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Influence of phylogenetic community structure on introduced fishes in the southeast United States

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USGS Nonindigenous Aquatic Species Database

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Introduced species

- Introduced taxa have potential to impact native species/communities
- Not all species have equal impacts in communities
- Not all introductions are successful

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- **What properties of native communities might aid/prevent introduction of non-natives?**

- **What properties of non-natives might influence their establishment?**

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Invasion success and ecological theory

- Introduced taxa
  - Broad environmental tolerance/generalist, habitat matching, propagule pressure, enemy release
- Native communities
  - Species diversity/richness, niche occupation, disturbance
- Phylogenetic distance as proxy measure of ecological similarity

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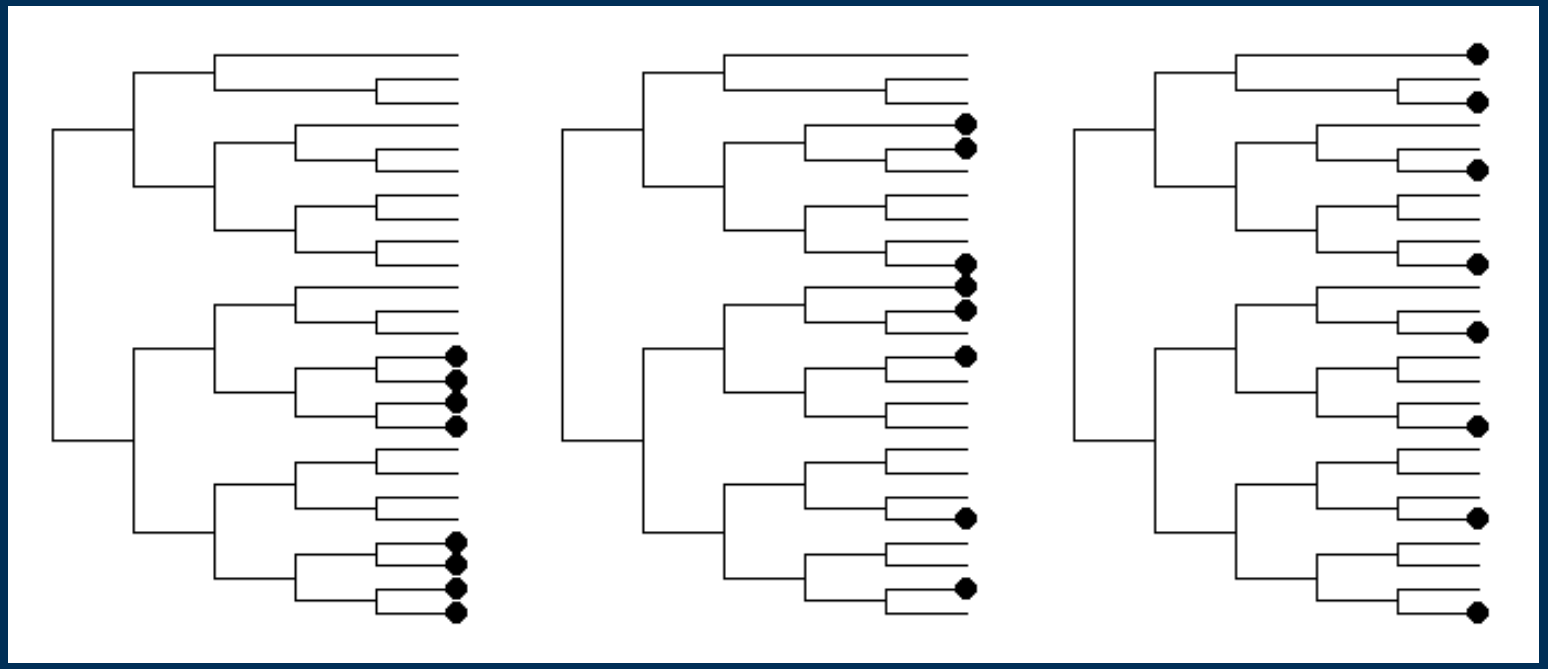
Types of phylogenetic community structure



Phylogenetically clumped ⟷ Phylogenetically random ⟷ Phylogenetically even

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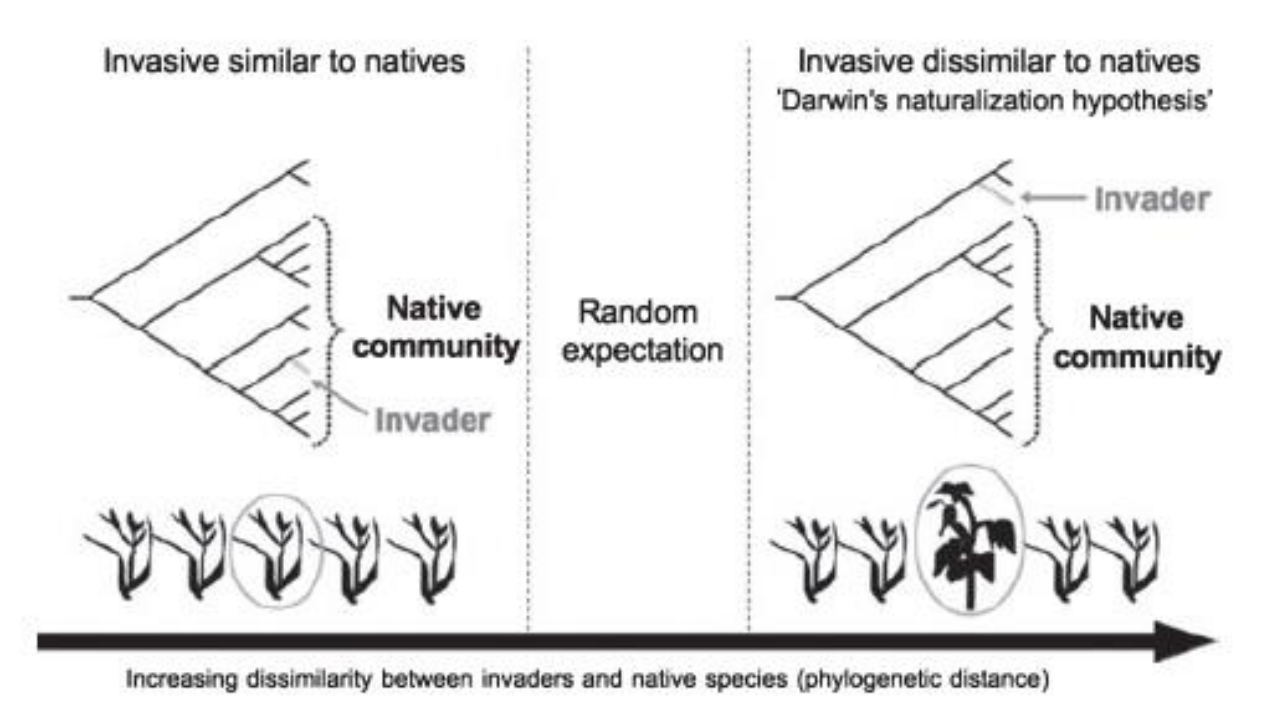
- **Darwin's naturalization conundrum**



