Linking remotely sensed optical diversity to genetic, phylogenetic and functional diversity to predict ecosystem processes

Dimensions of Biodiversity Team PIs


Cavender


Gamon

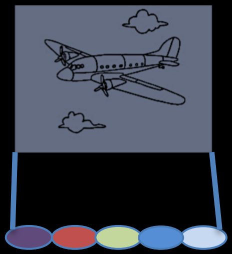

Townsend

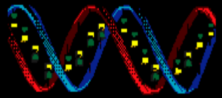

Hobbie


Montgomery


Zygielbaum


Maddritch





DEB
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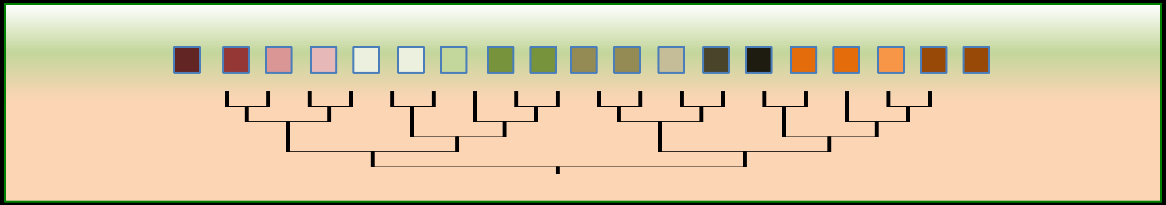
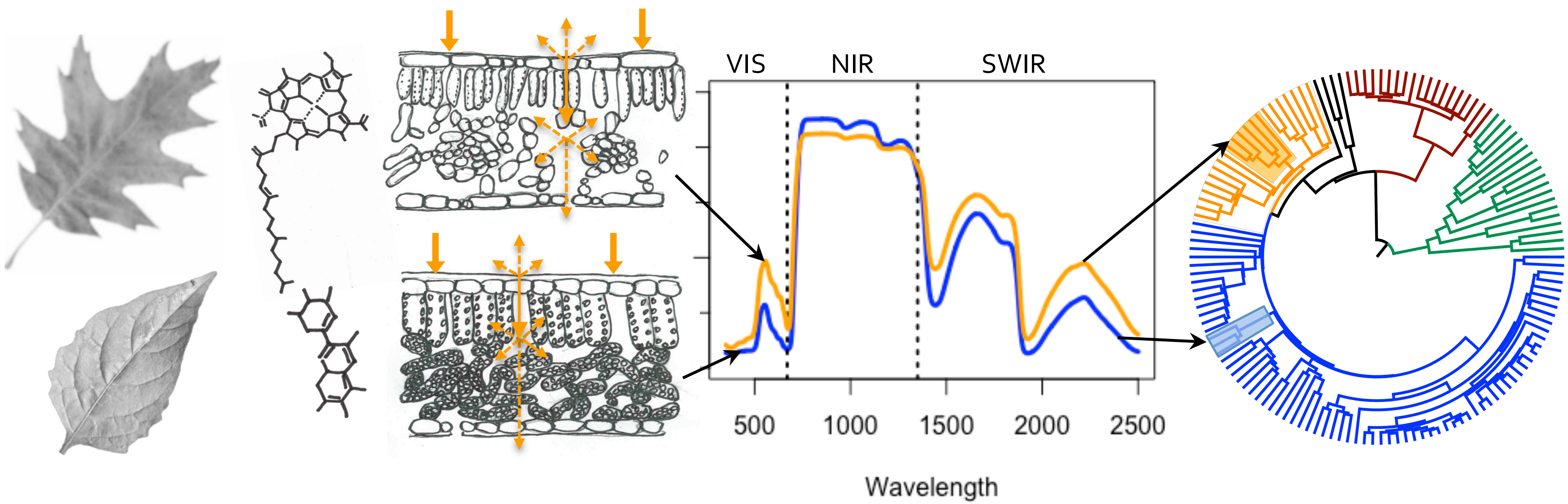
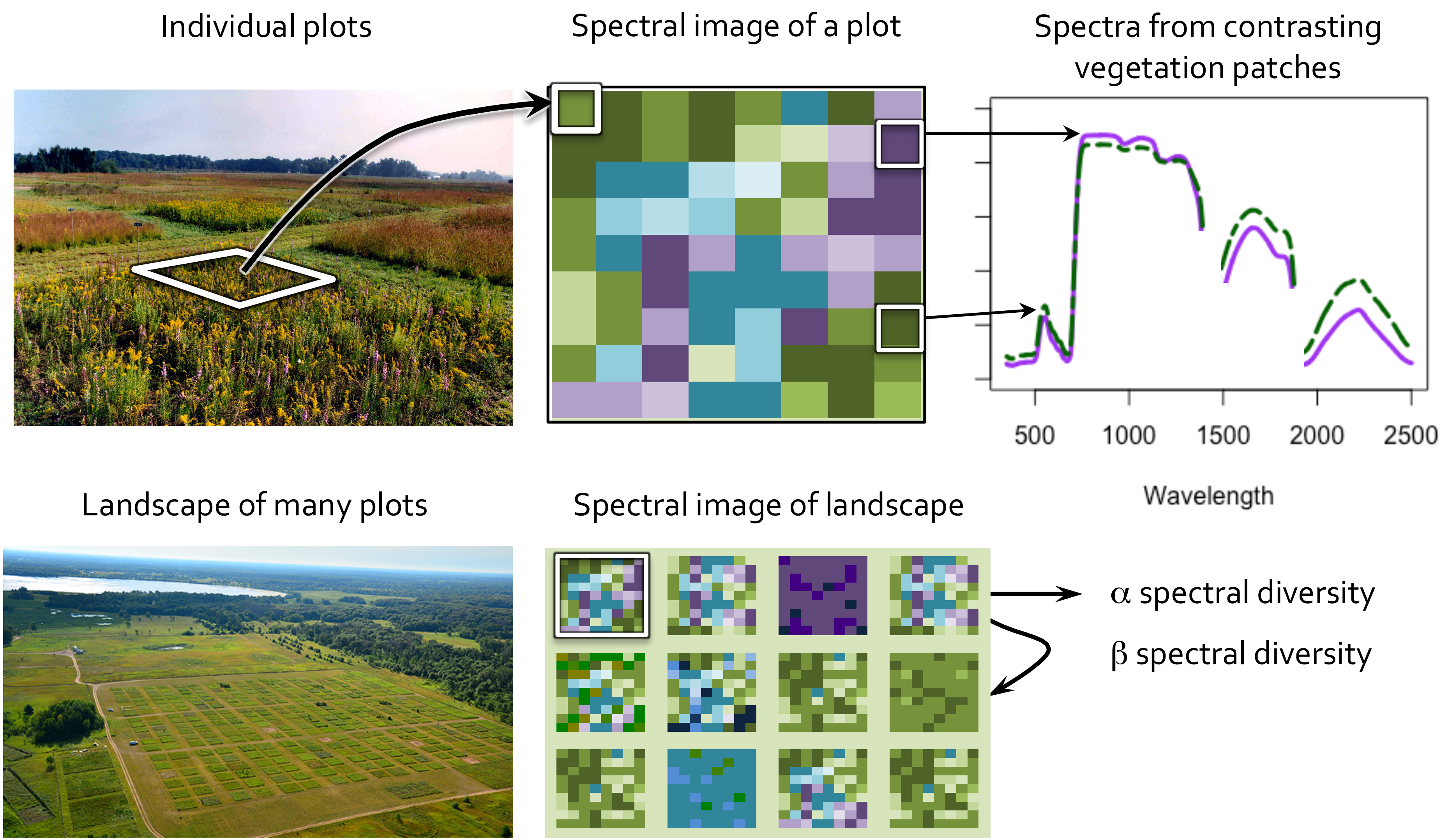


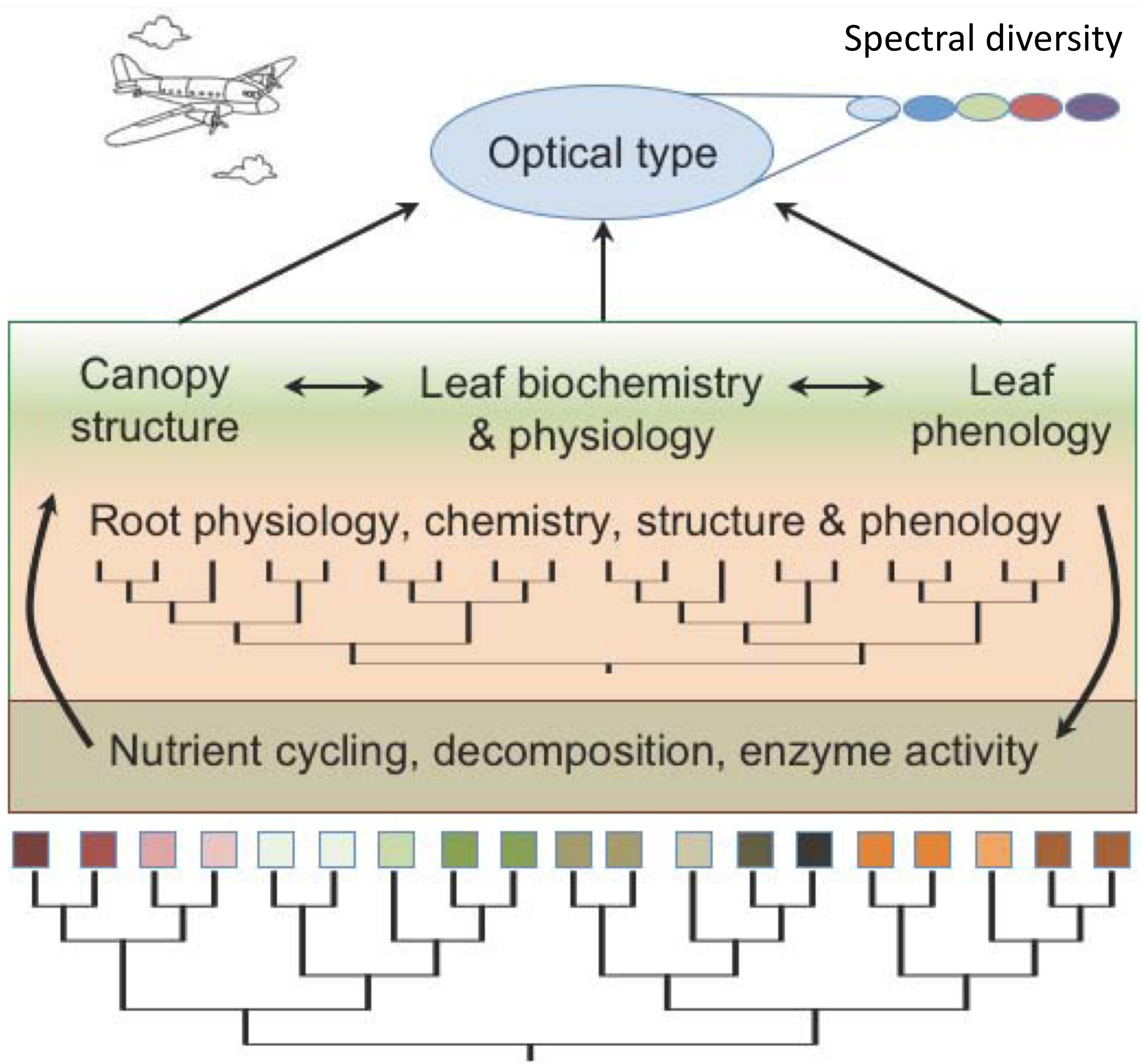


Linking plant spectra and spectral diversity to plant function, phylogeny and diversity

