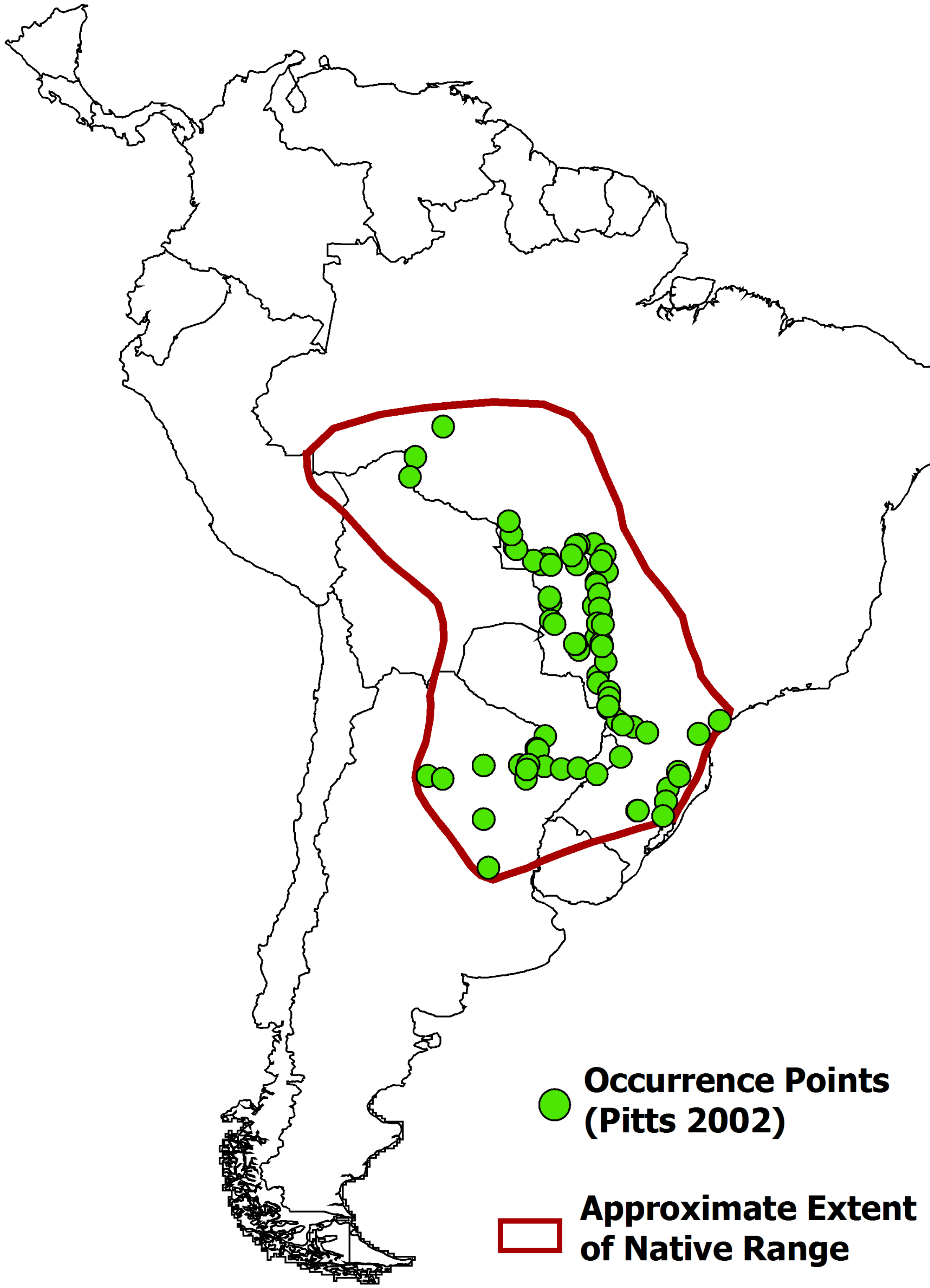
Johnston 1924

Native range of *Solenopsis invicta*

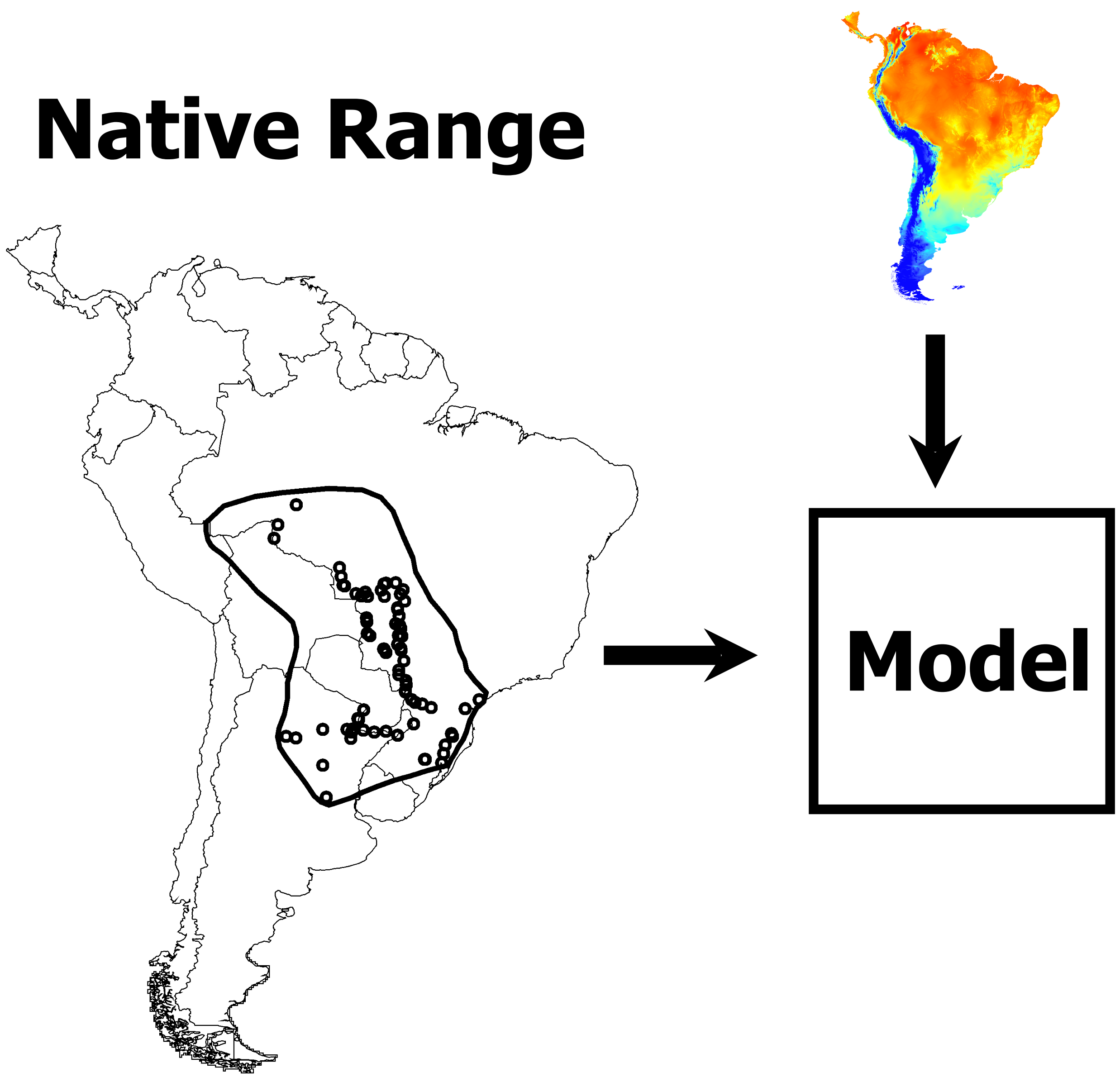
Introduced range in US






Occurrence Points
(Pitts 2002)
