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Soil Microbiome Scientist

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ASSESSING SOIL HEALTH AT SCALE AND INCORPORATING MEASURES OF THE MICROBIOME

SOIL HEALTH INSTITUTE SCIENCE TEAM

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SOIL HEALTH:
The capacity of a soil to function as a vital, living ecosystem that sustains plants, animals, and humans.
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THE FOUNDATION FOR
Regenerative Agriculture

Outline

- Choosing soil health indicators
- Interpreting soil health indicators
- Incorporating measures of the microbiome in soil health

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NORTH AMERICAN PROJECT TO EVALUATE SOIL HEALTH MEASUREMENTS TEAM

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Dr. Dianna Bagnall
Dr. Michael Cope
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Dr. Paul Tracy

Dr. Kelsey Greub
Dr. Dan Liptzin
Dr. Liz Rieke
Dr. Mac Bean
Dr. Charlotte Norris



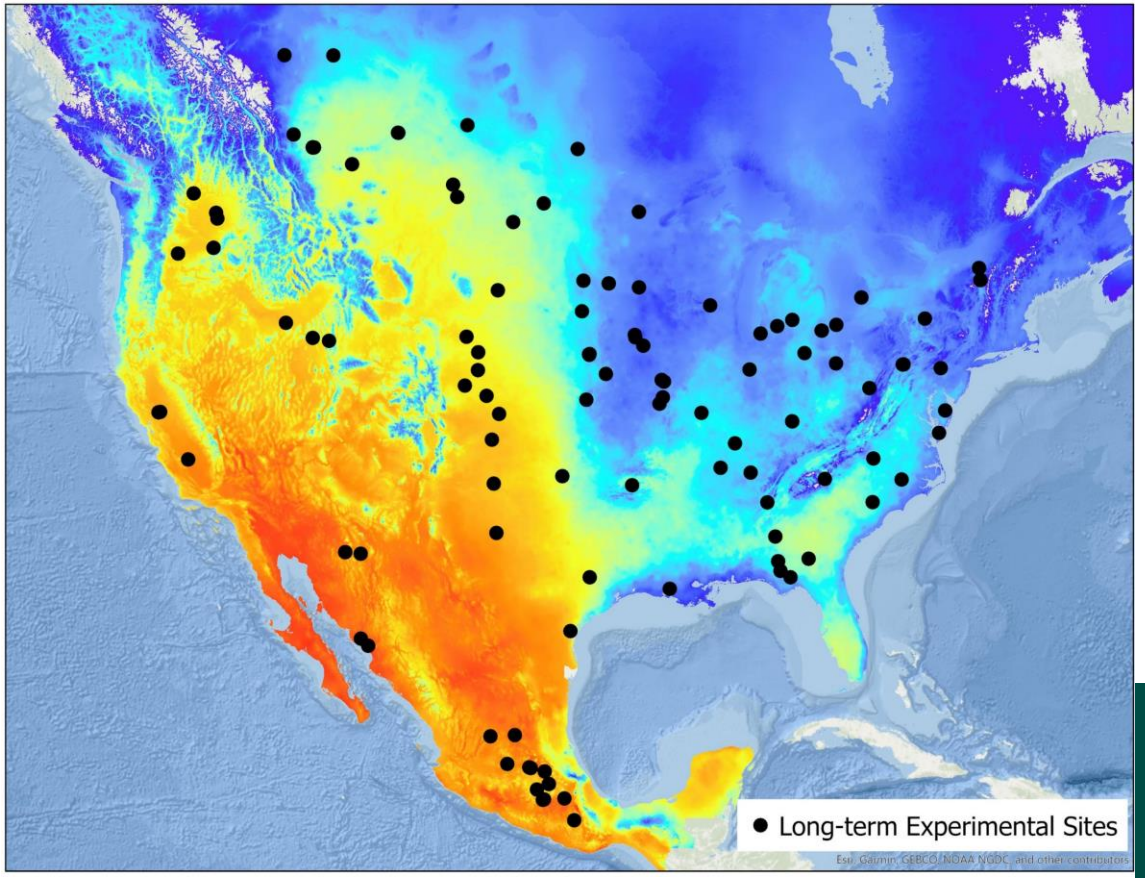



GOAL: Identify most effective indicators of soil health

APPROACH: Evaluate soil health indicators on long-term agricultural research sites

