FROM ROOTS TO LEAVES: UNDERSTANDING MULTI-SCALE TRAIT VARIATION IN FRESHWATER WETLANDS

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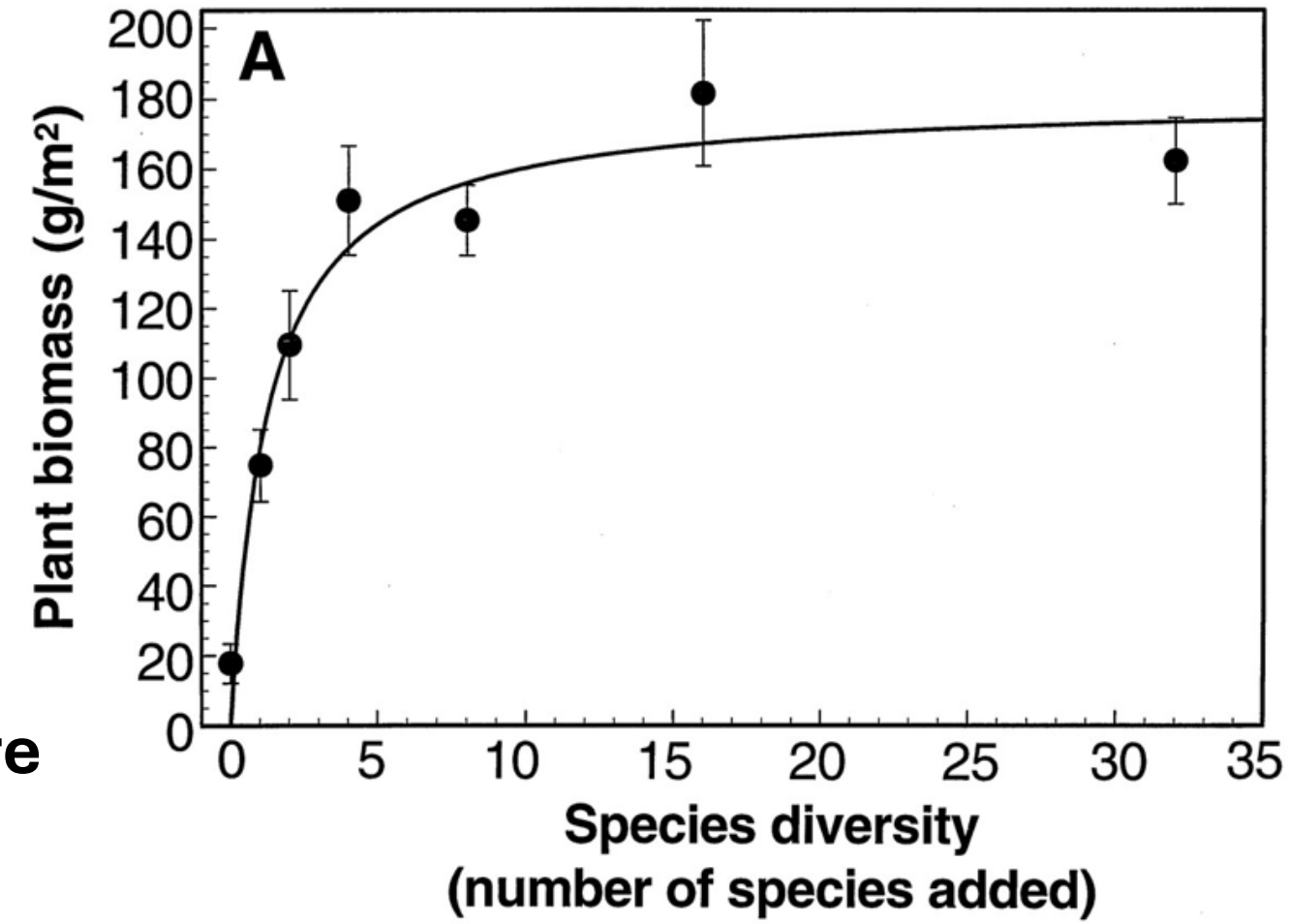
BIODIVERSITY ENHANCES ECOSYSTEM FUNCTION—BUT WITH LIMITS

- Ecosystem function generally increases with species diversity

- Redundancy leads to a plateau in function



Tillman et al., 1997

There's a saturation point—more species ≠ more function

Species Diversity AND Functional Diversity

IT ALL STARTS WITH TRAITS

Measurable characteristics

Trait Variation

Trait

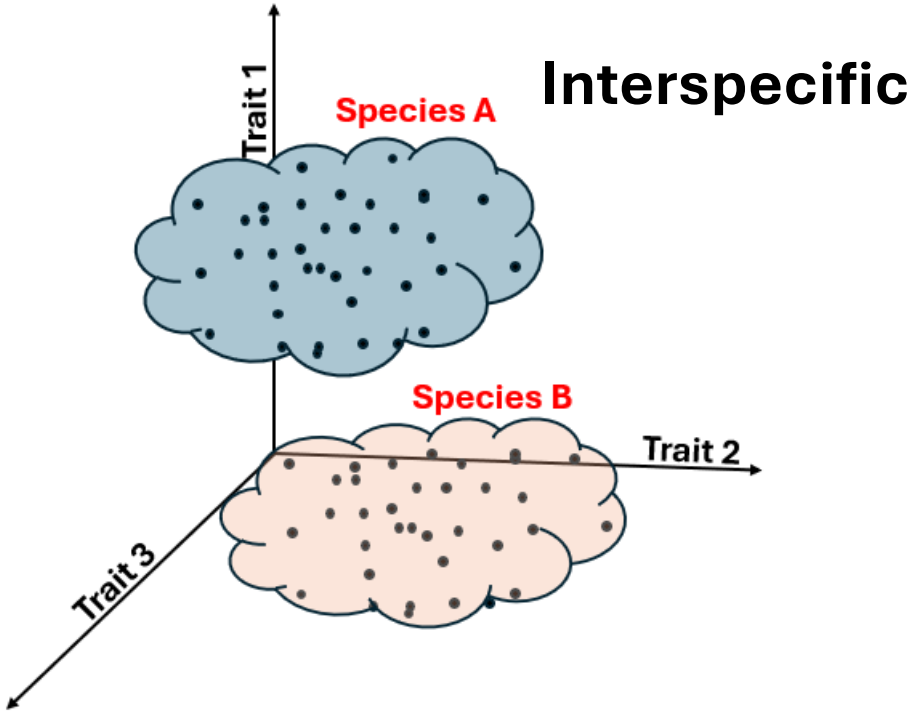
- Anatomical — Stomatal density, root stele
- Morphological — Plant height, root diameter, specific root tip abundance, leaf and root dry matter content
- Physiological — Photosynthetic rate, Water-use efficiency (WUE)
- Biochemical — Leaf or root carbon, nitrogen, or phosphorus content