Approximate Extent
of Native Range

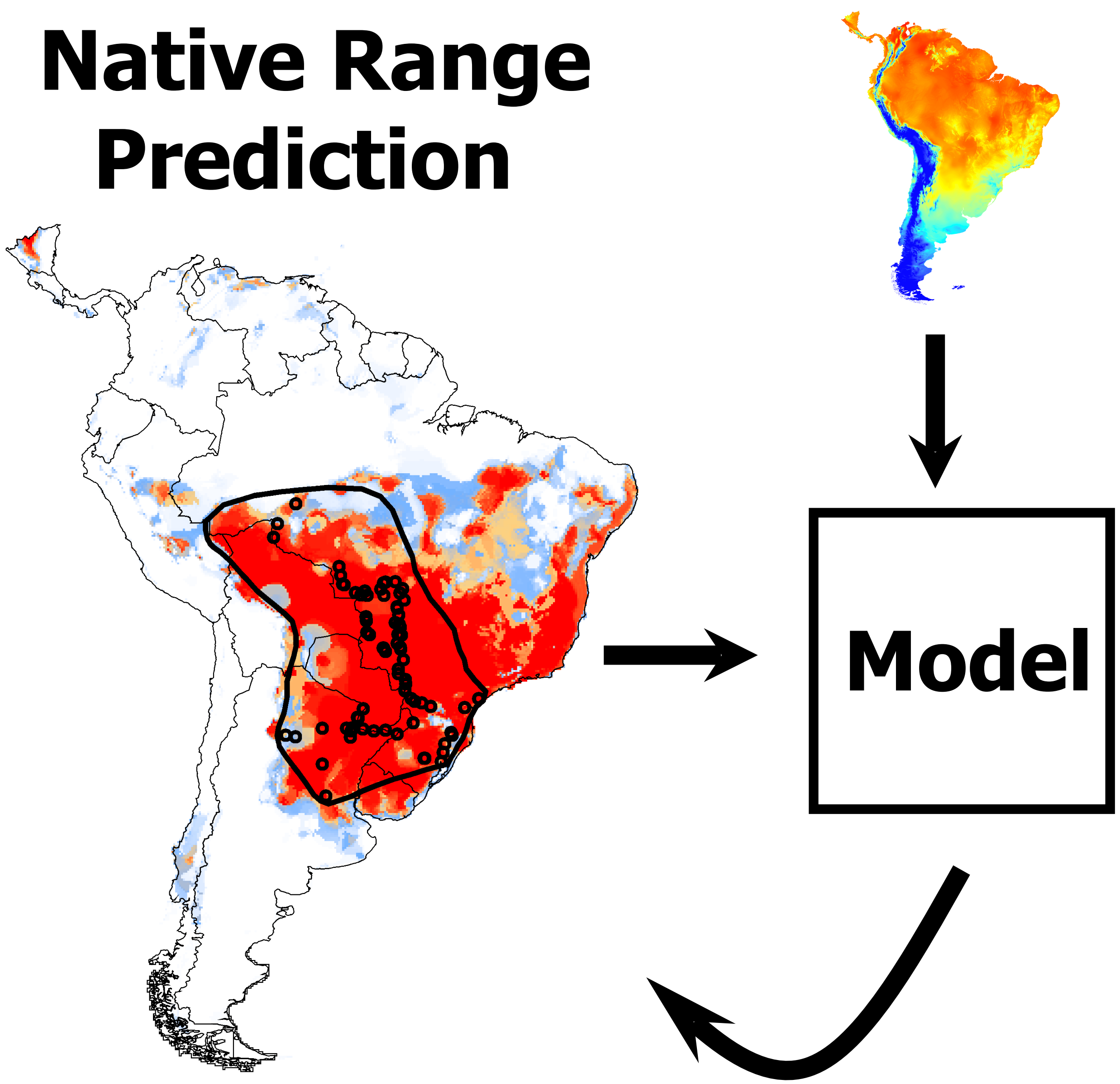
Native Range Models



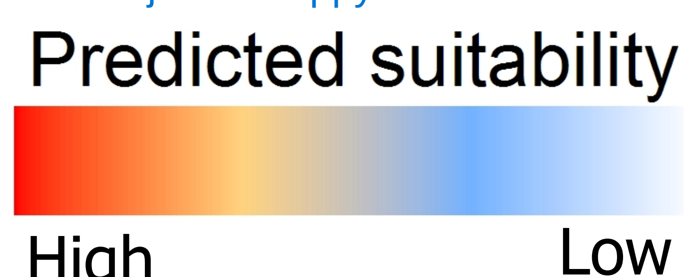
Fitzpatrick et al. 2007
Global Ecology & Biogeography