124 long term experimental sites

Over 30 Measurements that indicate soil health



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General Mills

FFAR

Measures of Soil Health

CARBON	NITROGEN	WATER/STRUCTURE	COMMUNITY
Soil Organic Carbon	Total N	Plant Available Water	16S Amplicon Sequencing
Active Carbon(POXc)	Autoclaved Citrate Extractable Protein - ACE	Saturated Hydraulic Conductivity	ITS Amplicon Sequencing
Potentially Mineralizable C (24 & 96 hr CO_2-C)	Potentially Mineralizable N - Anaerobic	Porosity/Bulk Density	Shotgun Function Metagenomics
B-glucosidase	N-acetyl B-glucosamidase	Soil Stability Index	Phospholipid Fatty Acid - PLFA
Water Extractable C	Water Extractable N	Aggregate Stability – Wet Sieve, SLAKES, Sprinkle Infiltrometer	Enzymes(C, N, P, S)
Microbial Biomass C	H3A Extractable N		

Measurement Criteria

- **Primarily indicate soil health**
  - Not inherent properties
  - Not fertility measurements
- **Responsive to soil health management practices**
  - Reduced tillage
  - Cover crops
  - Organic amendments
  - Residue retention
- **Applicable for measurement at scale**
  - Cost effective
  - Available commercially
- **Non-redundant**
  - Provide information on different ecosystem services

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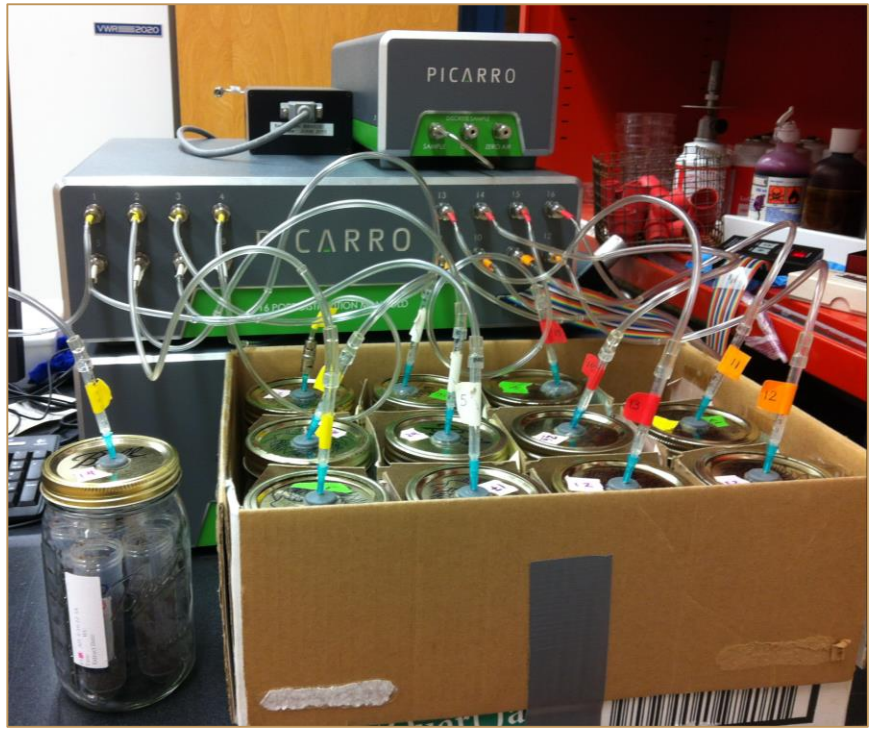
Measurement Selection

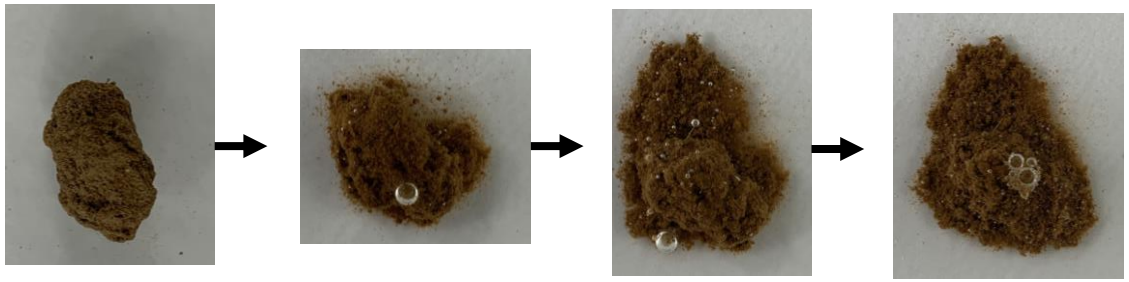
- **Soil organic carbon**
  - Major component of soil organic matter
  - Measure using dry combustion