(Violle et al., 2007)

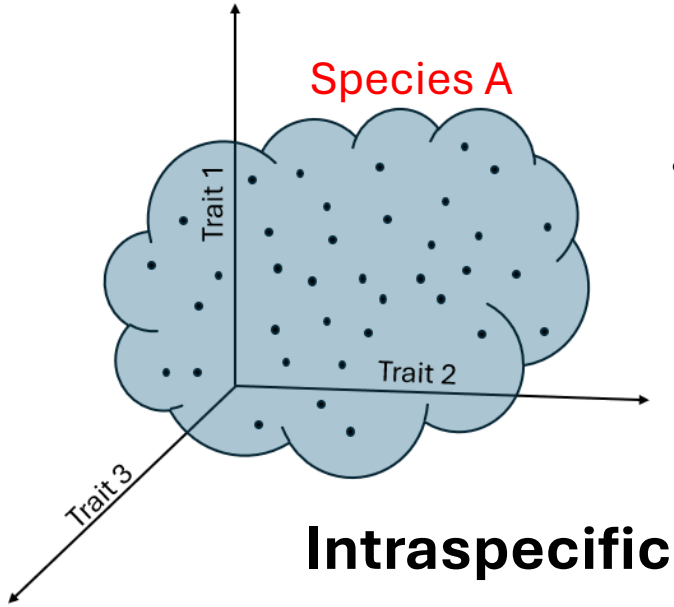
TRAIT SPACE

- Trait space as a multidimensional space where each axis represents a trait and each species (or individual) occupies a position in that space.

Trait Variation



Interspecific



Intraspecific

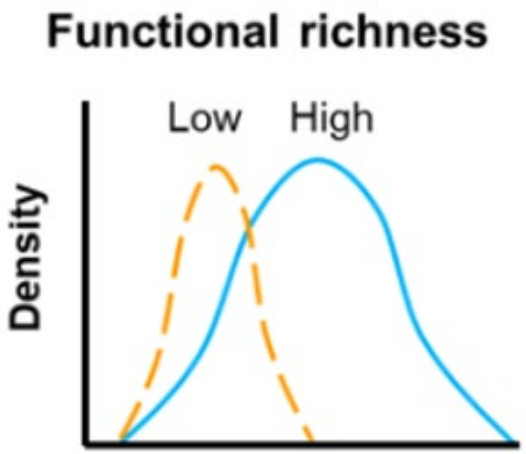
- *Each dot represents an individual organism from species*

Two species occupying different parts of trait space

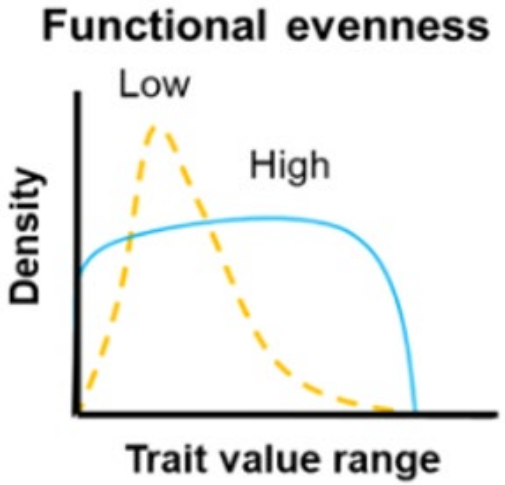
FUNCTIONAL DIVERSITY

Distribution and range of functional traits present in a community or system

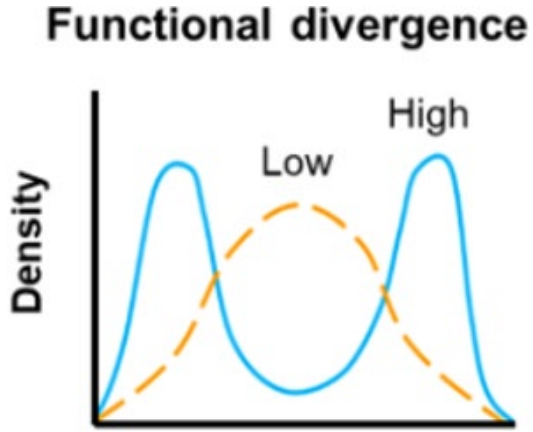
Community Assembly



Functional richness refers to the range of functional traits present



Functional evenness quantifies the evenness of species abundance distributions across functional trait space.