Native Range Models

Native Range Prediction

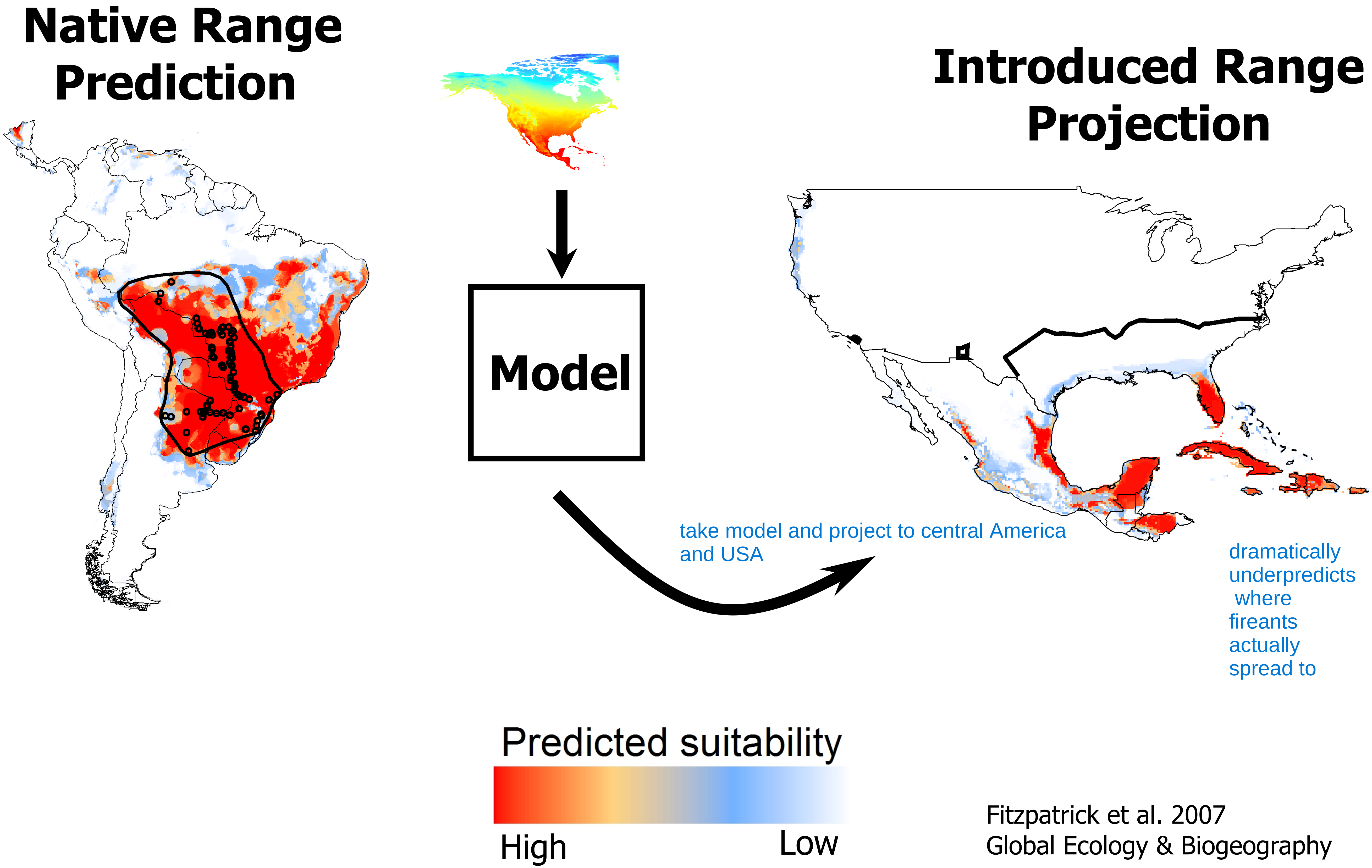


evaluate the model to see how it's doing. Does well on the boundaries except overpredicts the range to the