- **24-hr Potential carbon mineralization**
  - "Respiration"
  - Microbial response to soil rewetting
  - Related to microbial biomass



Measurement Selection

- **Aggregate stability**
  - Linked to reduced erosion, increased infiltration
  - Fraction of aggregates remaining after exposed to wetting and/or mechanical disturbances



Photos and video by Kade Flynn

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Measurement Selection

- F

Soil Science Society of America Journal

PAPERS ON ORIGINAL RESEARCH | Open Access

Carbon-sensitive pedotransfer functions for plant available water

Dianna Kathleen Bagnall, Cristine L.S. Morgan, Michael Cope, Gregory M. Bean, Shannon Cappellazzi, Kelsey Greub, Daniel Liptzin, Charlotte L. Norris, Elizabeth Rieke, Paul Tracy ... See all authors

First published: 23 February 2022 | https://doi.org/10.1002/saj2.20395

Assigned to Associate Editor Ryan D. Stewart

SOC (mg kg^{-1})
10
20
30
40

Conclusion

- Numerous soil health indicator options
- Most Responsive to Management
- Not all available at commercial laboratories
- Remove redundant measures to maximize knowledge

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Soil Health Interpretation at the Farm Level

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SOIL HEALTH TARGETS TEAM

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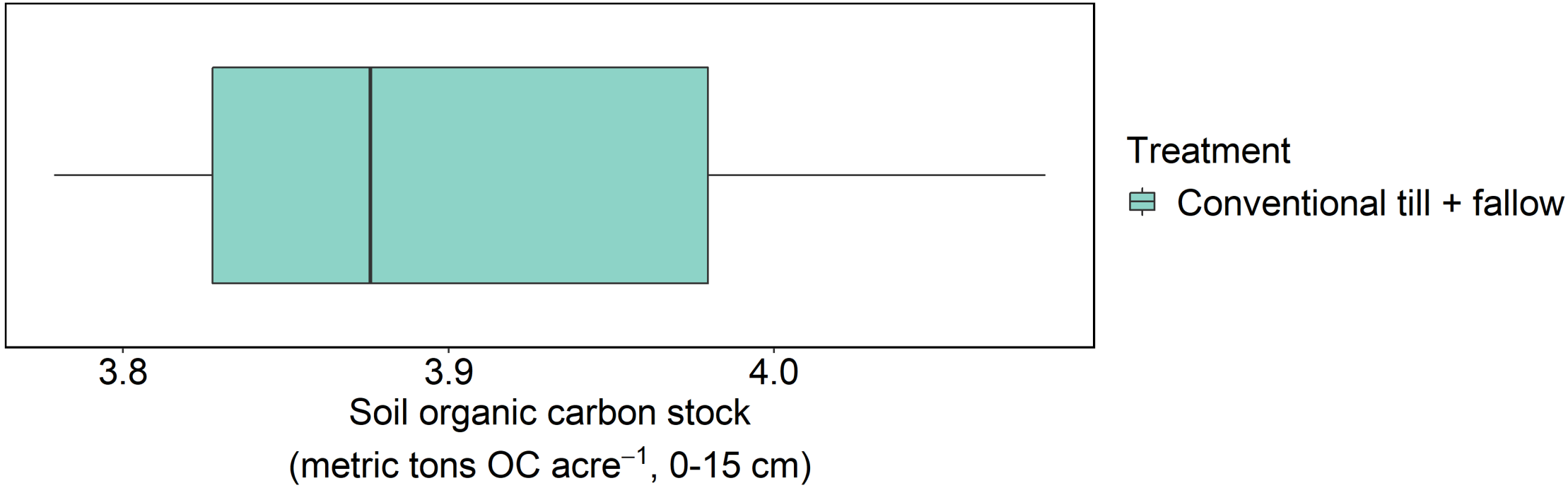
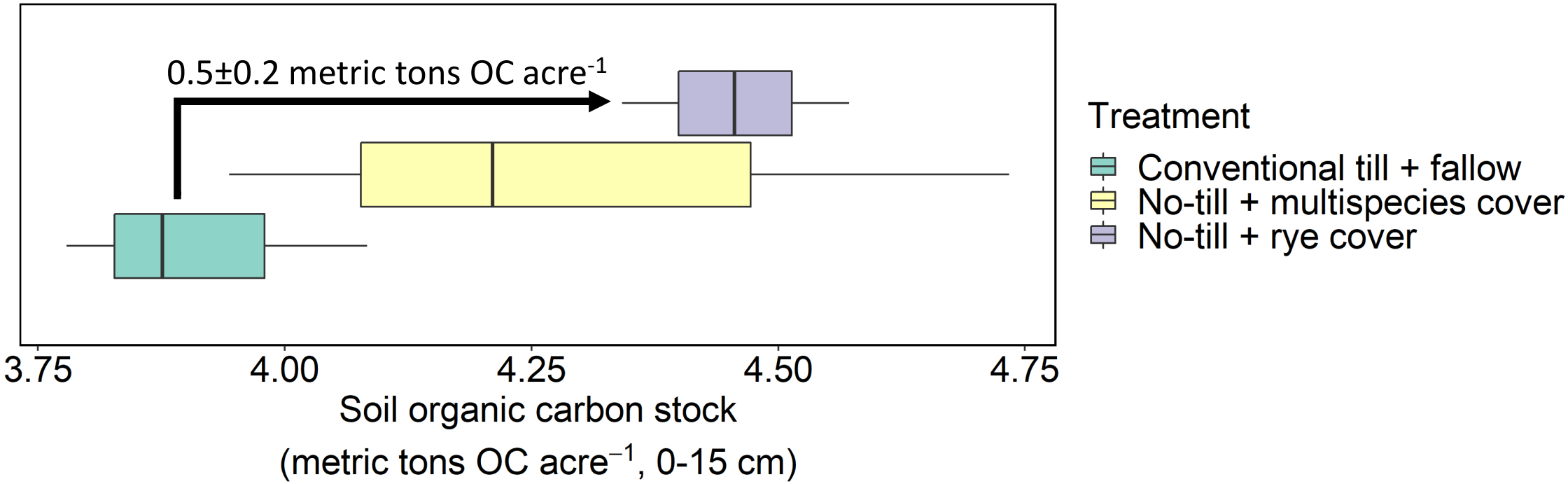
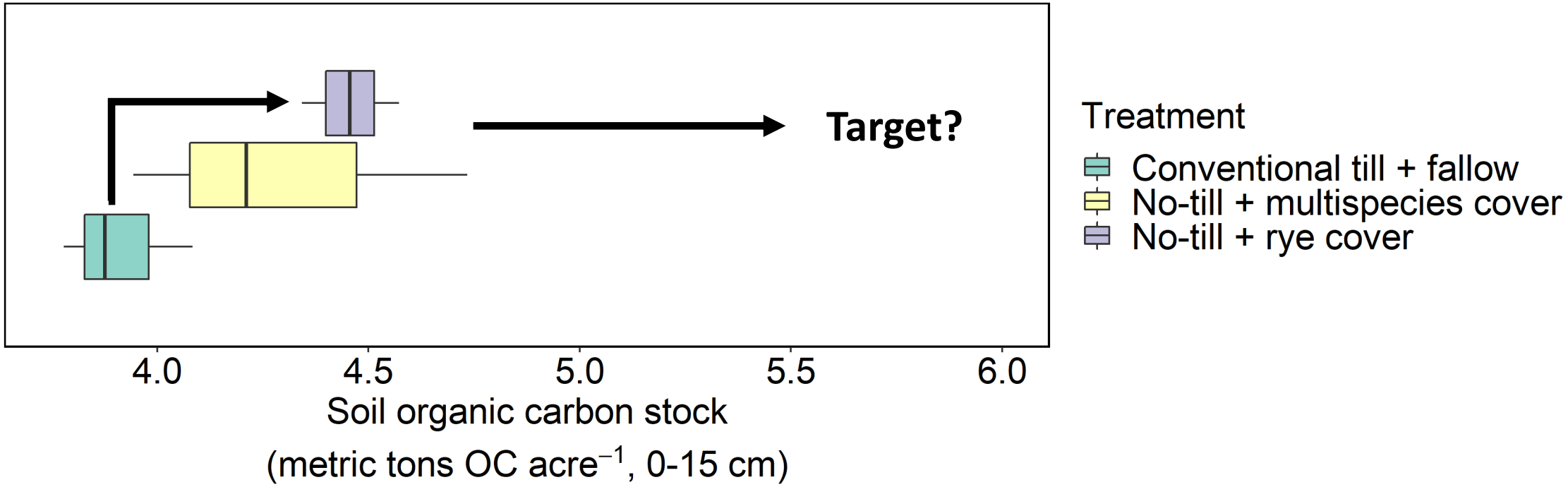
The Need for Quantifying Potential Soil Health Improvements