Thuiller et al (2010). Diversity and Distributions 16: 461-475

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- **Darwin's naturalization conundrum**
  - **Non-native species with close native relatives should have lower colonization/establishment success due to competitive exclusion**
  - **Non-native species with close native relatives should have higher colonization/establishment success due to pre-adaptations to local environmental conditions (environmental filtering)**

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Questions

- Is phylogenetic diversity of fish community related to invasion susceptibility/success?

- Are successful/unsuccessful invaders in a community more closely/distantly related to that community

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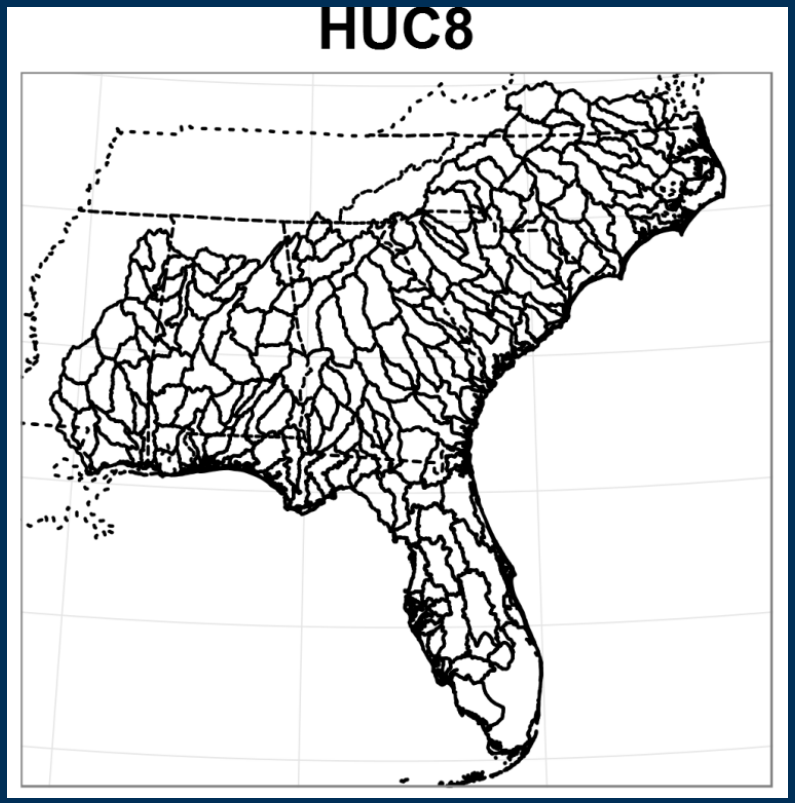
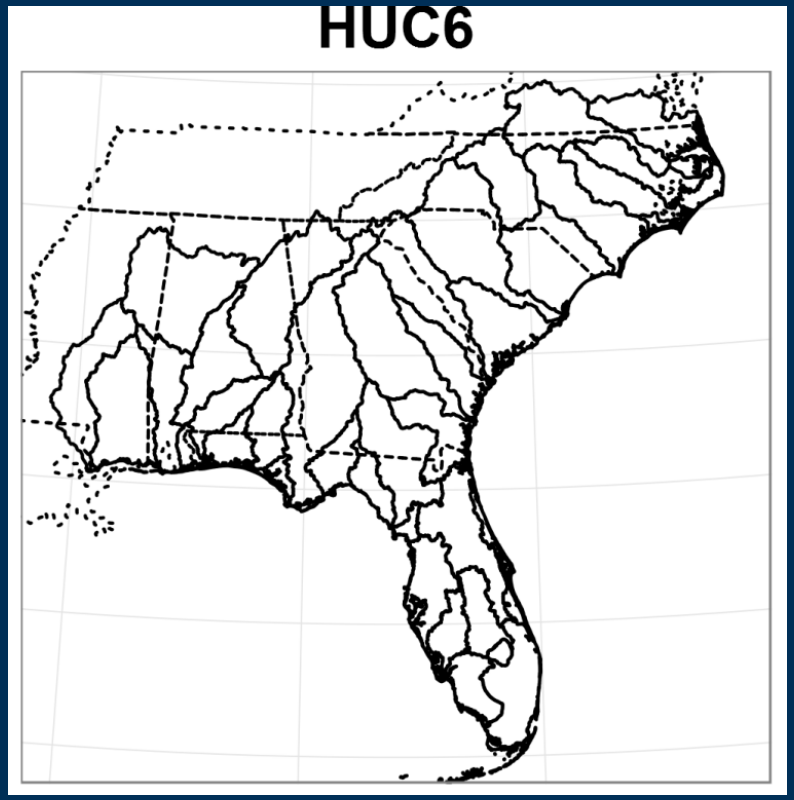
Study region

- HUC 03 – South Atlantic - Gulf





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Methods

- Native fish distributions
  - NatureServe digital distribution maps v. 3.0
- Non-native fish occurrences
  - USGS NAS database
    - Successful (established and eradicated)
    - Failed (failed and extirpated)
- Phylogenetic tree
  - DNA sequence data from Genbank

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Methods

- **Estimate metrics of phylogenetic community structure**
  - **Mean phylogenetic distance (MPD) – mean distance among all community members**
  - **Mean nearest neighbor distance (NN) – mean distance to closest relative**
  - **Standard effect sizes**

$$SES_X = \frac{X_{obs} - mean(X_{rand})}{SD(X_{rand})}$$

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Methods

- ***Is phylogenetic diversity of fish community related to invasion susceptibility/success?***
  - **Compare native community phylogenetic diversity to # successful/failed species**
- ***Are successful/unsuccessful invaders in a community more closely/distantly related to that community***
  - **Compare phylogenetic distance between successful/failed species to native communities**