northeast due to? ex: climate parameter, human development, competitor, fungus, etc OR just a crappy model



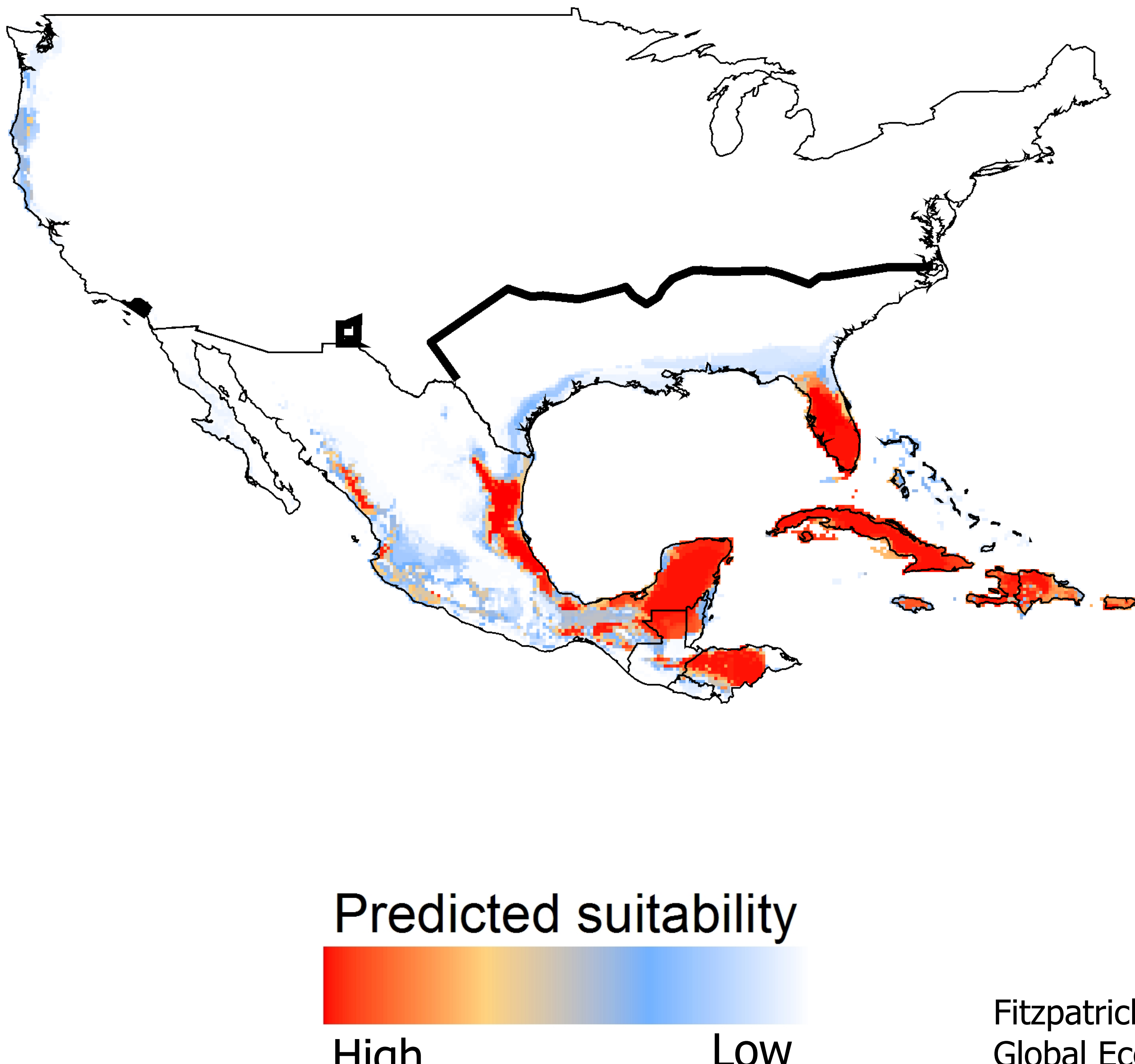
Fitzpatrick et al. 2007
Global Ecology & Biogeography