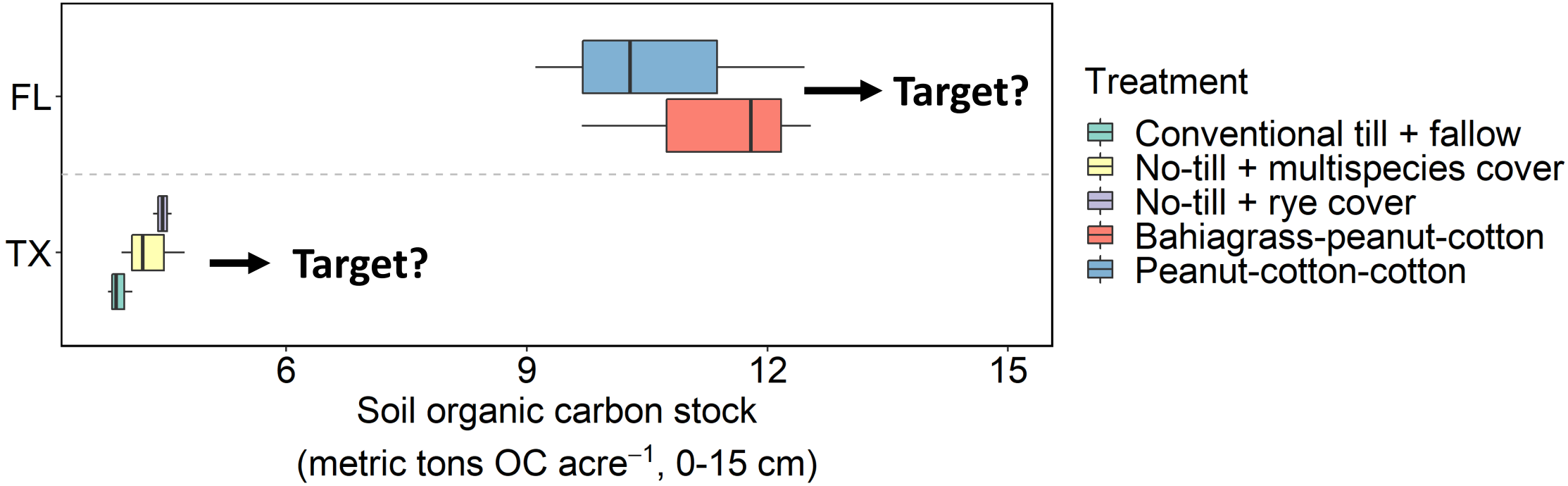
The Need for Quantifying Potential Soil Health Improvements



The Need for Quantifying Potential Soil Health Improvements: Effects of Long-Term Adoption/Innovation



The Need for Quantifying Potential Soil Health Improvements: Effects of Site Characteristics



Soil Health Targets Concept

Interpretable: Targets represent soil health achievable under optimal management (minimal disturbance, continuous living cover, …)

Scalable: Targets can be quantified even in locations where long-term soil health management systems are absent

Locally relevant: Targets are defined for groups of soils with similar site characteristics relevant to soil health (inherent soil properties, topography, and climate)

