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

Cavender-Bares

Gamon

Townsend

Hobbie

Schweiger

Wang

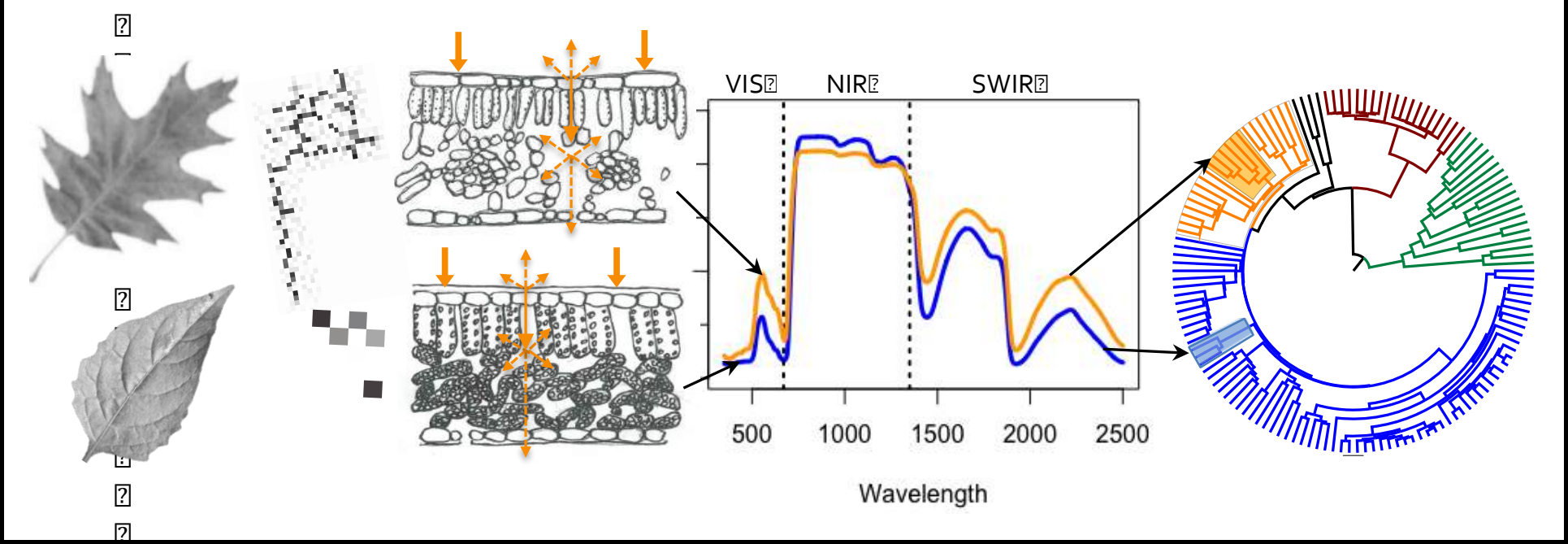
Wang

Madritch

Williams

Gholizadeh

Meireles

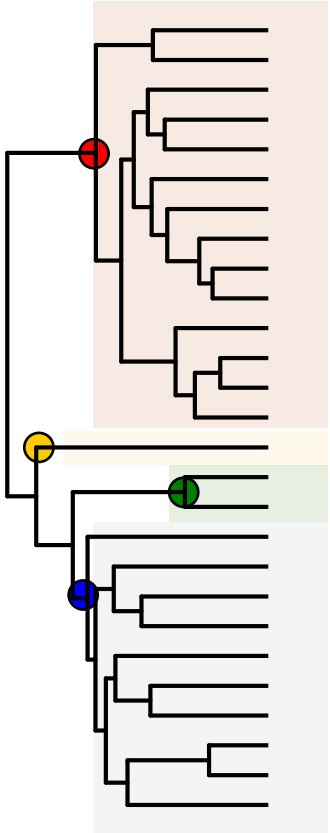


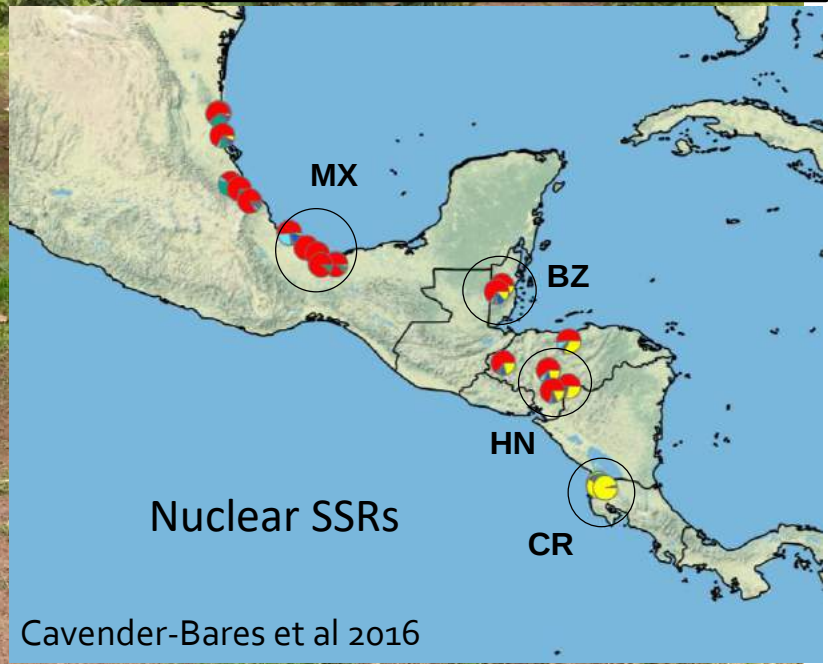
How well can we link plant spectra and spectral diversity to plant function, phylogeny and diversity?