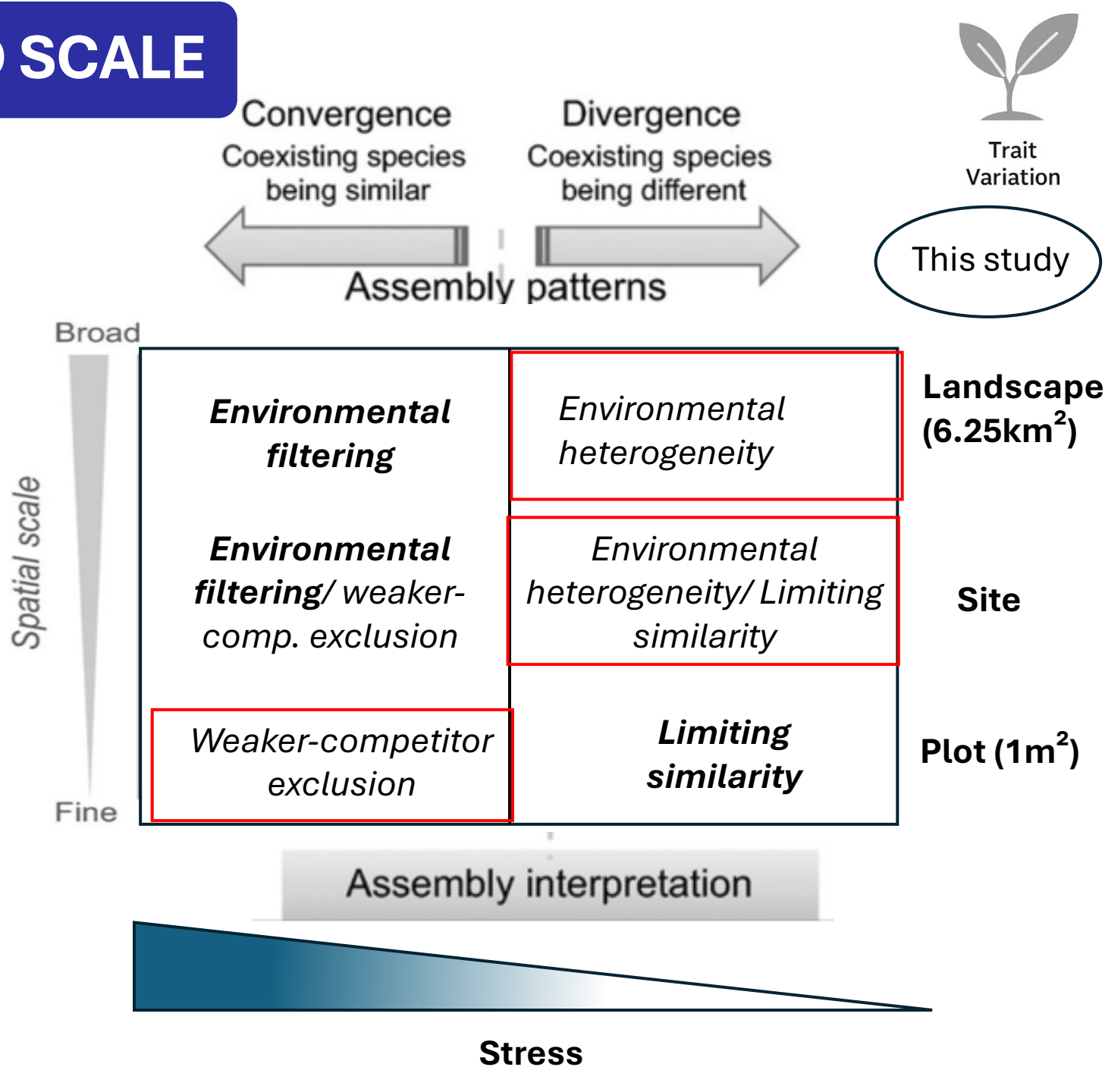
Functional divergence measures the degree to which species are distributed within the functional trait space, with some species exhibiting traits that are more extreme compared to others

Mason et al., 2013
Castro et al., 2022

TRAIT BASED ASSEMBLY AND SCALE

- How does functional diversity—derived from root and leaf traits—vary along environmental gradients in freshwater wetlands, and how do abiotic and biotic drivers across scales shape this variation?

- How do dominant freshwater wetland plant species differ in their root and leaf trait combinations?