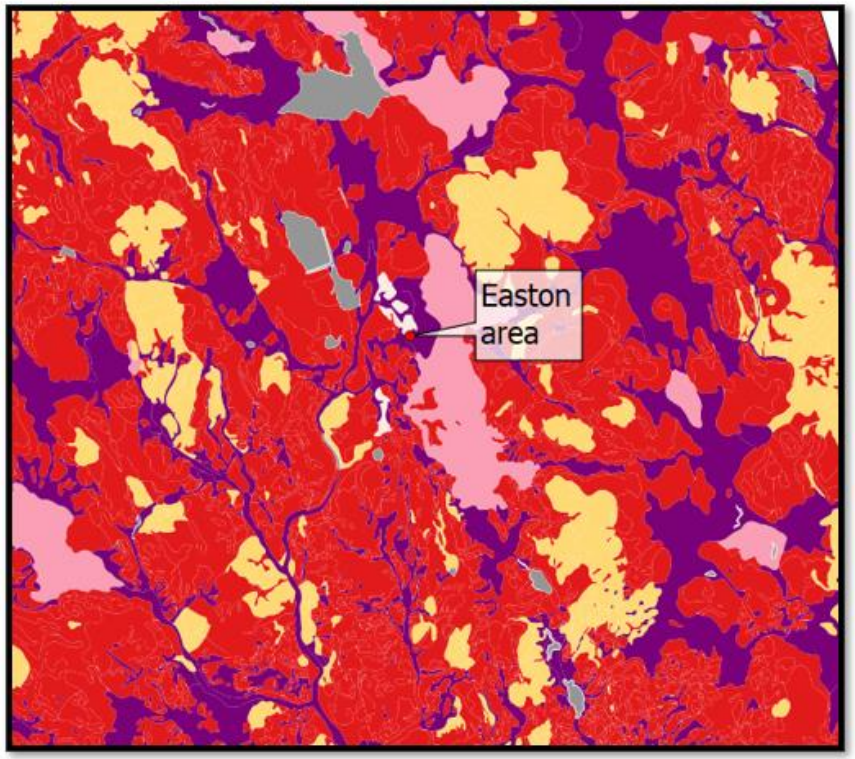
Soil Health Groups

- **Framework for site selection and reporting results**
- **Preliminary version implemented summer 2021**
- **Derived using publicly available data:**
  - USDA-NRCS Soil Survey
  - Gridded climate products
  - Topographic attributes
- **Soils are grouped according to inherent factors including:**
  - Mineralogy
  - Texture
  - Drainage

Soil Health Groups

Soil map units

Soil health groups



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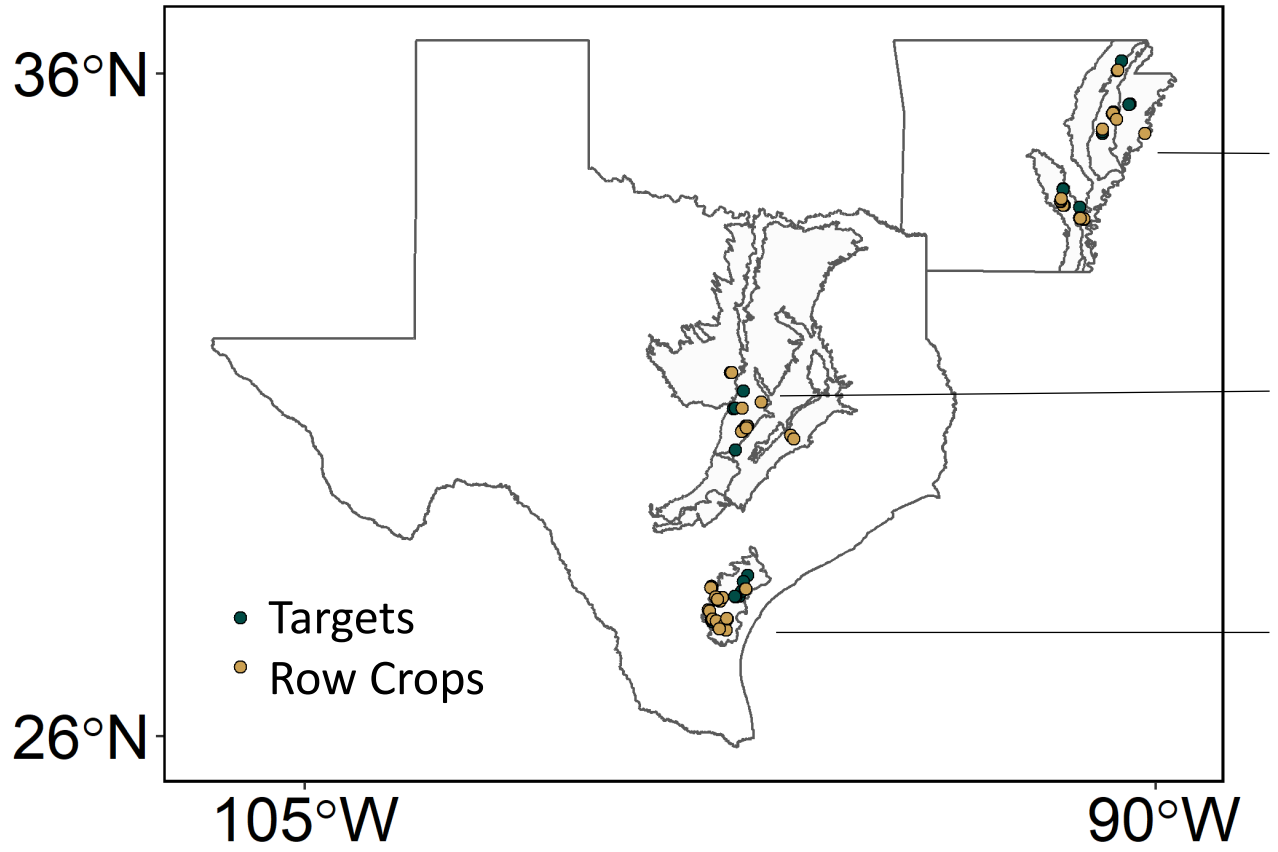
Soil Health Targets for Cotton-Producing Soils