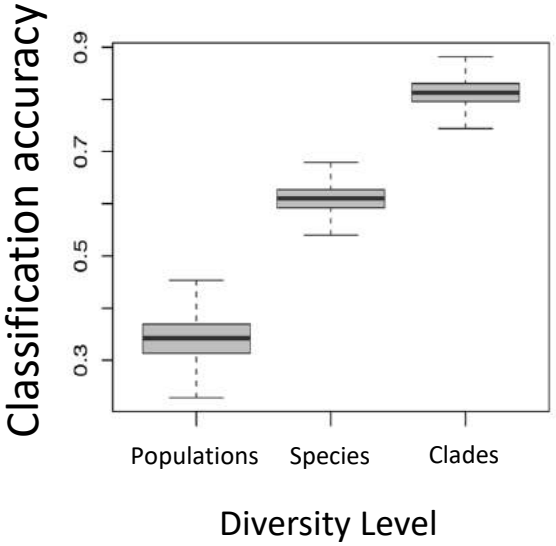
Cavender-Bares et al AJB 2017

Quercus oleoides –
four populations grown in a common garden in Honduras

33 oak species grown in a common garden

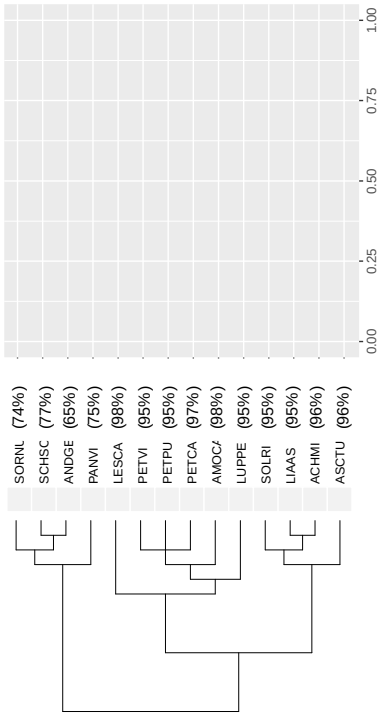


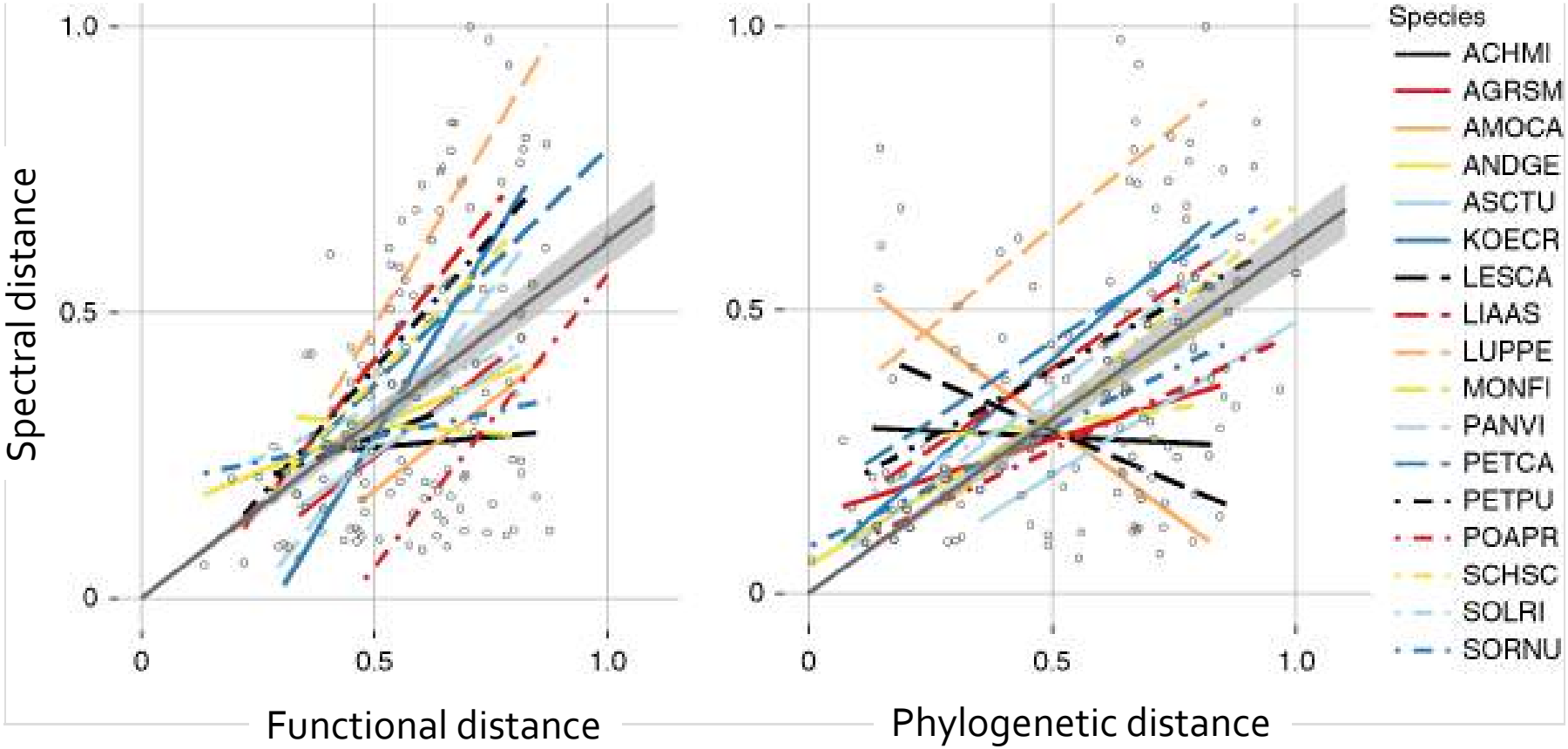




Spectral distance is associated with functional and phylogenetic distance between species

Spectral classification probability





Schweiger, Cavender-Bares et al, Nature EE 2018

NIMBioS Working Group:

Remotely Sensing Biodiversity

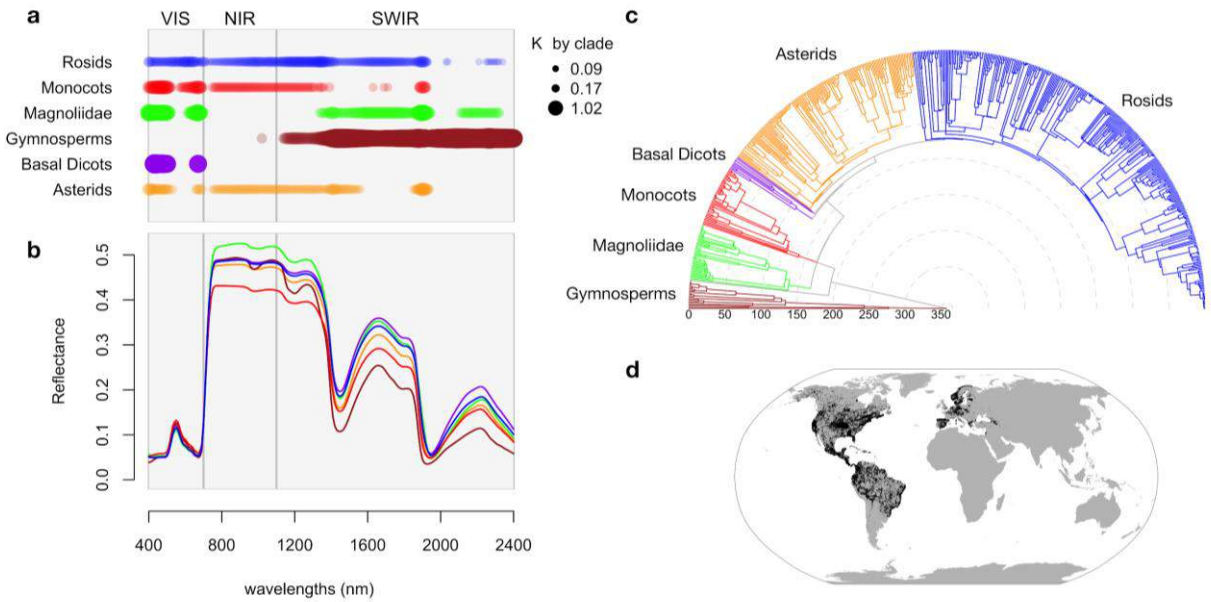
NIMBioS

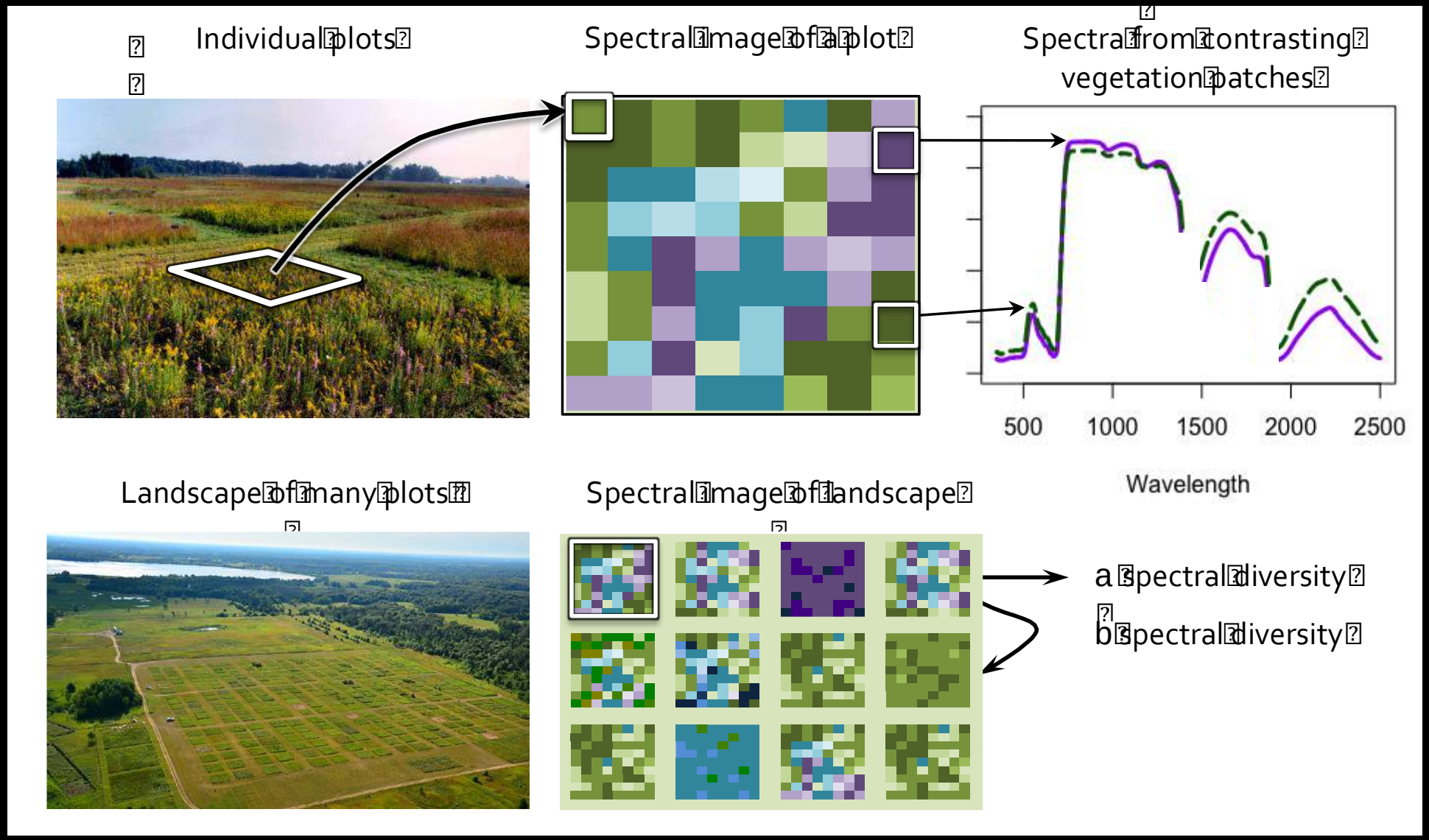
J.E. Meireles

Reference

Prediction

	Asterids	Basal.Dicots	Gymnosperms	Magnoliidae	Monocots	Rosids
Asterids	0.58	0.02	0.01	0	0.06	0.13
Basal.Dicots	0.08	0.86	0	0	0.02	0.09
Gymnosperms	0	0	0.96	0	0	0
Magnoliidae	0.09	0	0.01	0.98	0.05	0.06
Monocots	0.1	0.01	0.01	0	0.83	0.05
Rosids	0.14	0.11	0.01	0.01	0.04	0.66





