Biodiversity across Scales:

Mapping taxonomic, phylogenetic, and functional diversity with eDNA, field surveys, and remote sensing

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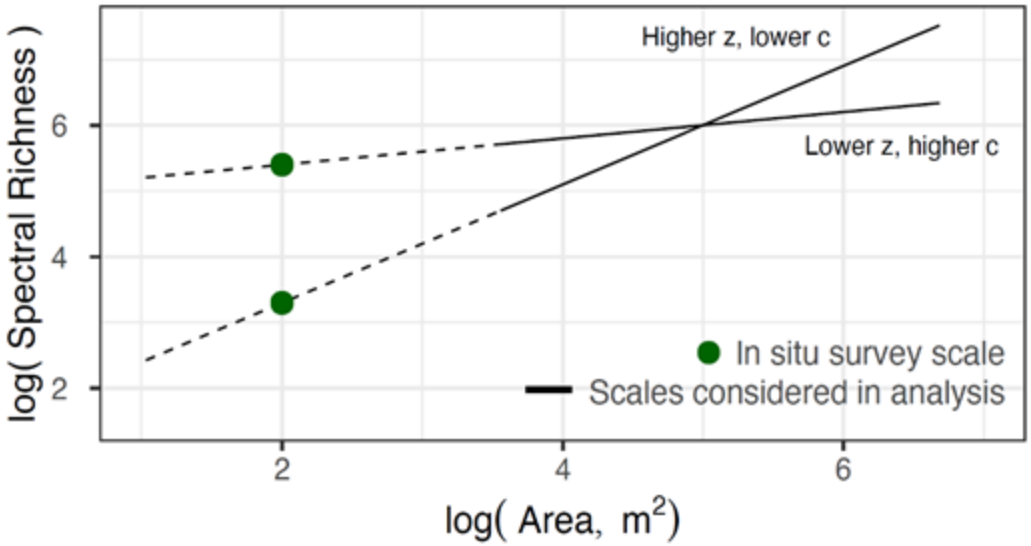
BIOSCAPE
Biodiversity Survey of the Cape

Objectives

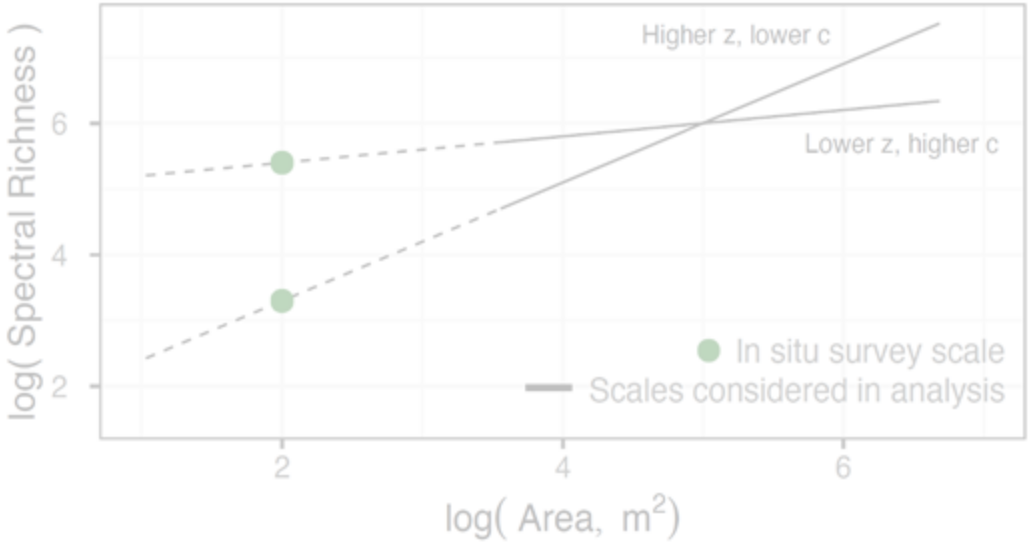
Question	Significance
RELATION: How are phylogenetic, taxonomic, and functional diversity related to each other?	Map biodiversity consistently, globally, and at regular intervals using remote sensing
SPACE: How does the hydrologic structure of watersheds organize phylogenetic, taxonomic, and functional diversity spatially?	As watersheds change and/or are modified, spatial patterns in biodiversity are also expected to change.
TIME: How do hydroclimatic processes influence the temporal signal of phylogenetic, taxonomic, and functional diversity ?	Constrain when and how frequently we need measurements of biodiversity using eDNA and remote sensing