STUDY AREA

Trait Variation

Landscape units

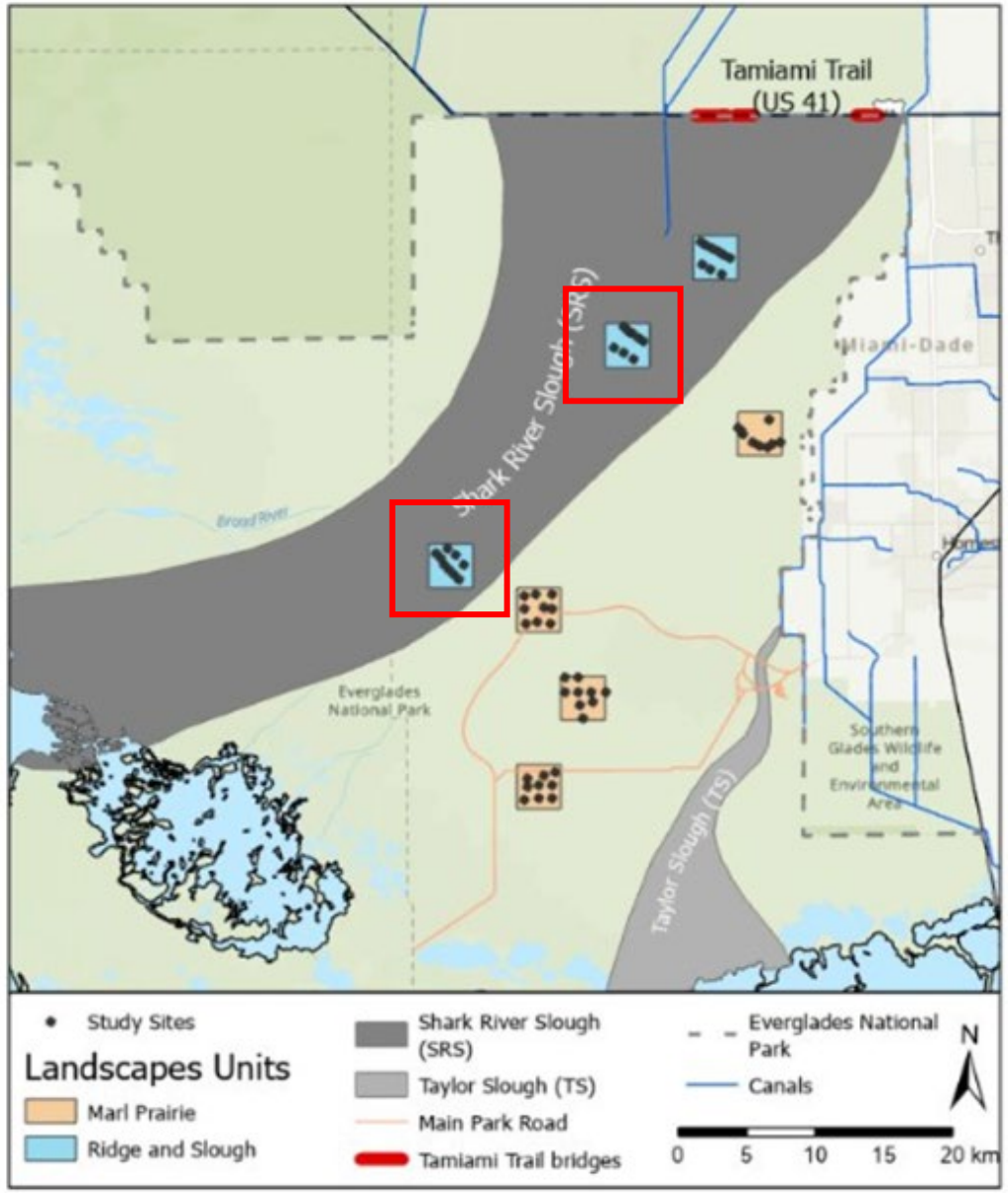
- 3 SRS
- 4 eastern marl prairies

Sites

- 42 sites

Plot level

- 3 plots ($1m^2$) / site
- Structure and composition
- Traits from 10 individuals / major species (>10% cover)



WORKFLOW

Trait Variation

- Plot level structure and composition
  - 3 replicates / individuals / species

-leaf samples

-Root samples

Scan rootlets and analyze (winRHIZO)

Leaf and root functional traits

- **Morphology**
- **Biochemical**

WORKFLOW: ENVIRONMENTAL VARIABLES

Trait Variation

Environmental variables

-Hydrology

- 4-year mean **water depth** and **hydroperiod**

(Armentano et al., 2006)