Cavender-Bares et al AJB 2017

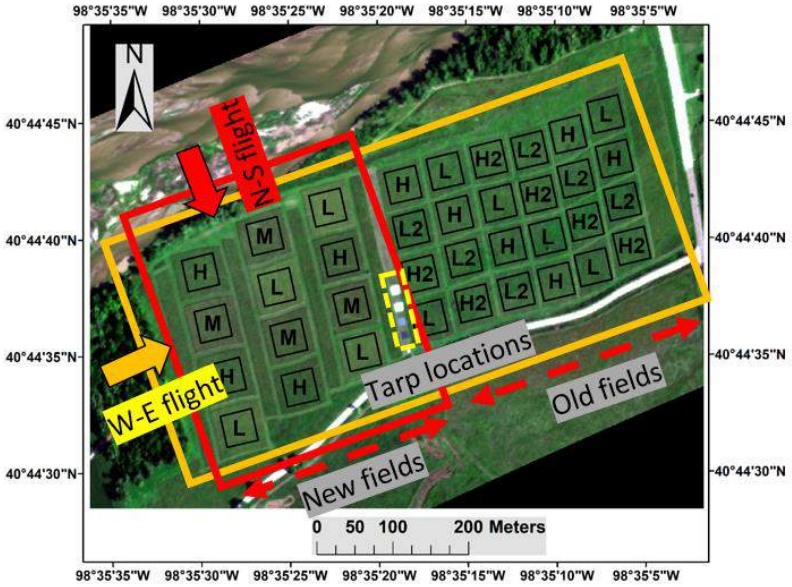
How well can we detect plant biodiversity and relationships between diversity and ecosystem function?

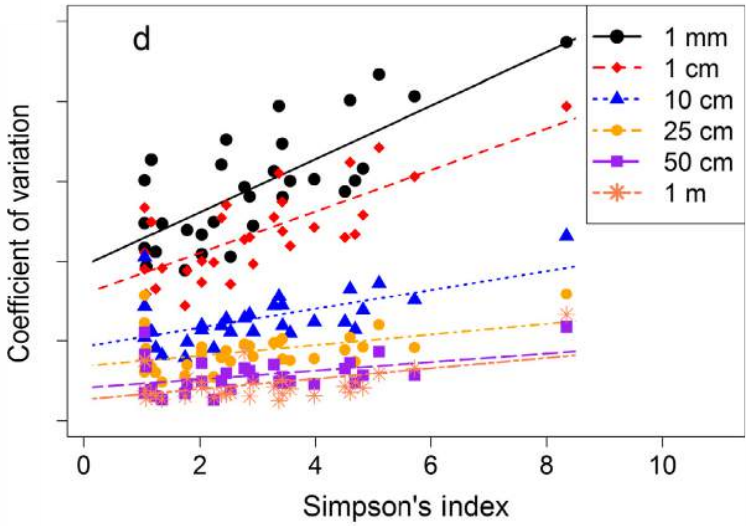
In grasslands, detecting plant biodiversity depends on spatial resolution and extent

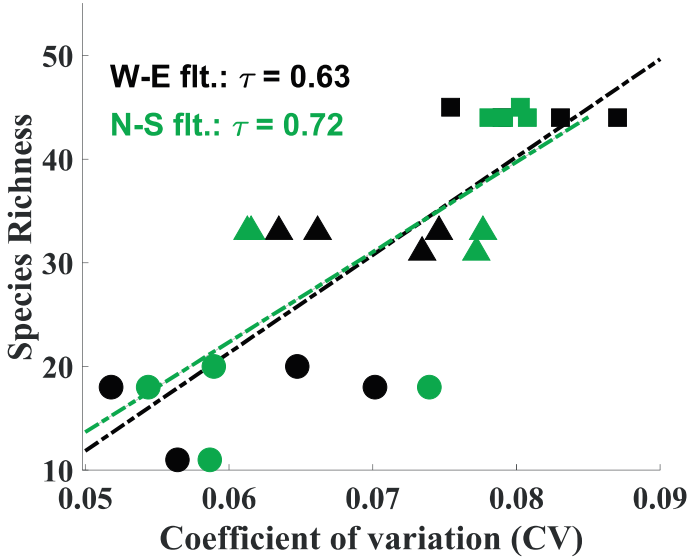
BioDIV
Cedar Creek

Ran Wang

Wood River
Nebraska





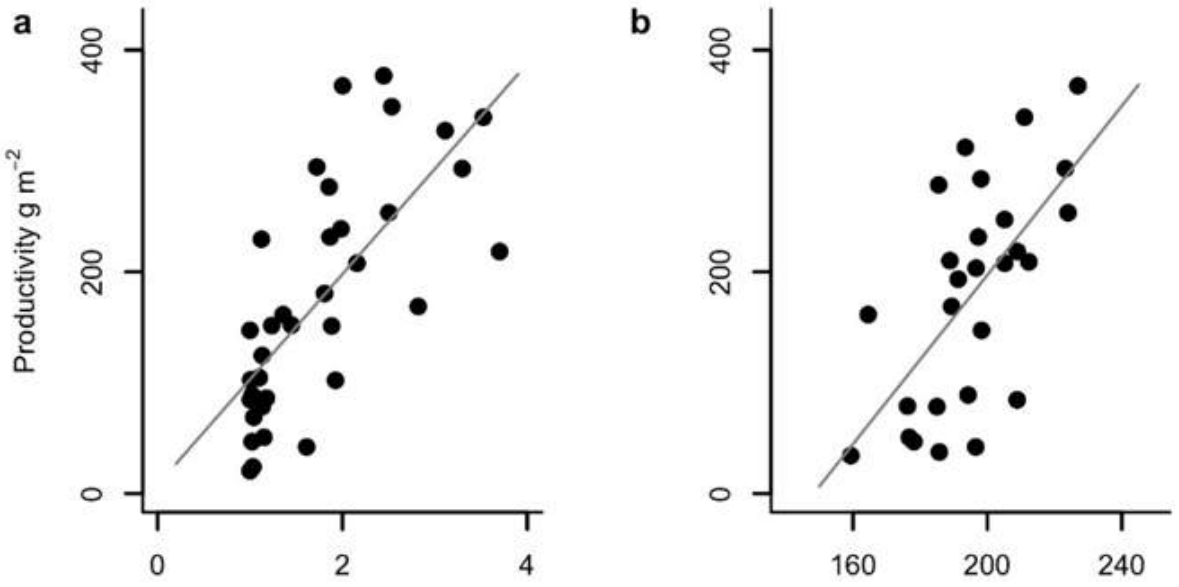


Gholizadeh

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

Spectral diversity predicts ecosystem productivity

Plant Productivity (g m^{-2})

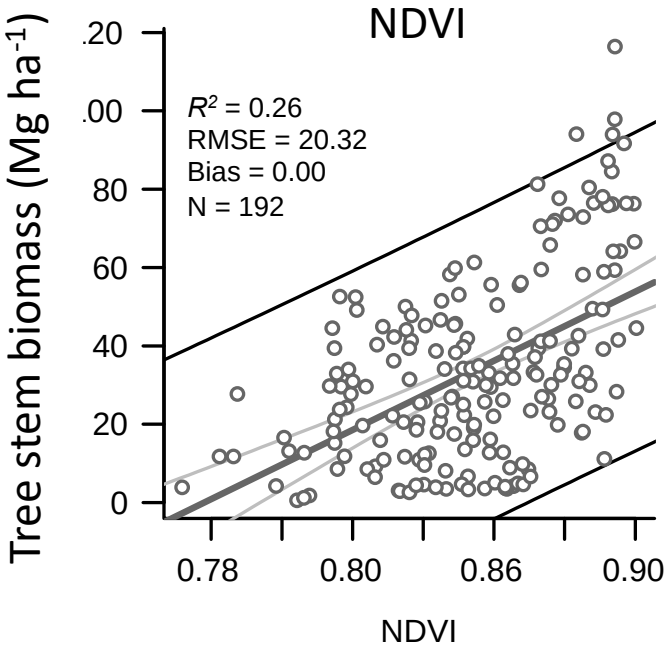


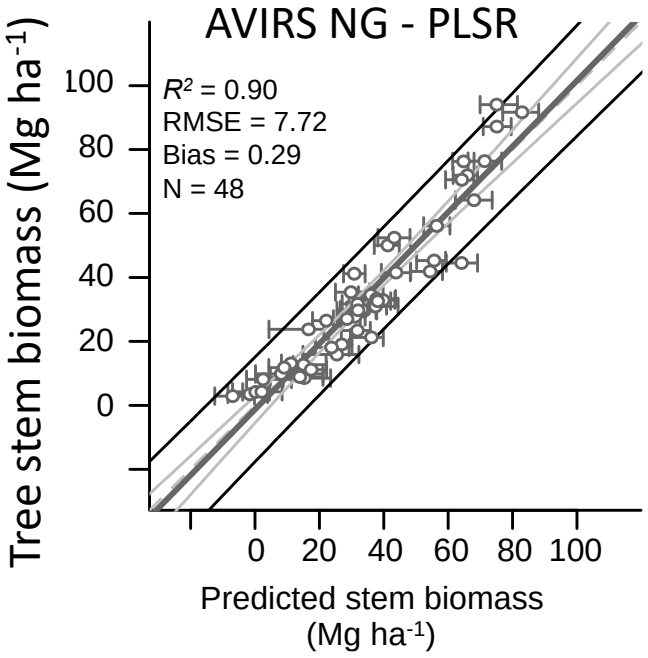
Spectral diversity - leaf level **RS Spectral diversity**

