Scale-dependent patterns of ant and spider diversity in the tree canopy of eastern deciduous forest

Michael B. Mahon

Hannah J. Penn

Kaitlin U. Campbell

Thomas O. Crist

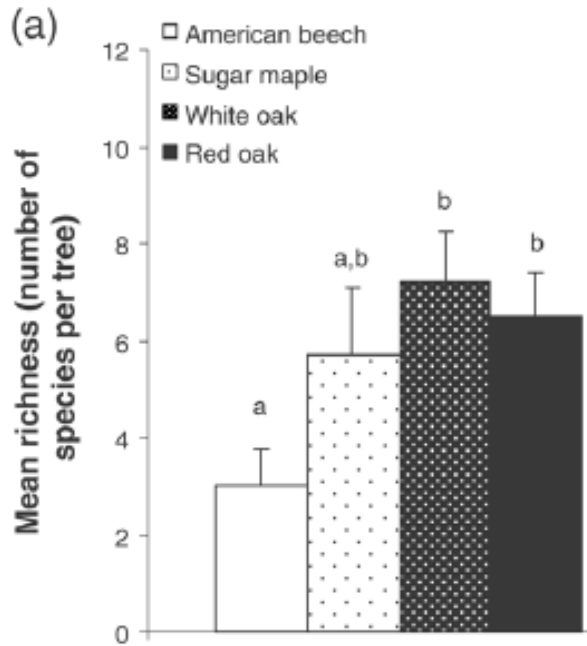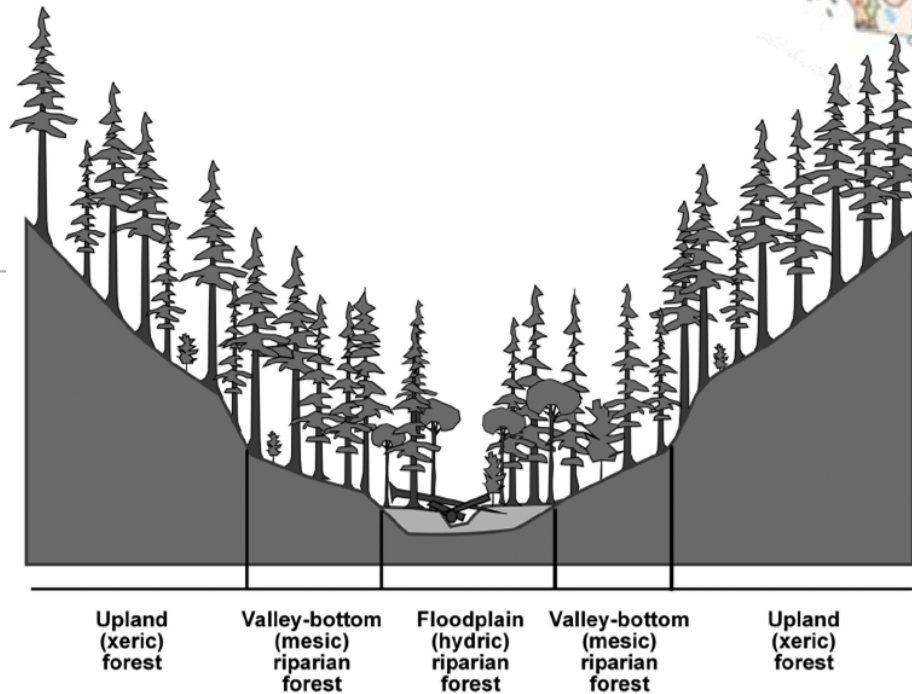Miami University, Dept. of Biology

Oxford, OH

@GlobalWorming19

Species Diversity and Spatial Scale

Summerville et al. 2003

Pollock et al. 2012

Forest Canopy

- Forest canopy is known as a major pool of global arthropod diversity

- Canopy research in temperate deciduous forests is still highly limited

Ants and Spiders

Alex Wild

Alex Wild

Dispersal

Adrian Smith

Dispersal

Adrian Smith

gifs.com

Questions

- What are the scaling patterns of diversity and community assembly of canopy dwelling ants and spiders?

Methods – Study Design

- Hierarchically nested design; four levels represented

Methods – Study Design

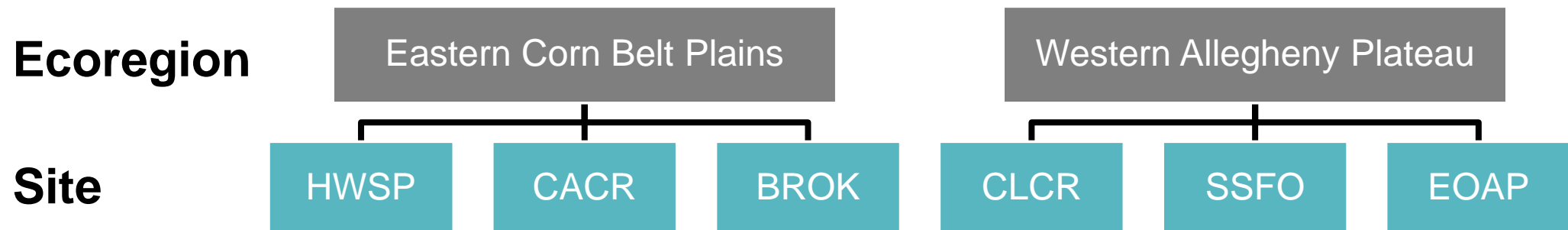- Hierarchically nested design; four levels represented

Ecoregion

Eastern Corn Belt Plains

Western Allegheny Plateau

Methods – Study Design

- Hierarchically nested design; four levels represented

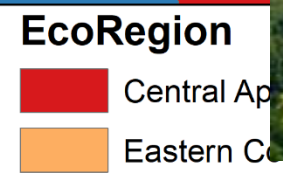|				
Ecoregion	Eastern Corn Belt Plains		Western Allegheny Plateau	
Site	HWSP	CACR	BROK	CLCR	SSFO	EOAP