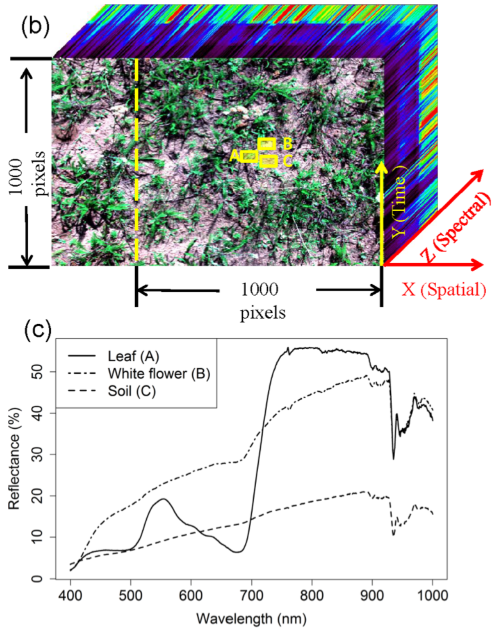
Cavender-Bares et al AJB 2017



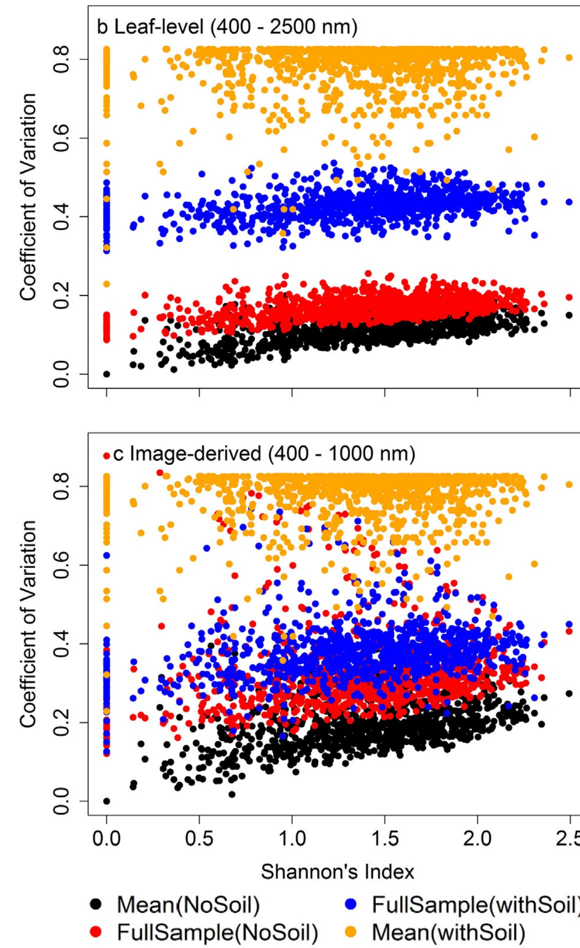
Cavender-Bares et al AJB 2017

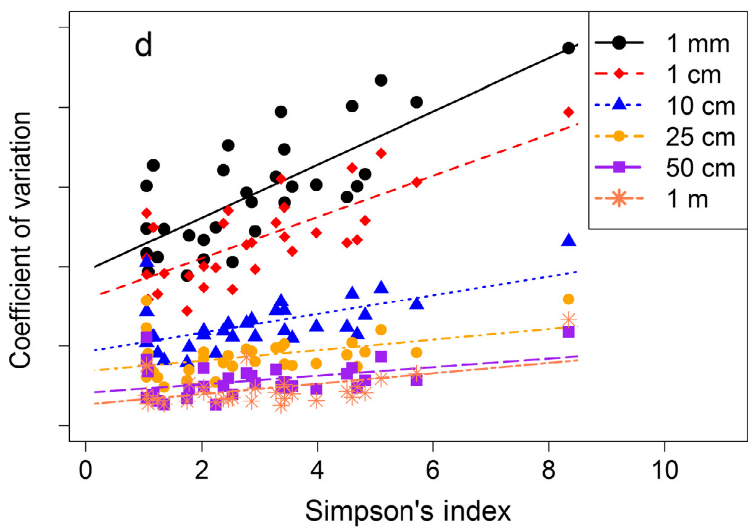

Spectral diversity
Optical type
Canopy structure
Leaf biochemistry & physiology
Leaf phenology
Root physiology, chemistry, structure & phenology
Nutrient cycling, decomposition, enzyme activity

Spectral diversity – plant diversity relationship depends on spatial resolution



Ran Wang

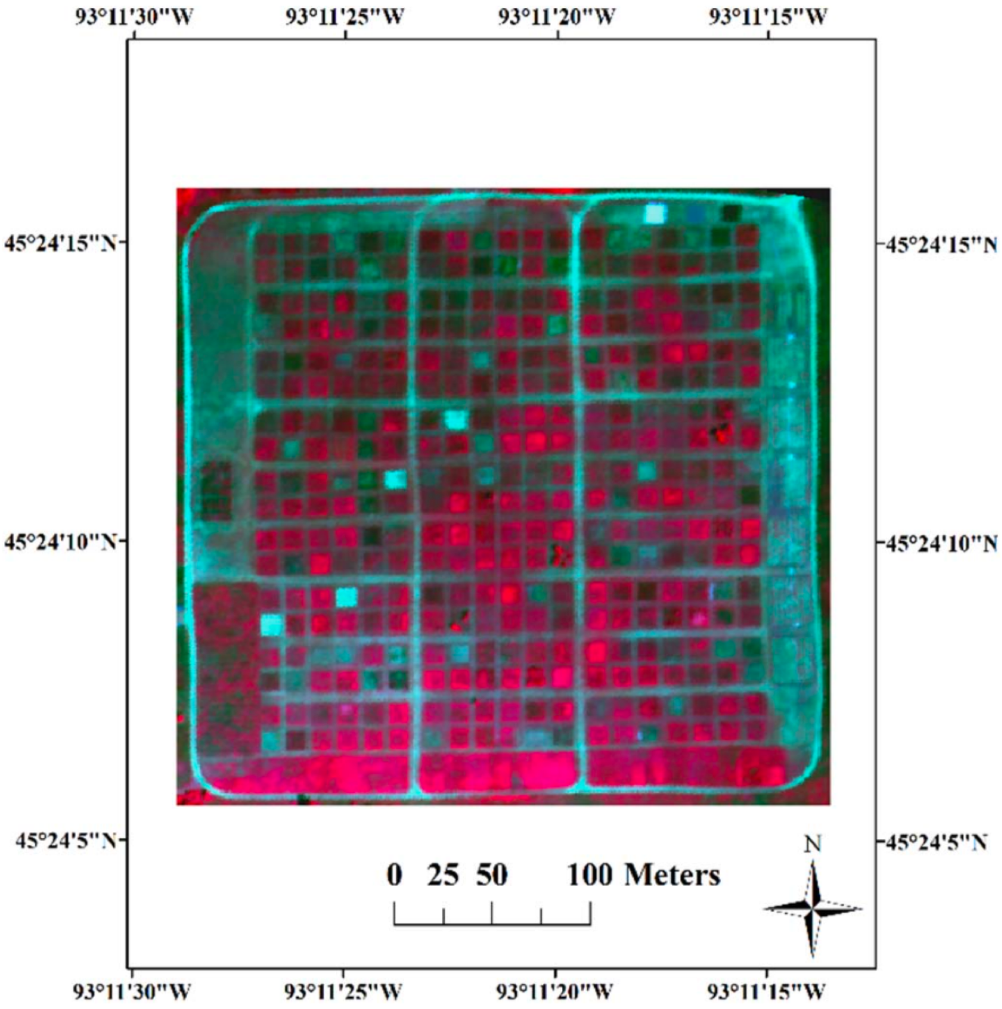


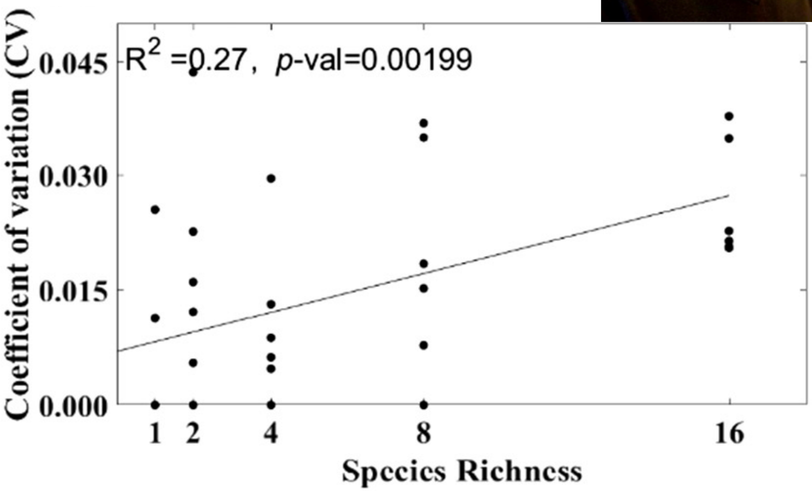


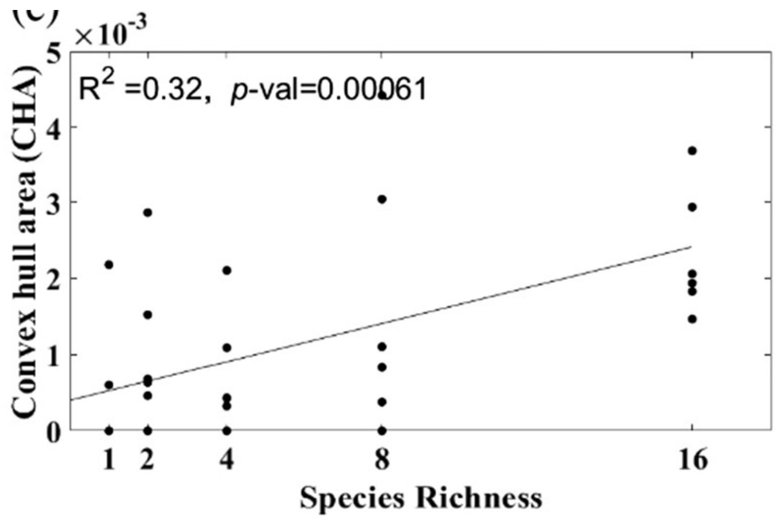
Wang, Gamon et al Ecological Applications, 28(2), 2018, pp. 541–556

Wang, Gamon et al Remote Sensing of Environment 211 (2018) 218–228

Spectral diversity – plant diversity relationship factoring out soil fraction (0.75 m² resolution)