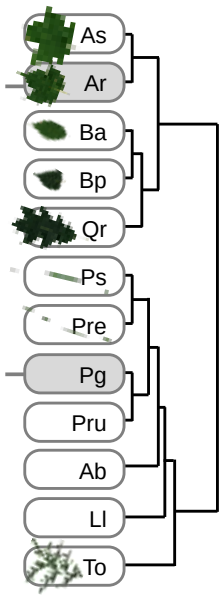
Anna Schweiger

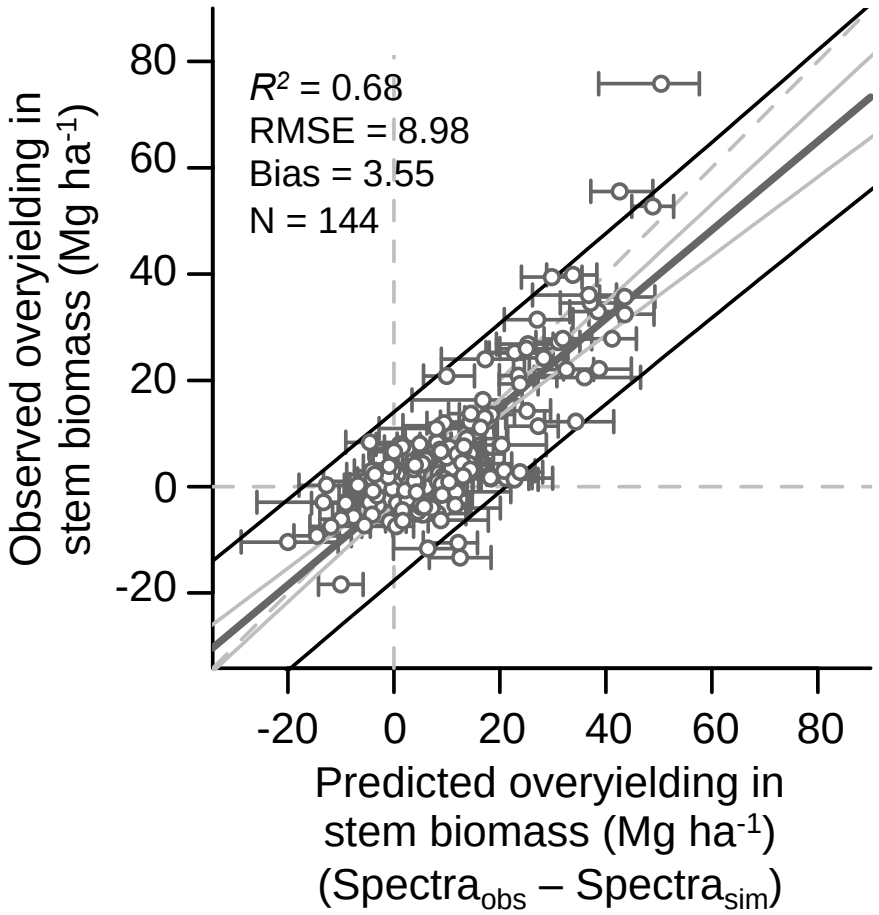
Schweiger, Cavender-Bares et al, Nature EE 2018

AVIRIS NG airborne imagery detects overyielding in a forest diversity experiment by comparing monoculture spectra to simulated and observed spectra in diverse communities