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Results

- HUC 03
  - 364 native species
  - 132 successful introduced species
  - 60 failed introduced species

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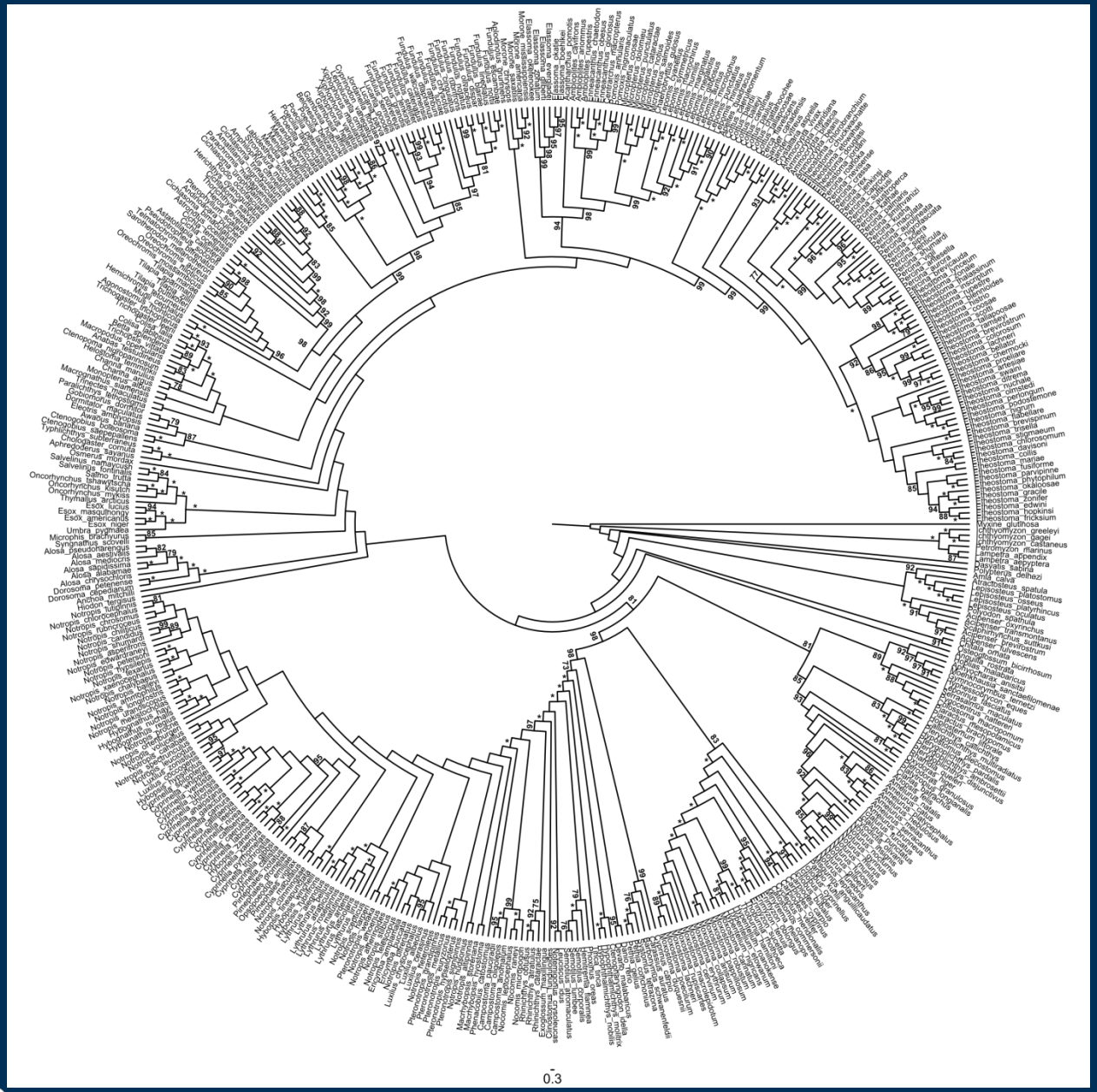

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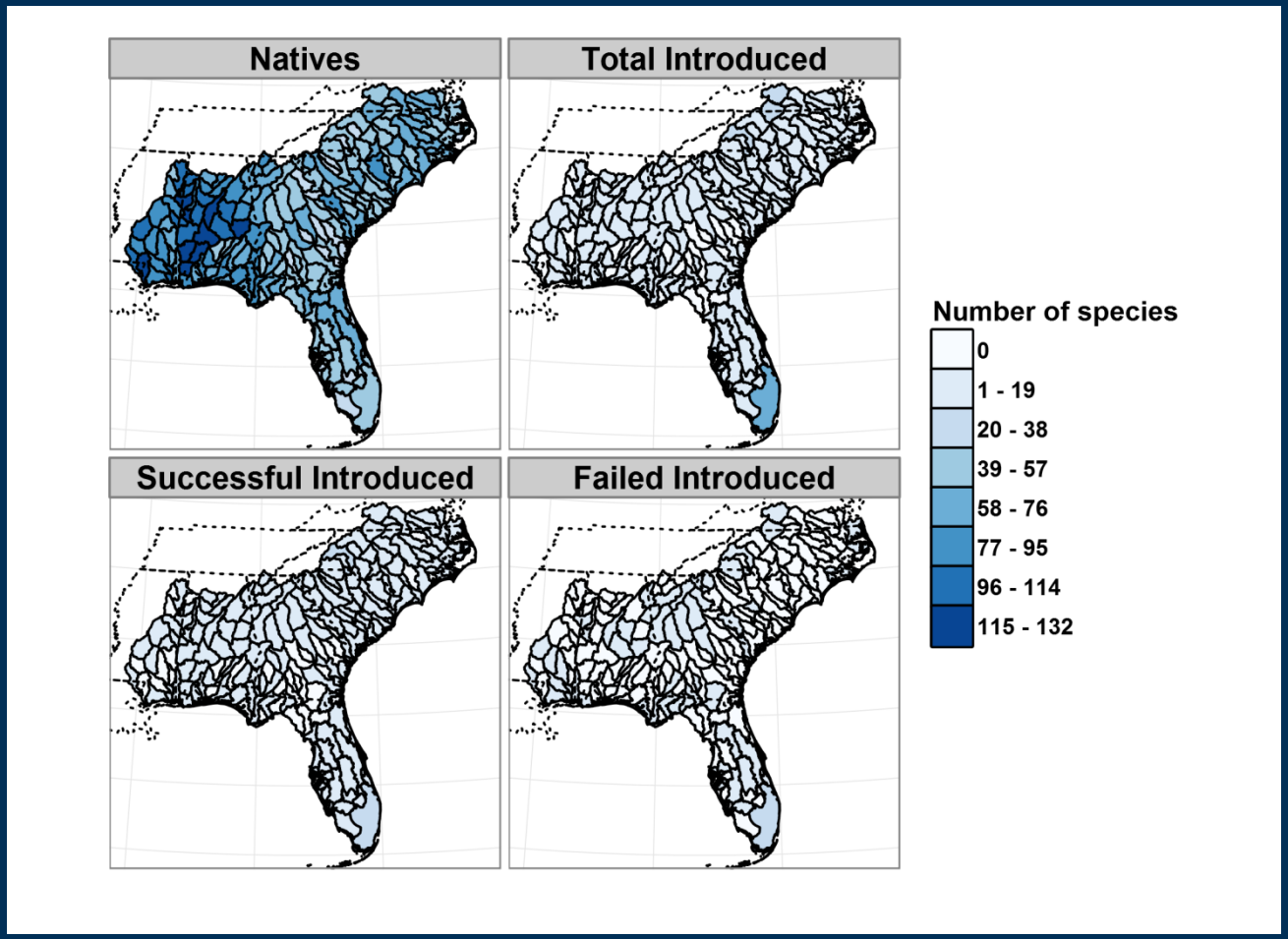
Distribution of species – HUC8