Bridging observations across scales



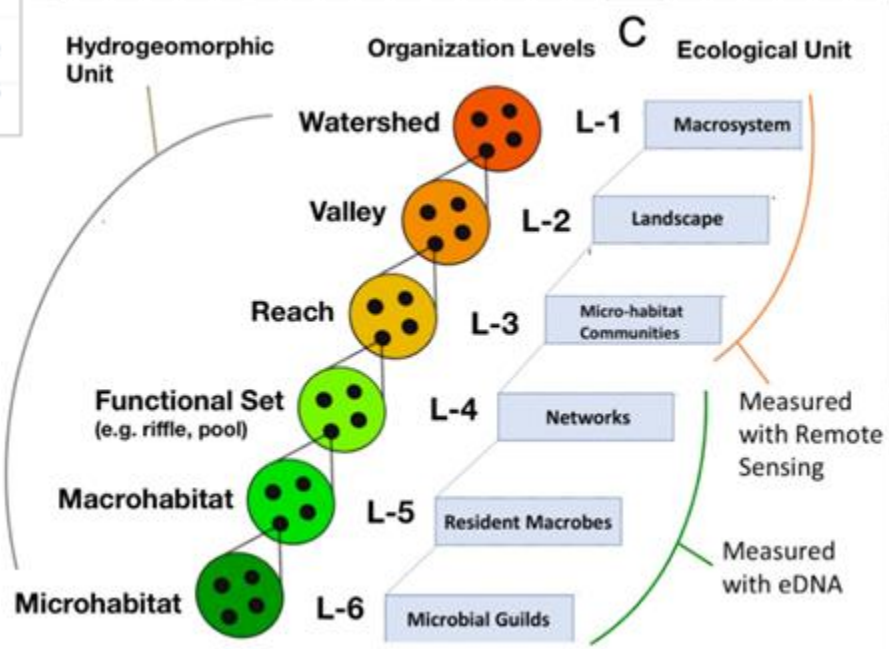
Remotely sensed biodiversity is at least **2 orders of magnitude** coarser than field surveys

Bridging observations across scales



Remotely sensed biodiversity is at least **2 orders of magnitude** coarser than field surveys

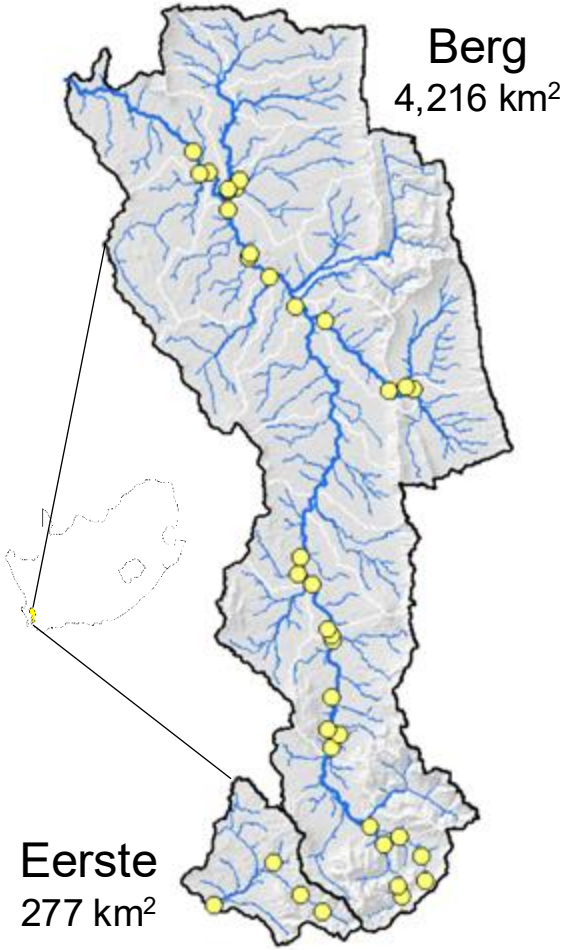
Scale dependency reflects **interactions** among observations, hydro-geomorphic structure, and ecosystem structure



Approach

Nested watershed approach towards sampling.

