Post-ENM Analysis

Elizabeth White
University of Florida

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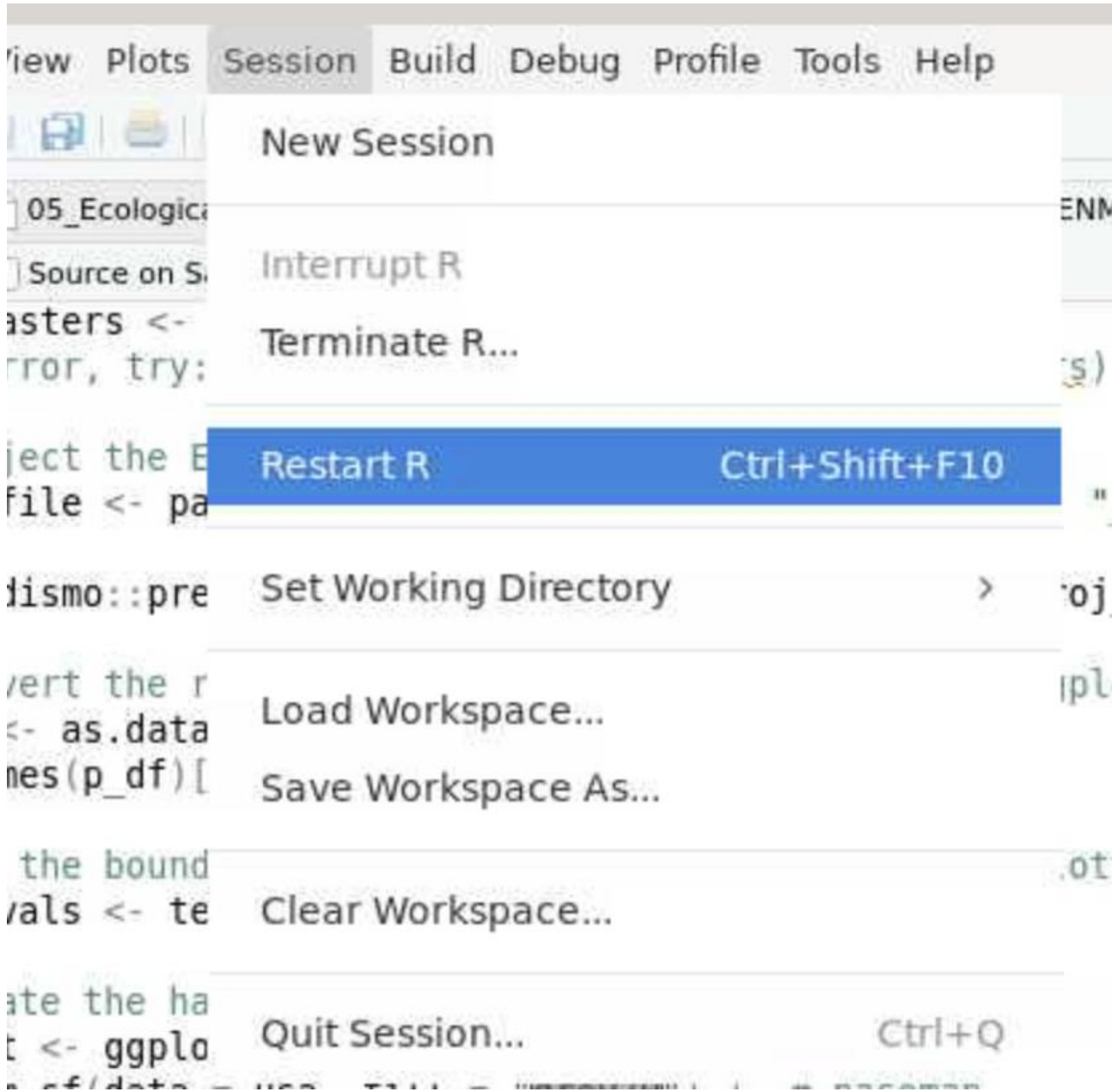
Post-ENM

- Analysis in environmental space
- Overview of commonly used post-modeling analyses.
  - **Niche Breadth**
  - **Niche Overlap**
  - Geographic Overlap
  - Niche Identity and Background test
  - **Age overlap correlation test**
- **Projecting models onto different climate scenarios (future)**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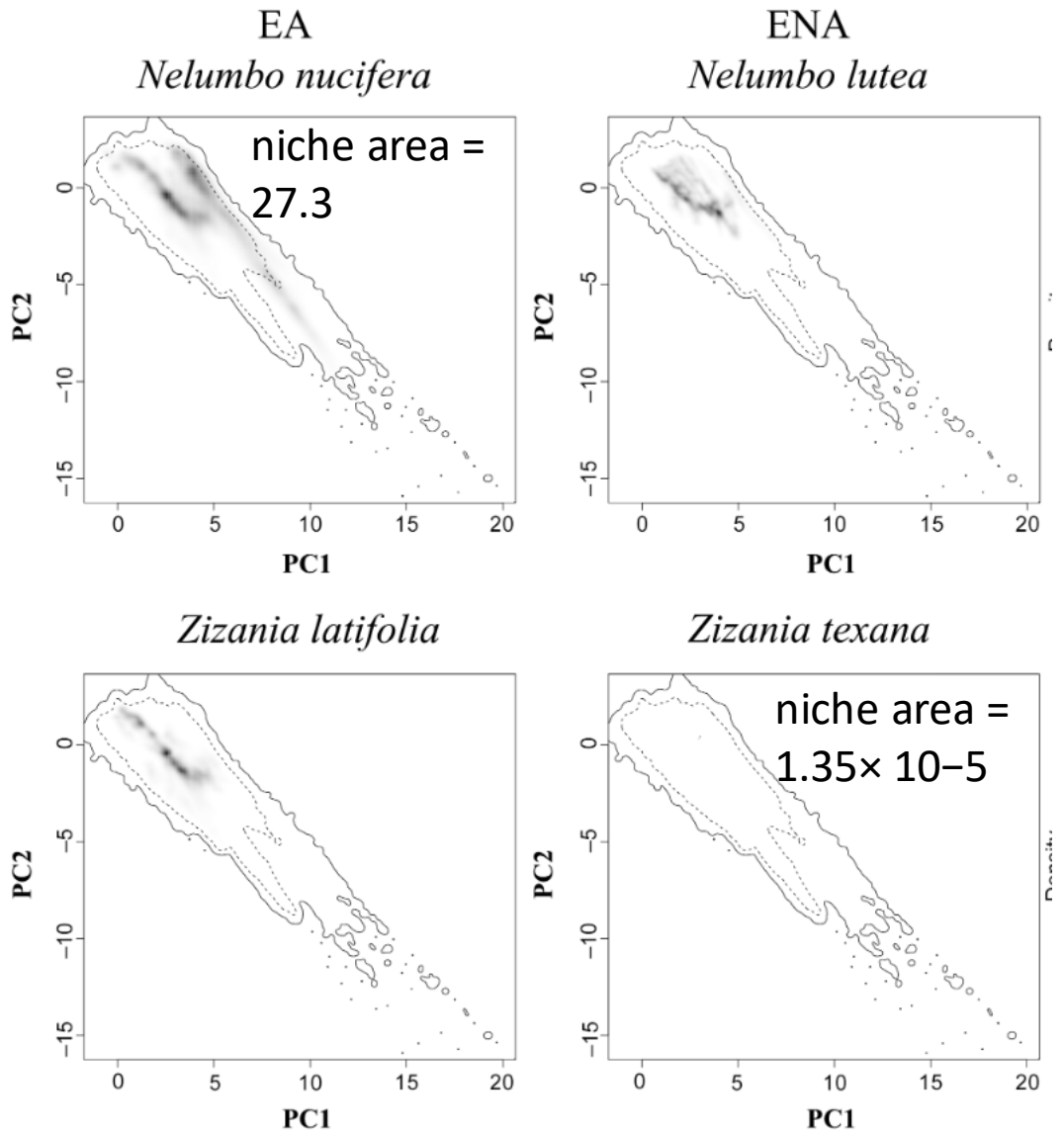
Analysis in environmental space