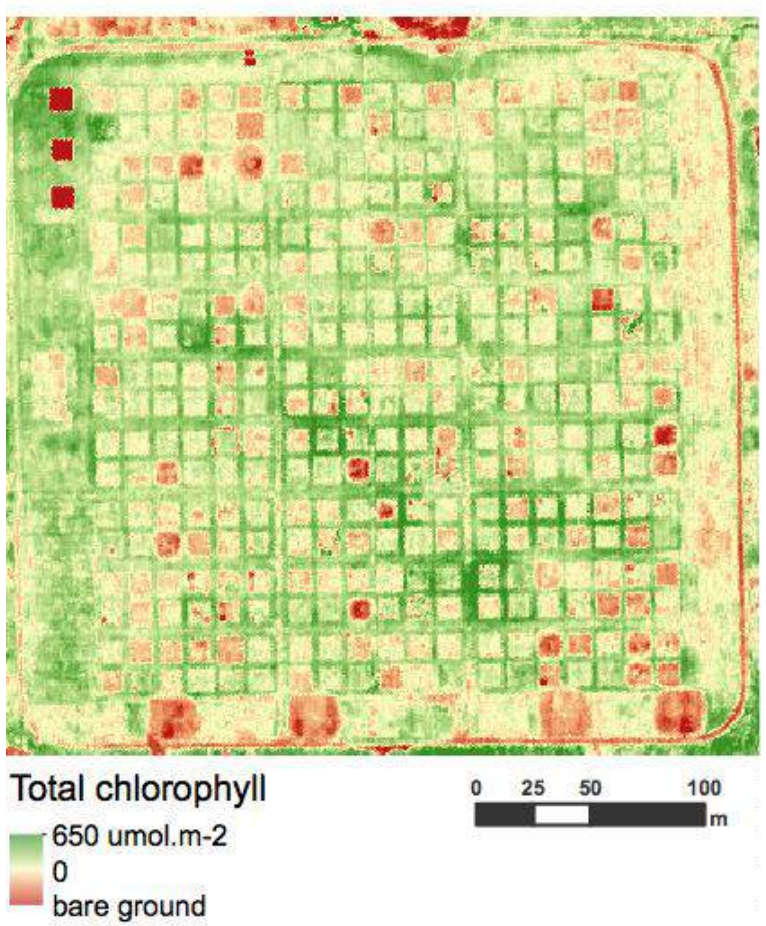


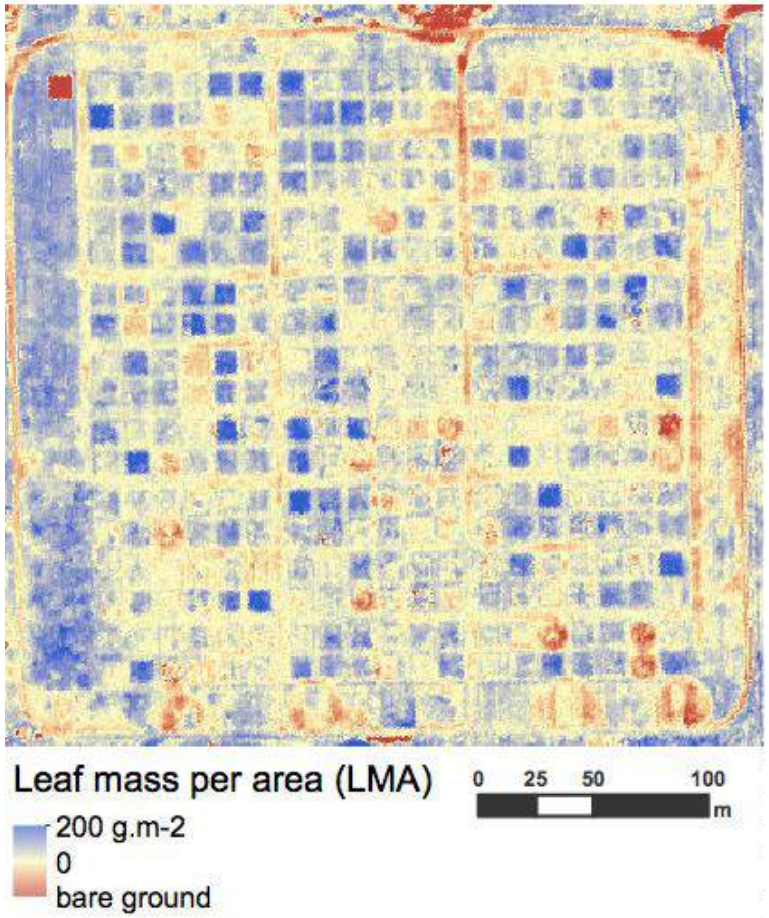






Trait maps of the BioDIV experiment at Cedar Creek





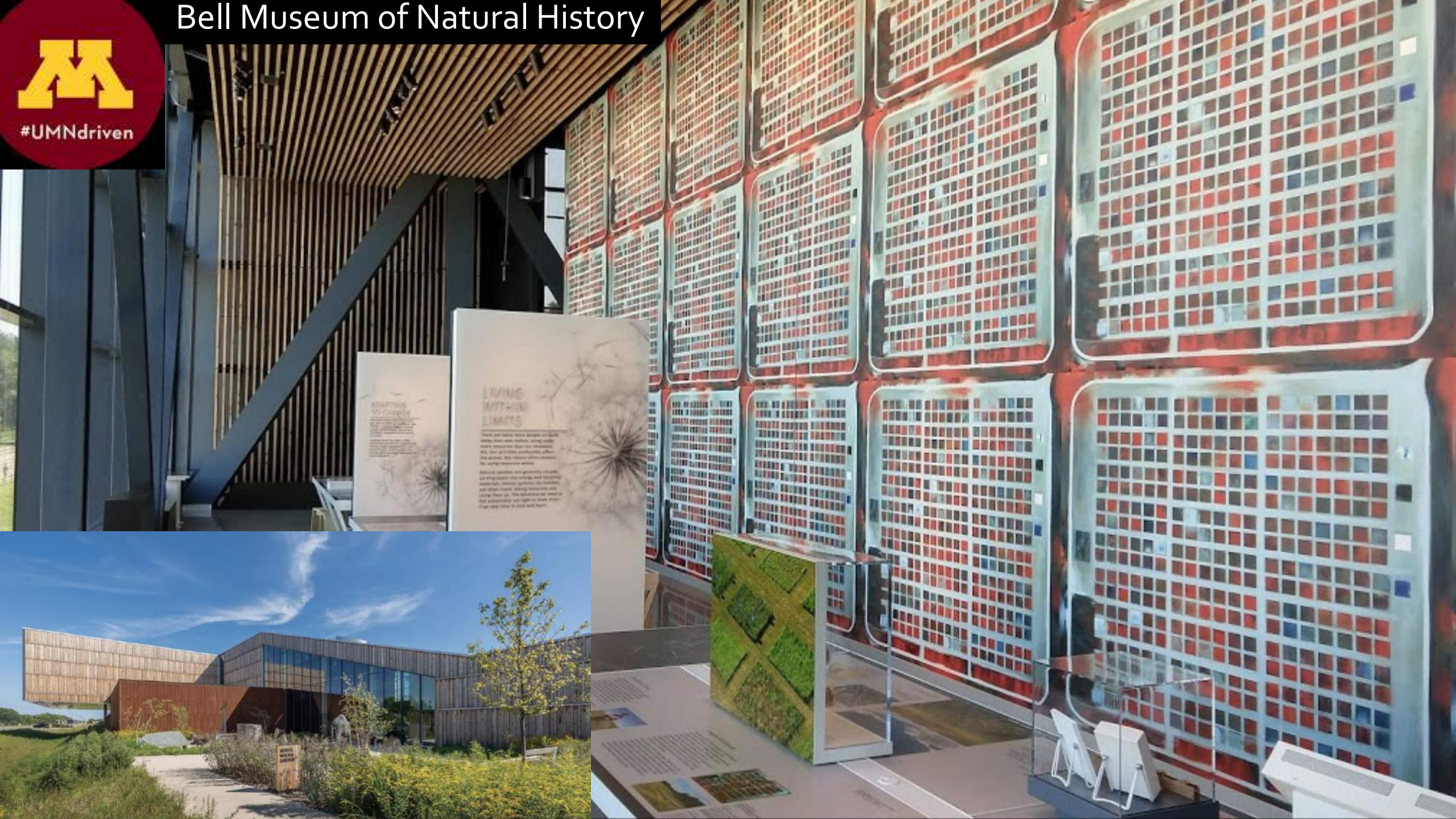
Zhihui Wang

Mapping foliar functional traits and their uncertainties across three years in a grassland experiment

Zhihui Wang[a,*], Philip A. Townsend[a], Anna K. Schweiger[b], John J. Couture[c], Aditya Singh[a,d], Sarah E. Hobbie[b], Jeannine Cavender-Bares[b]

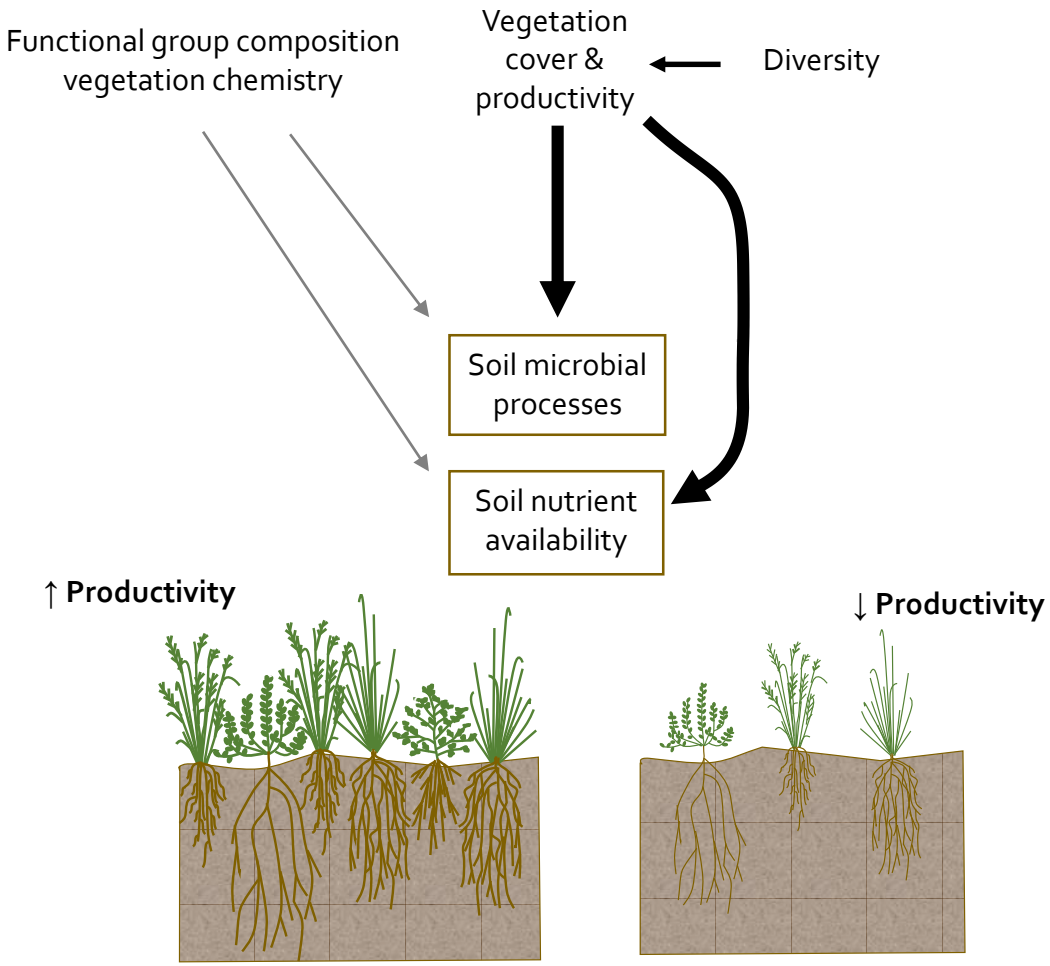
Wang, Townsend et al RSE 2019

Bell Museum of Natural History



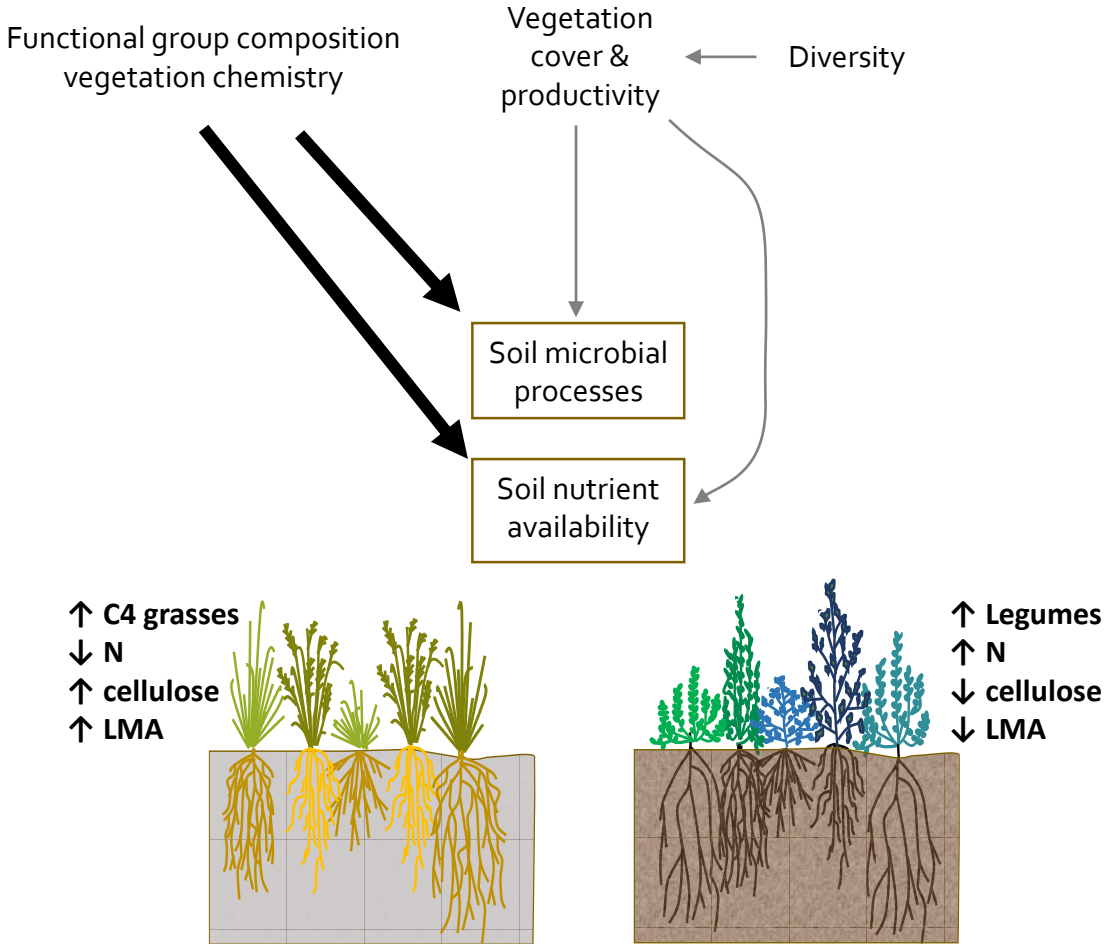
How well does AVIRIS NG imagery predict belowground soil and microbial processes?