- Unmix tributary contributions
- Sample across environmental gradients
- Repeat sampling (two field seasons)



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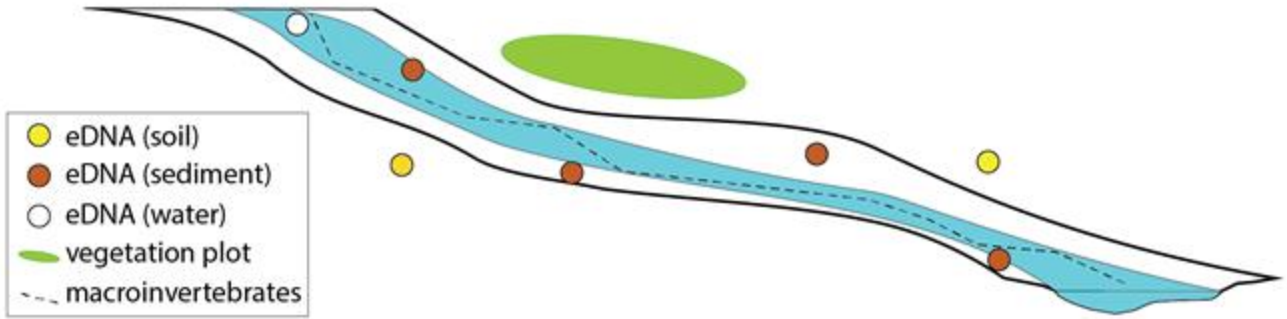
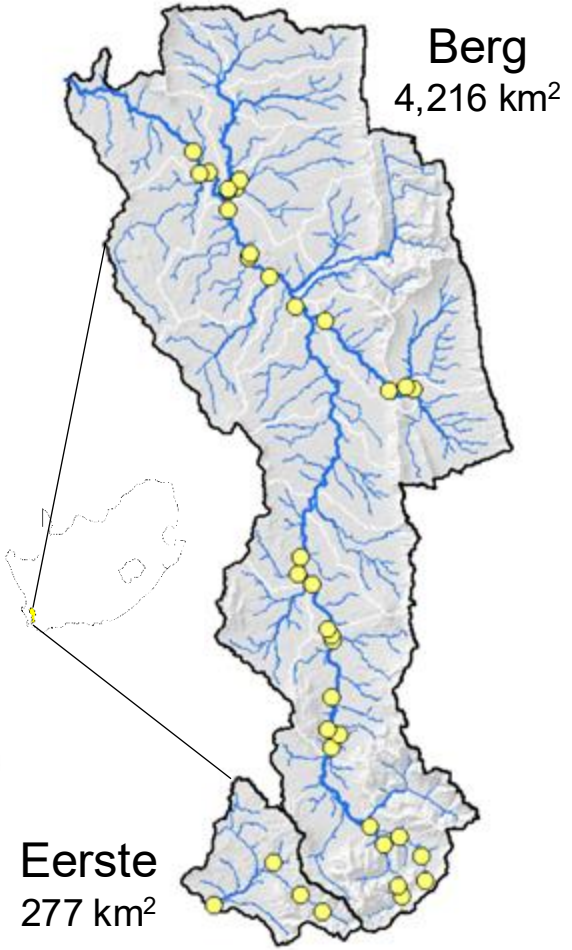
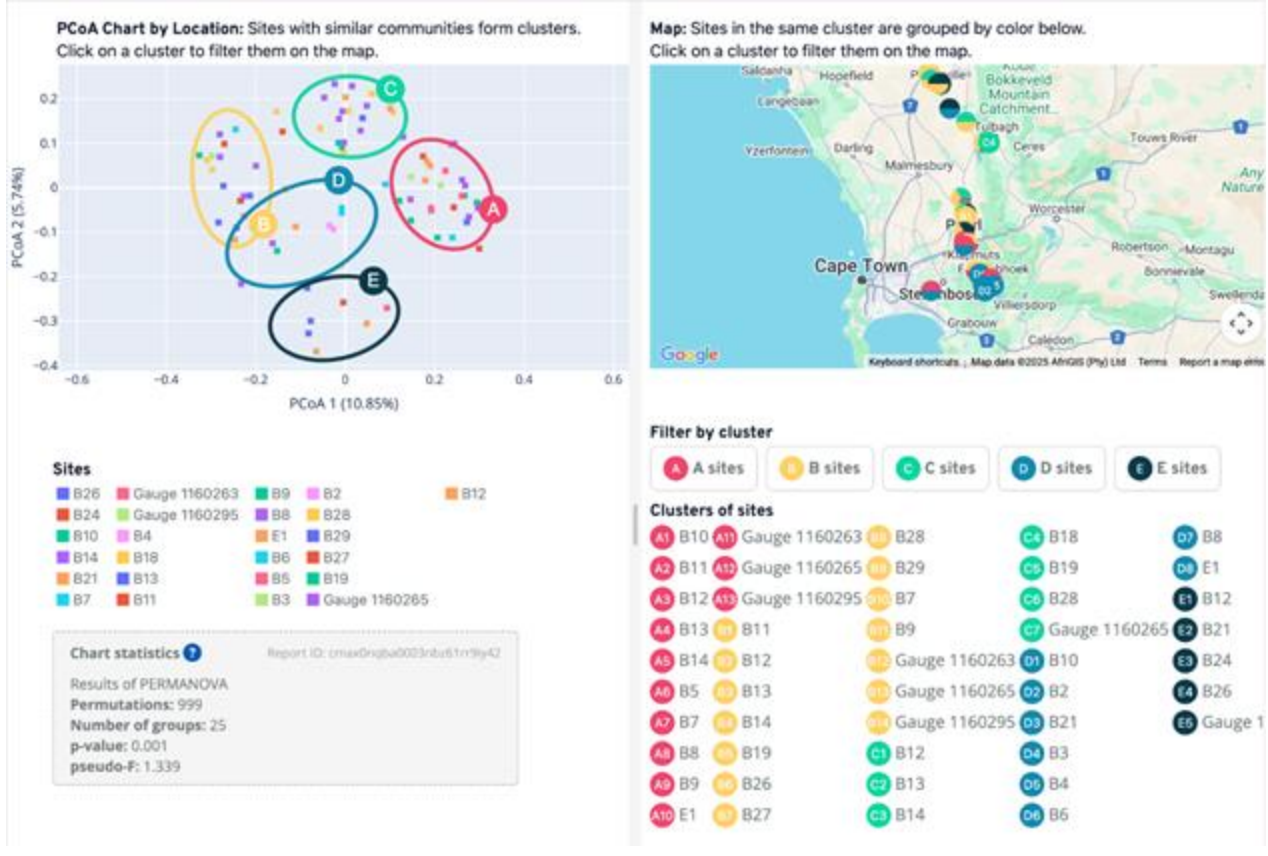