Soil biochemical

Soil total **Phosphorus**

STATISTICAL APPROACHES: N-DIMENSIONAL HYPERVOLUMES & TRAIT PROBABILITY DENSITIES

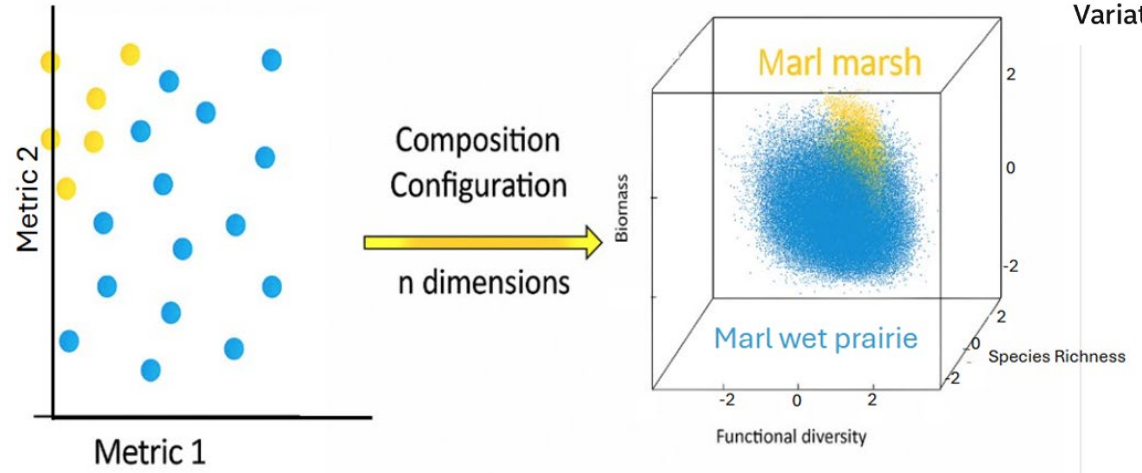
Trait Variation

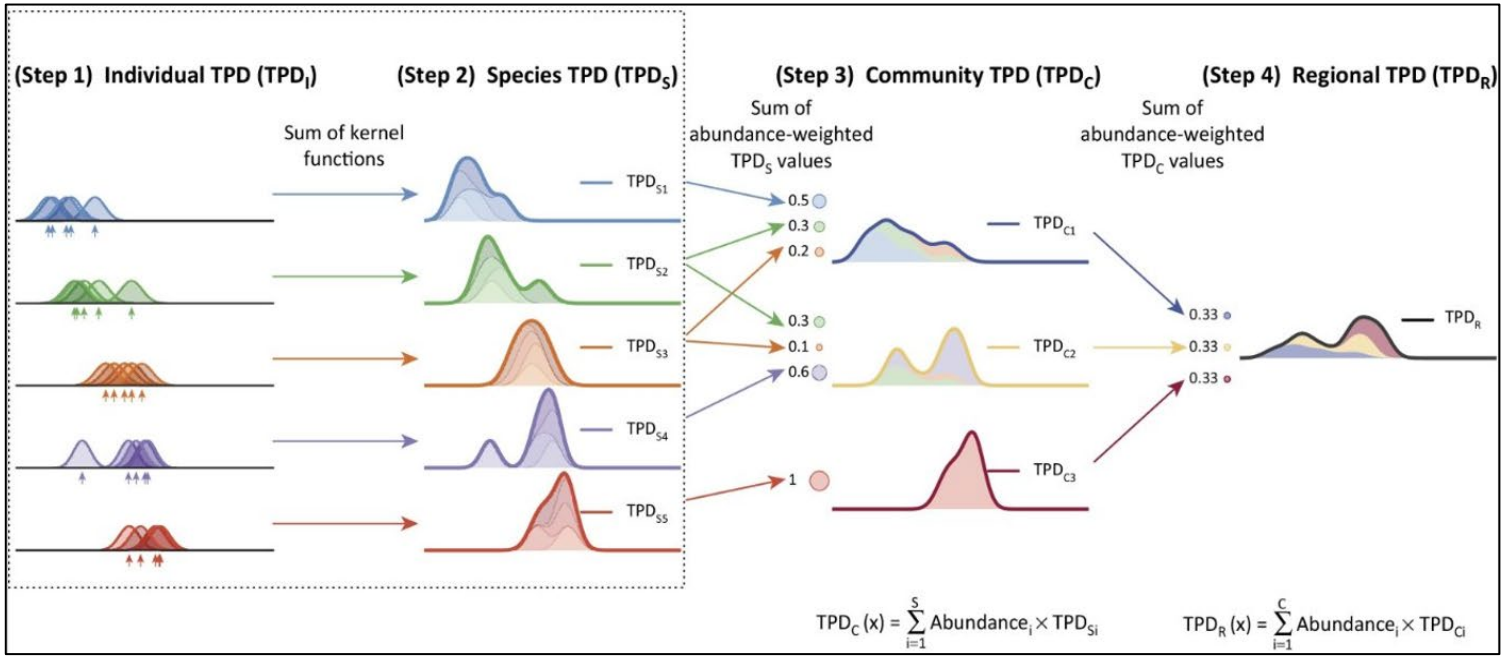
- **Hypervolumes**

- **Trait Probability Density**

  - **Model 1**: Explicitly includes intraspecific trait variation by directly using all individuals /species trait measurements from every site(population) n =127

  - **Model 2**: Summarizes trait variation into mean and SD.





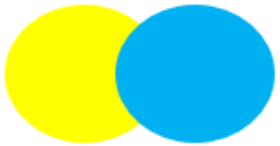
Blonder et al., 2017; Carmona et al., 2016

HYPERVOLUME METRICS

Ecosystem Stability

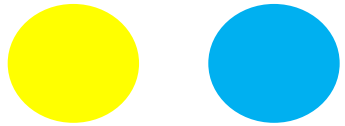
2. Volume overlap – space similarity

1.



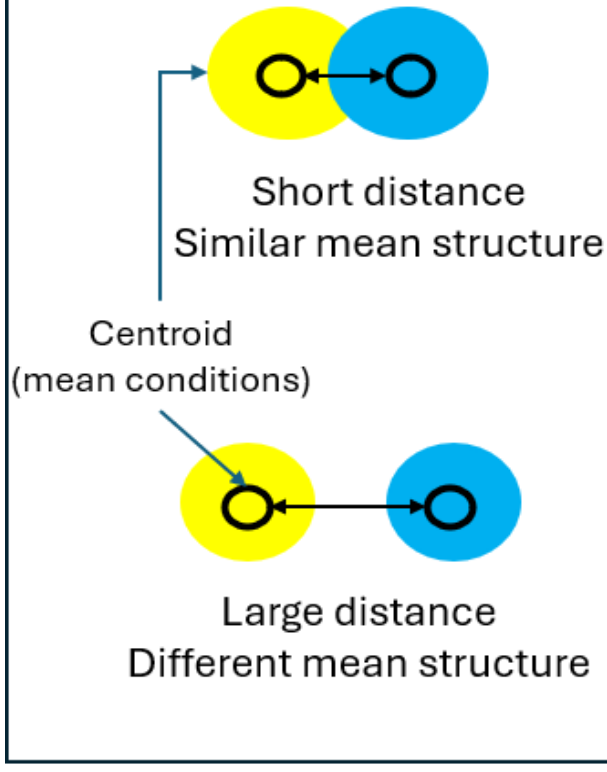
High overlap
Similar structure

No overlap
Different structure



Shared trait space

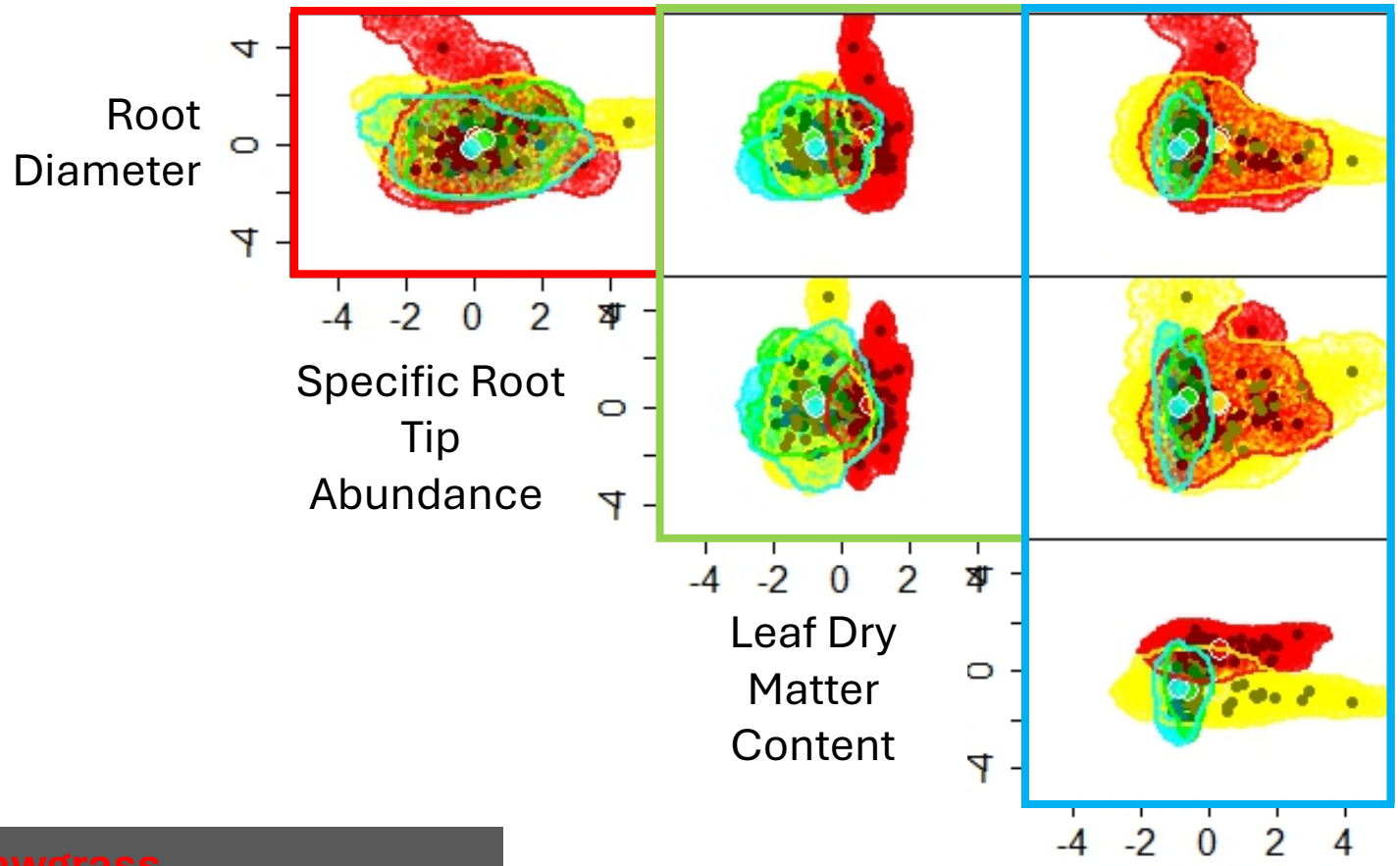
2. **Centroid distance – change in mean structure**