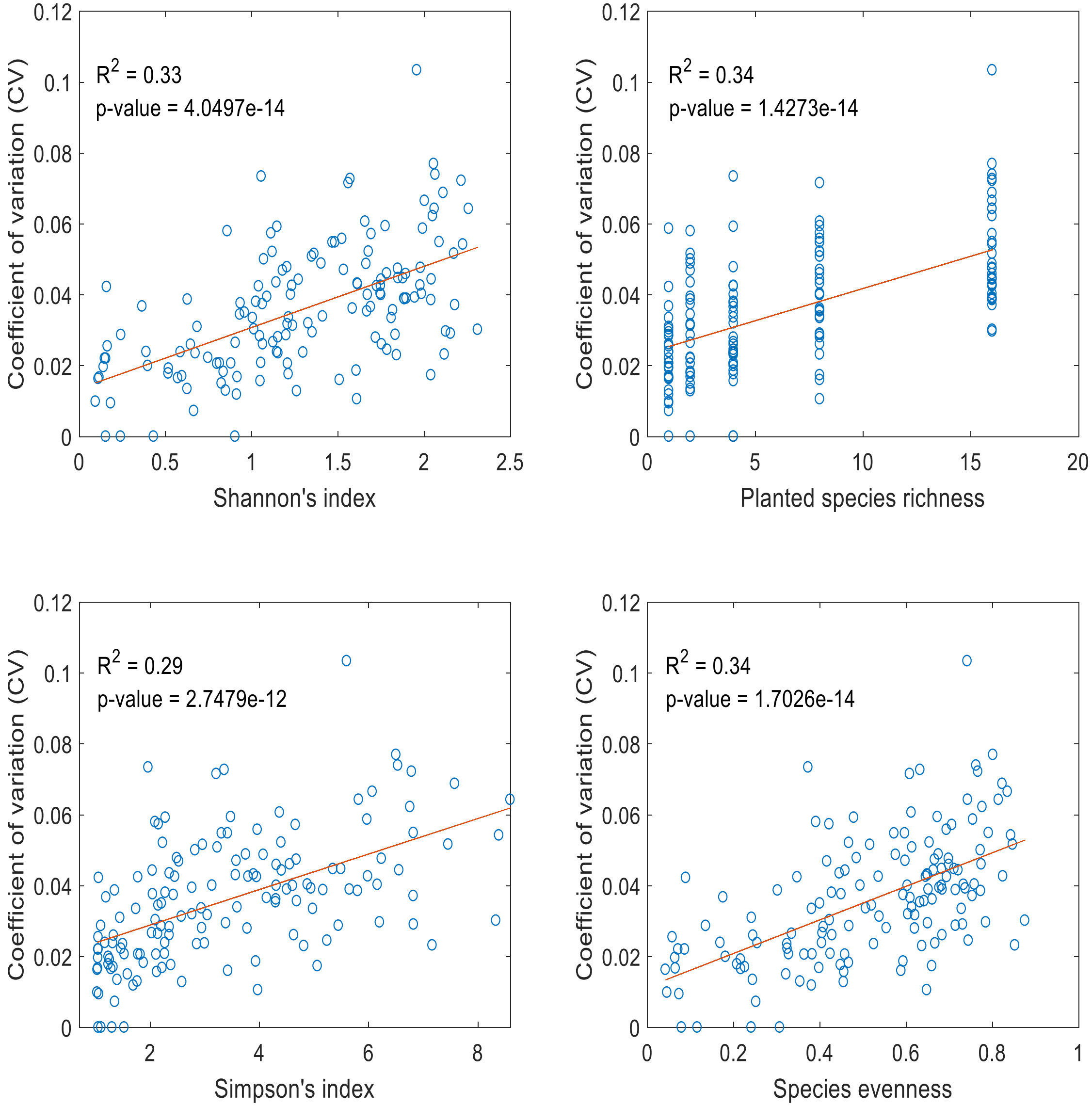




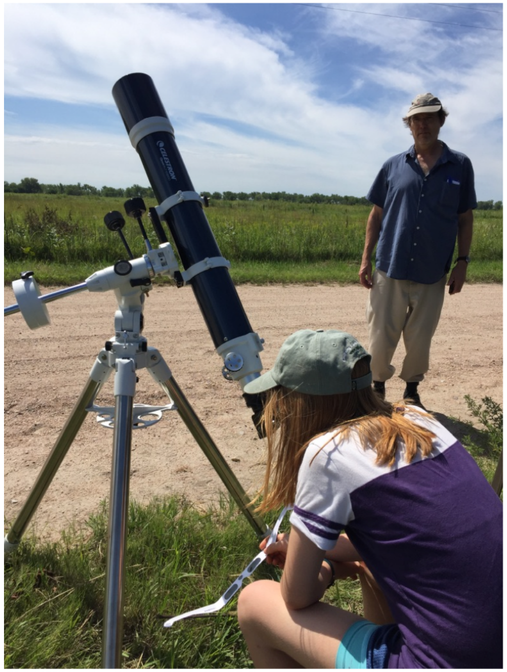
Cedar Creek - Minnesota

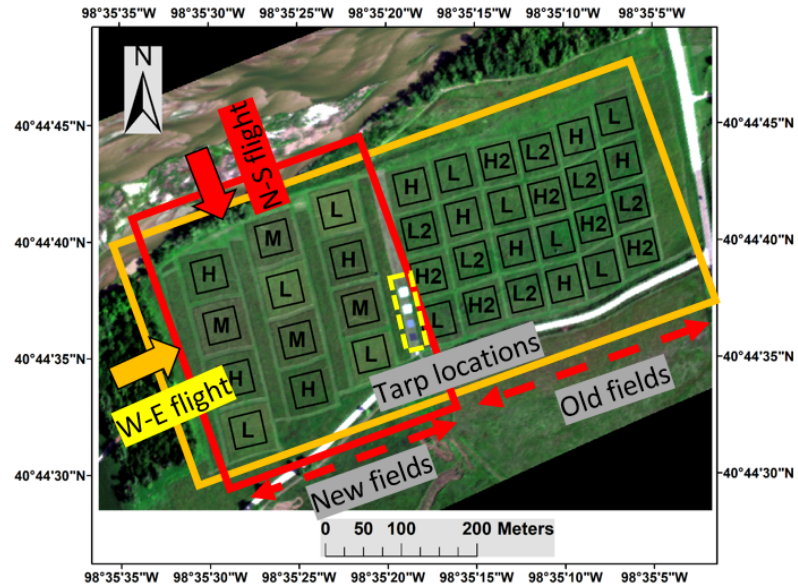
Gholizadeh, Gamon Remote Sensing of Environment 206 (2018) 240–253

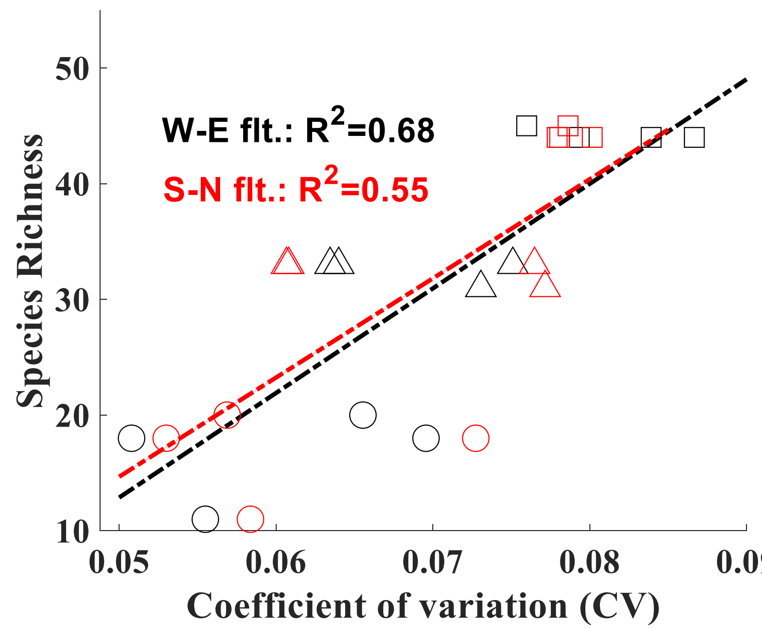
RS trait diversity (LMA) – species diversity (AVIRIS 1m²)



Townsend et al



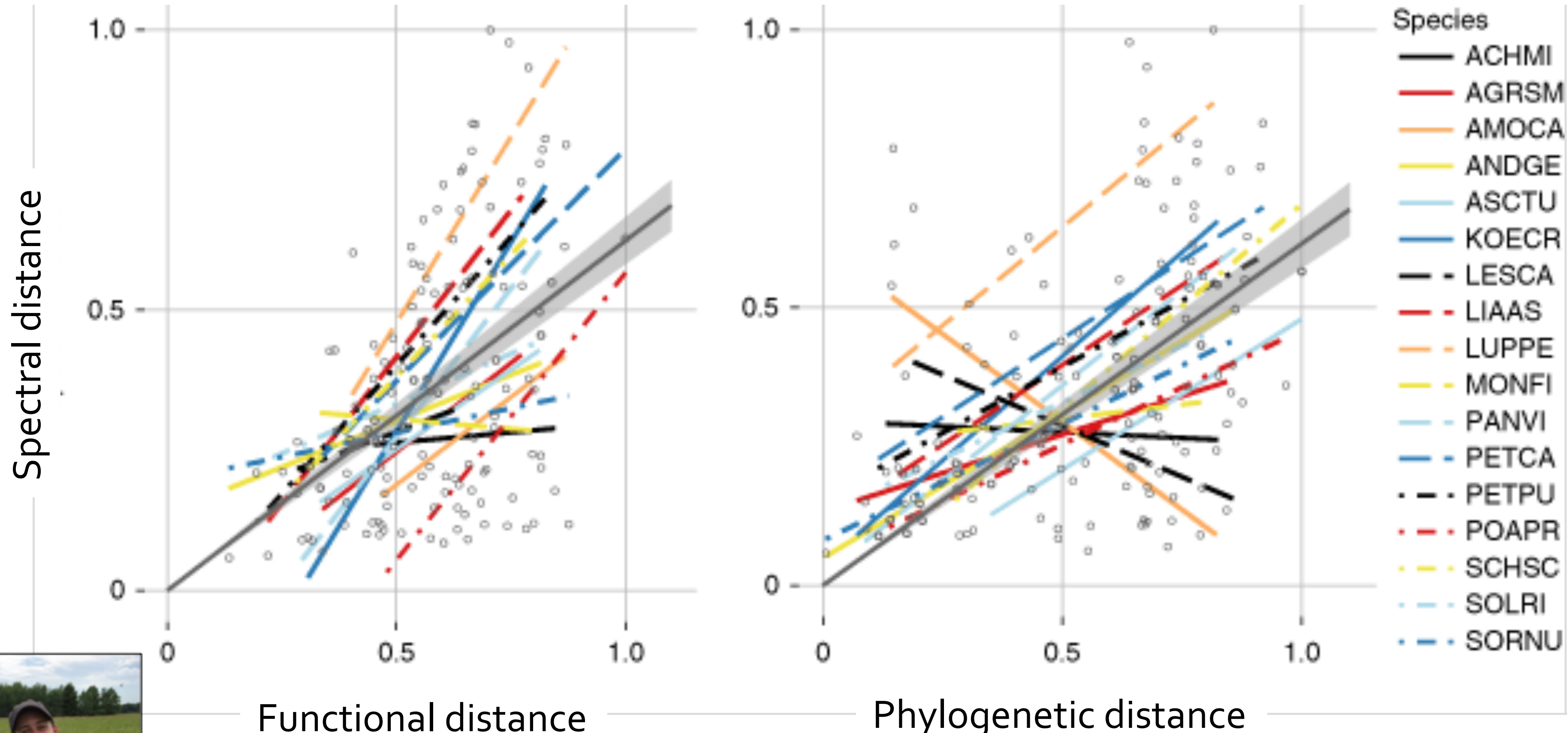


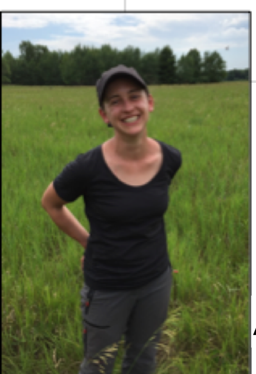


Nature Conservancy Expt - Nebraska

Gholizadeh et al

Spectral distance is associated with functional and phylogenetic distance between species