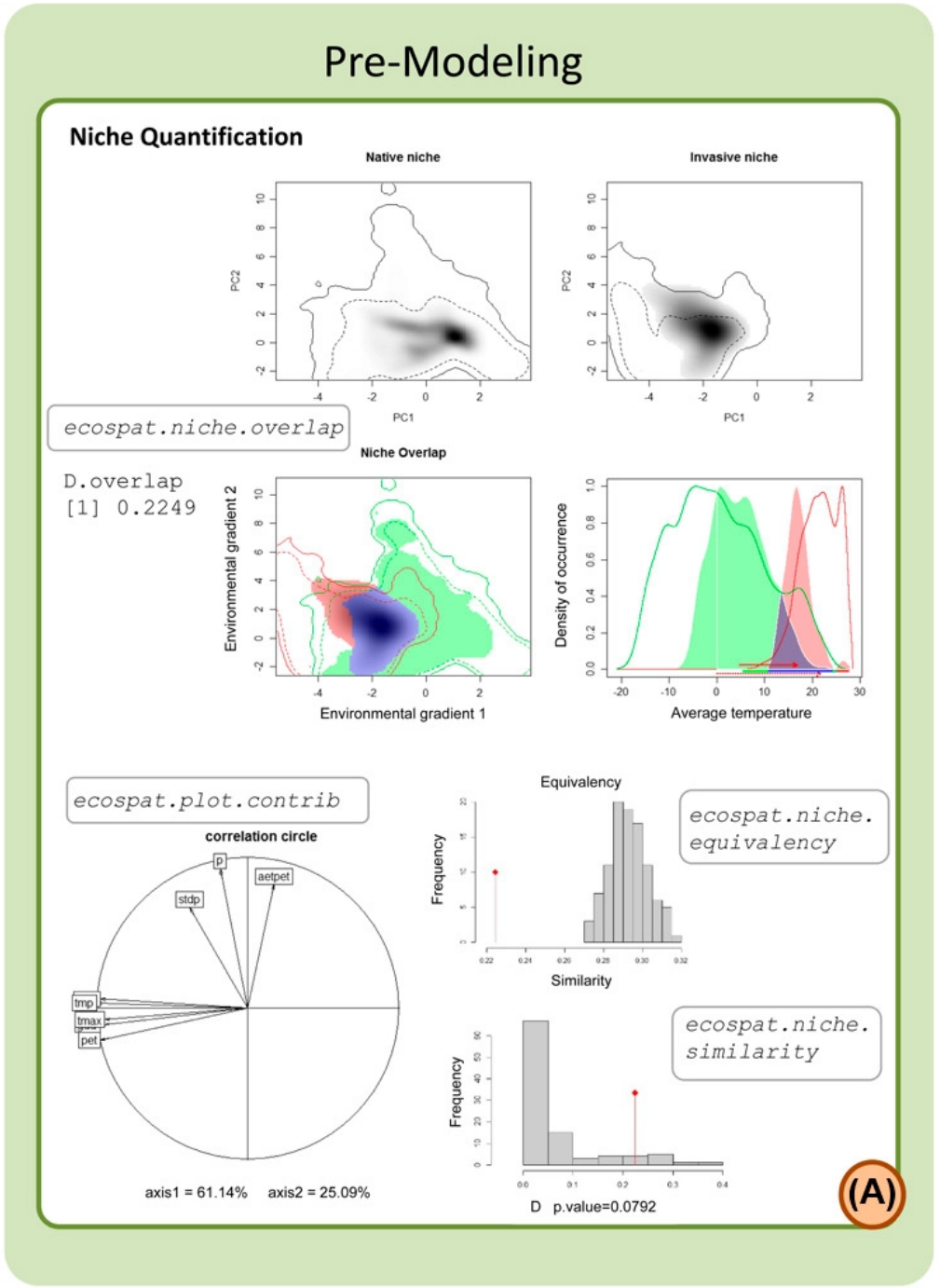


- **Quantifying niches in environmental space**
- Niche area is equal to the variance of ecological space along PC1 × variance of ecological space along PC2
  - Larger niche area = more suitable area

Melton et al. 2022. Global Ecology and Biogeography.

Post-ENM Analyses

- **Niche occupancy**
- **Niche breadth**
- **Niche overlap** based on Schoener's D
- **Correlation circle**
  - Plots contribution of initial variables to variation seen in the data.
- **Niche Equivalency** (Graham et al. 2004)
  - Are the niche of two species indistinguishable?
- **Niche Similarity** (Peterson et al. 1999)
  - Can the niche of one species predict that of another?



Di Cola et al. 2017. Ecography.

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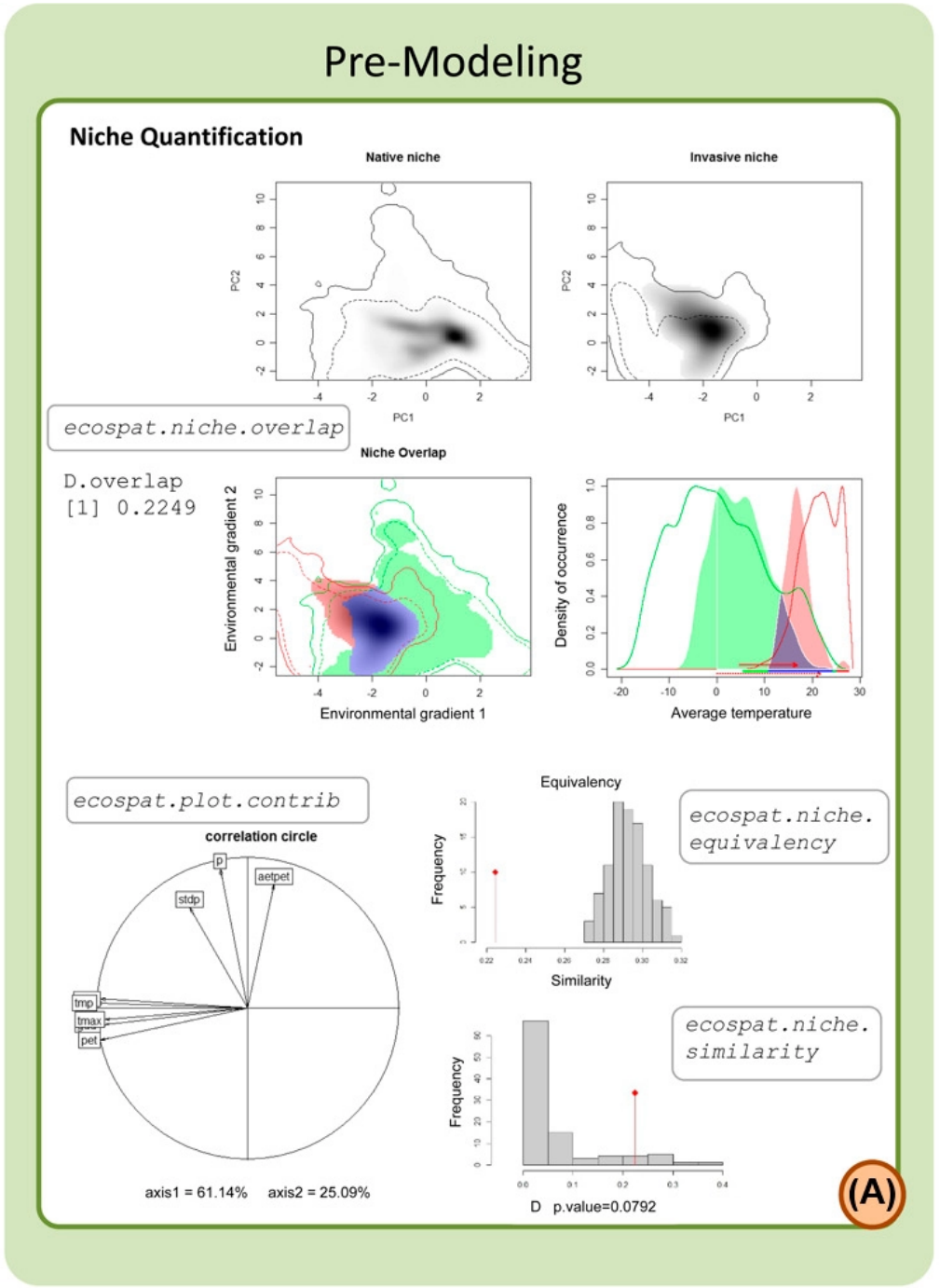