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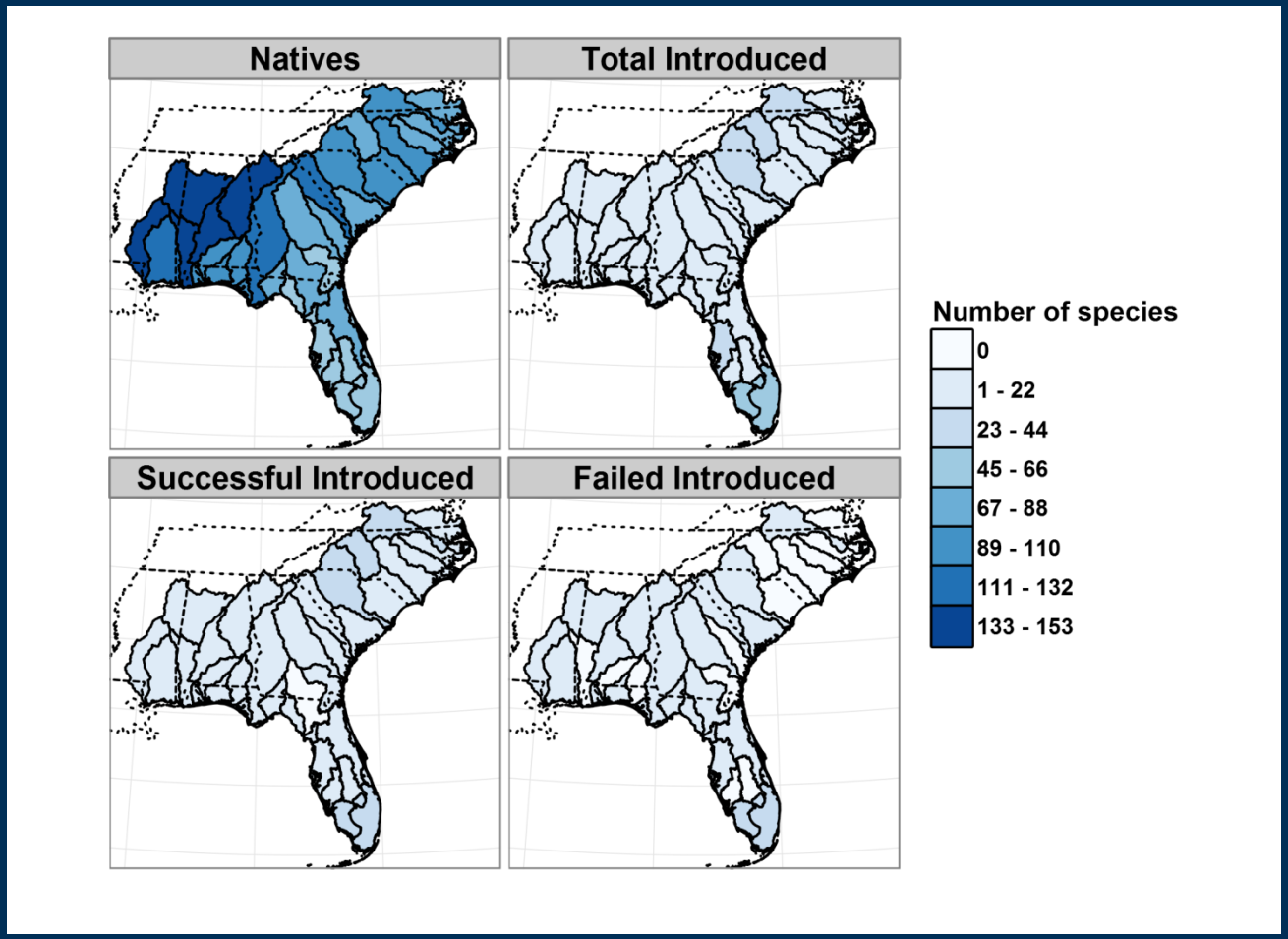
Distribution of species – HUC6