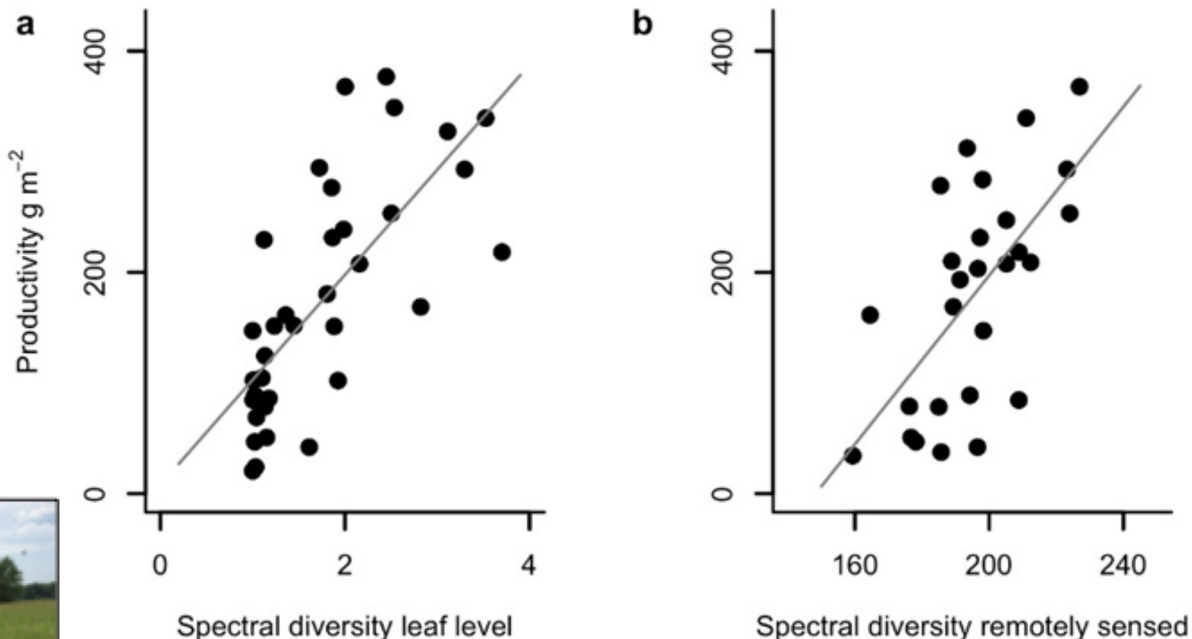



Anna Schweiger

Schweiger, Cavender-Bares et al, Nature EE 2018

Spectral diversity predicts productivity

Plant Productivity (g m⁻²)

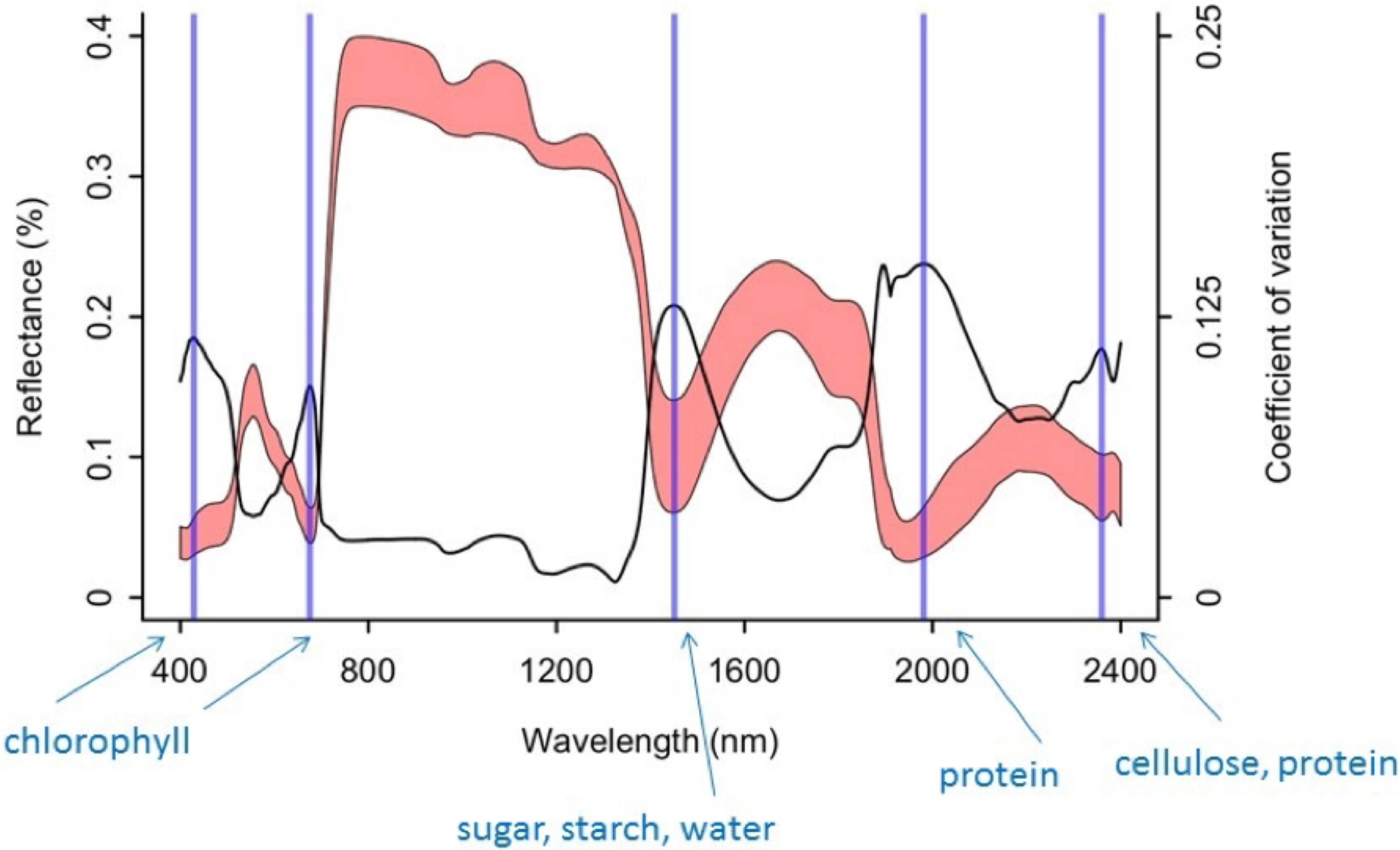


Anna Schweiger

Spectral diversity

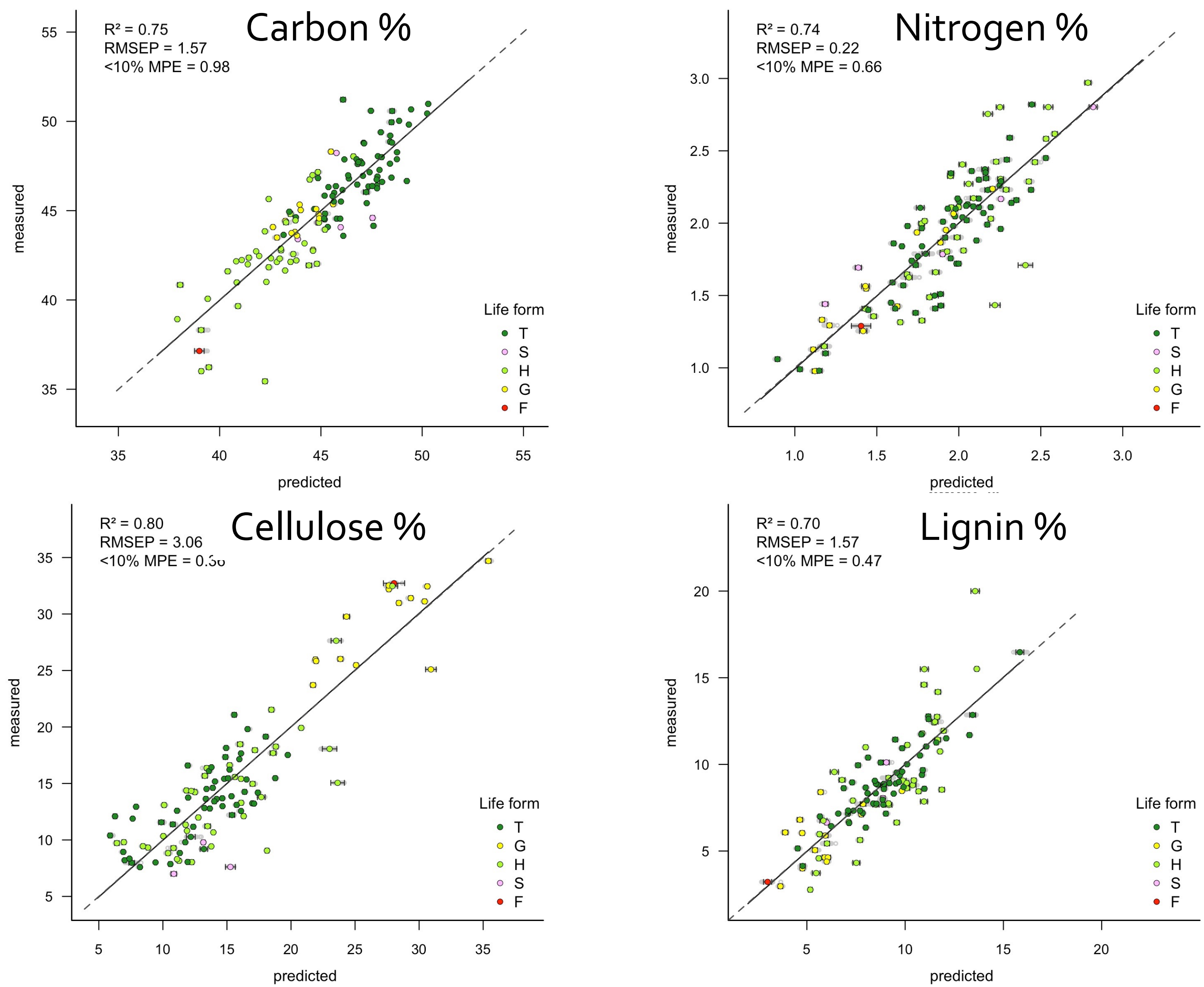
Schweiger, Cavender-Bares et al, Nature EE 2018

Spectral diversity using only local maxima of the coefficient of variation also predict productivity



Spectra predict functional traits with high accuracy

Anna Schweiger

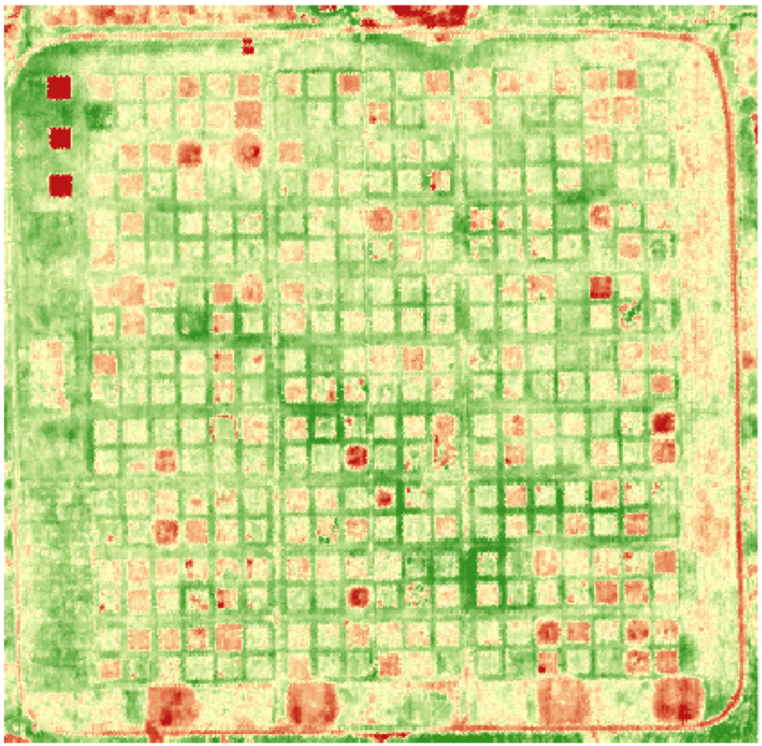


Chlorophyll A
Chlorophyll B
Lutein
Violaxanthin
Antherixanthin
Zeaxanthin
Beta Carotene
Anthocyanins
Solubles
Hemicellulose