Arkansas Delta

Blackland Prairie

Coastal Bend

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39 row crop fields and 52 targets

Targets: Soil Health under Optimal Management

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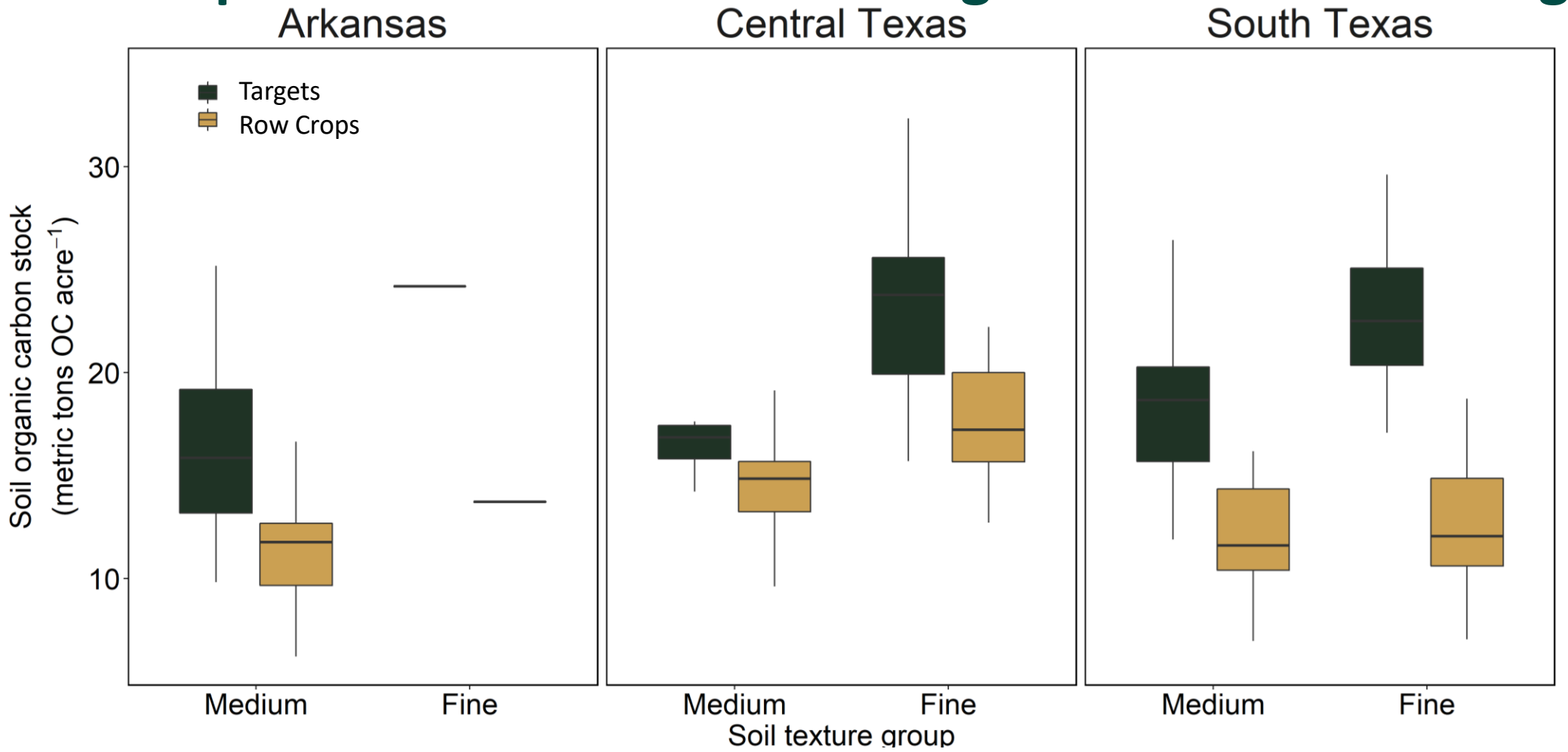
Potential Improvements in Carbon Storage across Soils and Regions