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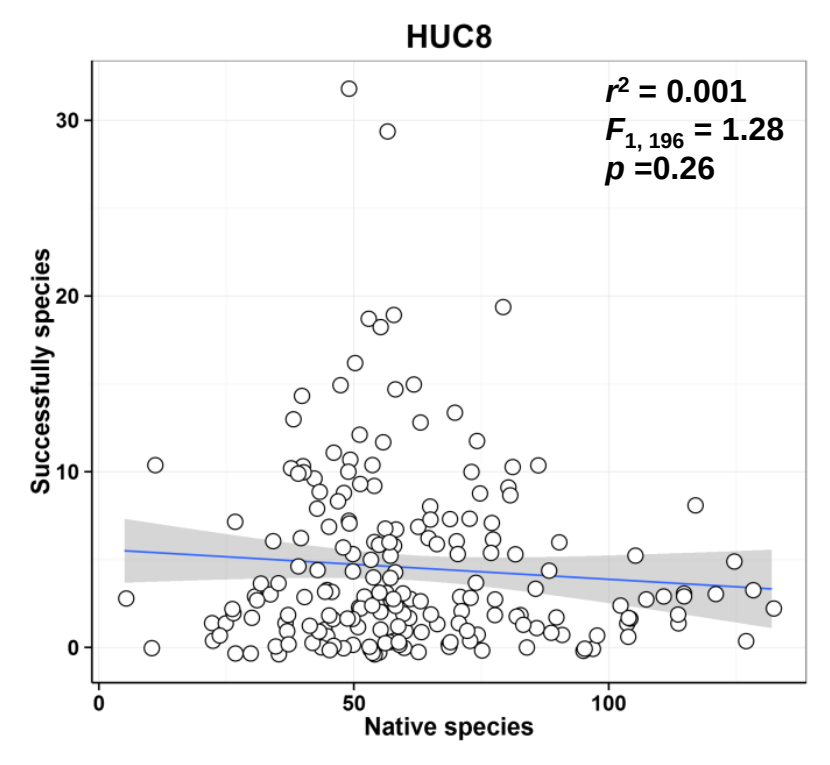
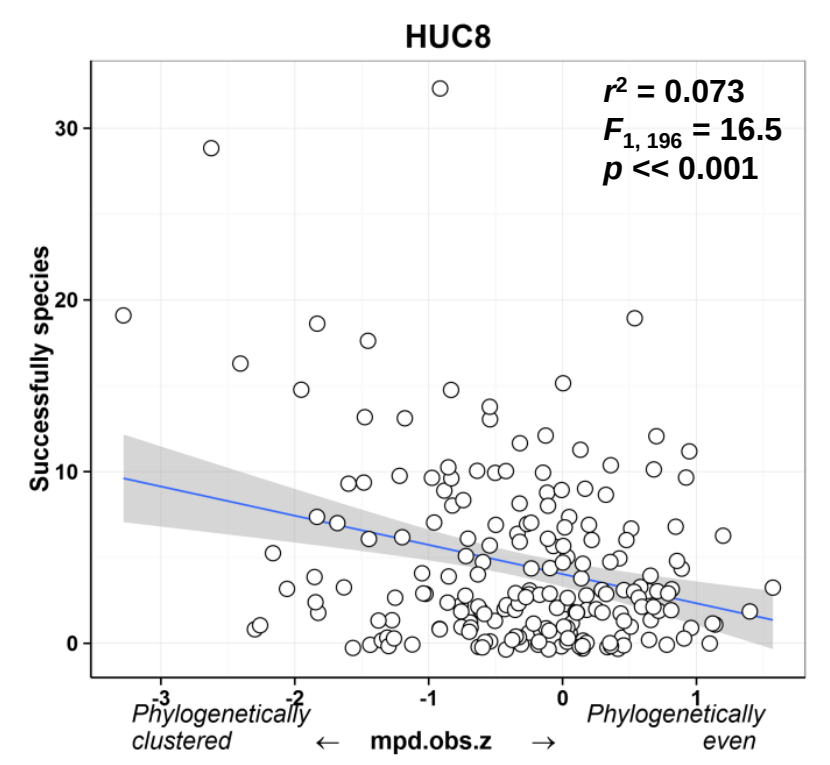
Increasing phylogenetic diversity of communities reduces number of successful species at HUC8





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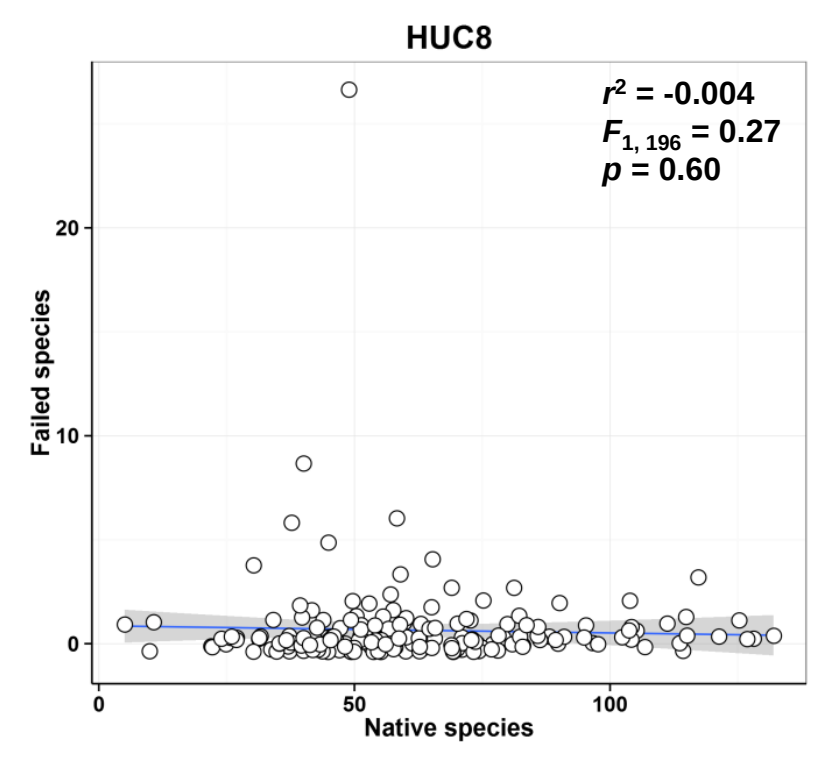
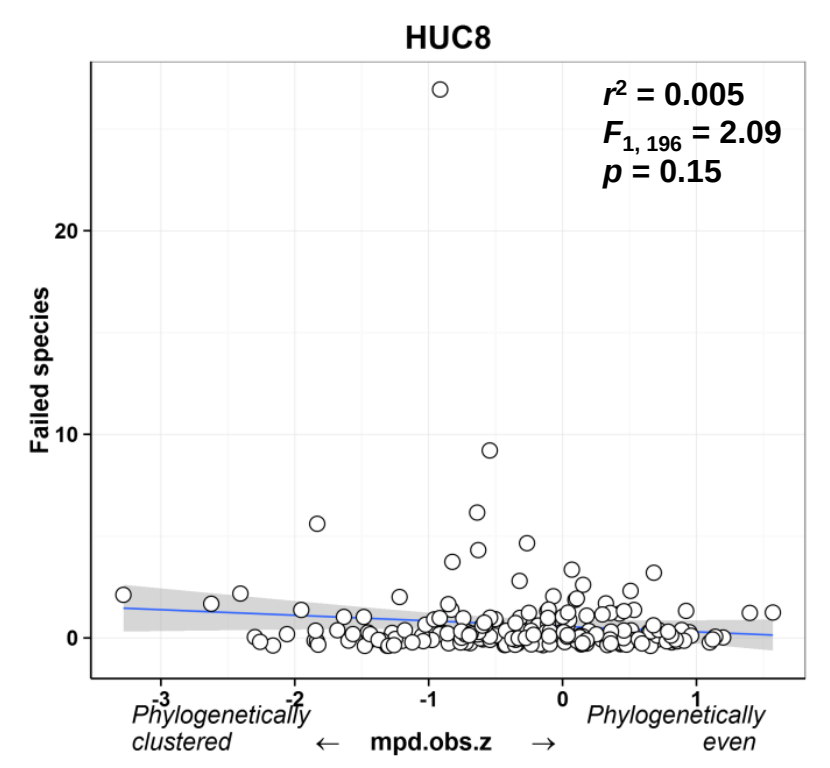
Increasing phylogenetic diversity of communities has no effect on failed species at HUC8