Schweiger, Cavender-Bares et al, Nature EE 2018

Zhihui Wang

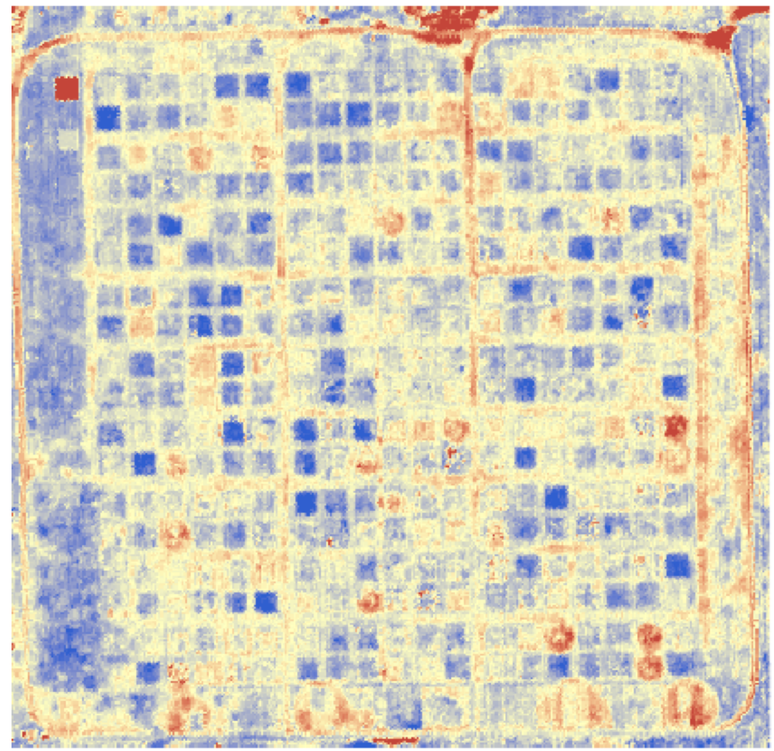
Trait maps of the BioDIV experiment at Cedar Creek



Total chlorophyll

0 25 50 100 m

650 umol.m-2
0
bare ground

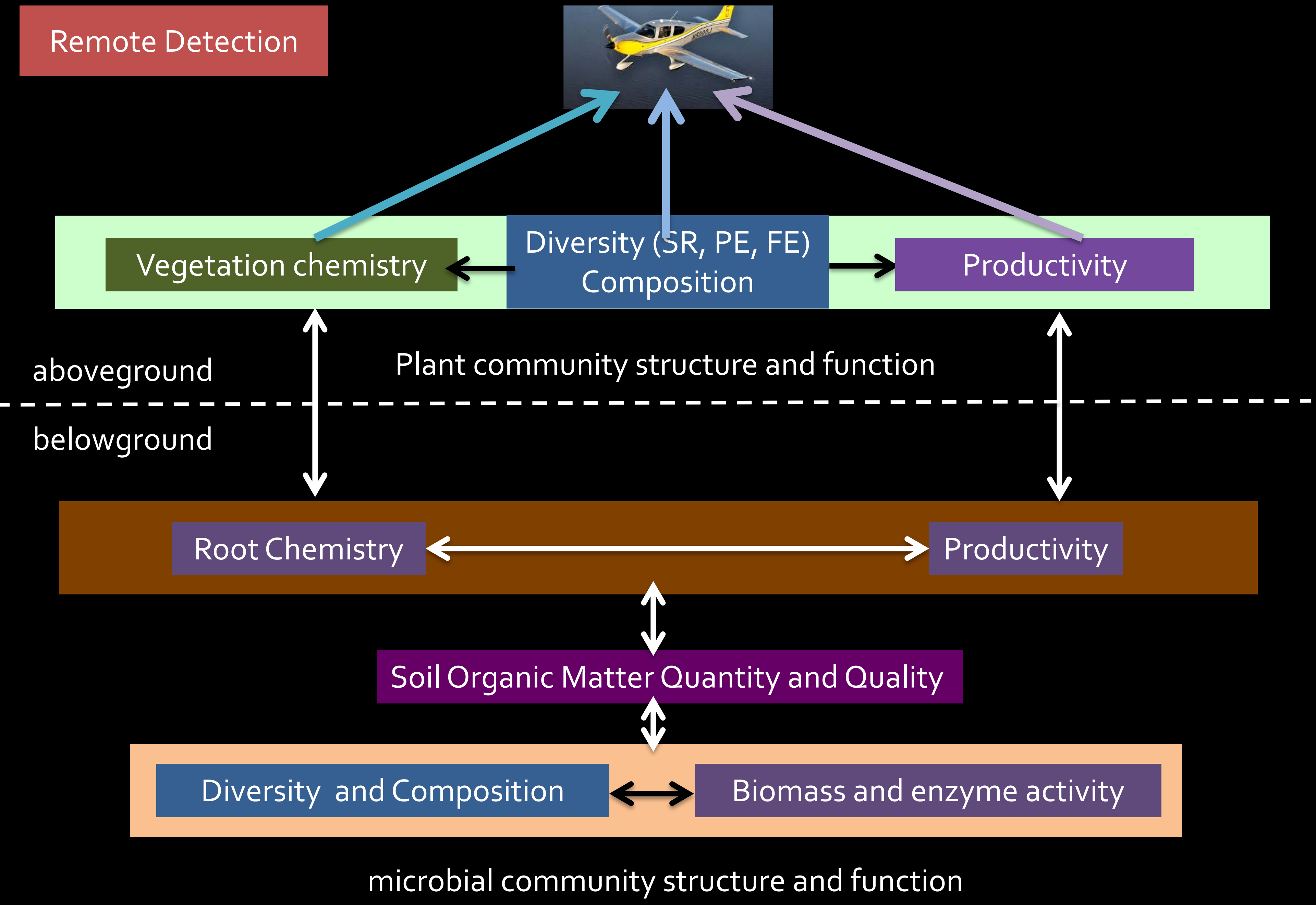


Leaf mass per area (LMA)

0 25 50 100 m

200 g.m-2
0
bare ground

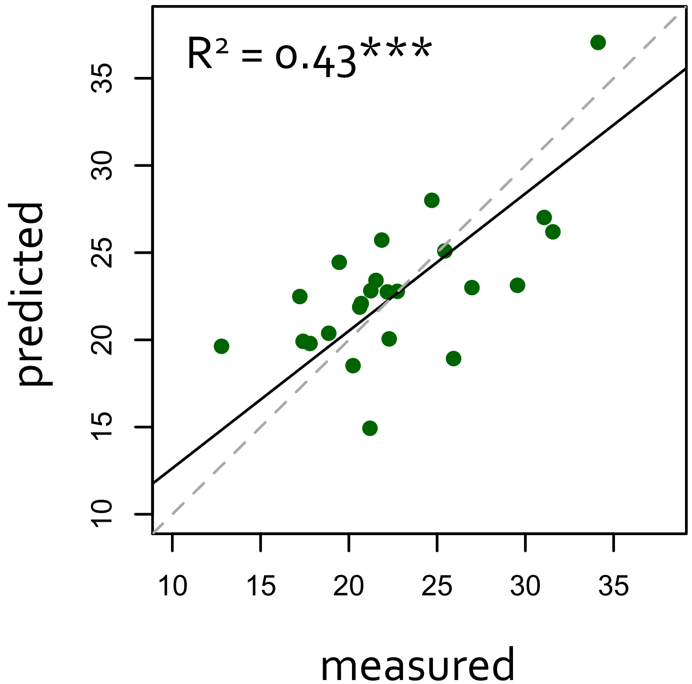
Wang/Townsend


Remote Detection
Vegetation chemistry
Diversity (SR, PE, FE) Composition
Productivity
Plant community structure and function
aboveground
belowground
Root Chemistry
Productivity
Soil Organic Matter Quantity and Quality
Diversity and Composition
Biomass and enzyme activity
microbial community structure and function