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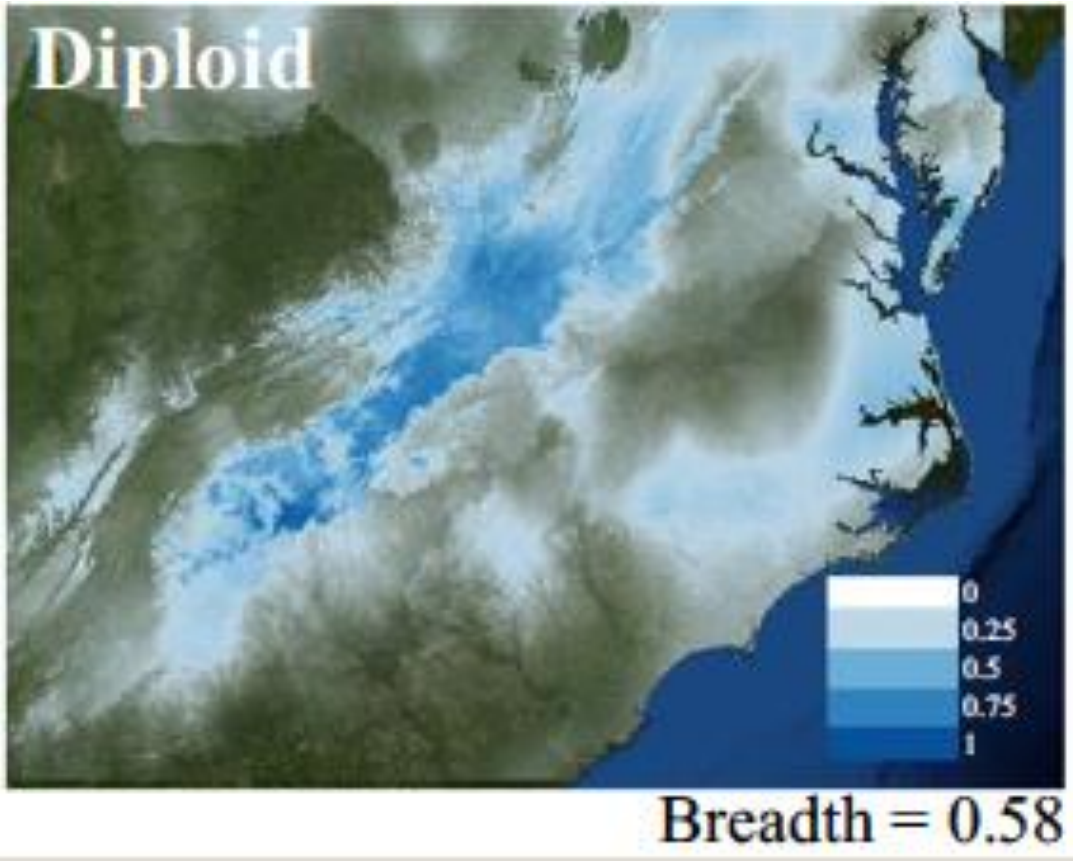
Post-ENM: Niche Breadth

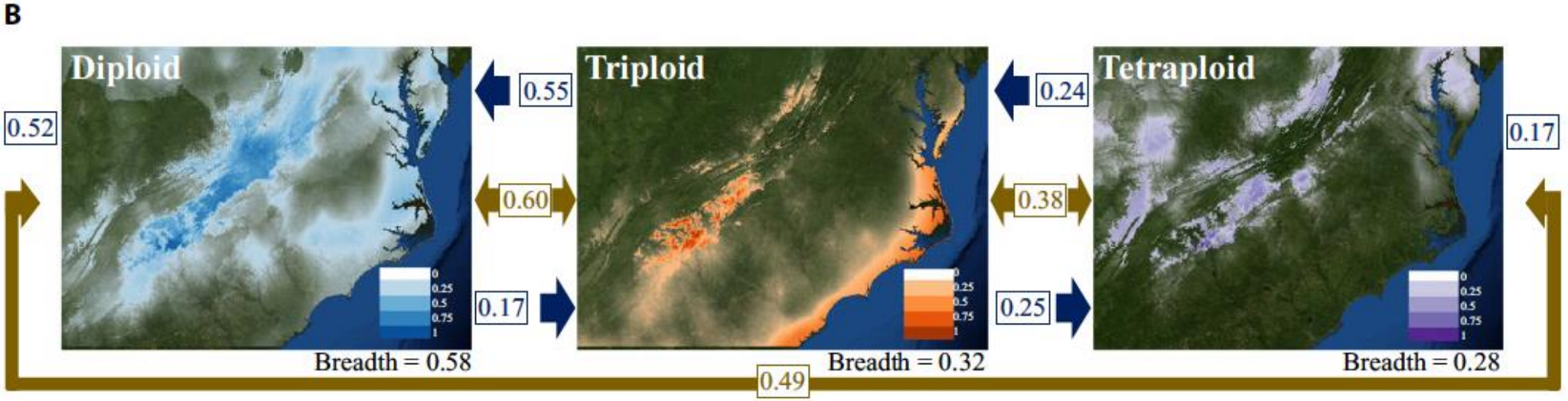


Niche breadth:

- is a means of calculating the breadth of suitable climatic factors for a species, providing a value ranging from 0 to 1.
- larger values represent more generalist species with wider climatic tolerances
- smaller values represent more specialized species with more narrow tolerance

Gaynor et al. 2018. American Journal of Botany.

Post-ENM: Niche Overlap



Niche overlap (gold):

- Schoener's D ranges from 0 to 1
- 0 represents no niche similarity between the models
- 1 represents completely identical niches

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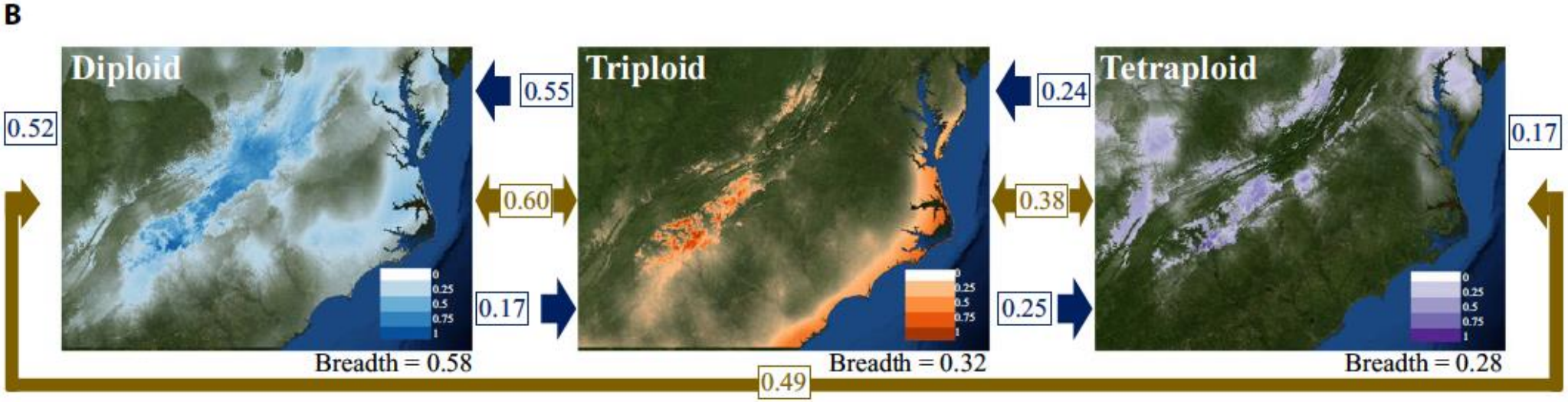
Post-ENM: Niche Overlap



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Geographic Overlap (blue):

- percentage of points found in the models A distribution relative to those in the model Bs distribution.

Gaynor et al. 2018. American Journal of Botany.