Edge of Appalachia: Western Allegheny Plateau

Hueston Woods: Eastern Corn Belt Plains

Methods – Study Design

- Hierarchically nested design; four levels represented

Ecoregion | Eastern Corn Belt Plains | Western Allegheny Plateau

Site | HWSP | CACR | BROK | CLCR | SSFO | EOAP

Stand | Mesic 1 | Xeric 1 | Mesic 2 | Xeric 2
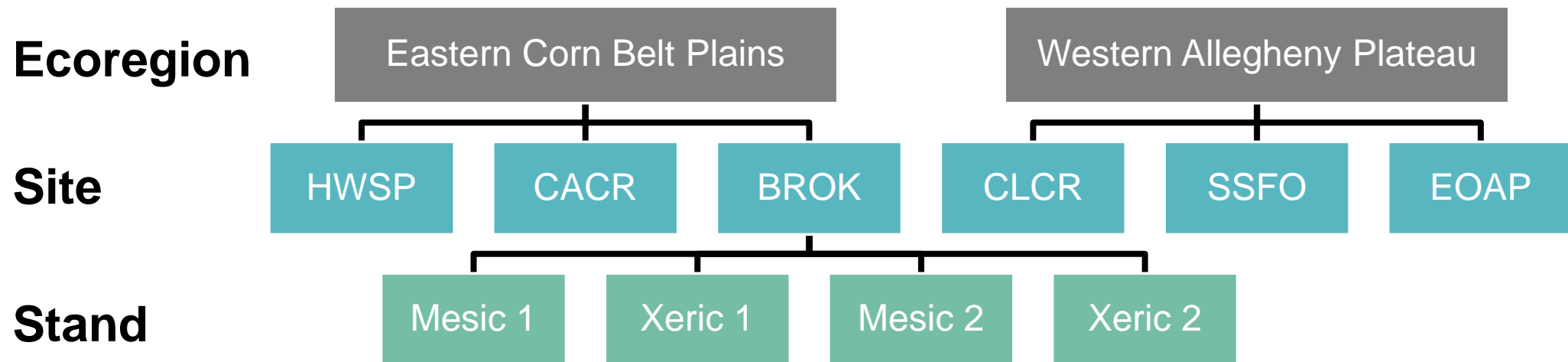
Methods – Study Design

- Hierarchically nested design; four levels represented

Canopy Fogging

- June and August of 2000

- Pyrethrin-based insecticide from a Curtis Dyna-Fogger

- Collecting effort was standardized for each tree (12 - 1m^2 funnels)

Diversity Partitioning

- Multiplicative Partitioning of Diversity ($\beta = \gamma / \alpha$)
  - **Species richness**
  - Expected diversity found with *PARTITIONR* R package
    - **Sample-based** randomizations; 1000 randomizations
    - github.com/partition/PARTITIONR

Beta(Stand) = Alpha(Forest) / Alpha(Stand)
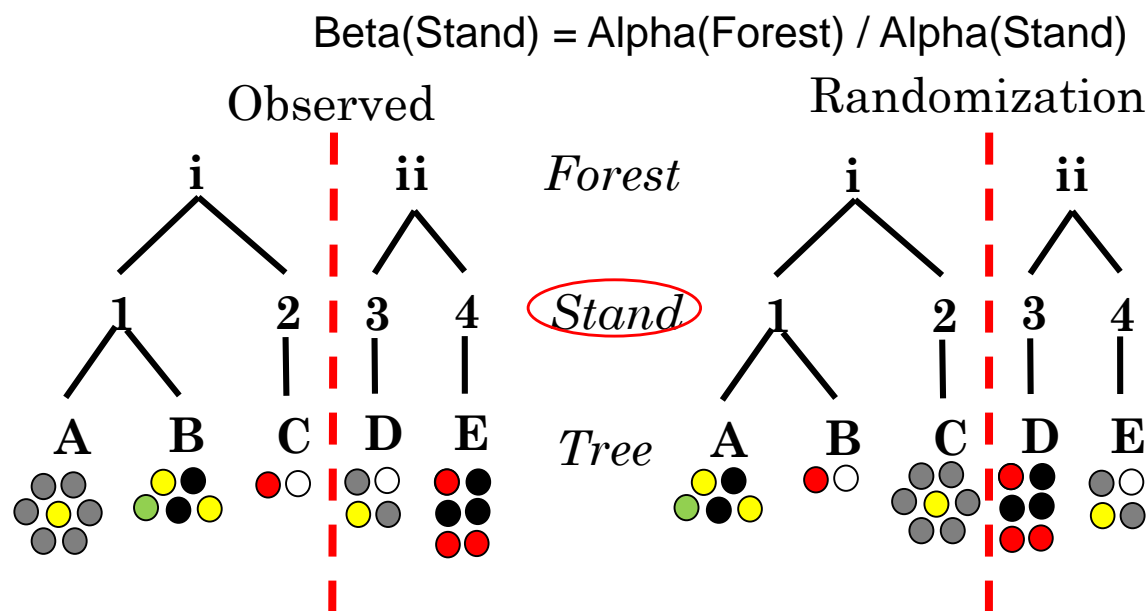
Diversity Partitioning

- Multiplicative Partitioning of Diversity ($\beta = \gamma / \alpha$)
  - **Species richness**
  - partition() function in *PARTITIONR* package
    - **Sample-based** randomizations; 1000 randomizations
    - github.com/partition/PARTITIONR

- Hierarchical PERMANOVA
  - PRIMER and PERMANOVA+ (Marti Anderson)
  - Bray-Curtis dissimilarity
  - Variance components interpreted as percent dissimilarity