environmental DNA



Current status:

- **560 samples** uploaded into eDNA Explorer

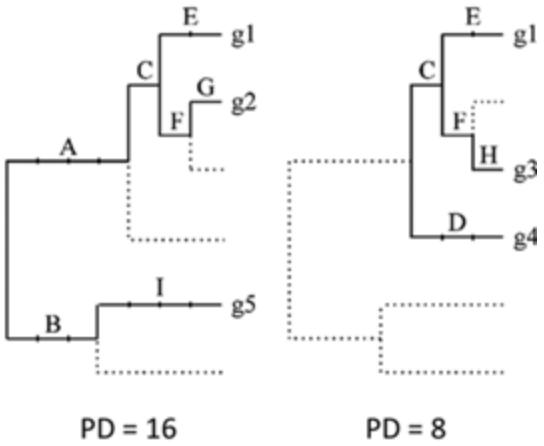
- Working with end-users on **permissions** and usability of interface

- Distinct fungal, eukaryotic, and bacterial communities as function of distance from **headwaters** and **human modification** index

environmental DNA

Ongoing:

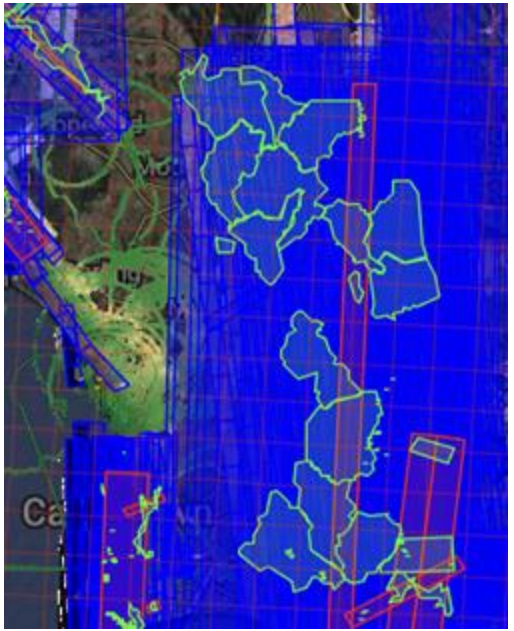
1. Analyze **phylogenetic diversity** within eDNA Explorer



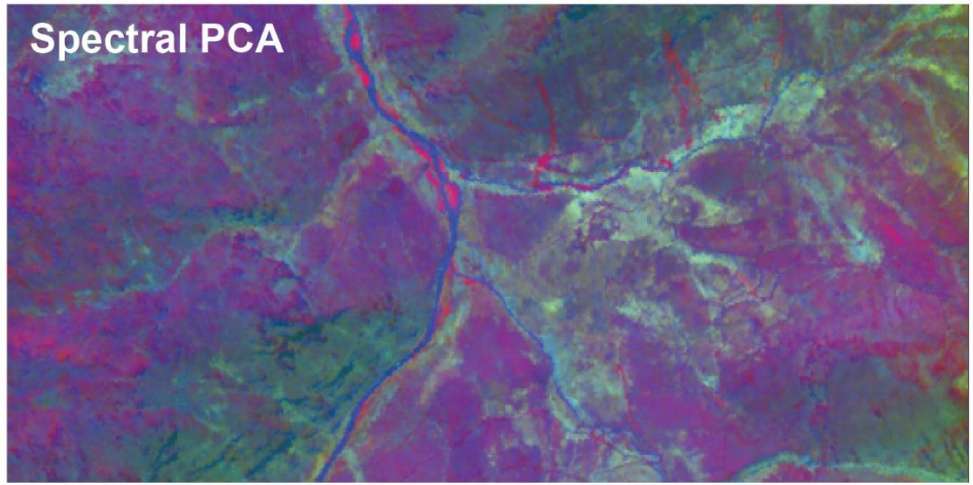
PD Figure from Cardillo 2023

2. Incorporate other variables like **invasive species cover** and **stream morphology**

3. Integrate with **functional diversity** metrics



Spectral and functional diversity

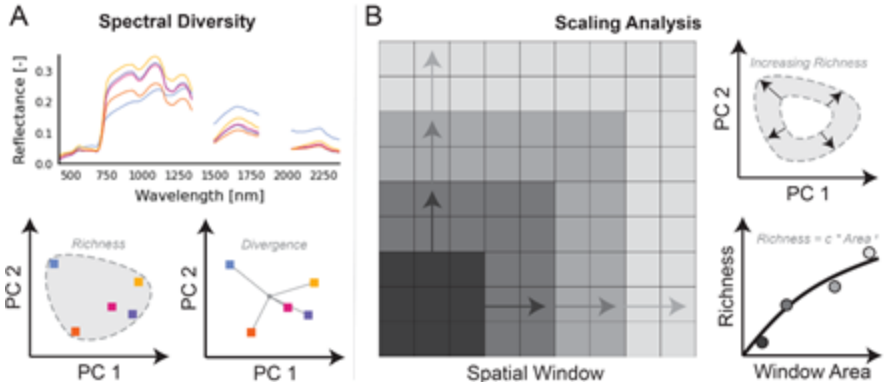


Current status:

- Built **cloud-based computational workflow** using v1 BRDF/Topo corrected reflectance (aviris-ng) and foliar traits