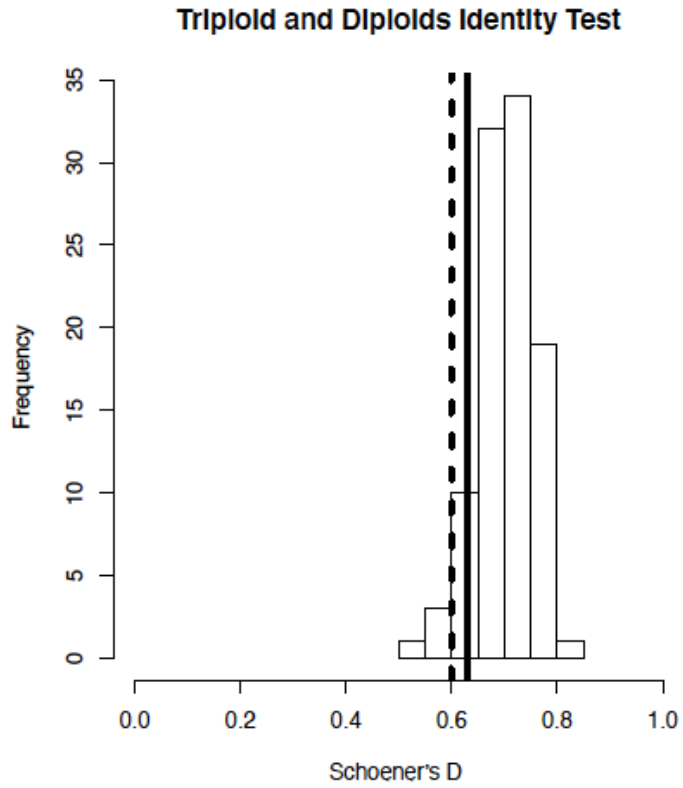
Niche Identity and Background Test

Niche Identity Test:

- **Niche Equivalency** (Graham et al. 2004)
  - Are the niches of two species indistinguishable?
- Compares niche models with the same number of occurrence records as the original models, but with randomly distributed localities x 100

Niche Background Test:

- **Niche Similarity** (Peterson et al. 1999)
  - Keep one species fixed, randomly sample the background of the other
  - Are niche more similar than expected by chance?



Warren et al. 2010. ENMTools: a toolbox for comparative studies of environmental niche models

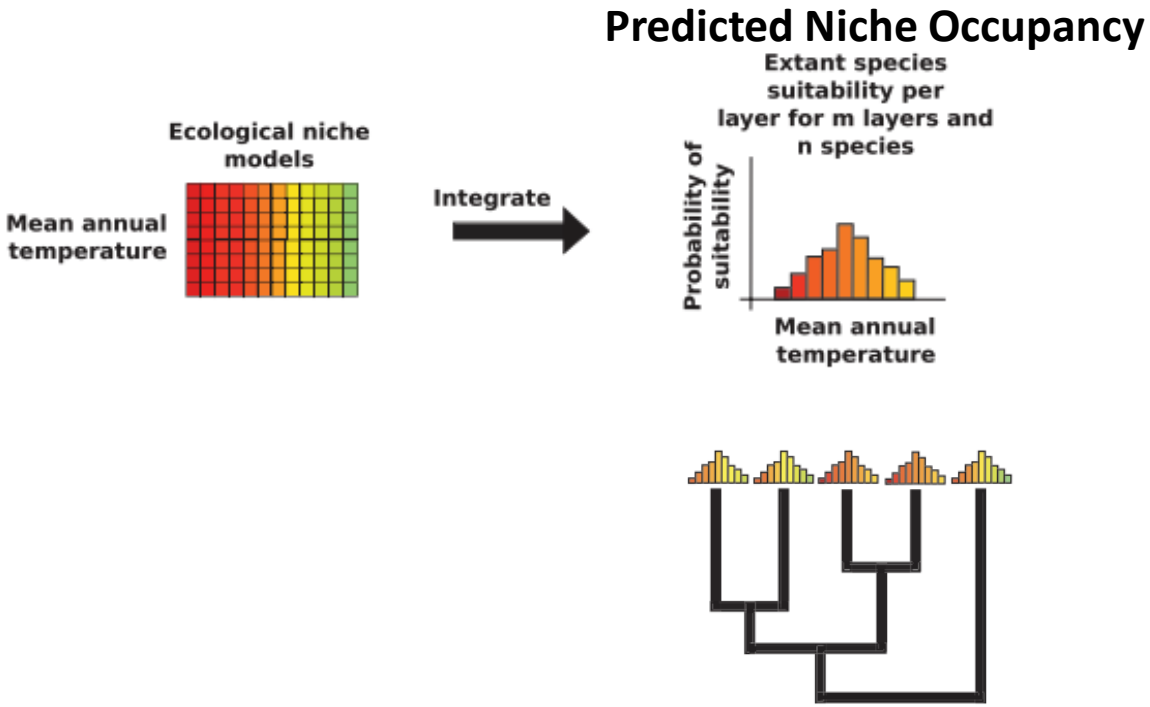
Niche and Phylogenetics

Point-Based

- Principal Component Analysis (PCA)
- Age-overlap correlation test:
  - Range & point based

Model-based

- Phylogenetic PCA (pPCA)
- Blomberg's K statistic and Pagel's lambda
- Ecological Niche Shifts
  - R package l1ou



Folk et al. 2018. The American Naturalist.

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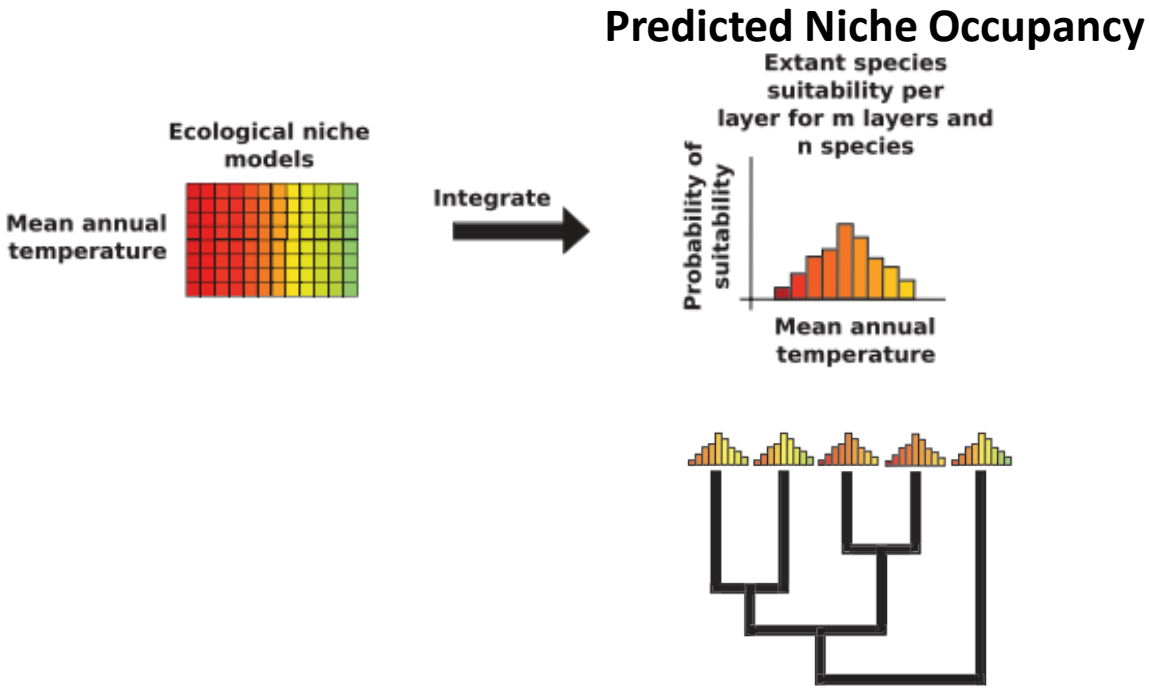
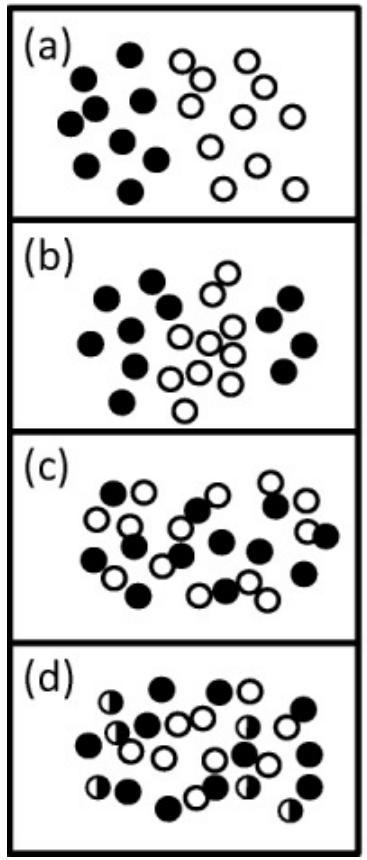


Folk et al. 2018. The American Naturalist.