Trait dissimilarity

PRELIMINARY RESULTS: SPECIES – TRAIT HYPERVOLUMES

Trait Variation

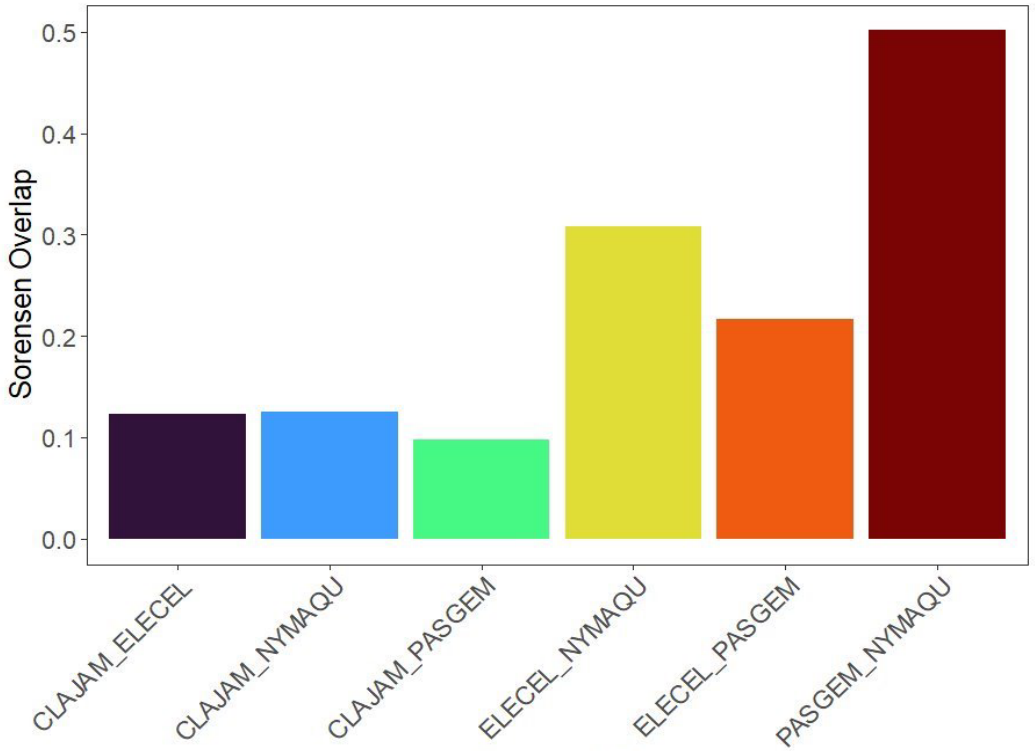


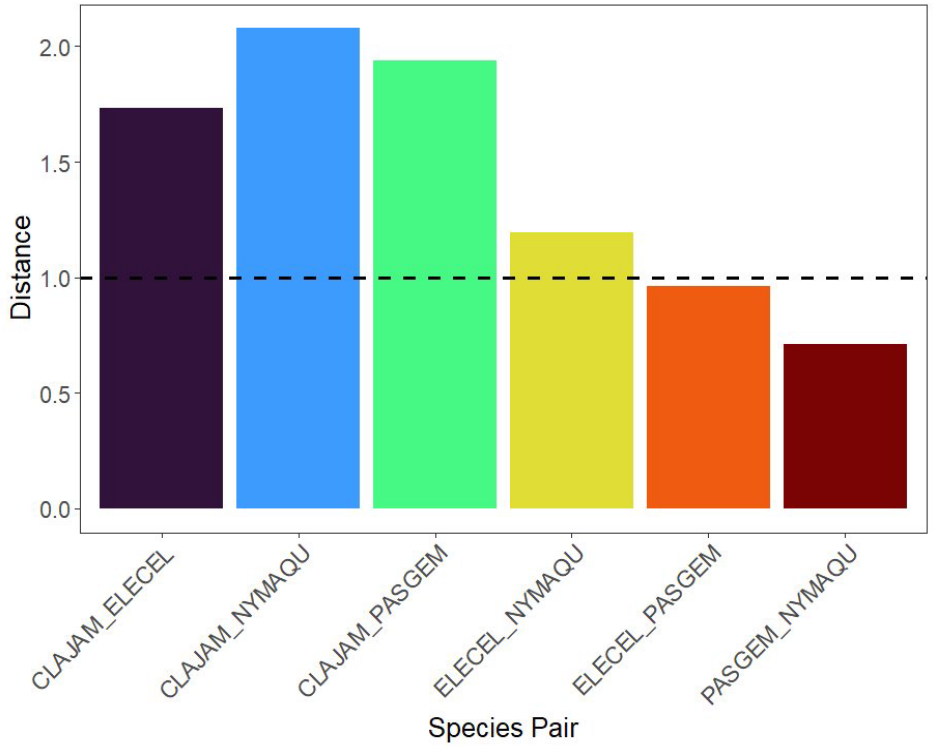
Sawgrass
Spikerush
Alligator grass
Water Lily