- Berge/Eerste analysis will use v2 data products

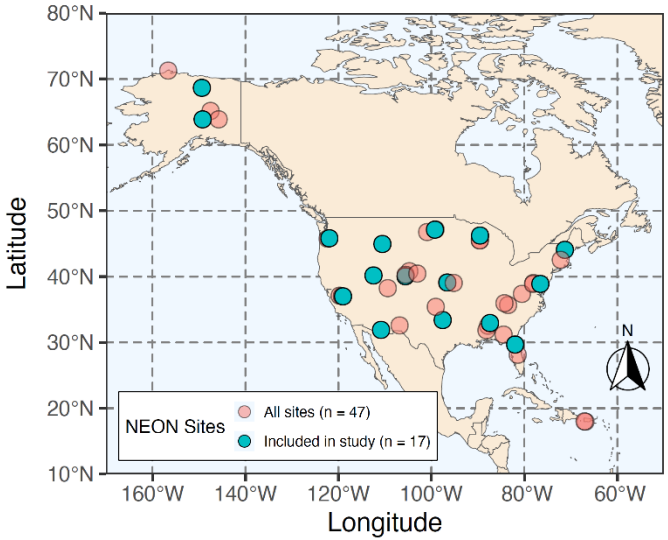
- Approach: Calculate spectral and functional **richness at different spatial scales** to characterize scaling relationship



Spectral and functional diversity

	Wavelengths	Spectral resolution	Spatial resolution	Temporal resolution
AVIRIS-NG	380 - 2510 nm	5 nm	5-7 m approx.	Single pass
NEON AOP	380 - 2500 nm	10 nm	1-3 m approx.	Single pass

Hyperspectral Data → **Corrections and Masking** → **Dimensionality Reduction** → **Compute Functional Metrics**



NEON Analysis

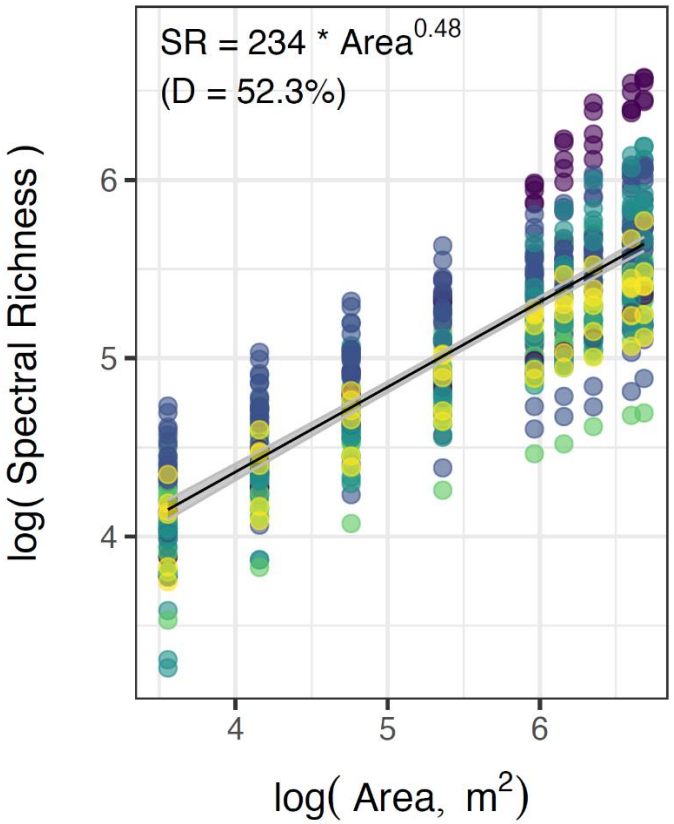
- 15 sites (105 plots) representing large range of ecosystems