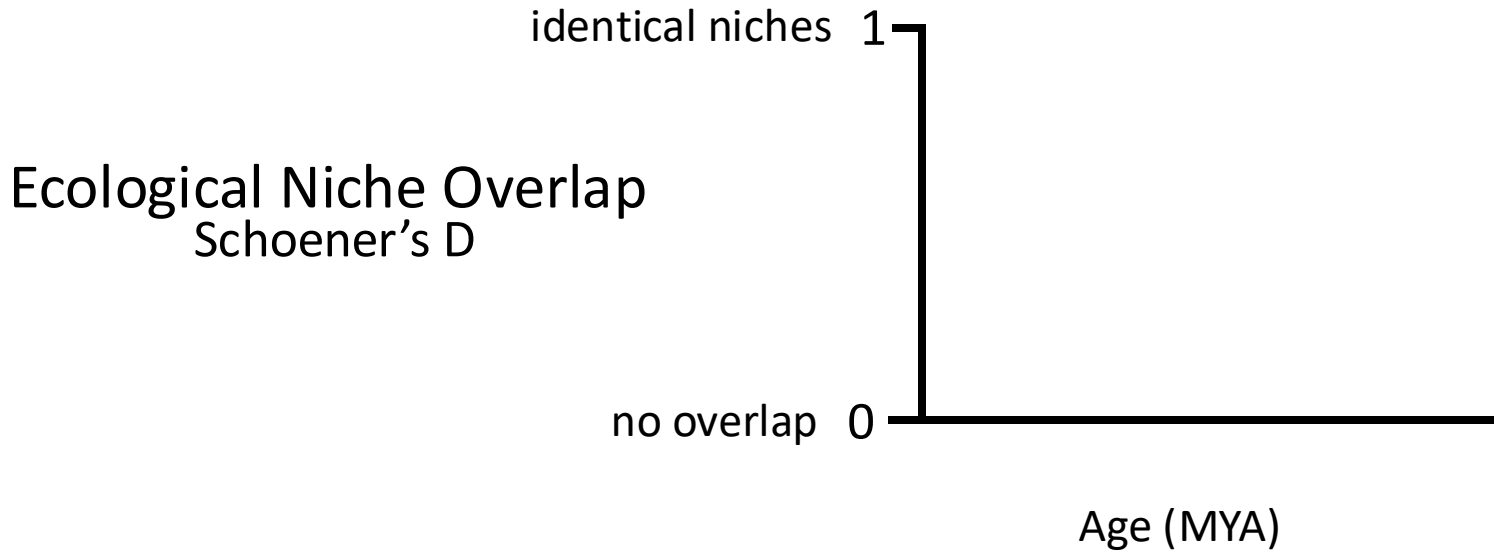
Age overlap correlation test



Spatial overlap measure			Example of possible interpretations of overlap pattern
Range Overlap	Point Overlap	Local co-occurrence	
low	low	low	Allopatric speciation with broad geographic barrier as isolating mechanism
high	low	low	Allopatric speciation with finer-scale landscape features as isolating mechanism
high	high	low	Sympatric speciation with habitat filtering
high	high	high	Sympatric speciation with ecological trait divergence

Cardillo and Warren. 2016. Global Ecology and Biogeography.

Age overlap correlation test



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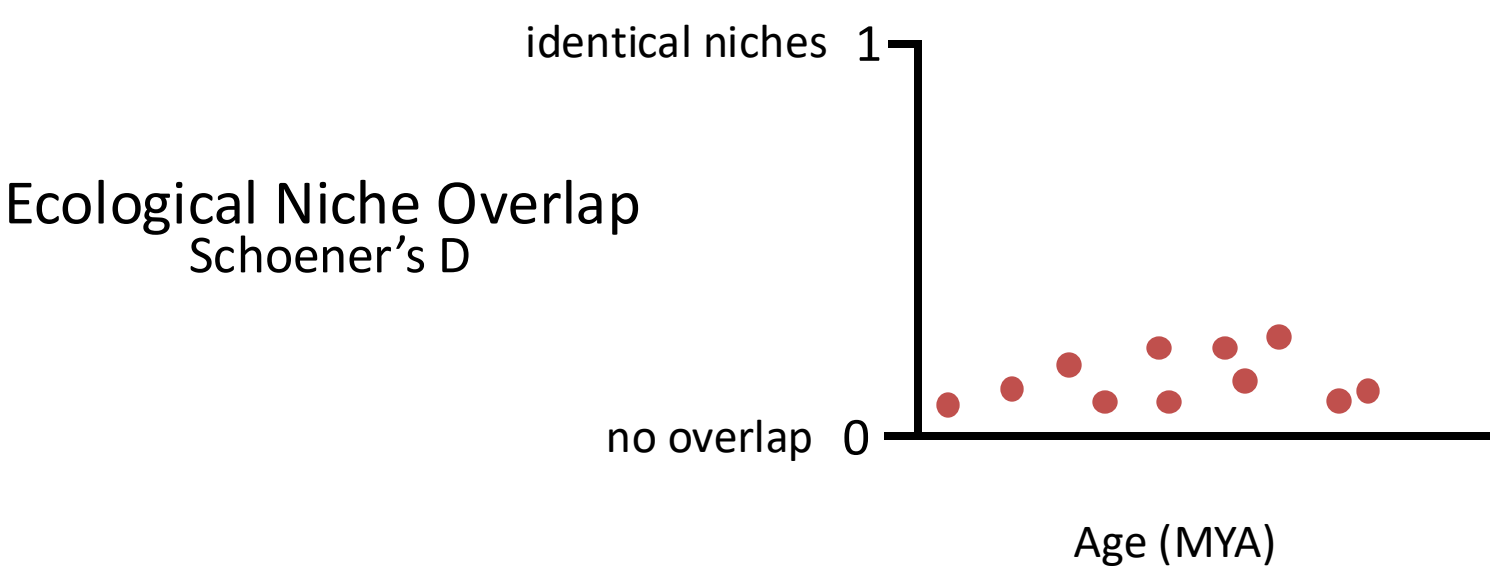
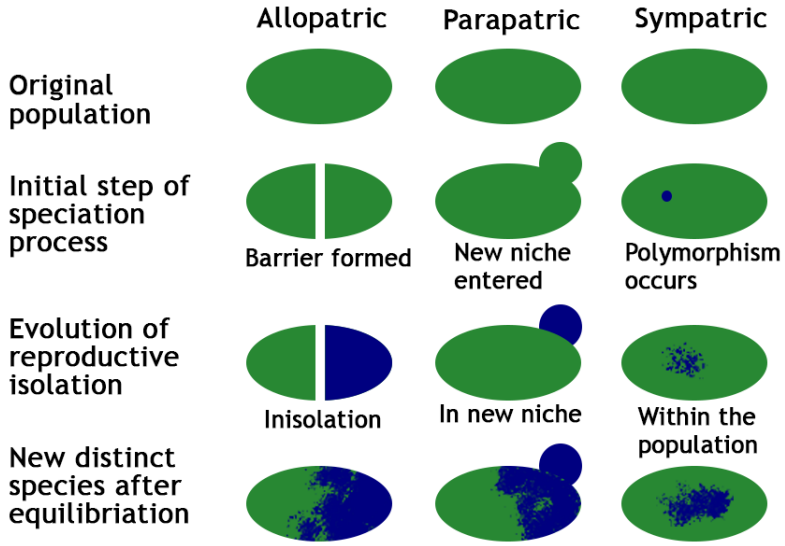
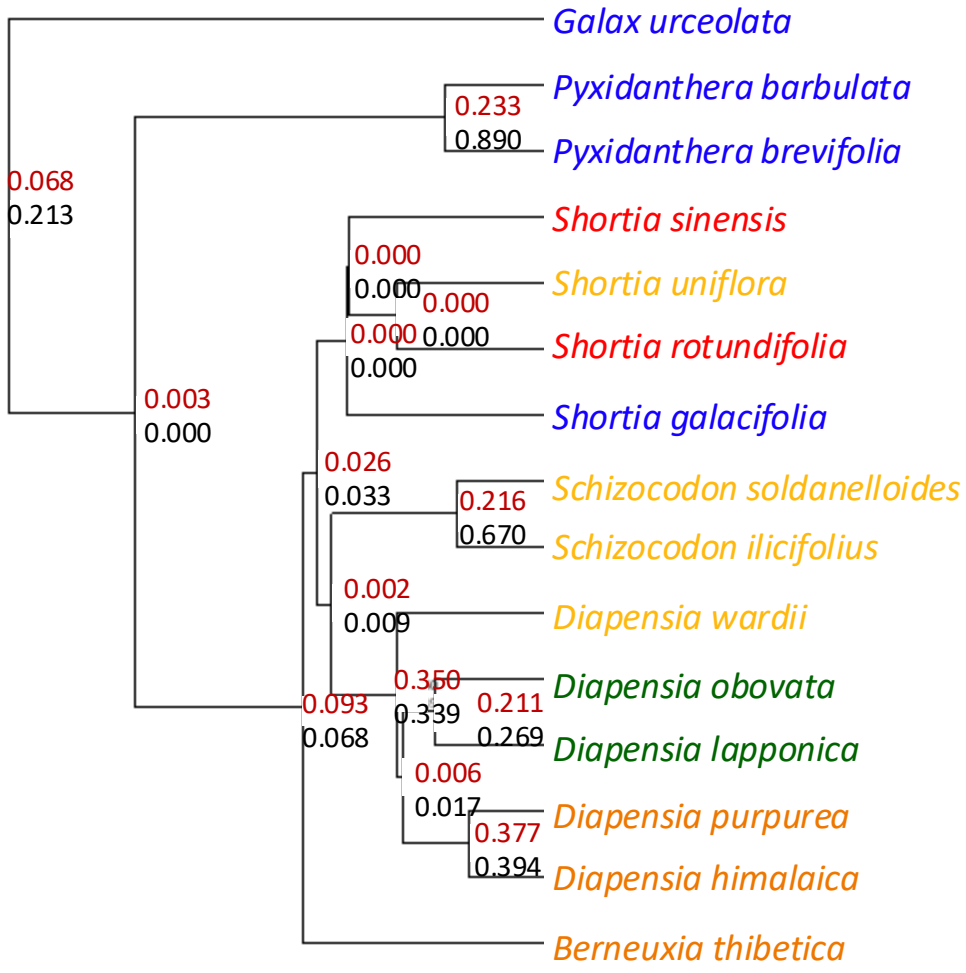