Remotely sensed vegetation chemistry predicts root chemistry

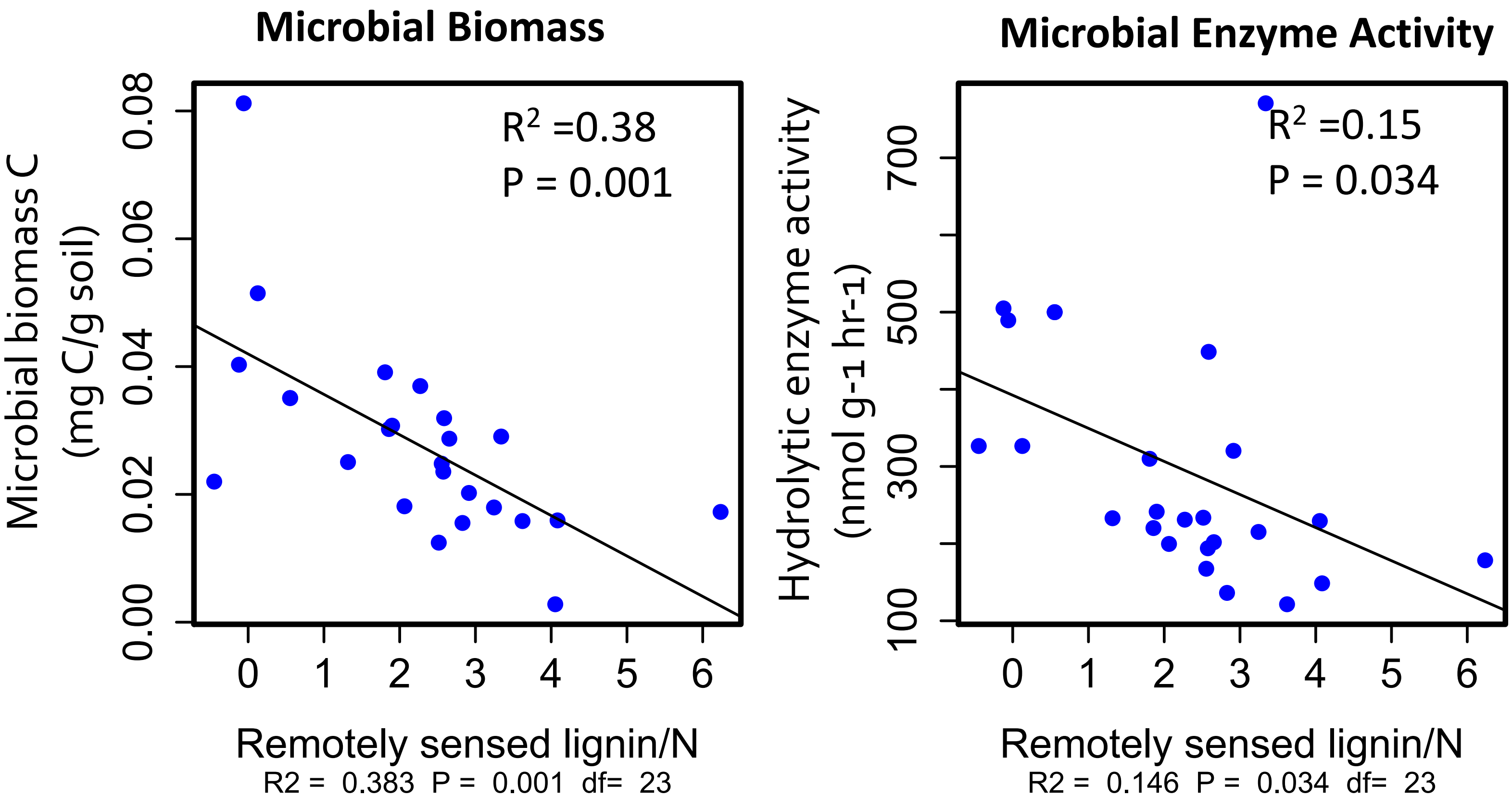
PLSR models of vegetation chemistry

Root soluble fraction:
sugars, organic acids and amino acids



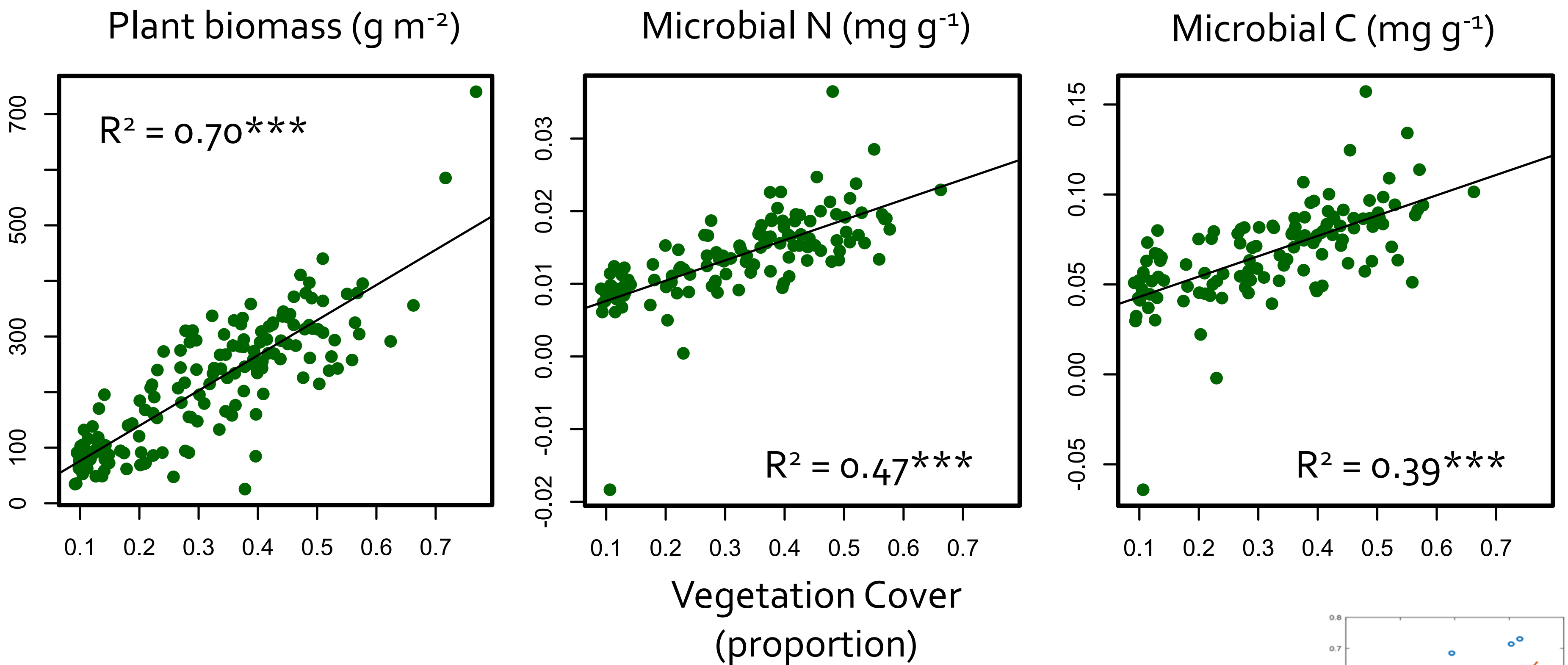
Sarah Hobbie

Remotely sensed above ground chemistry predicts below ground processes

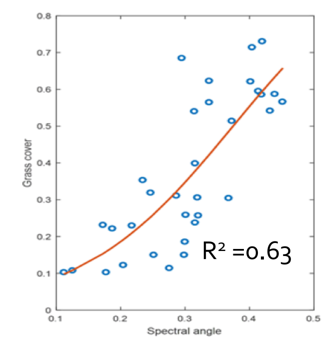


Lignin/N

Remotely sensed vegetation cover predicts aboveground plant biomass and soil microbial biomass belowground



Vegetation cover was estimated for every 1m² pixel, and averaged per 9x9 m² plot, by building a logistic model using ground cover measurements and soil angle (Serbin et al. 2015)

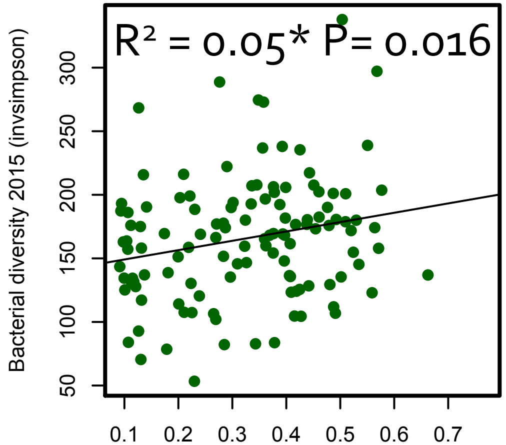


Remotely sensed vegetation cover predicts fungal and bacterial diversity and composition

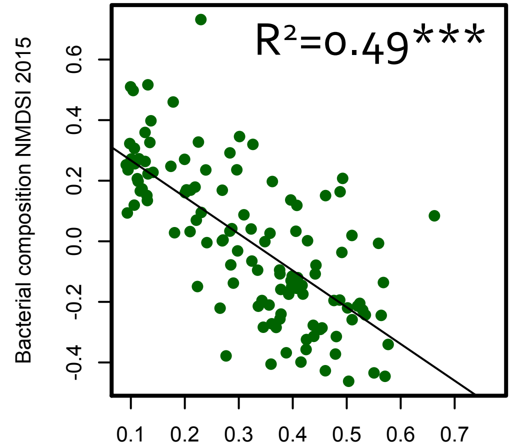
Madritch

L. Cline

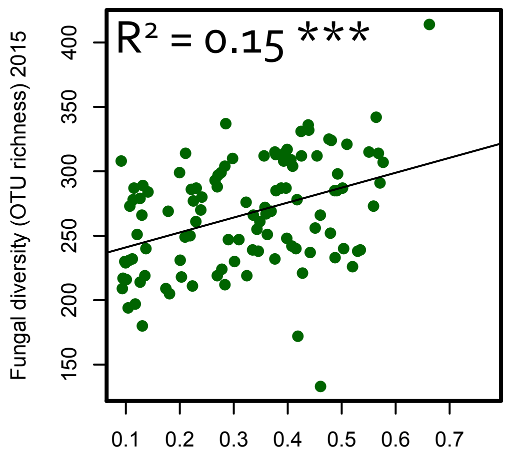
Bacterial diversity



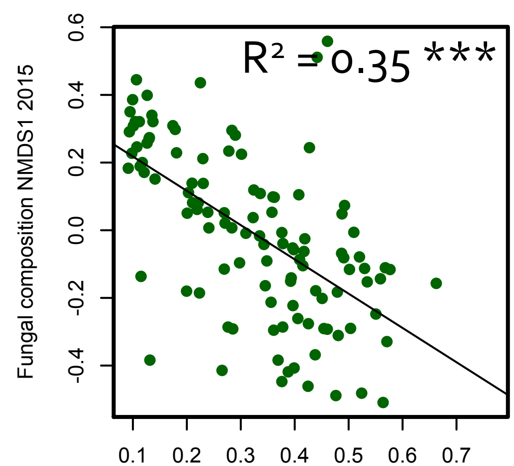
Bacterial composition NMDS1



Fungal diversity



Fungal composition NMDS1

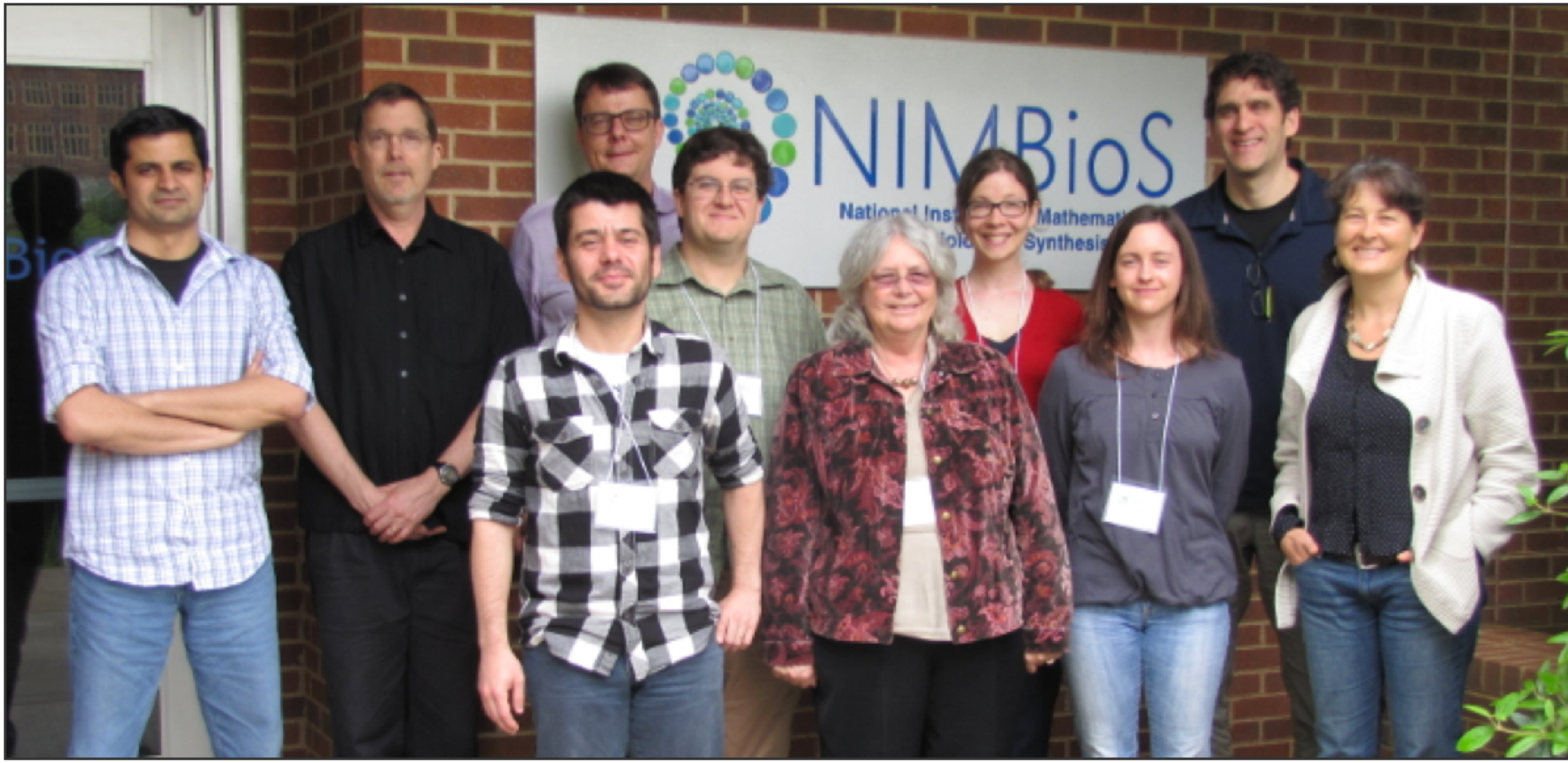


Vegetation Cover (proportion)

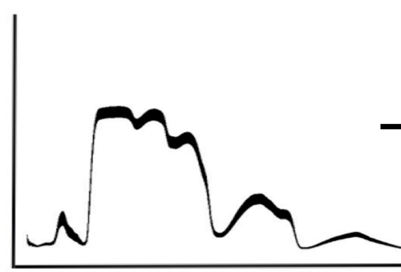
NIMBioS Working Group:

Remotely Sensing Biodiversity

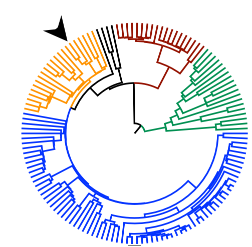
NIMBioS



Raw spectra → EcoSIS →



→ phylo model



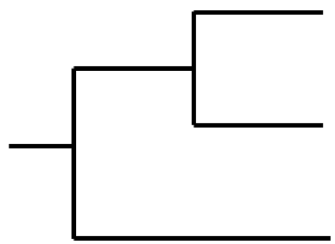
Phylogeny meets Spectra

Evolutionary Model

Spectral Model

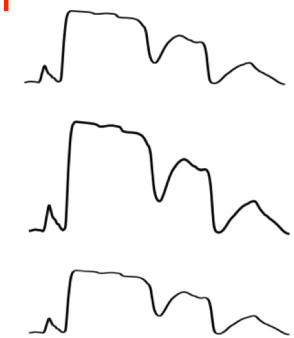
1.6	0.3	0.15	0.02	0.01

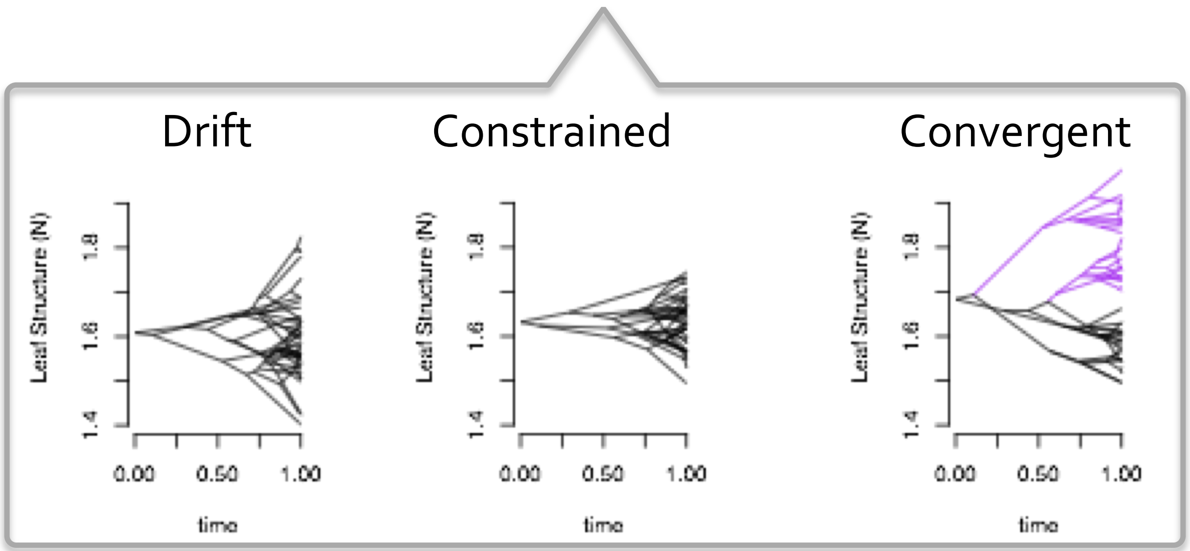
Leaf layers, Chlorophyll, Carotenoids, H2O, LMA



$$dX_t = \alpha(\theta - X_t)dt + \sigma dB_t$$

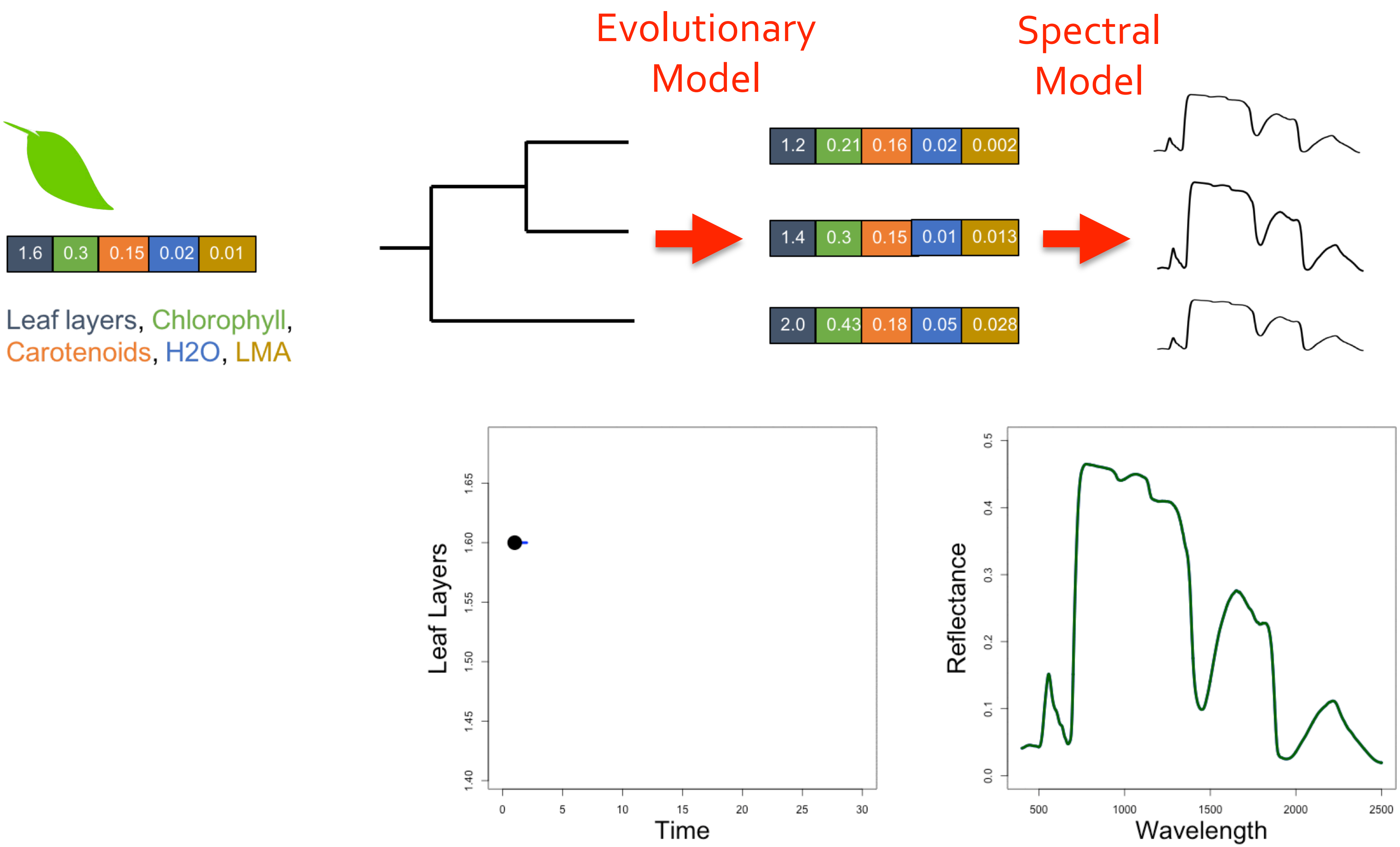
1.2	0.21	0.16	0.02	0.002
1.4	0.3	0.15	0.01	0.013
2.0	0.43	0.18	0.05	0.028





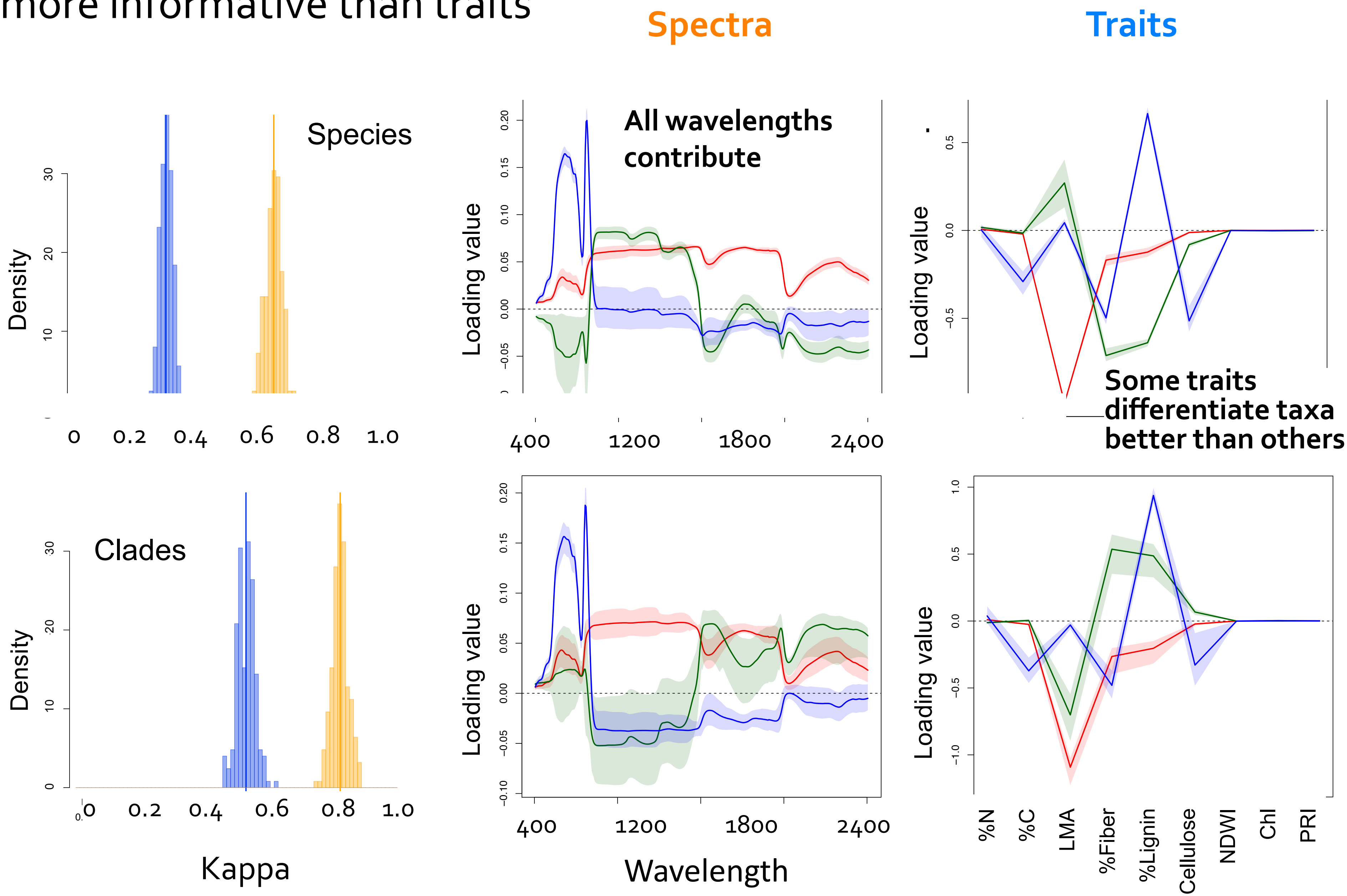
Meireles, Schweiger, Cavender-Bares 2017 — www.github.com/meireles/spectrolab

Phylogeny meets Spectra



Meireles *et al.* 2017; — www.github.com/meireles/spectrolab

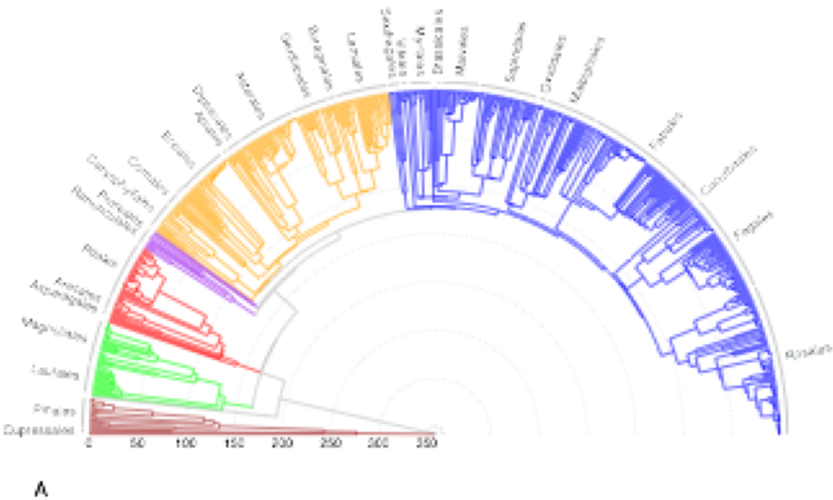
Spectra detect phylogenetic lineages better than species; spectra are more informative than traits