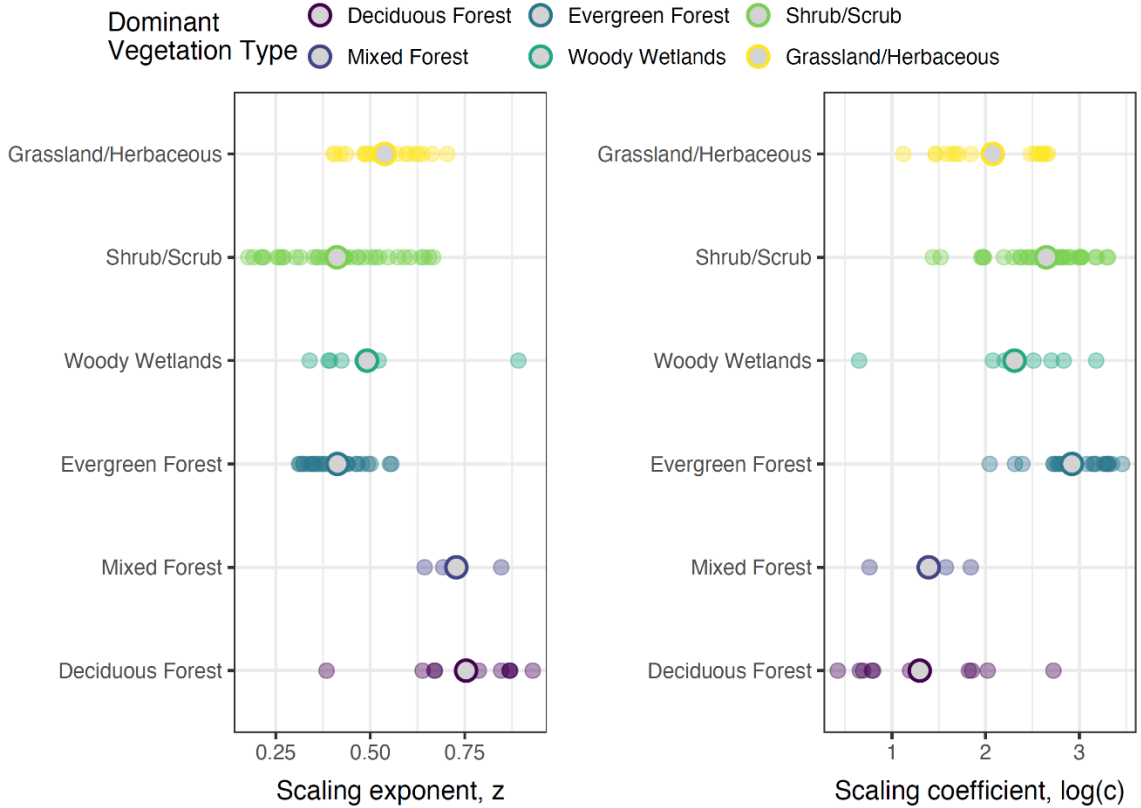
- Spectral richness calculated over large range of window sizes (60 to 2,000 m wide kernel)

- Scaling relationships characterized using **best-fit power law** regression

- Assess how regression parameters relate to other potential **environmental covariates** (e.g., climate, topography, landuse)

Spectral diversity of NEON sites



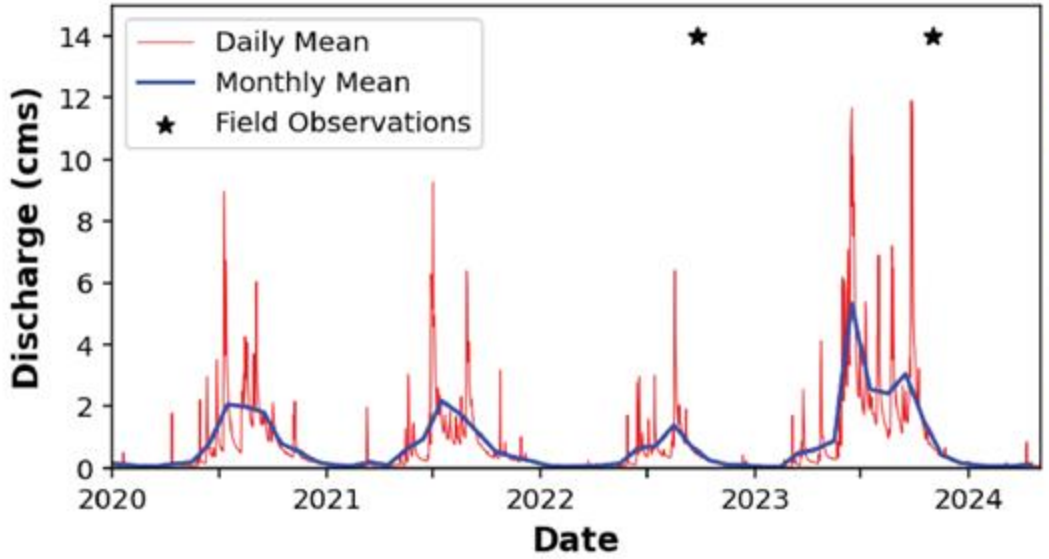


Nonlinear **scaling robust** but intra-site variations on par with inter-site ones