Native Range Models



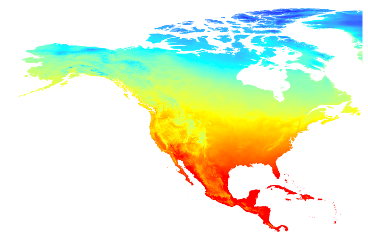
Fitzpatrick et al. 2007
Global Ecology & Biogeography

Native Range Models

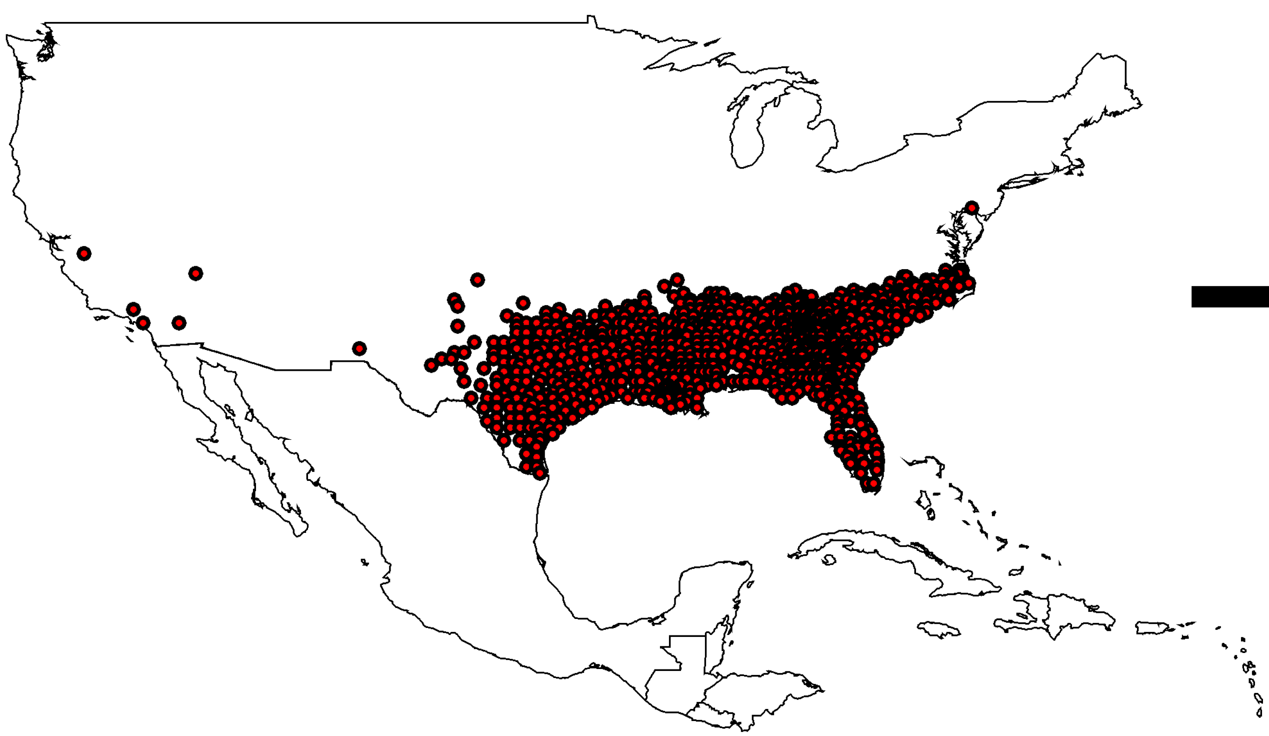


Fitzpatrick et al. 2007
Global Ecology & Biogeography

Invaded Range Models



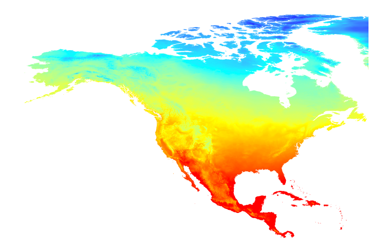
Introduced Range