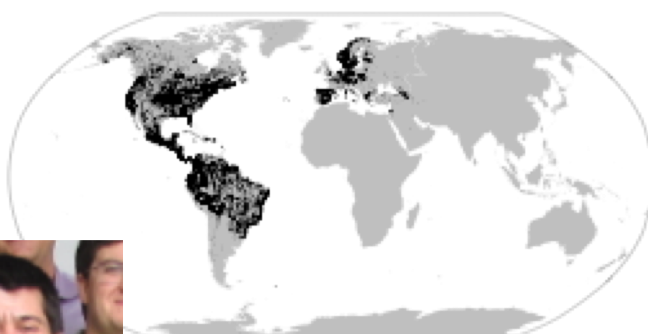


PLS-DA

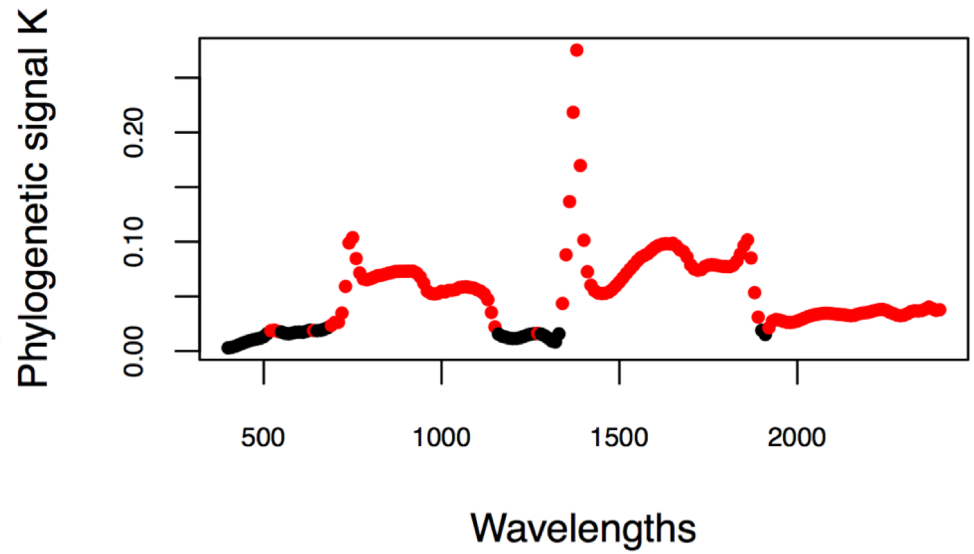
Cavender-Bares, Meireles et al RS 2016

Spectra are phylogenetically conserved EXCEPT in the *visible* range associated with pigments for light harvesting and photoprotection

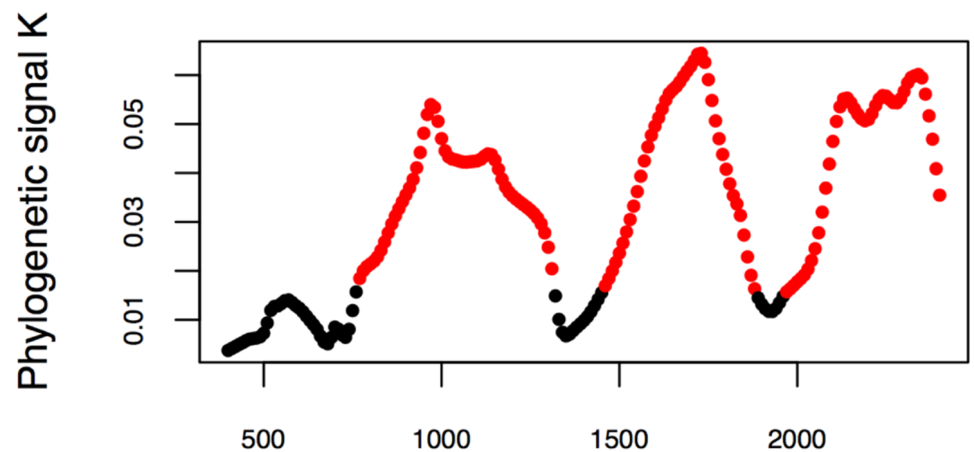




Temperate North America

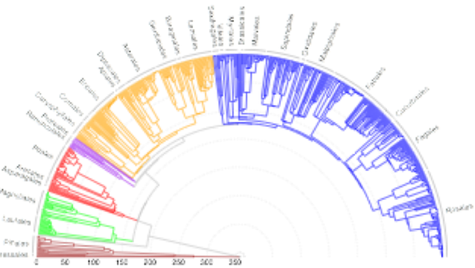


Tropical South America



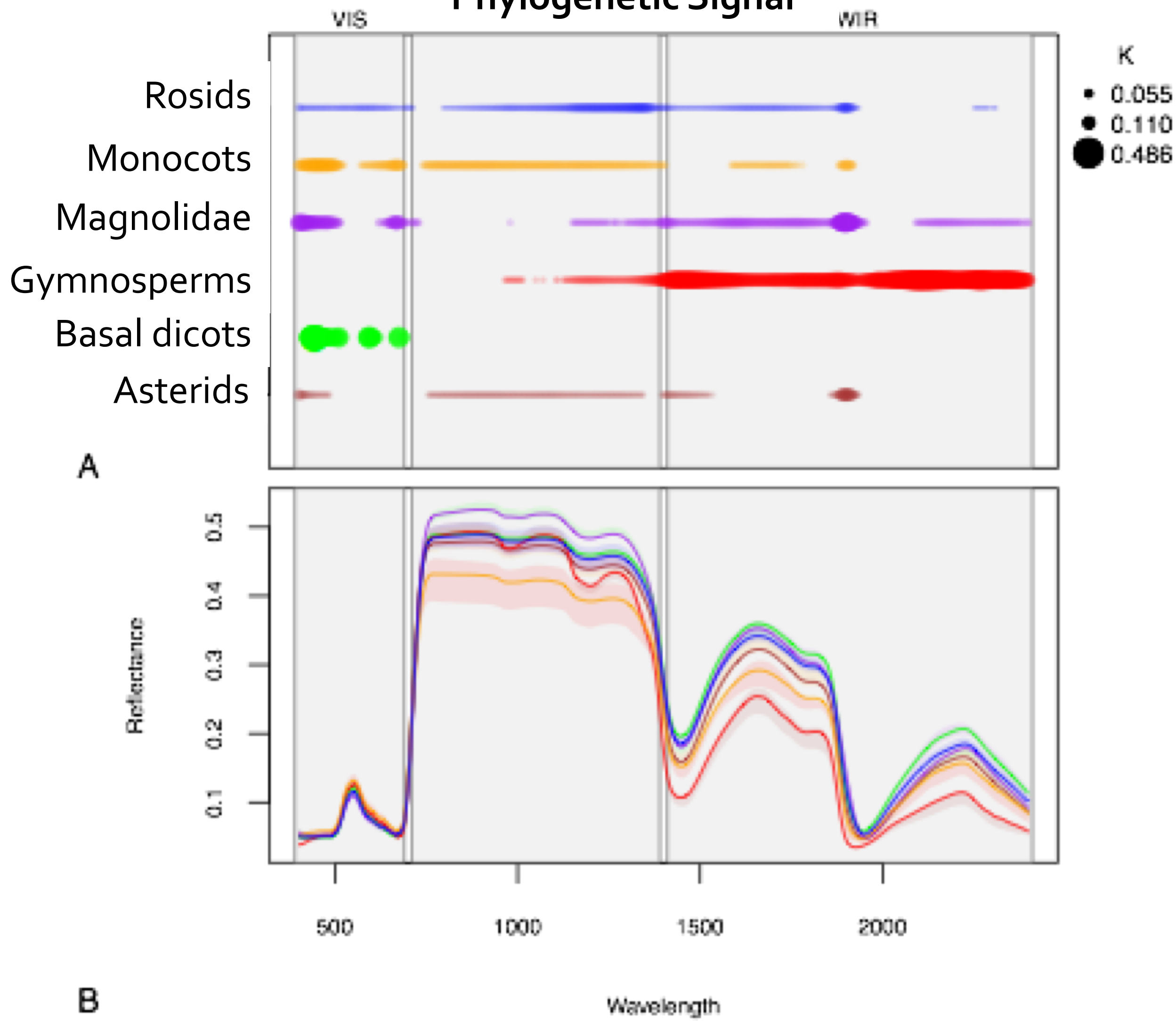
NIMBioS working group

Phylogenetic Signal



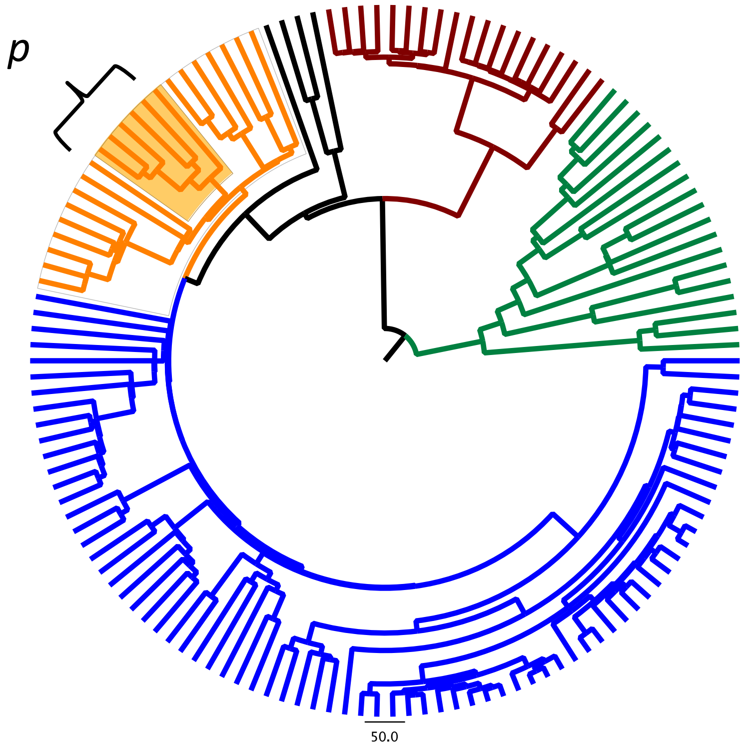
A

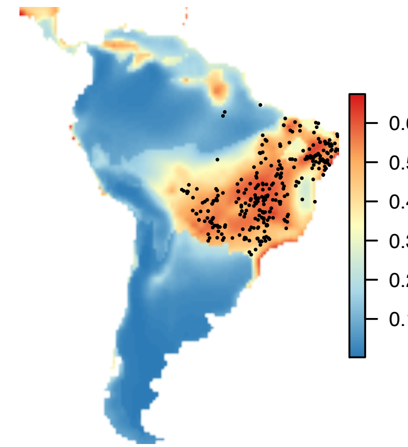
B

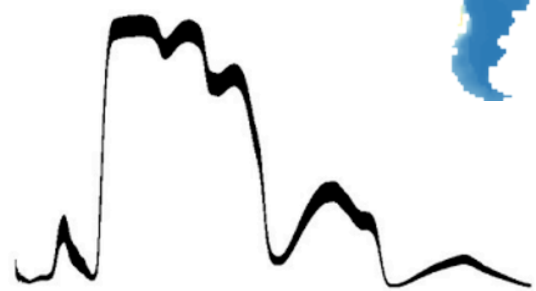


Meireles and NIMBioS working group

Constrain RS data using species distribution models







Place an unknown leaf spectrum within the plant tree of life and derive the probability that it falls within a given clade