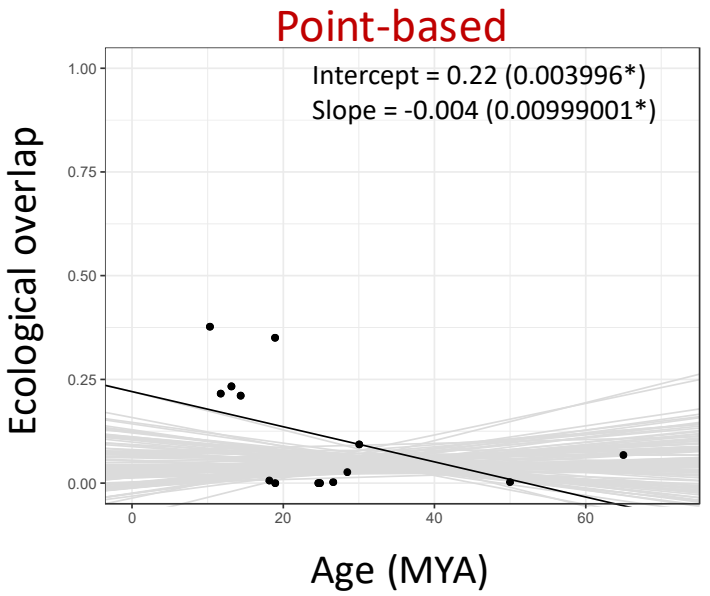


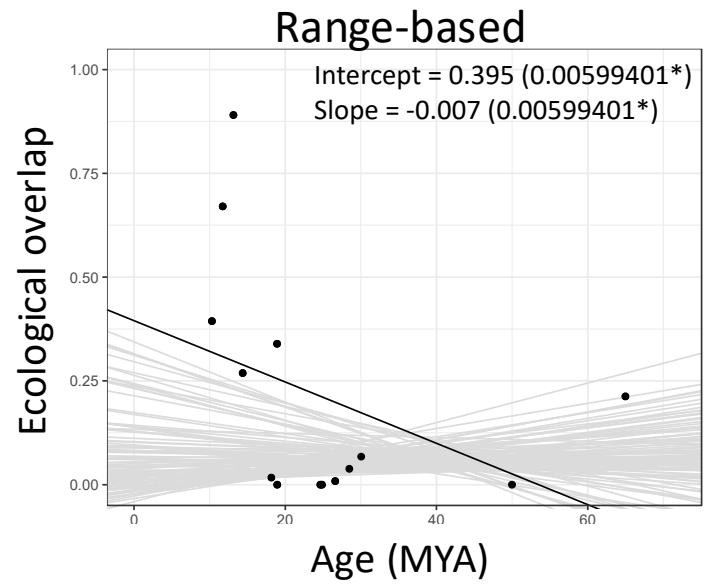
Mode of Speciation	Intercept	Slope
Sympatric	> 0.5	
Allopatric	< 0.5	positive
Parapatric	< 0.5	near or below 0

Fitzpatrick & Turelli. 2006. Evolution.

Age overlap correlation test







Gaynor et al. 2020. Journal of Systematics and Evolution.

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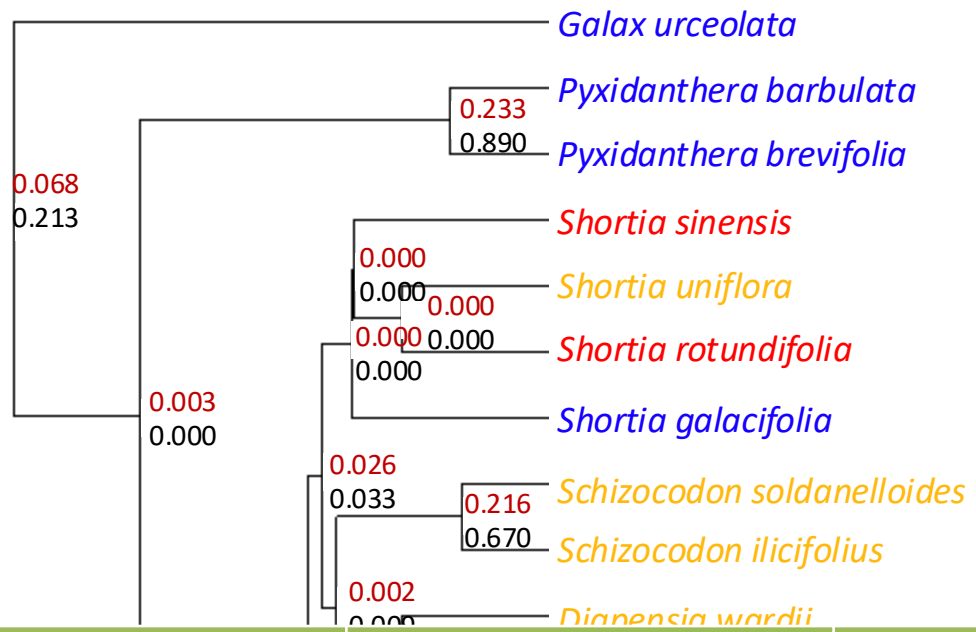