GitHub

Results

- Ants
  - 3053 individuals
  - 23 species
  - 2 singletons

- Spiders
  - 5221 individuals
  - 97 species
  - 15 singletons

Aphaenogaster mariae

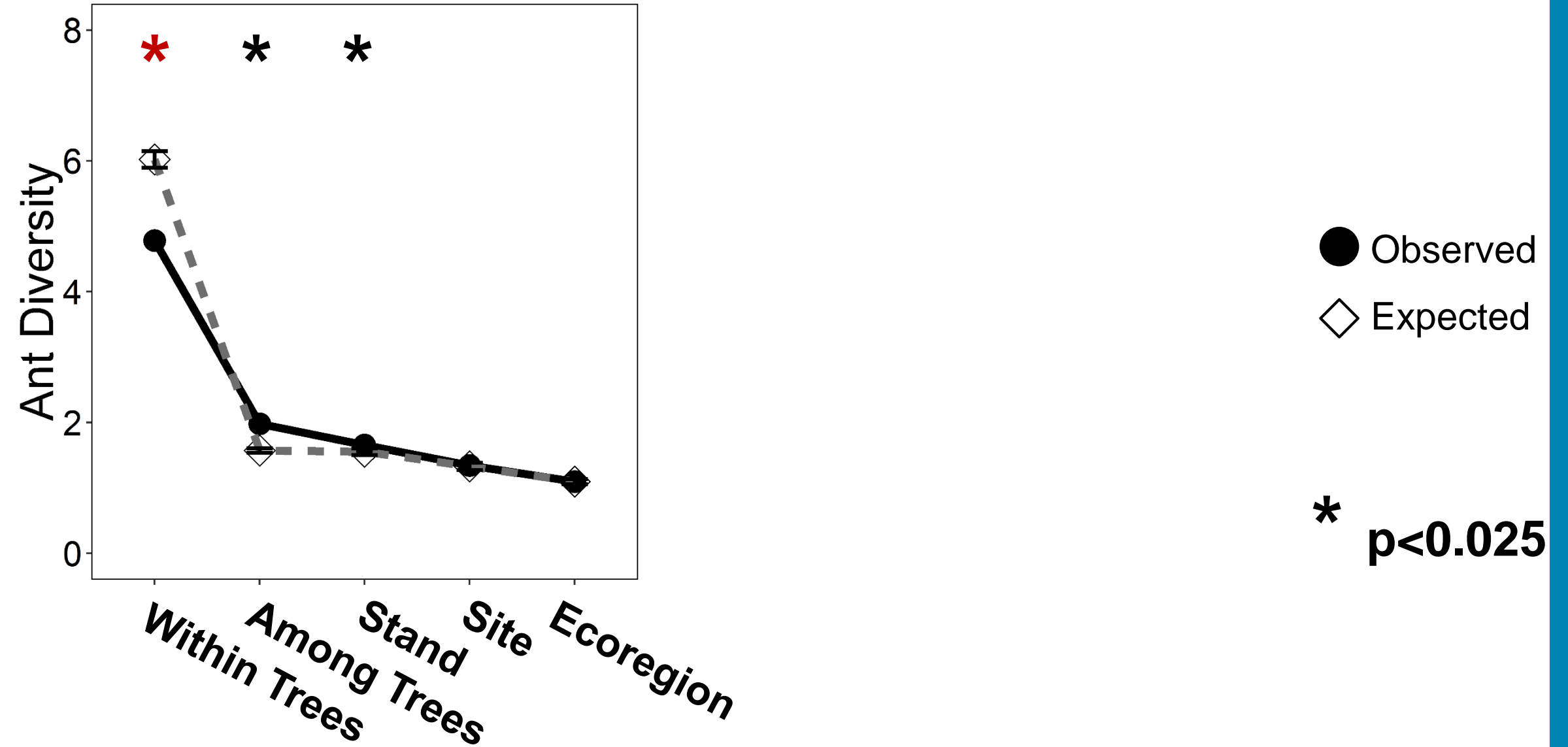*Camponotus nearcticus*

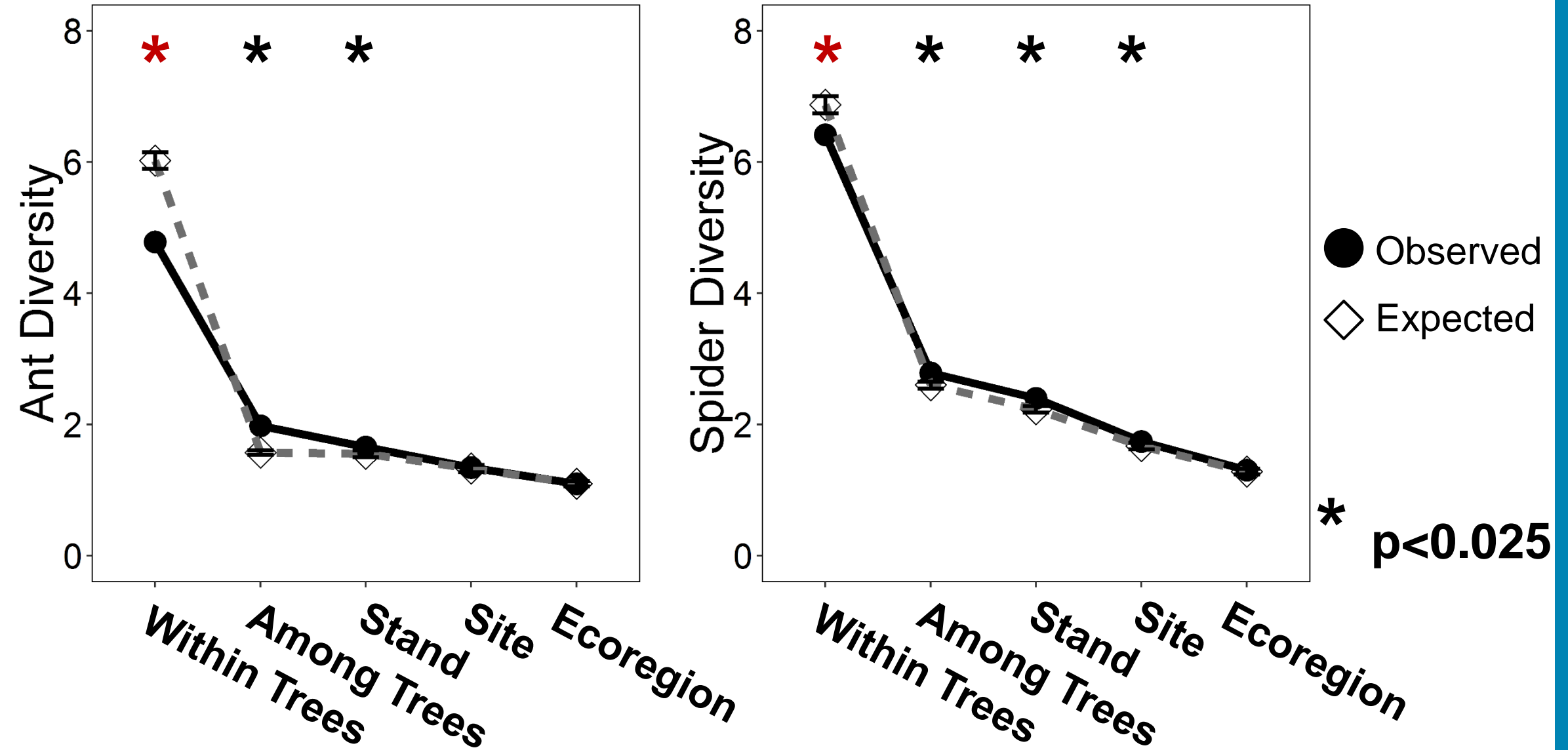*Eris militaris*

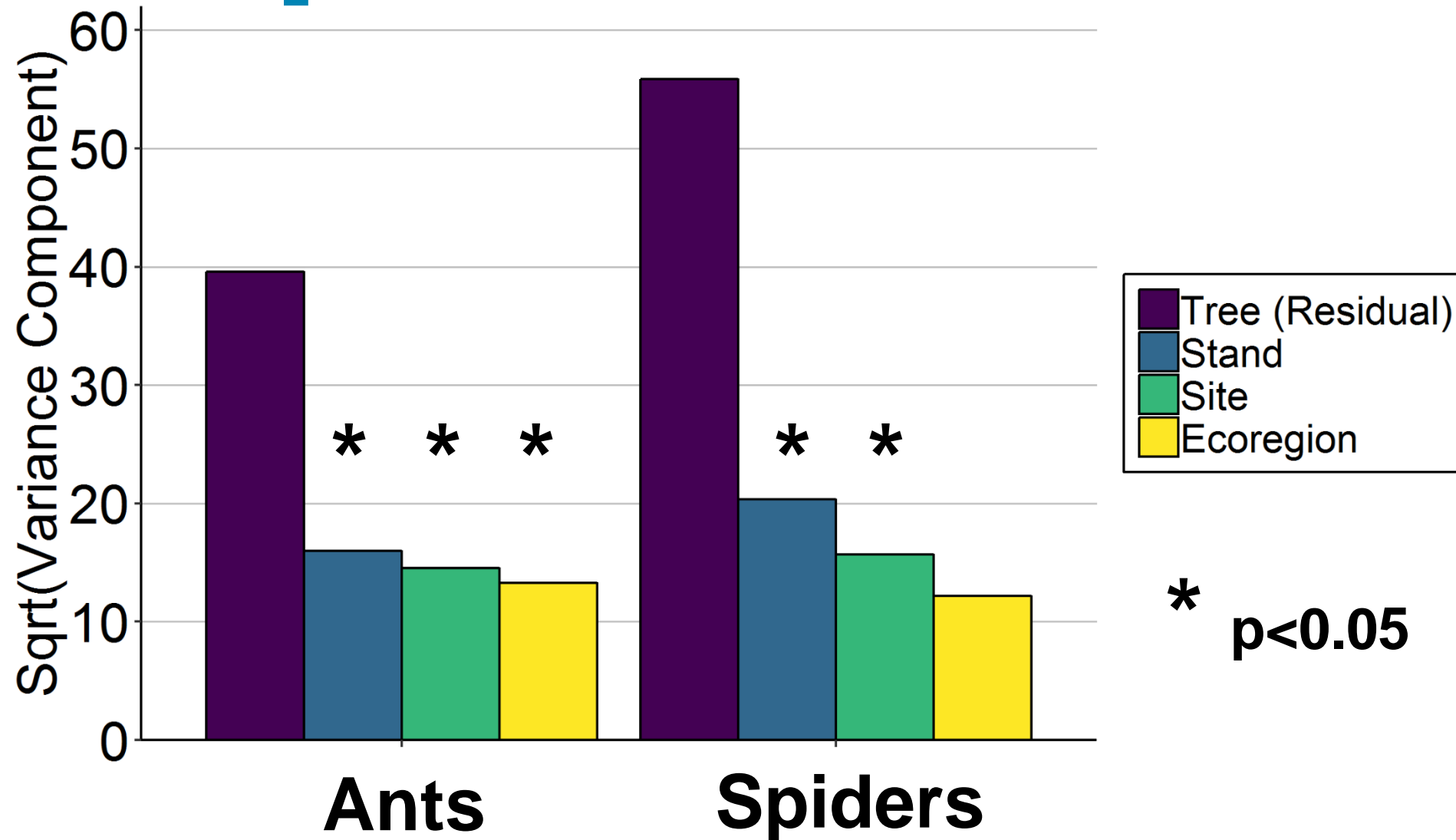*Theridion glaucescens*

Photo credit: TGIQ, BugGuide, Alex Wild

Diversity decreases with spatial scale

Diversity decreases with spatial scale

Community dissimilarity decreases with spatial scale

Questions

- What are the scaling patterns of diversity and community assembly of canopy dwelling ants and spiders?

- What environmental factors drive patterns of diversity at local and intermediate scales?