n =127; 4 species

PRELIMINARY RESULTS: HYPERVOLUME METRICS

Trait Variation





CLAJAM = sawgrass

ELECEL = spike rush

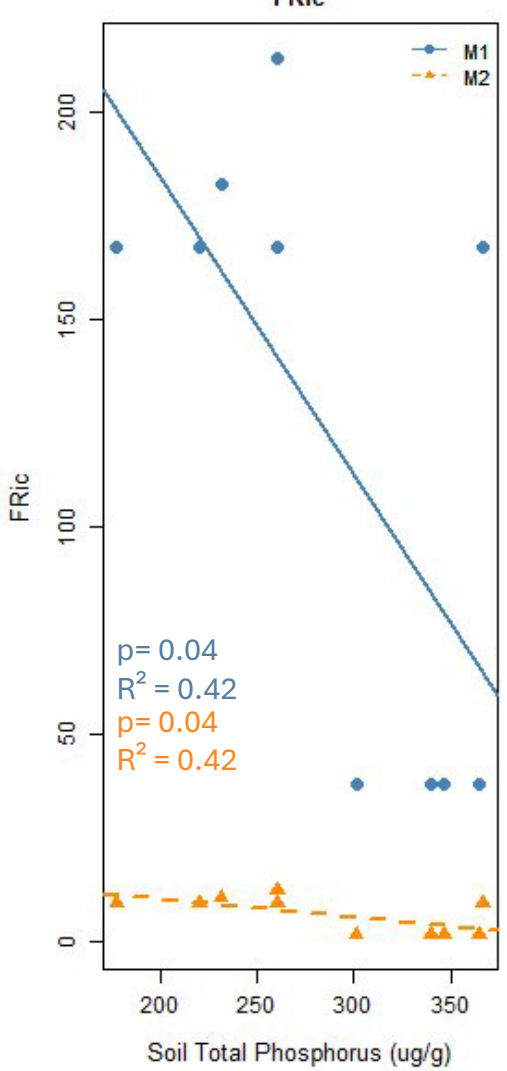
PASGEM = alligator grass

NYMAQU = water lily

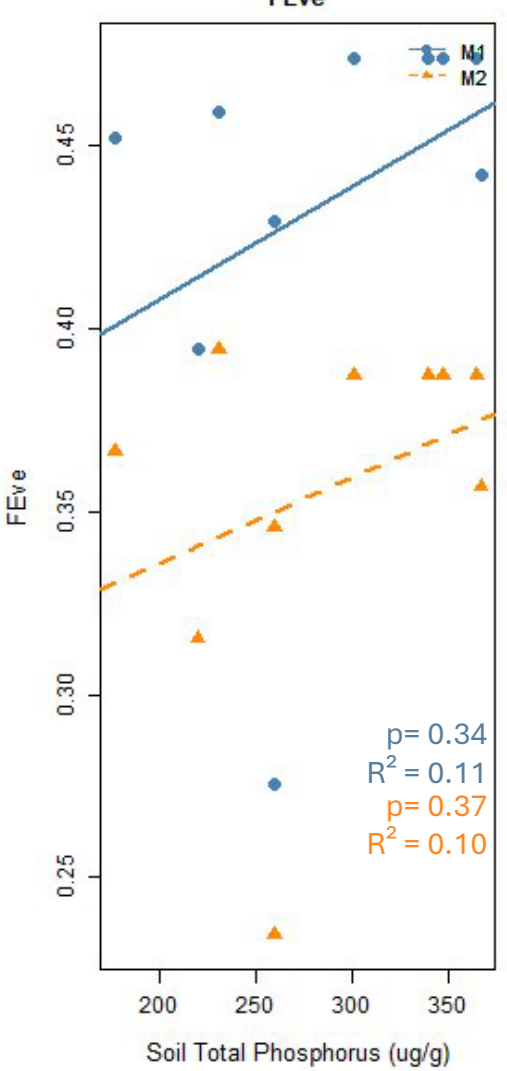
PRELIMINARY RESULTS: FUNCTIONAL DIVERSITY IN SHARK RIVER SLOUGH SOIL TOTAL PHOSPHORUS

- **Lower functional richness and divergence at communities with high soil total P**
  - Soil P acts as strong environmental filter
  - Trait convergence in high P environments
- Species are clustering around similar strategies
  - Reduced niche differentiation