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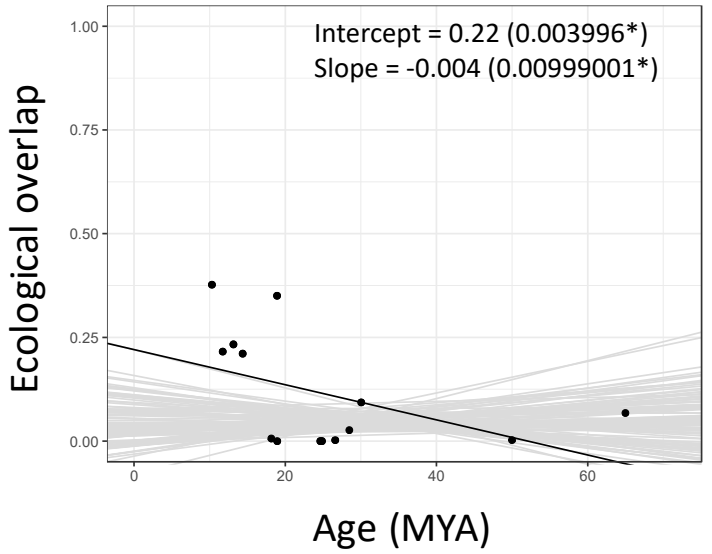
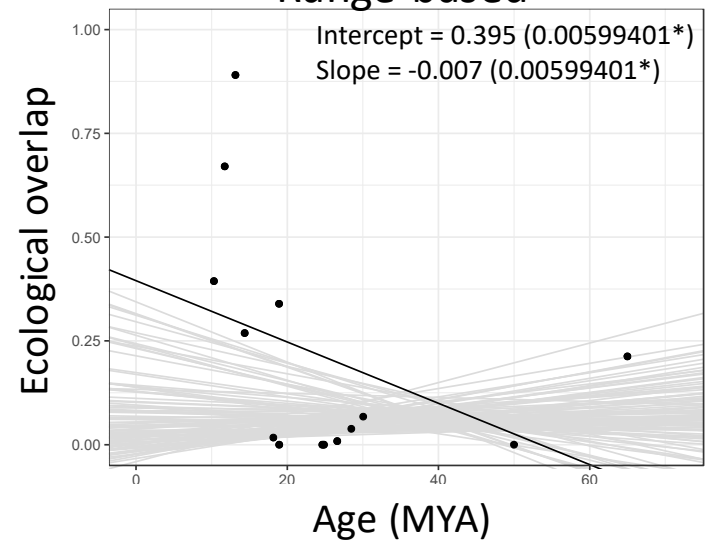
Point-based



Range-based



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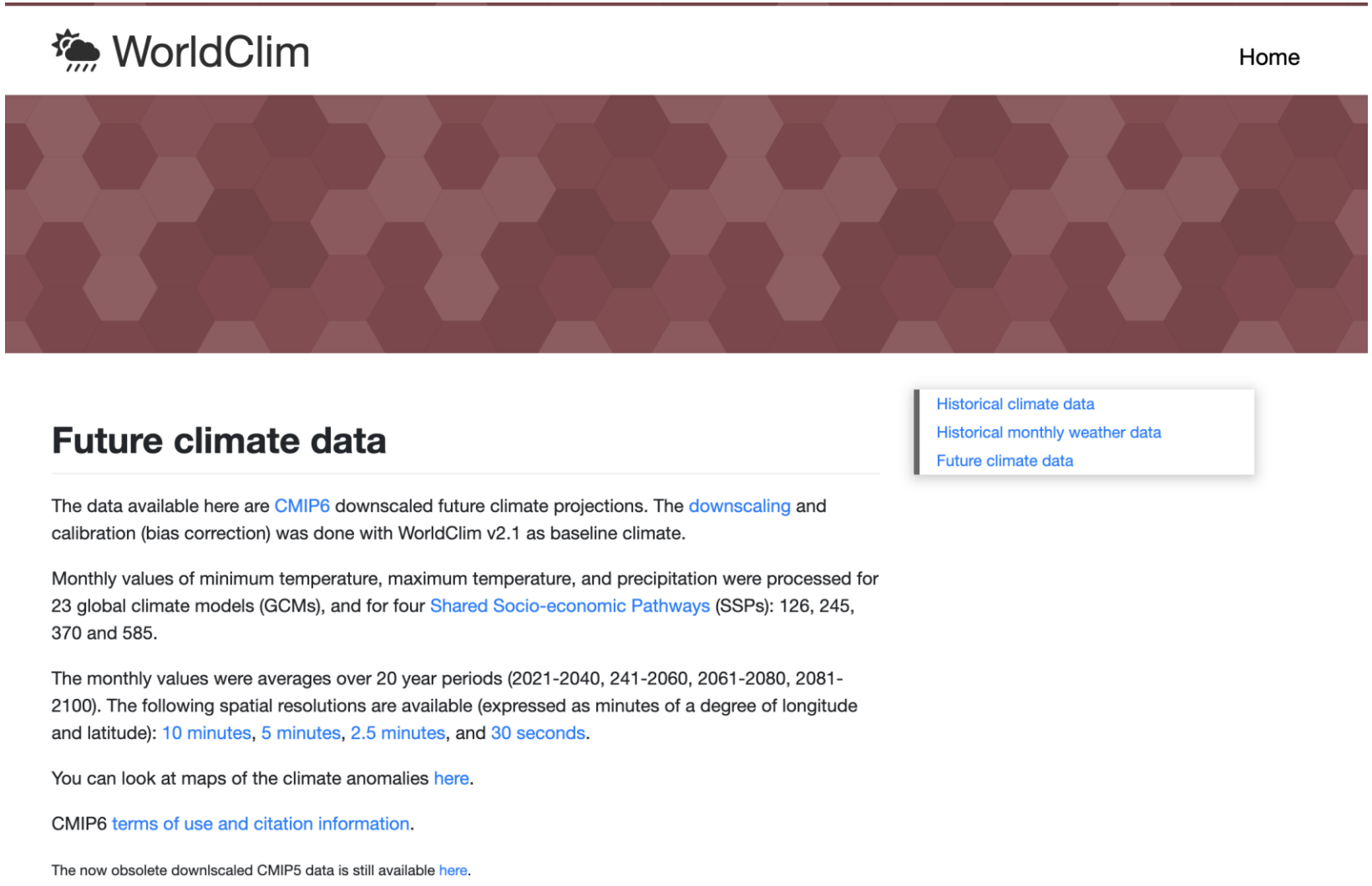
Projecting models to future climates

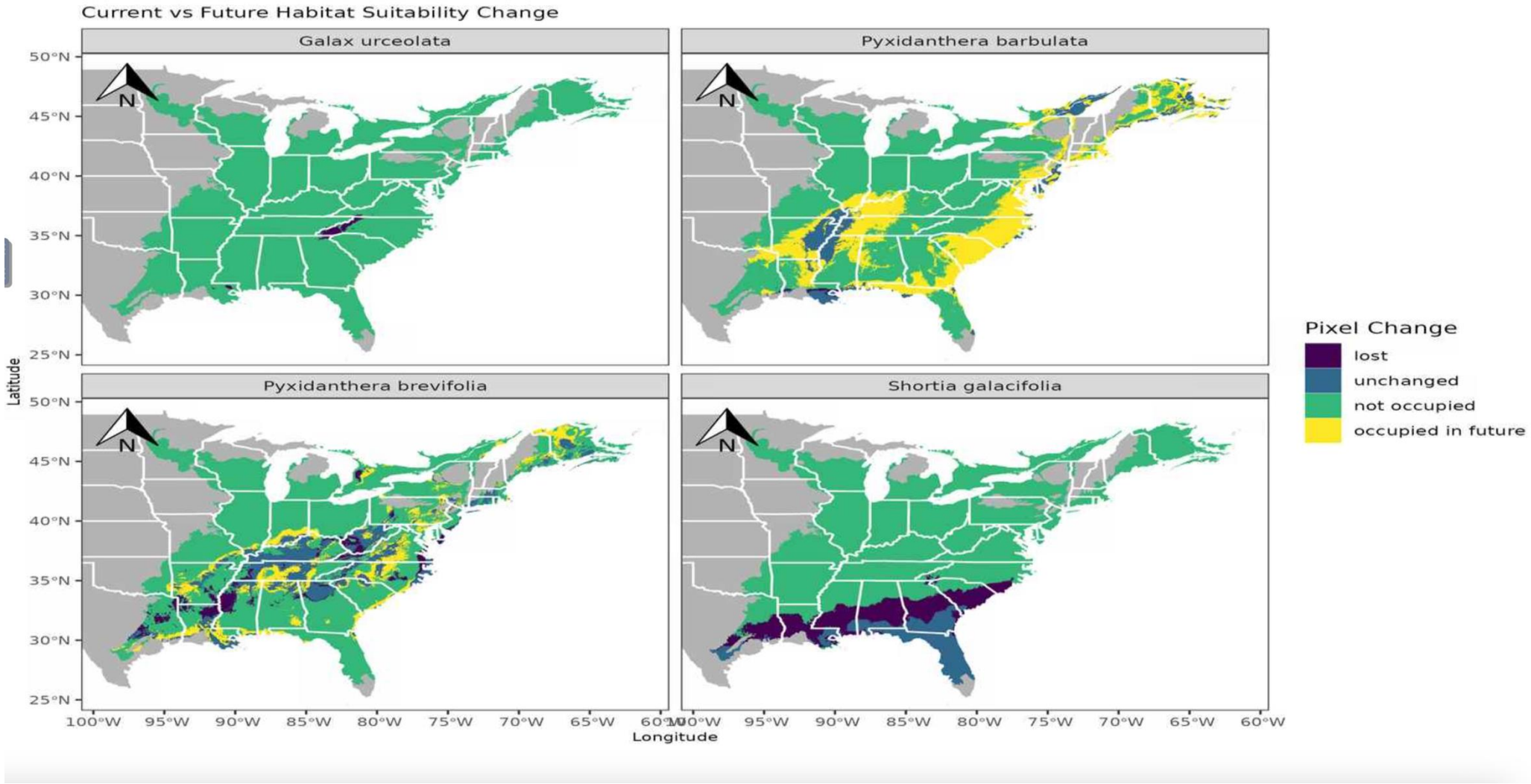
- Predict potential range shifts under different climate change scenarios