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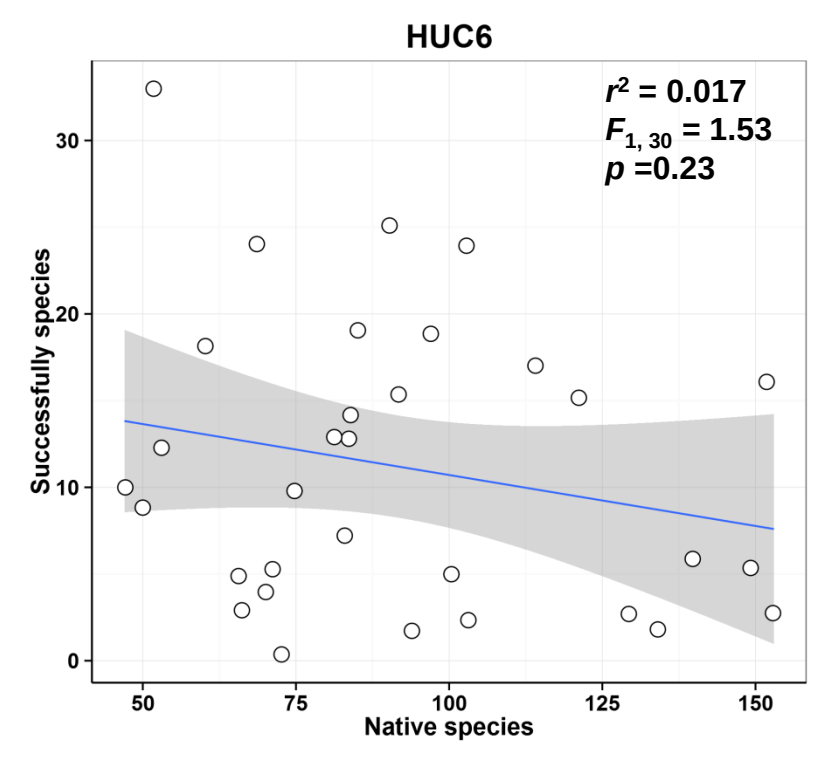
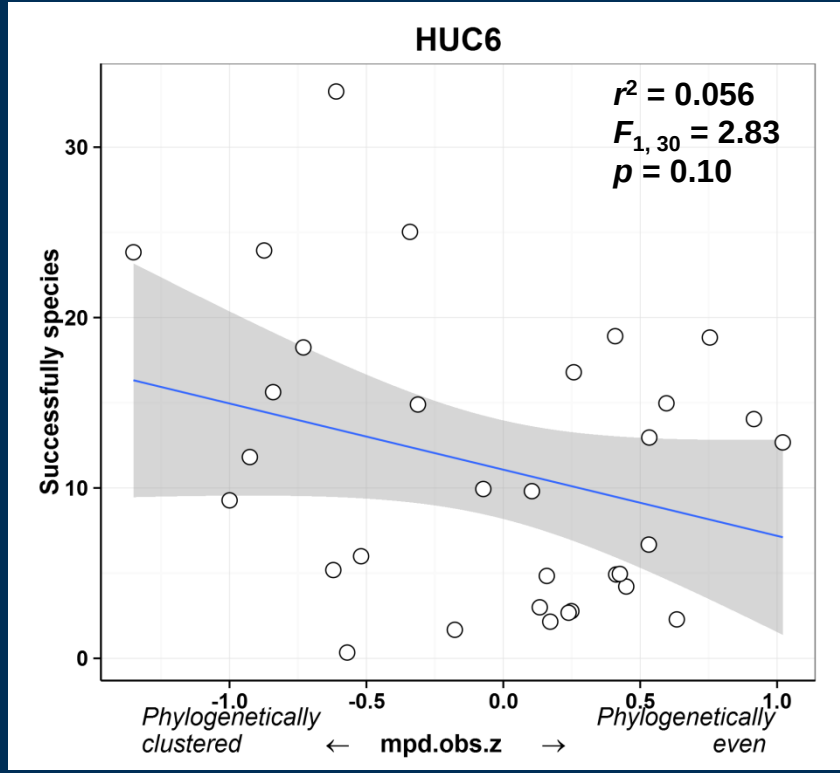
Increasing phylogenetic diversity of communities does not reduce number of successful species at HUC6