Environmental Drivers of Diversity

- β_M among trees and community composition within each stand
  - Regressions and dbRDA, AICc model selection
  - Environmental variables (11 variables)
    - 5 Bioclimatic (WorldClim 2.0)
    - 5 Landscape (USDA crop layer; Fragstats; 6.5 km buffer)
    - Stand-level tree richness

Ant beta diversity is driven by precipitation variability and landscape connectivity
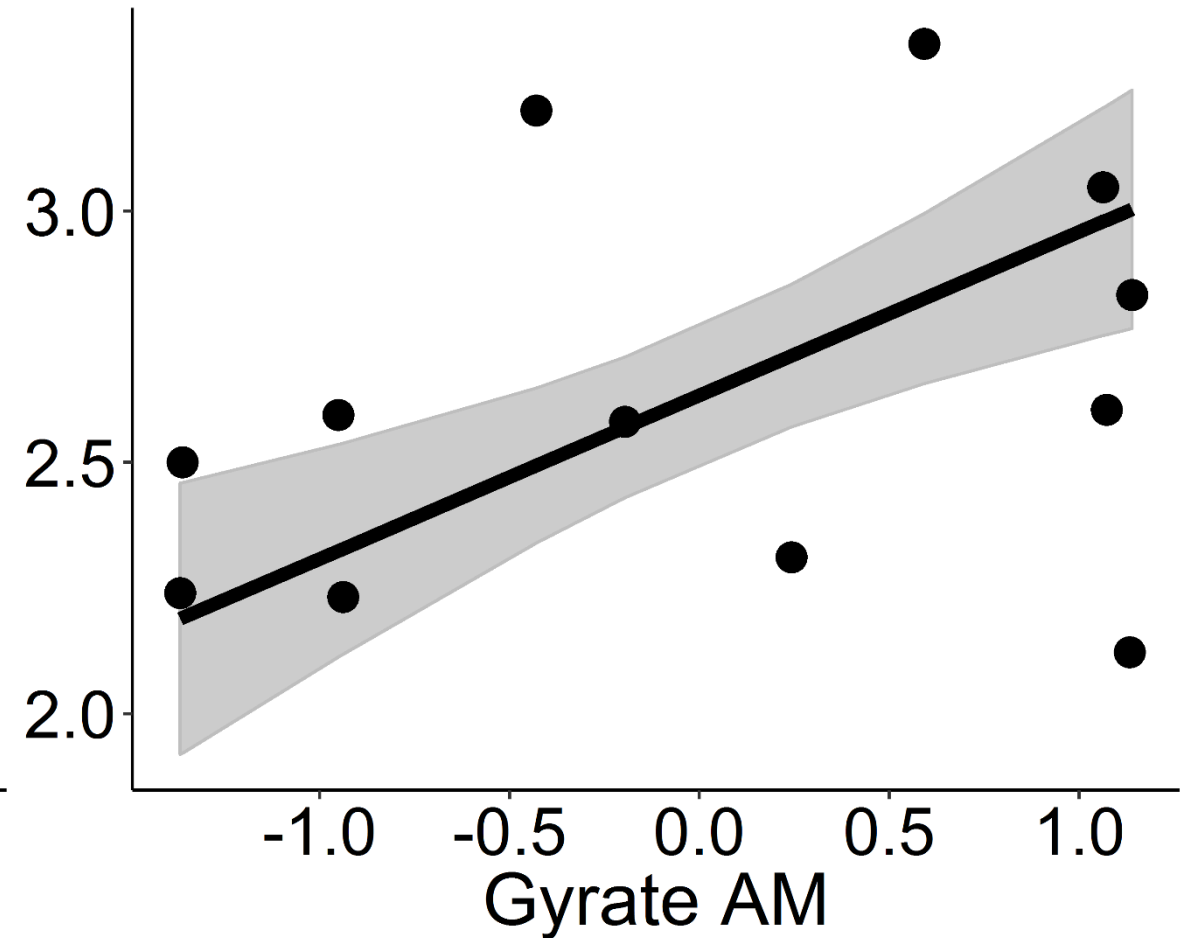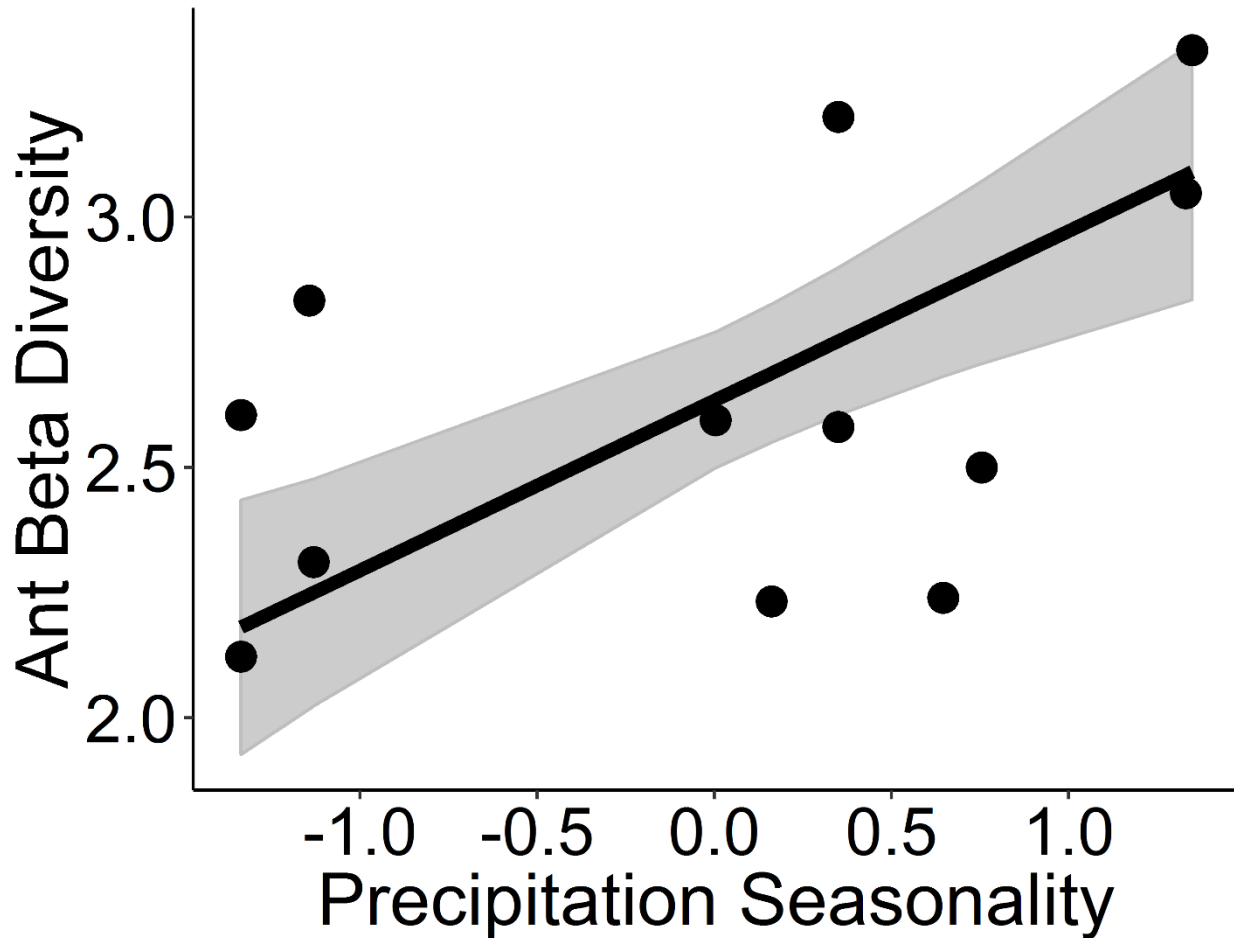