- Assess vulnerability of rare or endemic species
  - Inform conservation planning



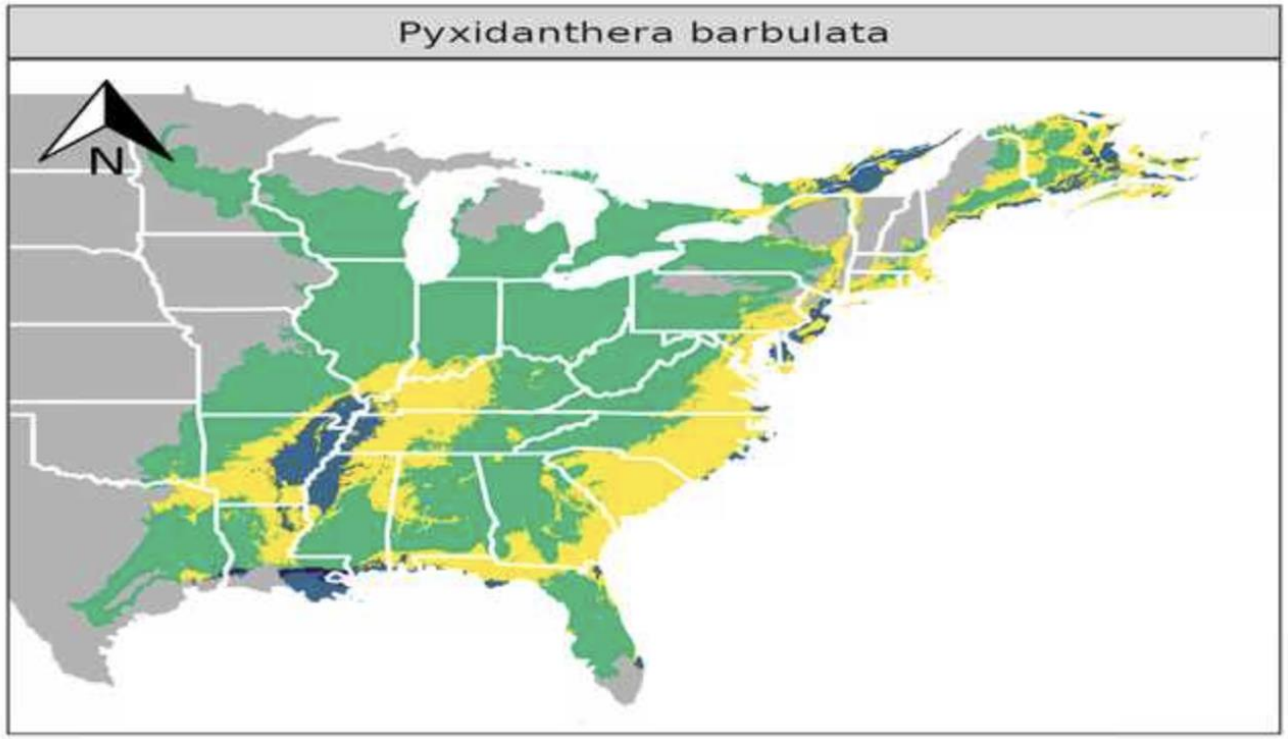
GCM data available at: https://www.worldclim.org/data/cmip6/cmip6climate.html

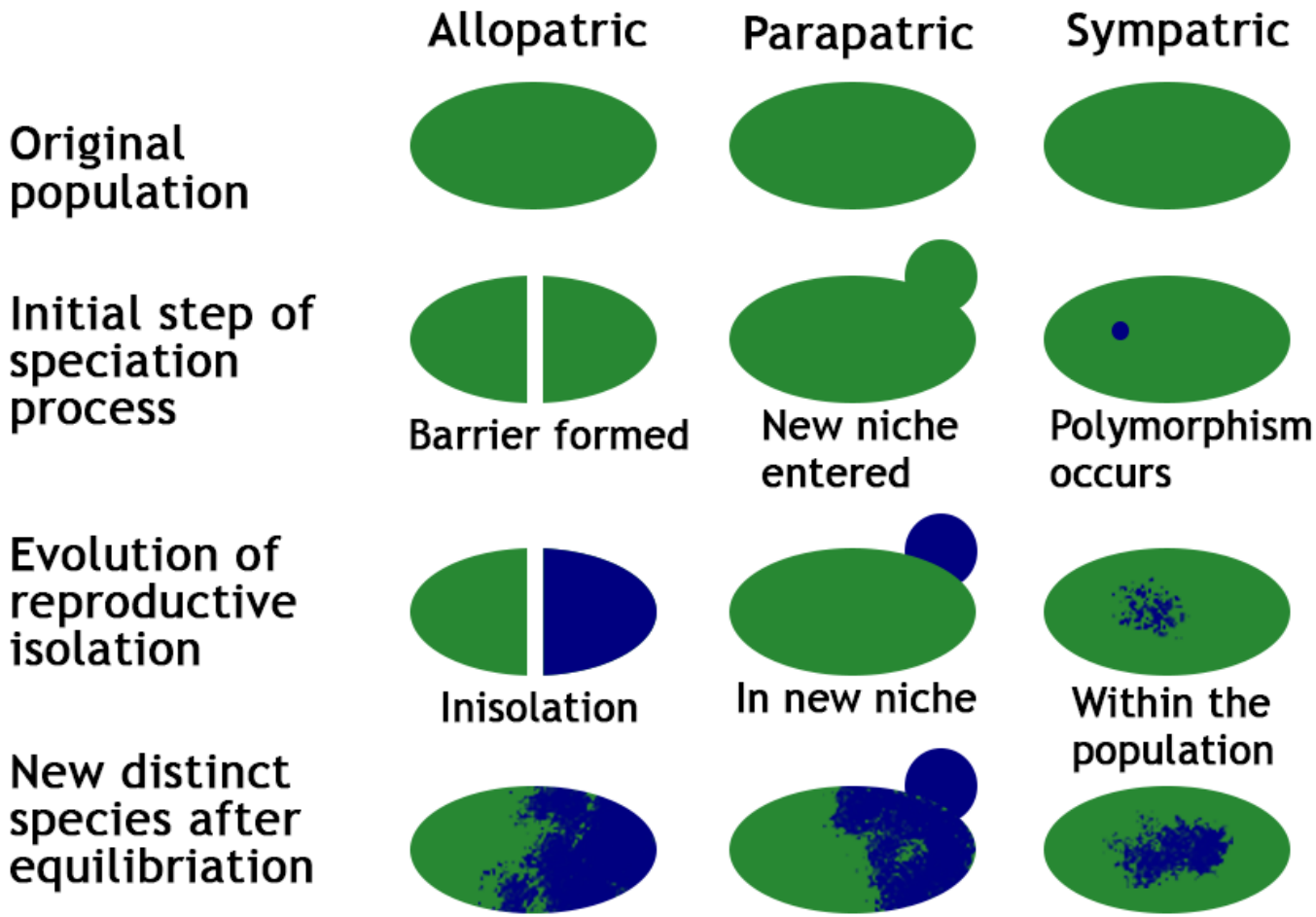
Projecting models to future climates



Projecting models to future climates

- Caveats to accessible areas- avoid overinterpretation of models based on what you know about the region
- Uncertainty from model choice, resolution, and GCMs




Allopatric
Parapatric
Sympatric
Original population
Initial step of speciation process
Barrier formed
New niche entered
Polymorphism occurs
Evolution of reproductive isolation
Inisolation
In new niche
Within the population
New distinct species after equilibriation