BioDIV



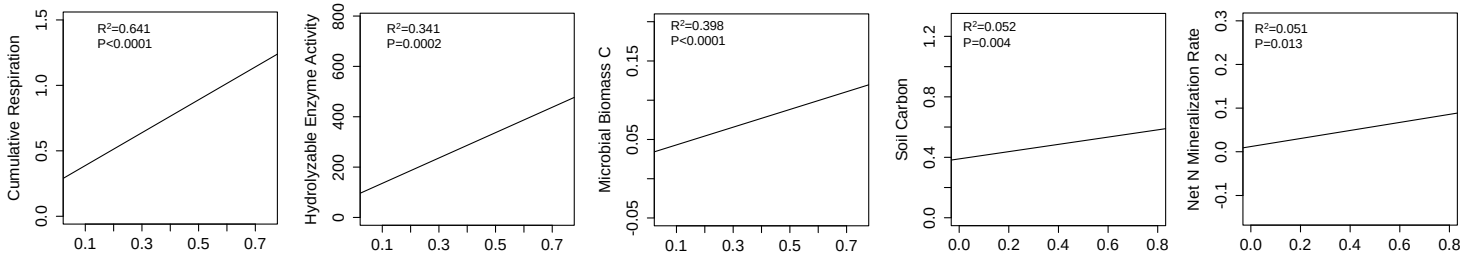
Quantity of soil inputs

Wood River



Quality of soil inputs

BioDIV



RS Vegetation Cover

Quantity of inputs (Vegetation cover) predicts belowground processes:

Soil respiration, soil microbial enzyme activity, microbial biomass, soil carbon and N mineralization rate

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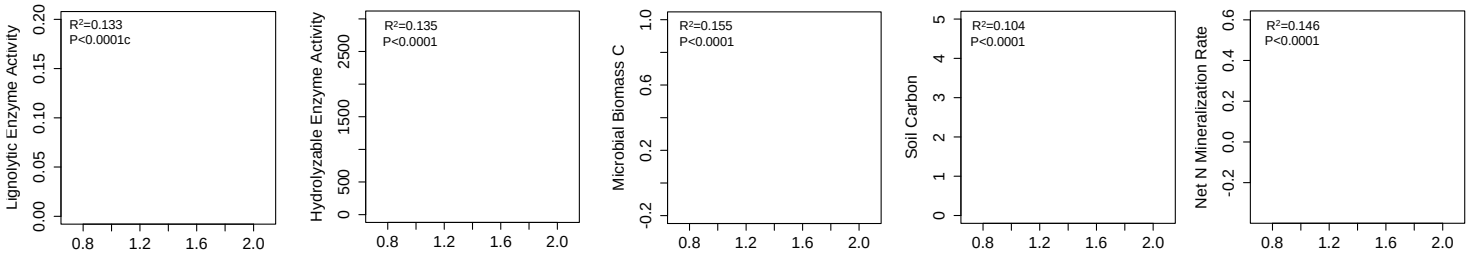
Wood River



RS %N

Quality of inputs (RS foliar %N, etc.) predicts belowground processes:

Soil microbial enzyme activity, microbial biomass, soil carbon and N mineralization rate

BioDIV

	Lignolytic activity	Hydrolytic activity	Microbial biomass C	Microbial biomass N	Net N mineralization	Cumulative respiration	Soil C	Soil N
LMA	0.1	-0.2	-0.3	-0.1	0.2	-0.3	0.3	0.0
% N	0.0	0.1	-0.1	0.0	0.3	-0.2	0.2	0.1
% Solubles	0.1	0.0	-0.2	-0.1	0.3	-0.4	0.7	0.1
% Cellulose	-0.1	0.0	0.2	0.1	-0.3	0.3	-1.0	-0.1
% Hemicellulose	-0.1	0.0	0.2	0.1	-0.3	0.4	-0.4	-0.1
% Lignin	0.1	-0.1	-0.1	0.0	0.2	-0.3	-0.6	0.0
Biomass	-0.2	**0.5**	**0.6**	**0.6**	0.2	**0.6**	**0.6**	0.1
RS LMA	0.2	-0.1	**-0.4**	-0.2	0.2	-0.4	-0.2	-0.1
RS % N	0.0	0.3	-0.3	-0.2	0.1	-0.1	-0.2	-0.2
RS % Solubles	0.2	0.2	-0.3	-0.2	0.2	-0.2	-0.2	-0.1
RS % Cellulose	-0.1	-0.2	0.1	0.0	-0.2	0.1	0.0	0.1
RS % Hemicellulose	-0.2	-0.2	0.2	0.1	-0.2	0.2	0.1	0.1
RS % Lignin	0.2	0.0	-0.3	-0.3	0.1	-0.3	-0.3	-0.2
RS Vegetation cover	-0.2	**0.6**	**0.6**	**0.7**	0.2	**0.8**	**0.7**	0.1
C3 proportion	0.1	-0.1	-0.2	-0.1	0.1	-0.3	0.1	0.1
C4 proportion	0.1	0.2	0.2	0.1	**-0.3**	0.3	0.0	0.0
Forb proportion	-0.3	-0.1	0.0	0.1	0.2	0.1	0.1	0.1
Legume proportion	0.2	0.1	0.1	0.2	0.1	-0.1	-0.2	-0.1

Wood River

	Lignolytic activity	Hydrolytic activity	Microbial biomass C	Microbial biomass N	Net N mineralization	Cumulative respiration	Soil C	Soil N
LMA	-0.2	0.2	**0.2**	**0.3**	**0.3**		0.2	0.2
% N	**-0.3**	**0.3**	**0.4**	**0.4**	**0.3**		**0.2**	**0.3**
% Solubles	**-0.3**	**0.3**	**0.4**	**0.4**	**0.4**		**0.2**	**0.2**
% Cellulose	**0.2**	**-0.3**	**-0.3**	**-0.3**	**-0.3**		-0.2	**-0.2**
% Hemicellulose	0.2	-0.2	**-0.3**	**-0.3**	**-0.2**		**-0.2**	**-0.2**
% Lignin	**-0.3**	**0.3**	**0.4**	**0.4**	**0.2**		**0.3**	**0.3**
Biomass	0.0	-0.1	-0.1	-0.1	0.0		0.0	0.1
RS LMA	**-0.2**	**0.3**	0.2	**0.3**	**0.4**		**0.2**	**0.2**
RS % N	**-0.4**	**0.4**	**0.4**	**0.4**	**0.4**		**0.3**	**0.3**
RS % Solubles	**-0.3**	**0.3**	**0.4**	**0.4**	**0.4**		**0.3**	**0.3**
RS % Cellulose	**0.3**	**-0.3**	**-0.3**	**-0.4**	**-0.4**		**-0.3**	**-0.3**
RS % Hemicellulose	**0.2**	**-0.3**	-0.2	**-0.3**	**-0.3**		-0.2	-0.2
RS % Lignin	**-0.3**	**0.3**	**0.3**	**0.3**	**0.3**		**0.3**	**0.3**
RS Biomass	0.1	0.0	-0.1	-0.1	-0.1		-0.1	-0.1
C3 proportion	-0.1	0.1	0.2	0.2	0.0		0.2	0.2
C4 proportion	**0.3**	**-0.3**	**-0.4**	**-0.4**	**-0.3**		**-0.3**	**-0.3**
Forb proportion	-0.2	**0.2**	**0.2**	**0.3**	**0.3**		0.2	0.2
Legume proportion	**-0.3**	**0.2**	**0.3**	**0.3**	**0.2**		0.2	0.2