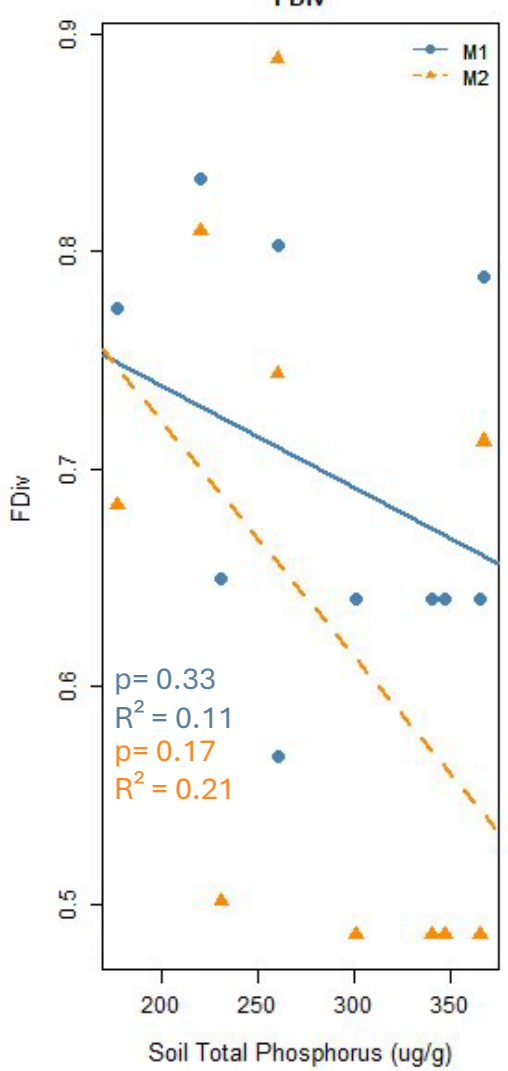
Functional Richness



Functional Evenness



Functional Divergence



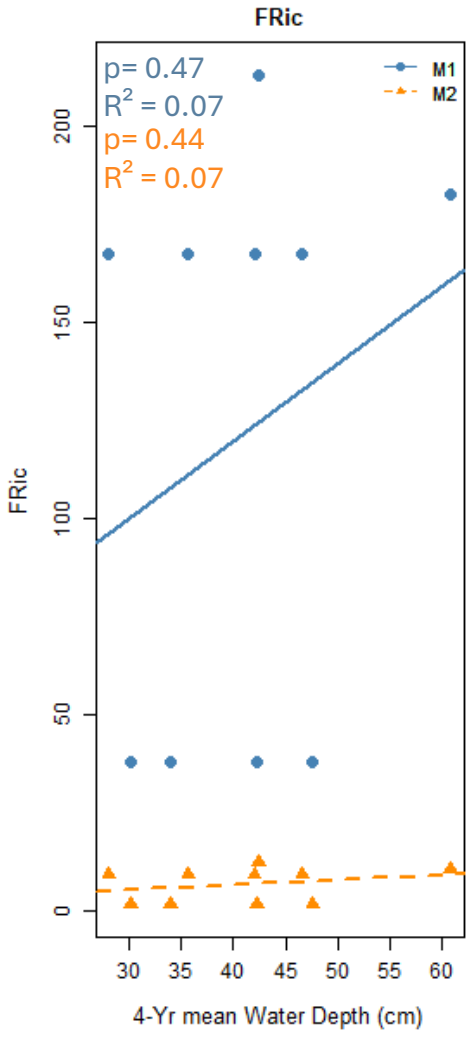
PRELIMINARY RESULTS: FUNCTIONAL DIVERSITY IN SHARK RIVER SLOUGH

4-YEAR MEAN WATER DEPTH

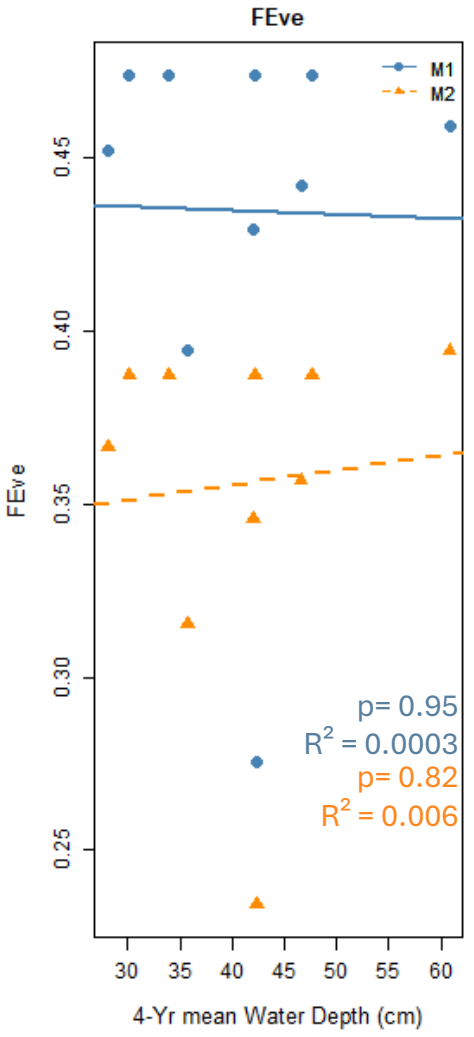
Trait Variation

- Trait redundancy
- Community resilience to long-term flooding
- The gradient range may not be strong enough to capture selective pressure

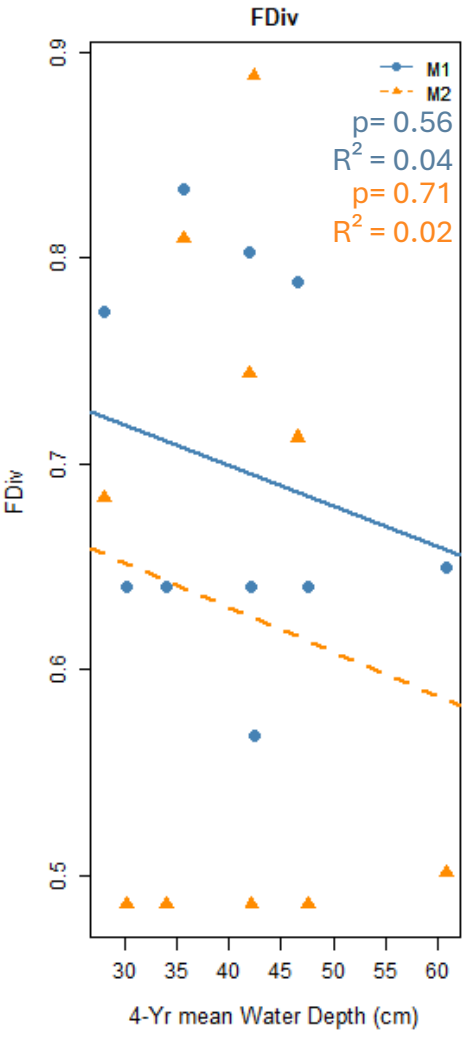
Functional Richness



Functional Evenness



Functional Divergence



Overview

Trait Variation

- In Shark River Slough (SRS), functional diversity appears stable relative to increased flooding
- Nutrient management in SRS may have a stronger influence on functional diversity
- Collect more individuals of dominant species from remainder of SRS and marl prairie landscape units
- Incorporate more aboveground and belowground biochemical traits

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