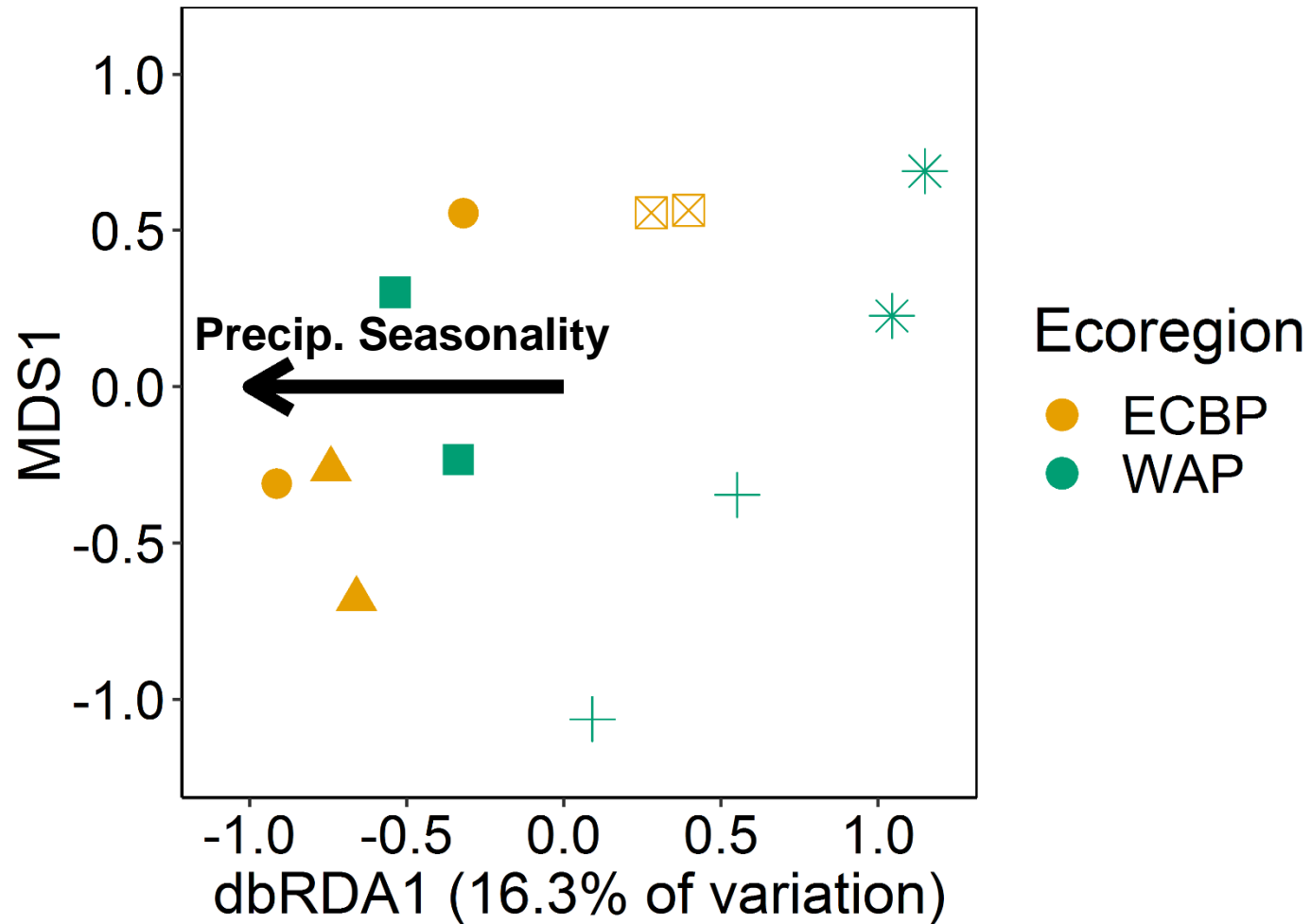
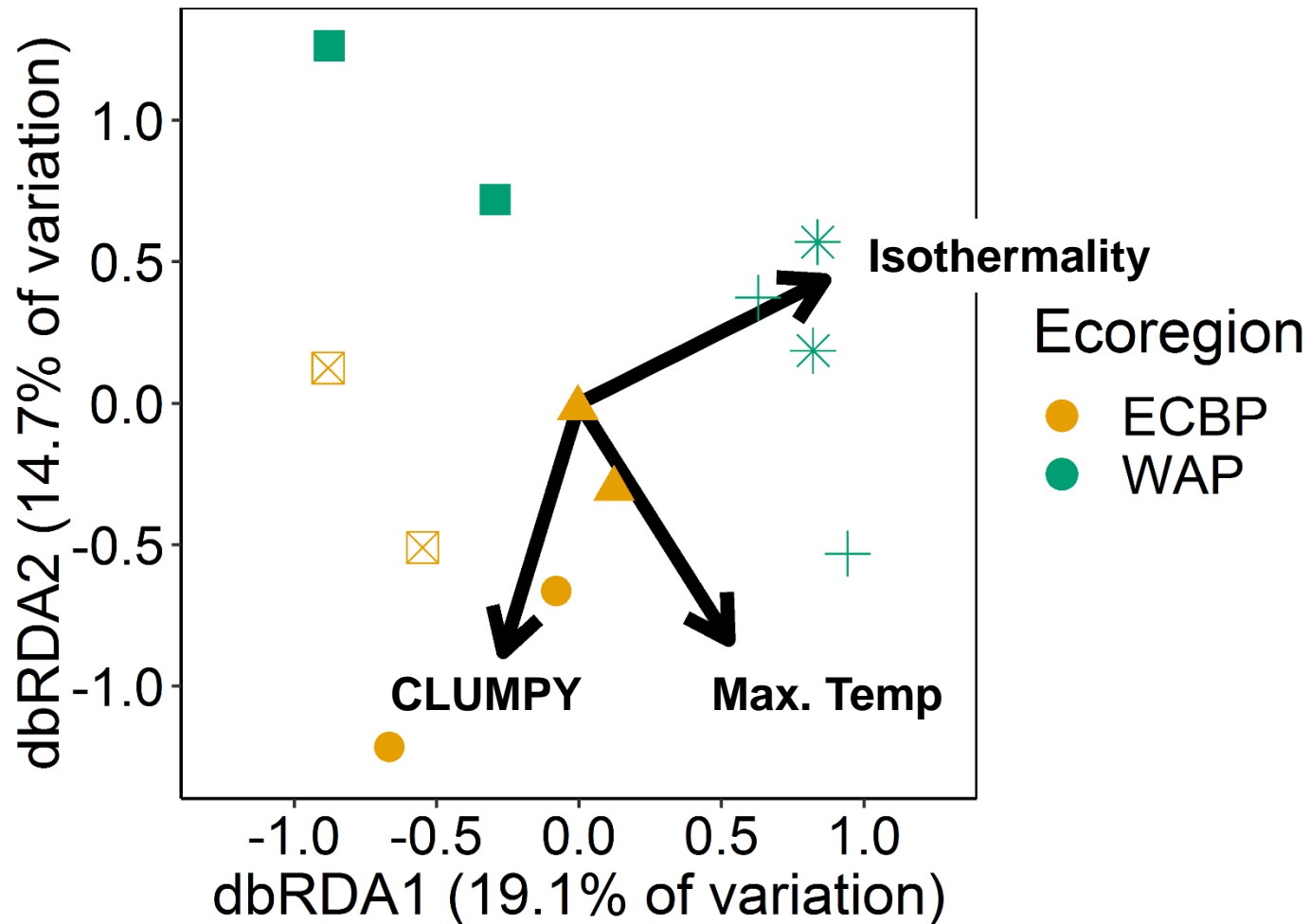# Spider beta diversity is driven by temperature evenness
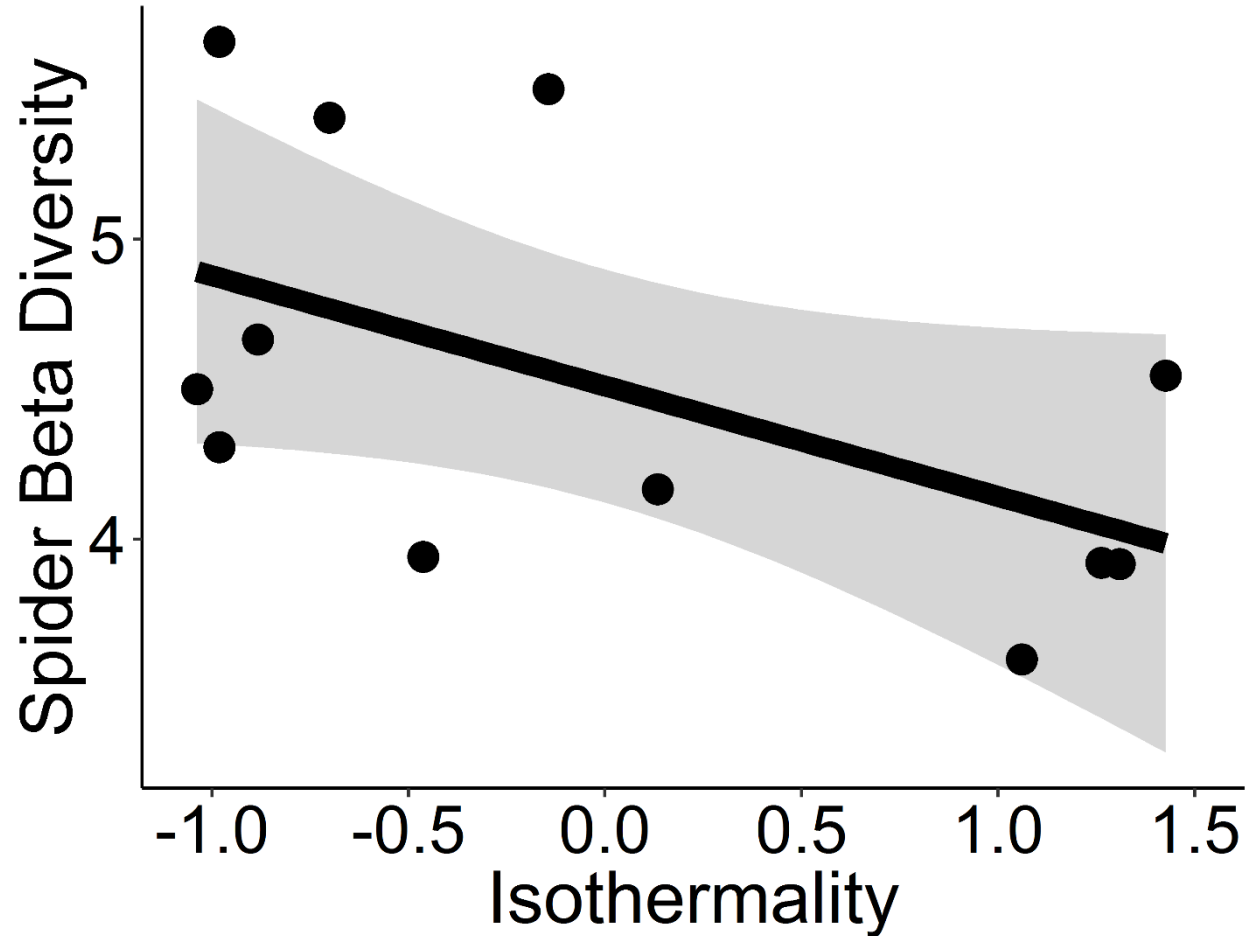
Ant community assembly is driven by precipitation