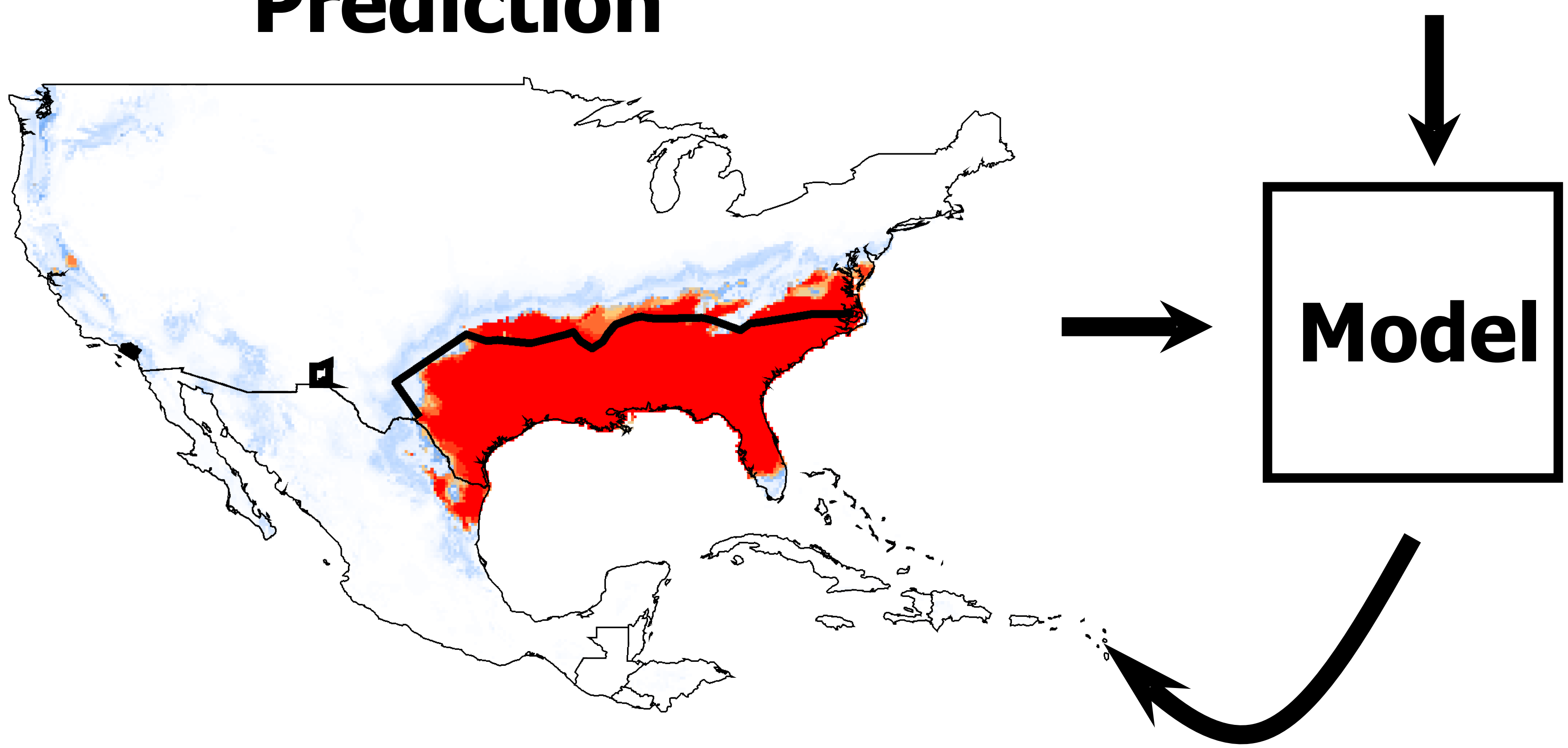
Model

Fitzpatrick et al. 2007
Global Ecology & Biogeography

Invaded Range Models



Introduced Range Prediction

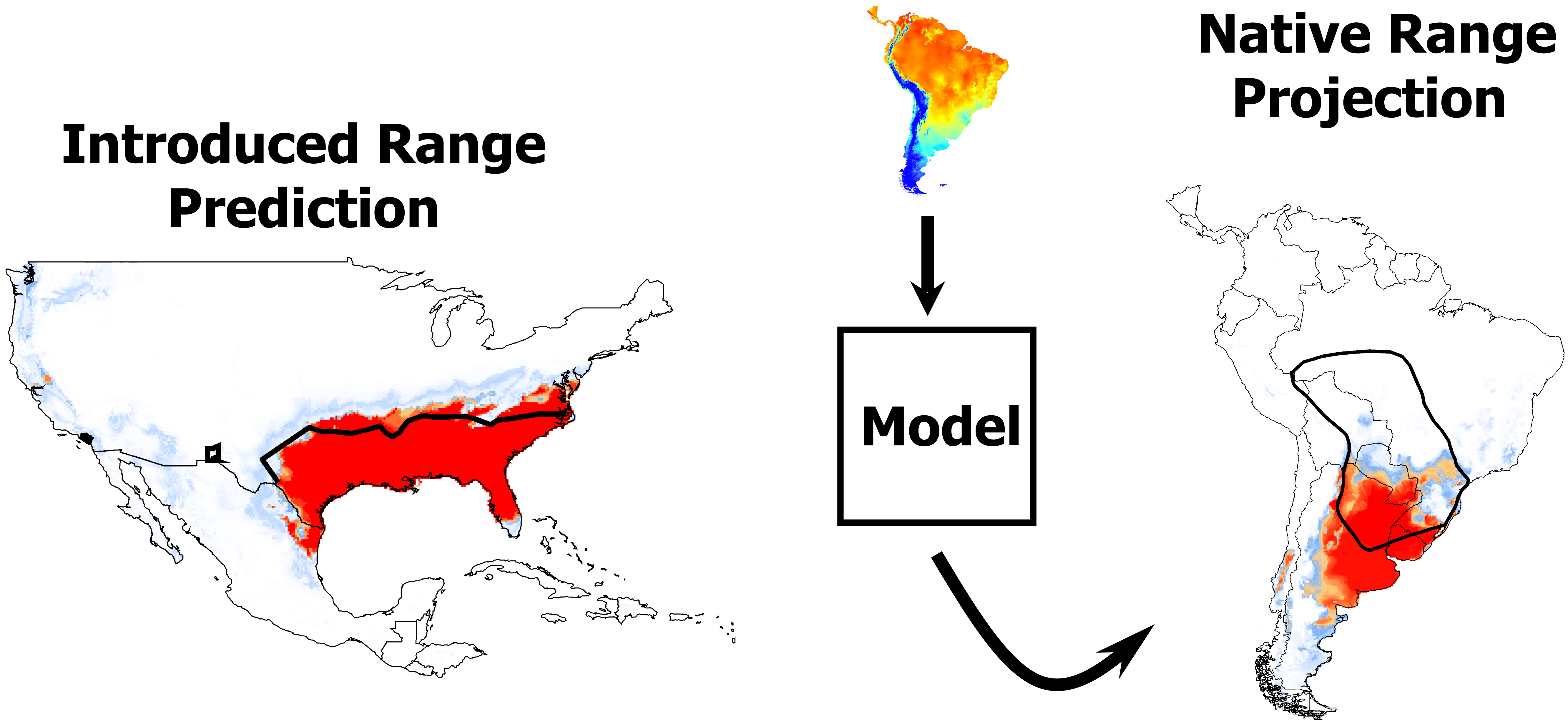


gave the model the new input for the actual

Predicted suitability

Fitzpatrick et al. 2007
Global Ecology & Biogeography

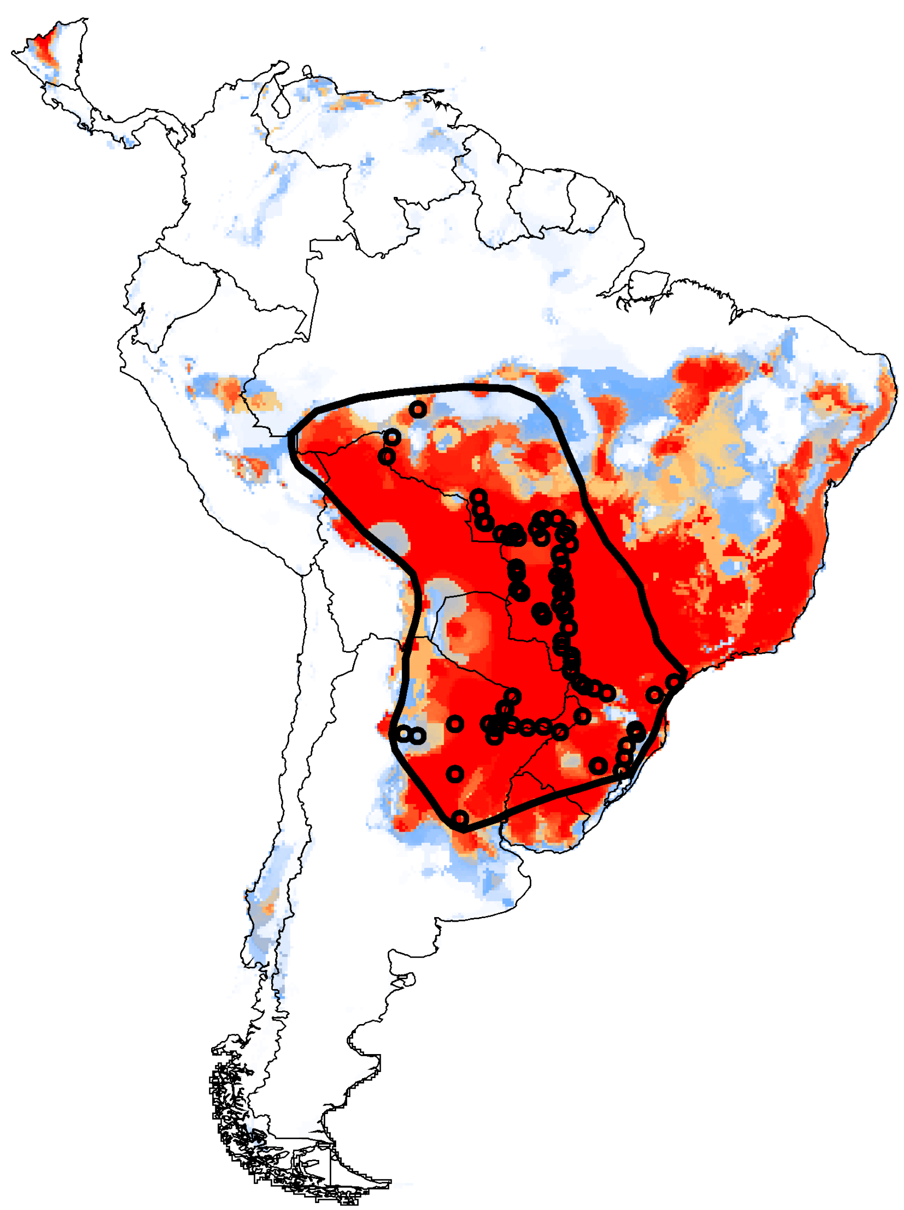