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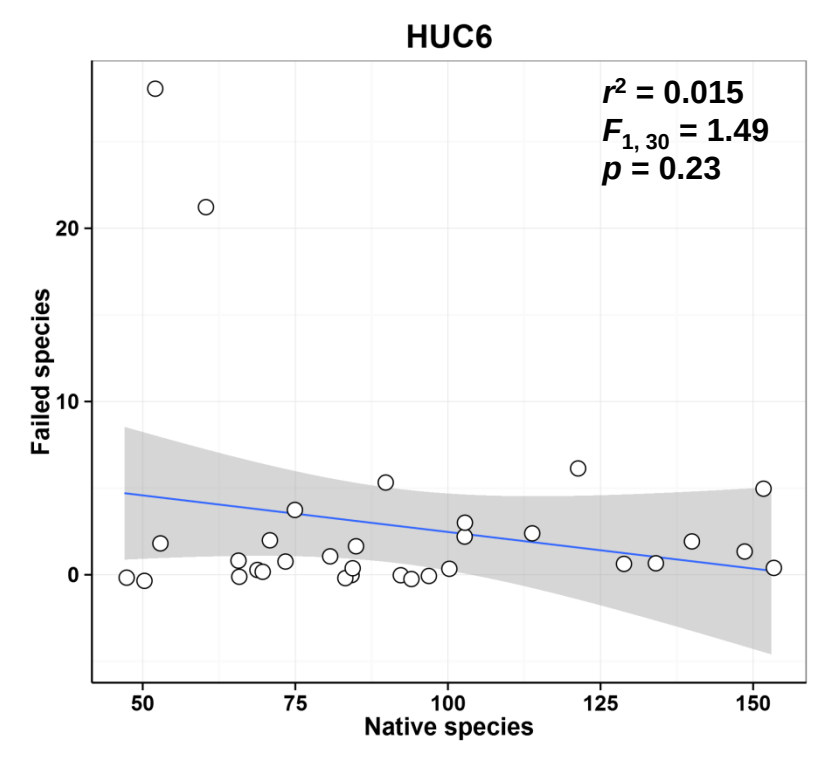
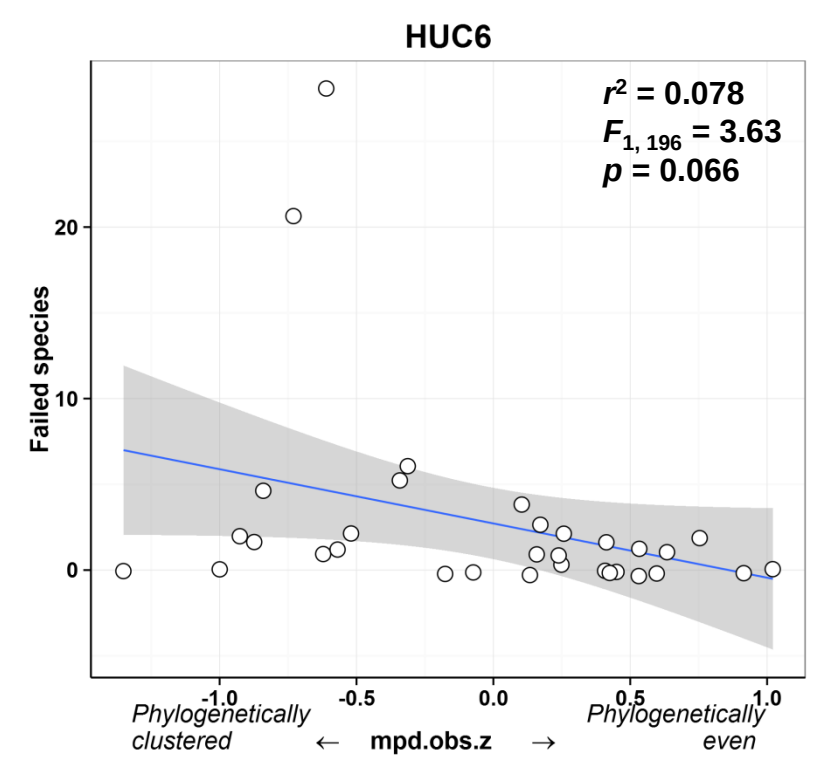
Increasing phylogenetic diversity of communities has no effect on failed species at HUC6





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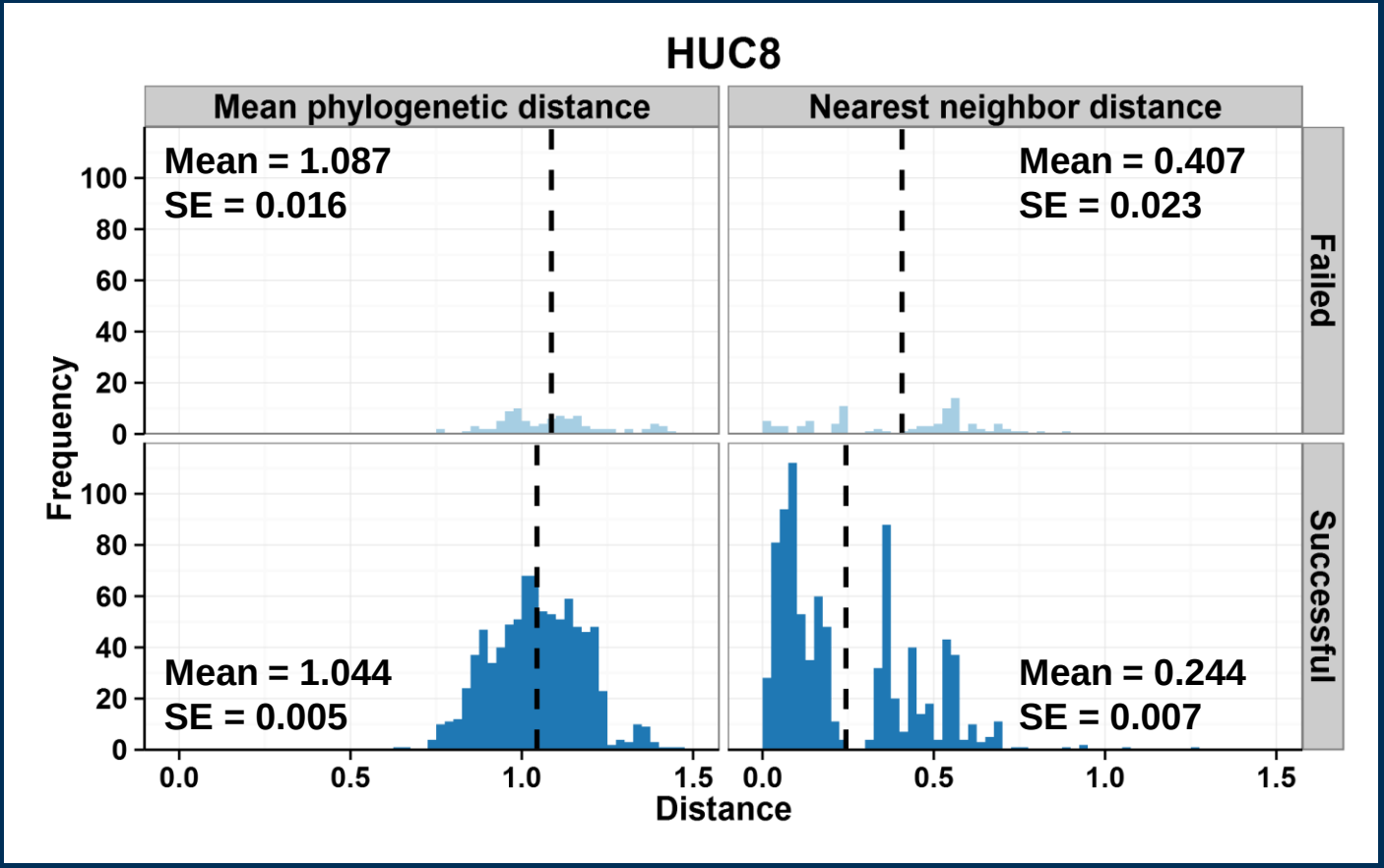
Successful species more closely related to native community than failed ones