Opportunities in the Berg/Eerste systems

Historic floods (and debris flows) along Berg in between field seasons

- Test how diversity signals are to temporal disturbances



Opportunities in the Berg/Eerste systems

Functional Process Zones: river reaches with similar hydrological, geomorphological, and ecological traits

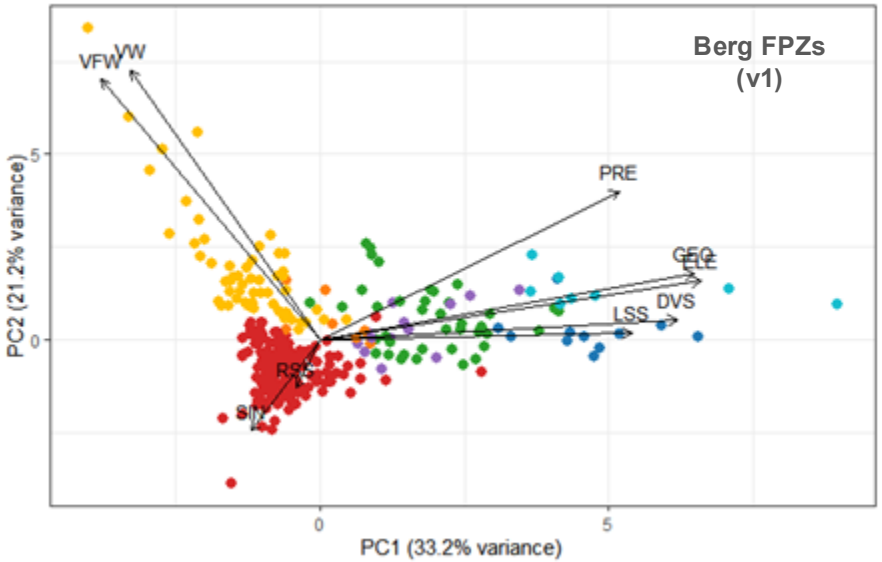
- Test how robust diversity signals are to spatial patterning set up by the river network

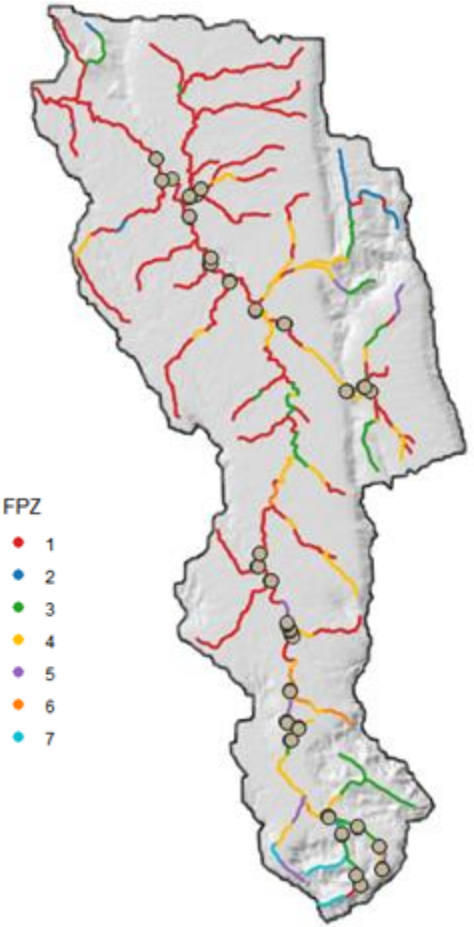
Derived using OpenRES, a QGIS plugin our team is developing to classify FPZs:

OpenRES extracts 9 key variables for each user-defined stream segment:

ELE: Elevation
PRE: Mean Annual Precipitation
GEO: Geology
VFW: Valley floor width
VW: Valley width
LSS: Left side slope
RSS: Right side slope
DVS: Down valley slope
SIN: Sinuosity

FPZs derived from unsupervised classification of these key variables





Much thanks to our sponsors and collaborators