Invaded Range Models



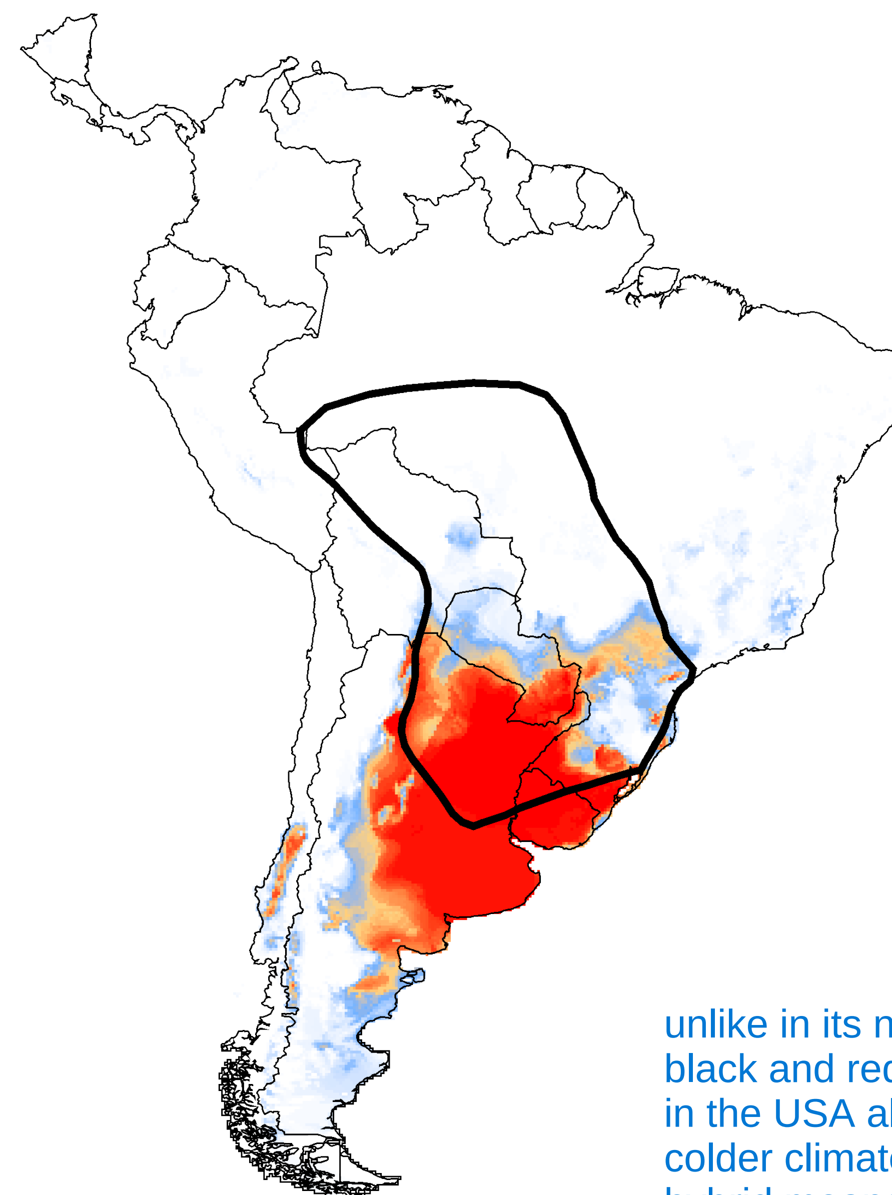
take USA model and project back to South America

Fitzpatrick et al. 2007
Global Ecology & Biogeography

Modeled native range



Projected introduced range



Predicted suitability

High Low

unlike in its native range, the black and red fireants hybridize in the USA allowing it to invade colder climates in USA but no hybrid means no colder range in South America

Fitzpatrick et al. 2007
Global Ecology & Biogeography

What I work on today…

- Spatial modeling of biodiversity / forecasting climate change impacts
- Spatial modeling of genomic variation & climate adaptation
- Remote sensing + biodiversity modeling