Soil and microbial processes

Vegetation quality: leaf-level chemistry

Quantity: biomass

RS vegetation quality

RS quantity

Vegetation quality: FG Composition

Positive correlation Negative correlation

Remote Sensing of Plant Biodiversity

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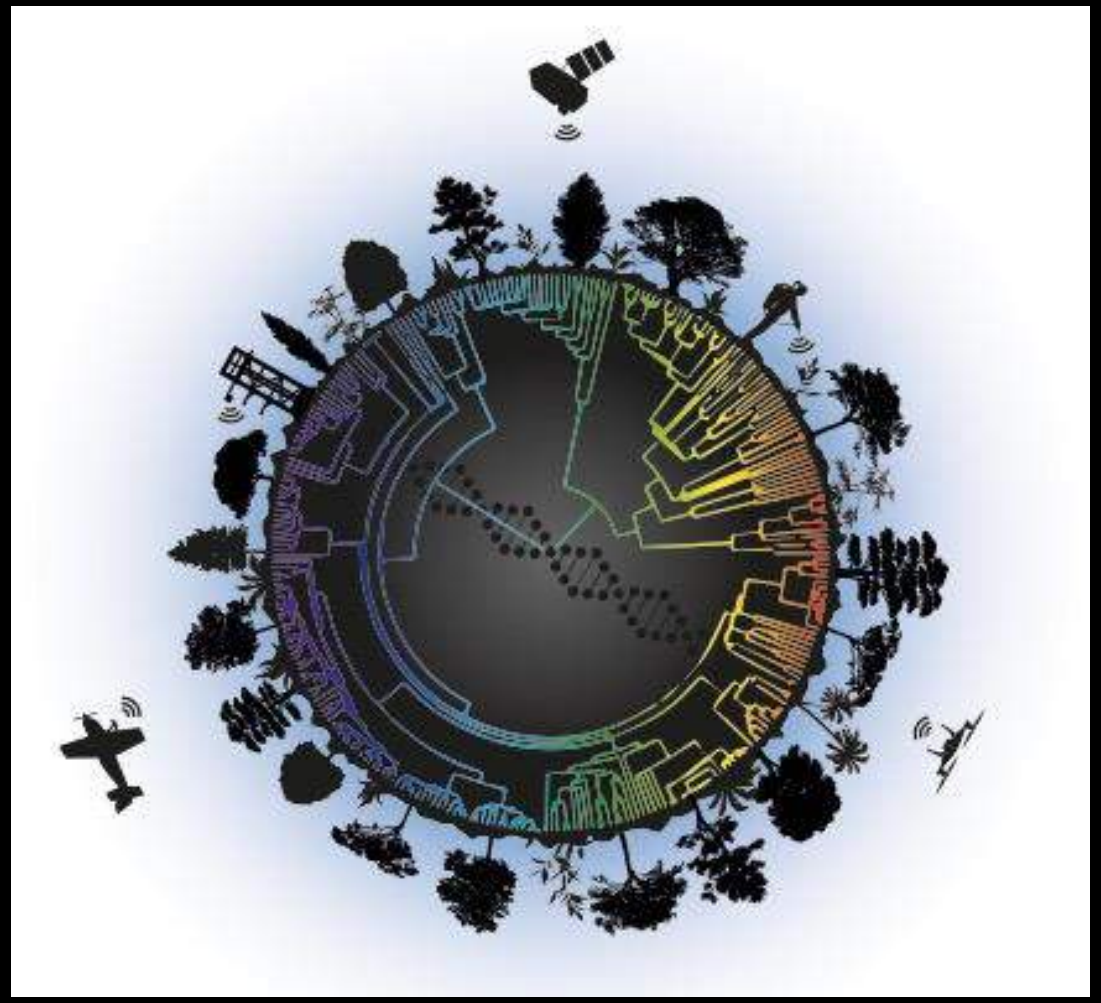
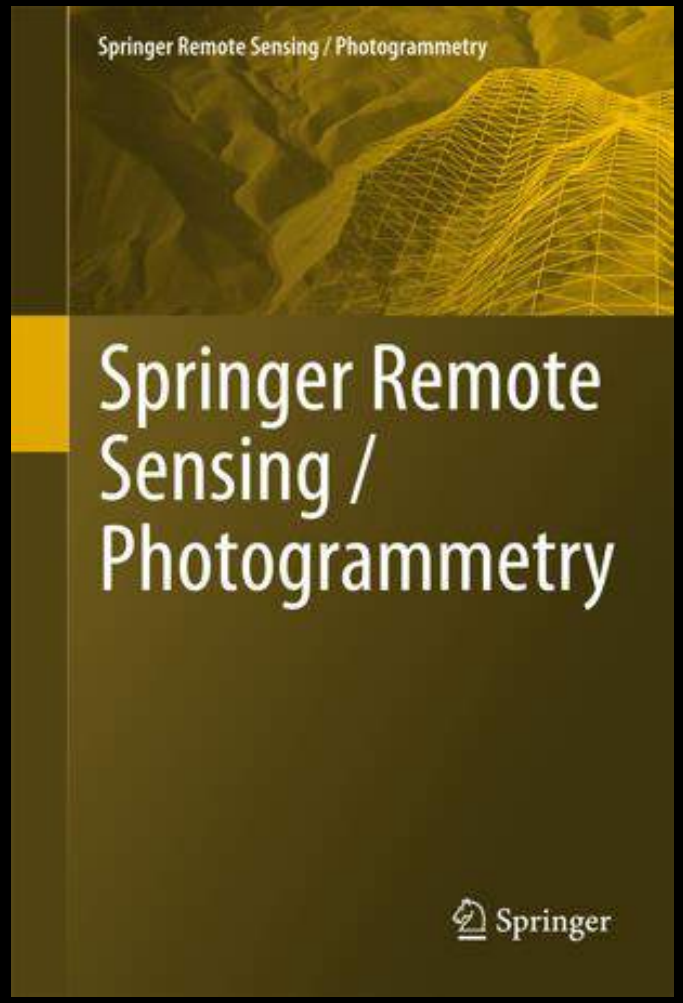
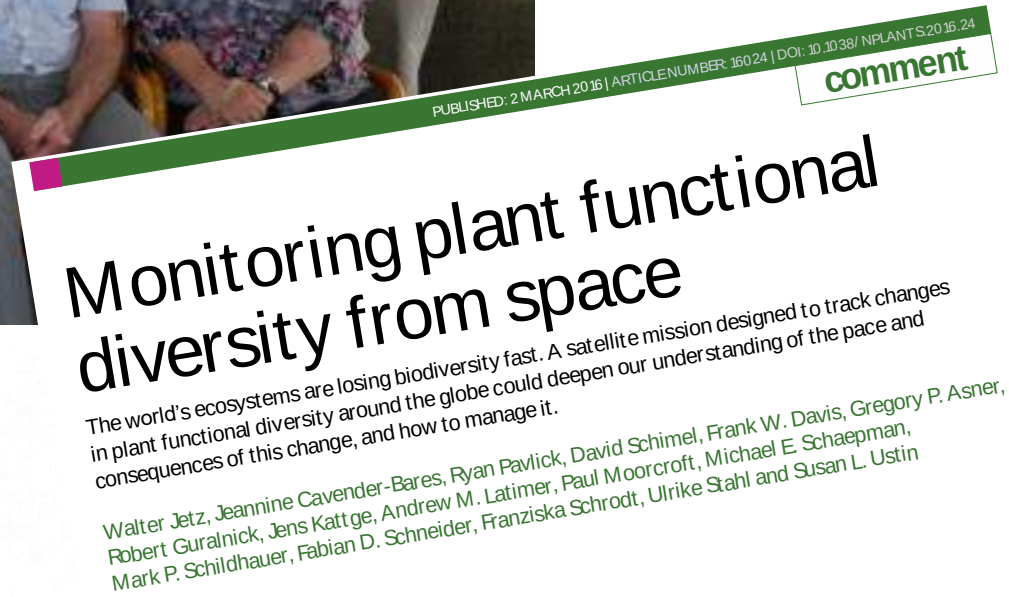




Forthcoming…December 2019

Prospects and priorities for satellite monitoring of global terrestrial biodiversity



PUBLISHED: 2 MARCH 2016 | ARTICLE NUMBER: 16024 | DOI: 10.1038/NPLANTS.2016.24

comment

Monitoring plant functional diversity from space

The world's ecosystems are losing biodiversity fast. A satellite mission designed to track changes in plant functional diversity around the globe could deepen our understanding of the pace and consequences of this change, and how to manage it.