Precipitation Variability R^2 = 16.3%

# Temperature and forest fragmentation drive spider community structure

Isothermality: 17.6%; Maximum temperature: 15.6%, CLUMPY: 10.4%, TOTAL R^2 : 43.6%

Conclusions

- Spiders and ants show similar diversity scaling patterns, but spiders have greater diversity and dissimilarity across scales

- Dispersal ability and habitat characteristics likely limit canopy arthropod diversity

- Different environmental filters act on ant and spider communities

Next Steps

- Hierarchical Zeta diversity partitioning
  - Average number of species shared by *i* assembalges
  - Describes the structure of multispecies distributions

ζ_2

ζ_3

ζ_4
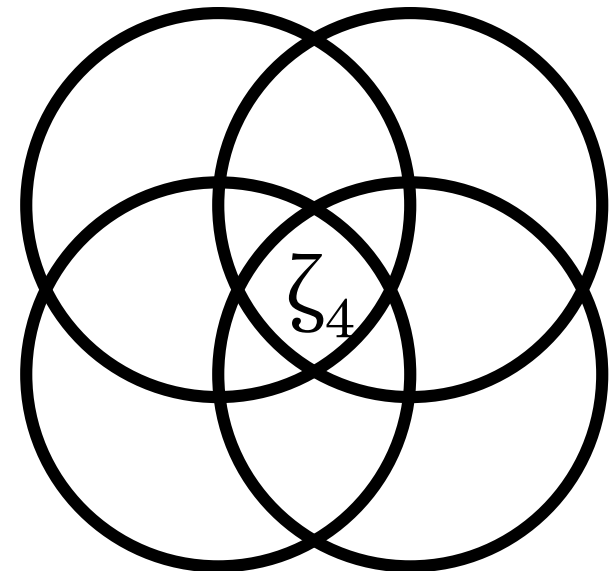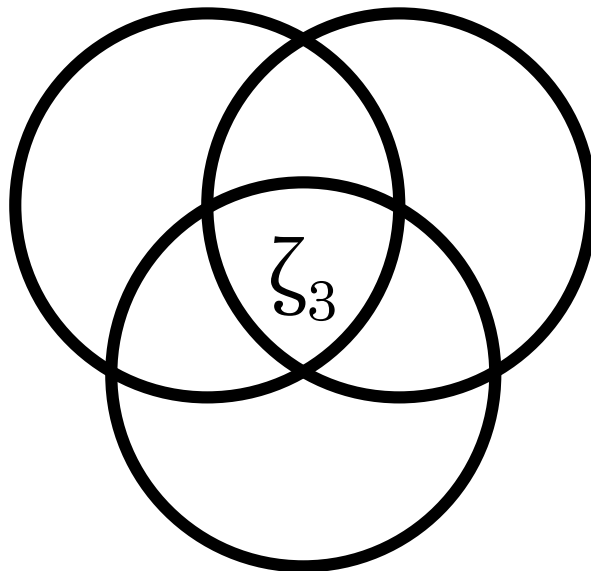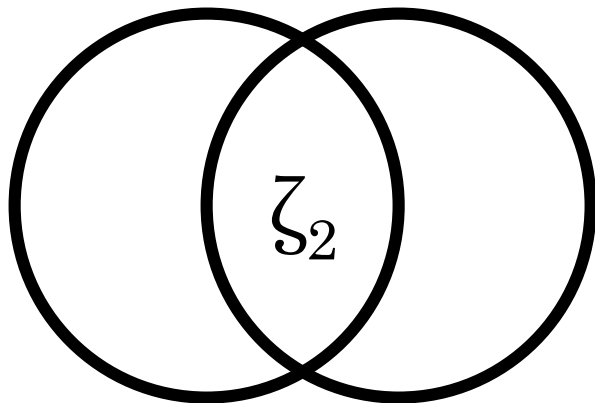
Acknowledgements

- Samples and PARTITION software
  - K. Summerville, J. Gering, J. Veech

- Sample Processing
  - A. VanGorder, K. Donahue, M. Crist, A. Schaefer

- PARTITIONR
  - M. Cunningham-Minnick
  - K. Summerville
  - J. Veech

PARTITION 3.0 — Software for partitioning species diversity

by Joseph A. Veech and Thomas O. Crist

Release Date: August 2009

Questions?

- Email: mmahon4@nd.edu

Adrian Smith

- Github: partitionr/PARTITIONR

- Twitter: @GlobalWorming19

gifs.com