MPD
t = -2.55
df = 107
p = 0.012

NN
t = -6.71
df = 107
p << 0.001

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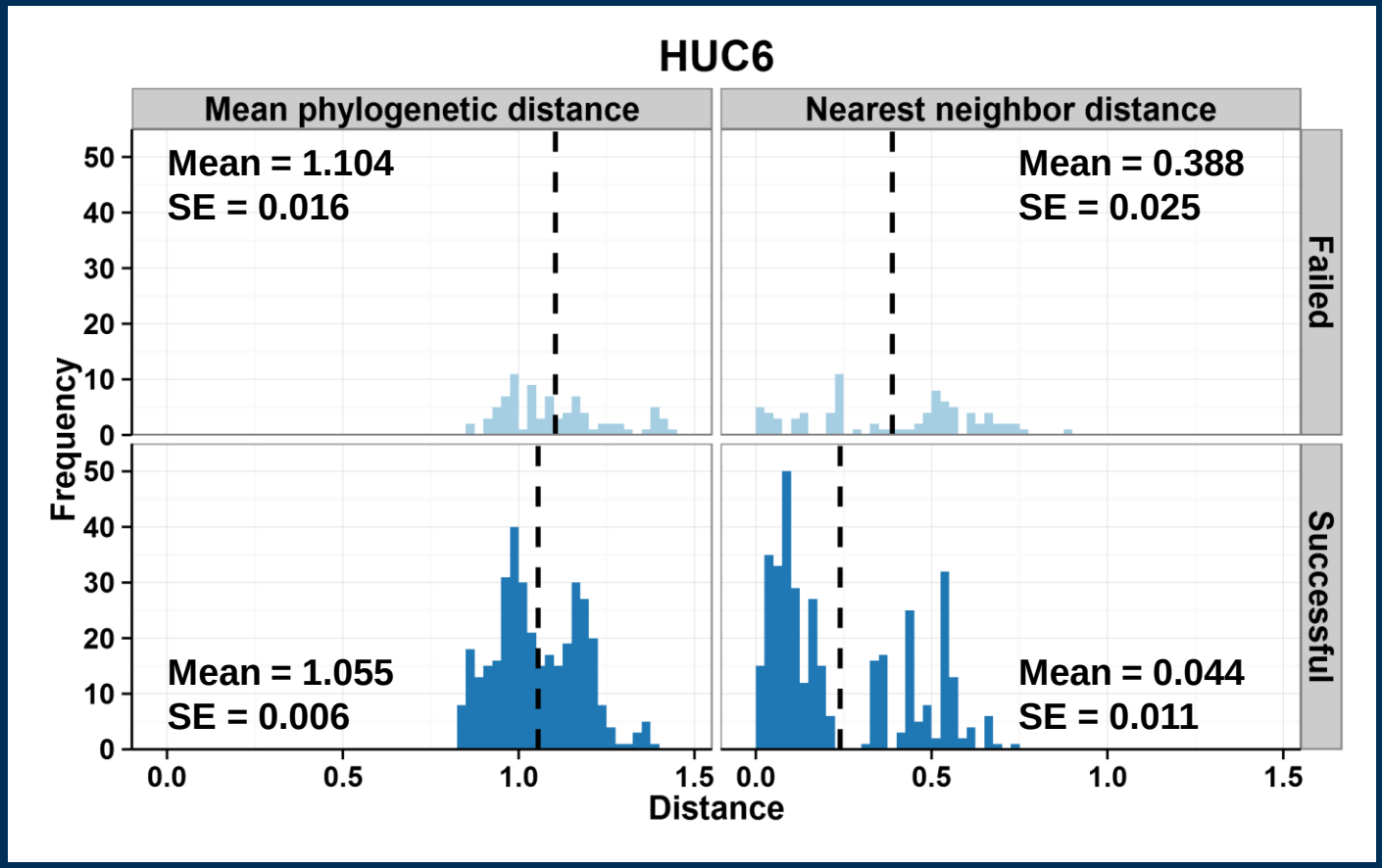
Successful species more closely related to native community than failed ones



MPD
t = -2.82
df = 111
p = 0.006

NN
t = -5.41
df = 114
p << 0.001

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Conclusions

- No impact of phylogenetic diversity on establishment failure
- Phylogenetically diverse/even communities show lower numbers of successful introduced species than clustered ones
  - Diversity/evenness = wider portion of occupied niche space?

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Conclusions

- **Successful invaders are more closely related to native fish communities than failed species**
  - **Opposite pattern than observed in other systems**
  - **Suggests environmental filtering/pre-adaptation rather than release from competitive exclusion**

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Future directions

- Smaller watershed scale (HUC10/12 vs HUC8)
- Incorporate ecological traits to more directly measure/compare niches of native and introduced taxa
- Landscape analysis/GIS
  - Environmental layers
  - Physiographic boundaries
  - Habitat type – lentic vs. lotic habitats

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Acknowledgements

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All contributors to USGS NAS database

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