Walter Jetz, Jeannine Cavender-Bares, Ryan Pavlick, David Schimel, Frank W. Davis, Gregory P. Asner, Robert Guralnick, Jens Kattge, Andrew M. Latimer, Paul Moorcroft, Michael E. Schaepman, Mark P. Schildhauer, Fabian D. Schneider, Franziska Schrodt, Ulrike Stahl and Susan L. Ustin

NCEAS

National Center for Ecological Analysis and Synthesis

NSF-RCN MEETING: Cross-Scale Processes Impacting Biodiversity

JUNE 10-15, 2018; Cedar Creek Ecosystem Science Reserve

Cedar Creek Ecosystem Science Reserve | 2660 Fawn Lake Drive NE East Bethel, Minnesota 55005 | Phone: 612-301-2600

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The regional assessment report on

BIODIVERSITY AND ECOSYSTEM SERVICES **FOR THE AMERICAS**

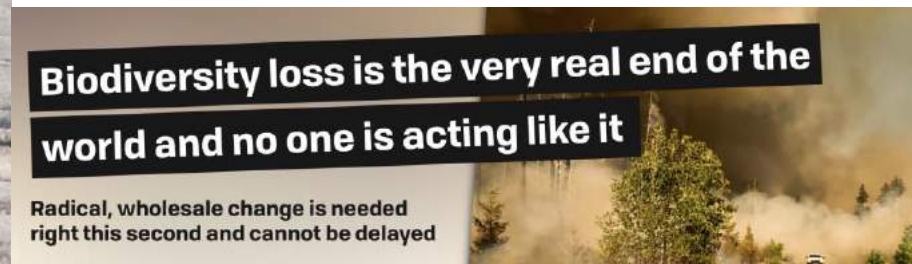
SUMMARY FOR POLICYMAKERS

ipbes

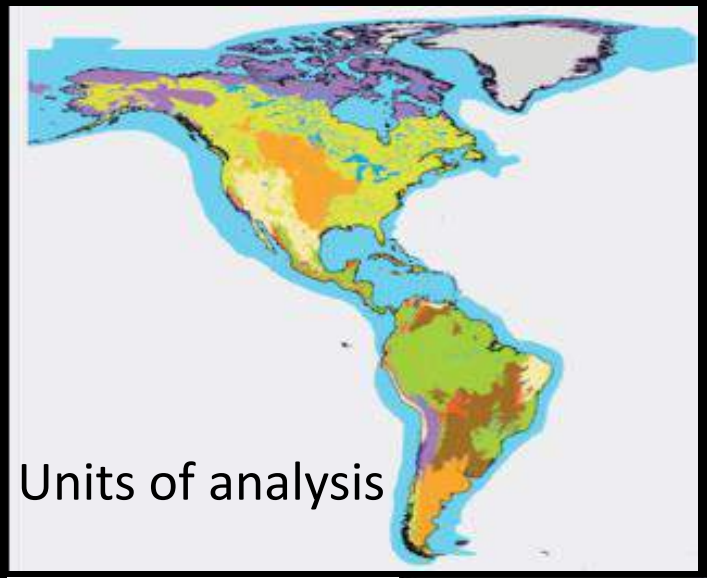
NEWS · 06 MAY 2019 · UPDATE 06 MAY 2019

Humans are driving one million species to extinction

Landmark United Nations-backed report finds that agriculture is one of the biggest threats to Earth's ecosystems.



IPBES: Assessing trends in diversity and ecosystem function



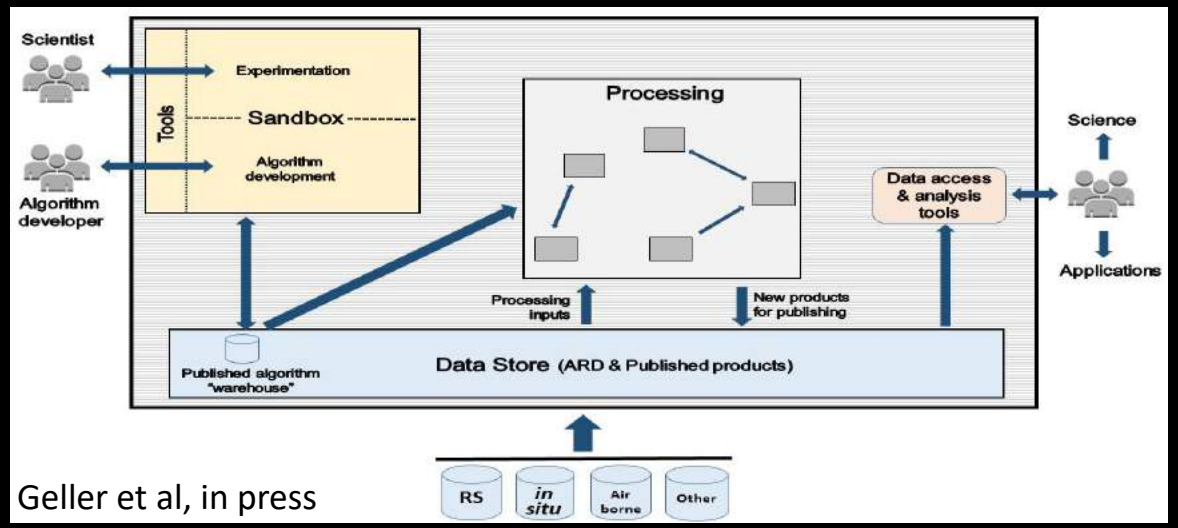
(expert opinion…)

We can do better!

	Units of analysis	Recent trends (40 yrs)				
		Habitat amount	Habitat degradation	Native species diversity	Threatened species	Alien & Invasive species
North America	Temperate and boreal forests and woodlands	↗....	↗....	↘...	↔....	↗...
	Mediterranean forests, woodlands and scrub	↘....	↗....	↘....	↗....	↗....
	Tundra and high mountain habitats	↔..	↗....	↔....	↔....	↗..
	Temperate grasslands	↘....	↗....	↘....	↗....	↗....
	Drylands and deserts	↘....	↗....	↘....	↗....	↗....
	Wetlands - peatlands, mires, bogs	↘....	↗....	↘.	↗.	↗....
	Freshwater	↘.	↗....	↘...	↗...	↗....
	Coastal marine	↘....	↗....	↘...	↗..	↗....
	Sea Ice	↘..	↗.	↔..	↔..	↗..

UNIT OF ANALYSIS	MATERIAL NCP				NON-MATERIAL NCP		
	Food and Feed	Materials and assistance	Energy	Medicinal, biochemical and genetic resources	Learning and inspiration	Supporting identities	Physical and psychological experiences
Tropical and subtropical moist forest	↘	→	↗	↗	→	→	→
Tropical and subtropical dry forest	↓	↘	→	↗	→	↘	→
Temperate and boreal forests and woodlands	↘	→	→	→	→	↘	→
Mediterranean forests, woodlands and scrub	↘	↘	↘	↘	→	→	→
Tundra and high montane habitats	↘	→	↓	↘	→	↘	→
Tropical and sub-tropical savannas and grasslands	↘	↘	↘	↗	→	→	→

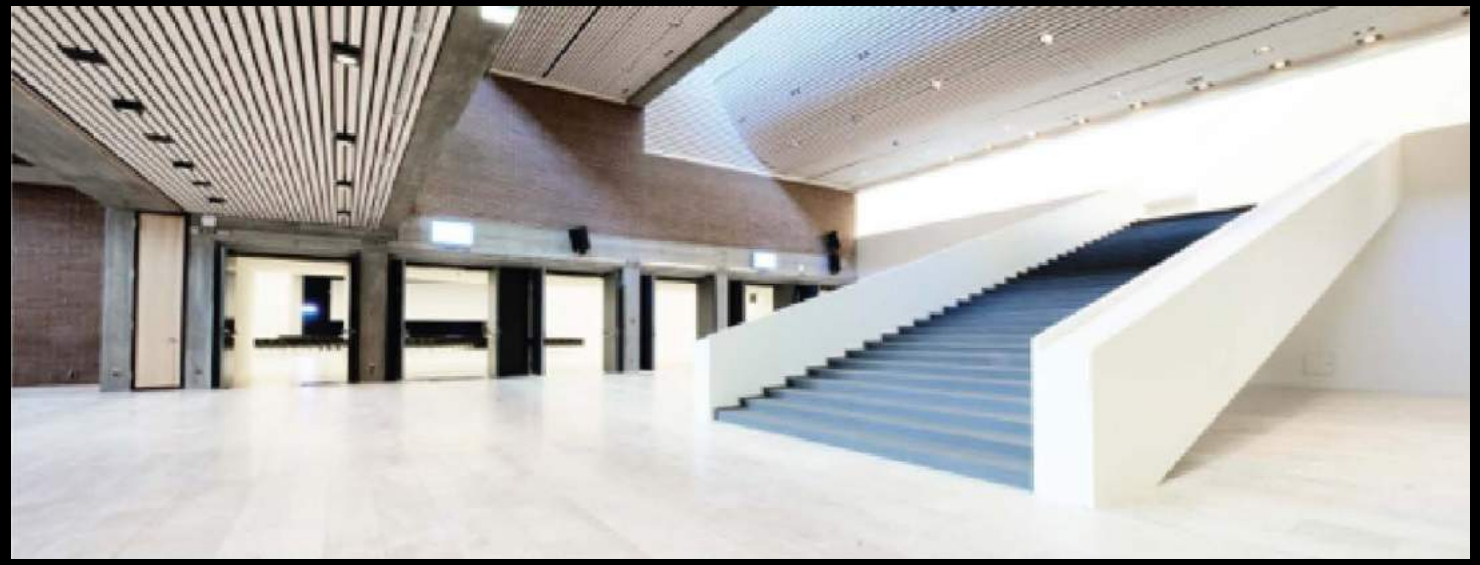
Keck Institute for Space Studies – "Unlocking a New Era in Biodiversity Science"



Geller et al, in press

Towards a Global Biodiversity Monitoring System

WORLD BIODIVERSITY FORUM 2020



Davos, Switzerland - February 2020