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Conclusion

- Multiple indicators provide complementary insights on potential improvements in soil functioning
- Soil health groups capture trends in soil health potential across soils and regions
- Reference sites give fuller picture of soil health potential for soils lacking examples of long-term SHMS adoption

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Microbiome Measurements & Soil Health

1) Enhance interpretation of common soil health measurements

2) Use as a stand alone measure

- Specific organisms
- Functional characteristics

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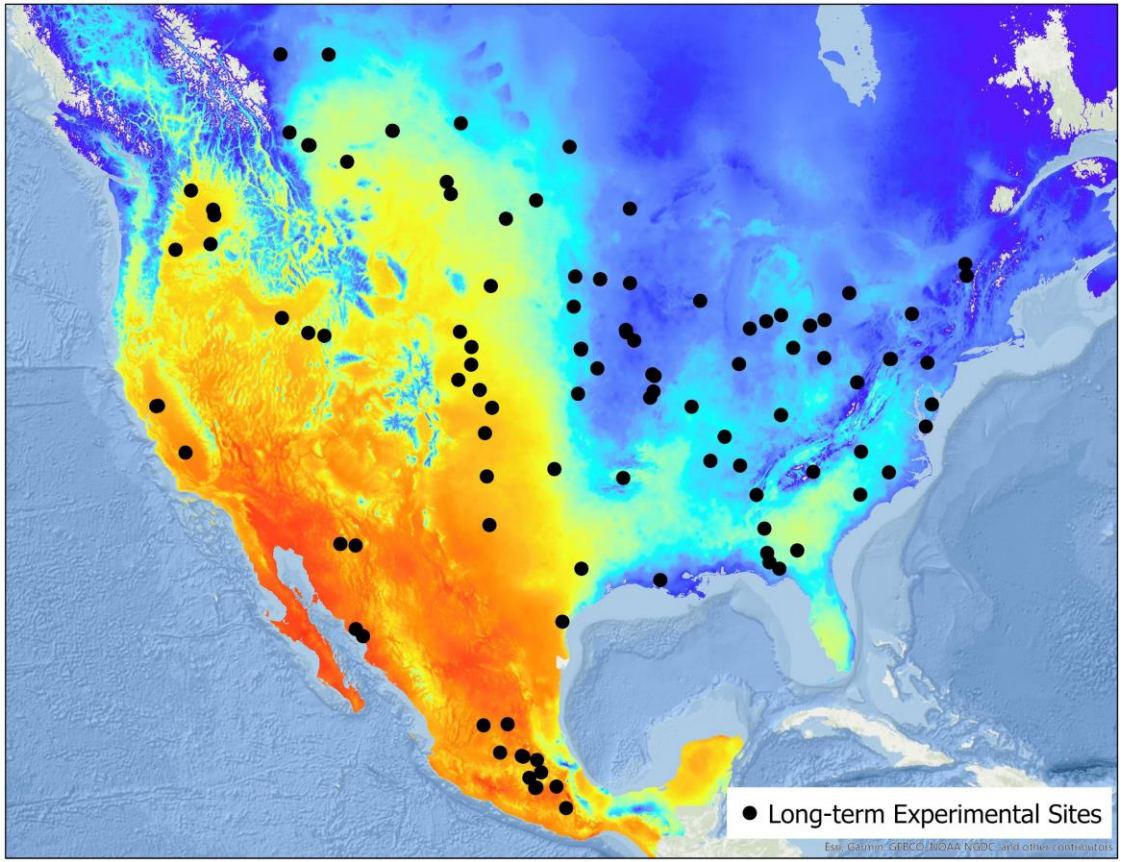
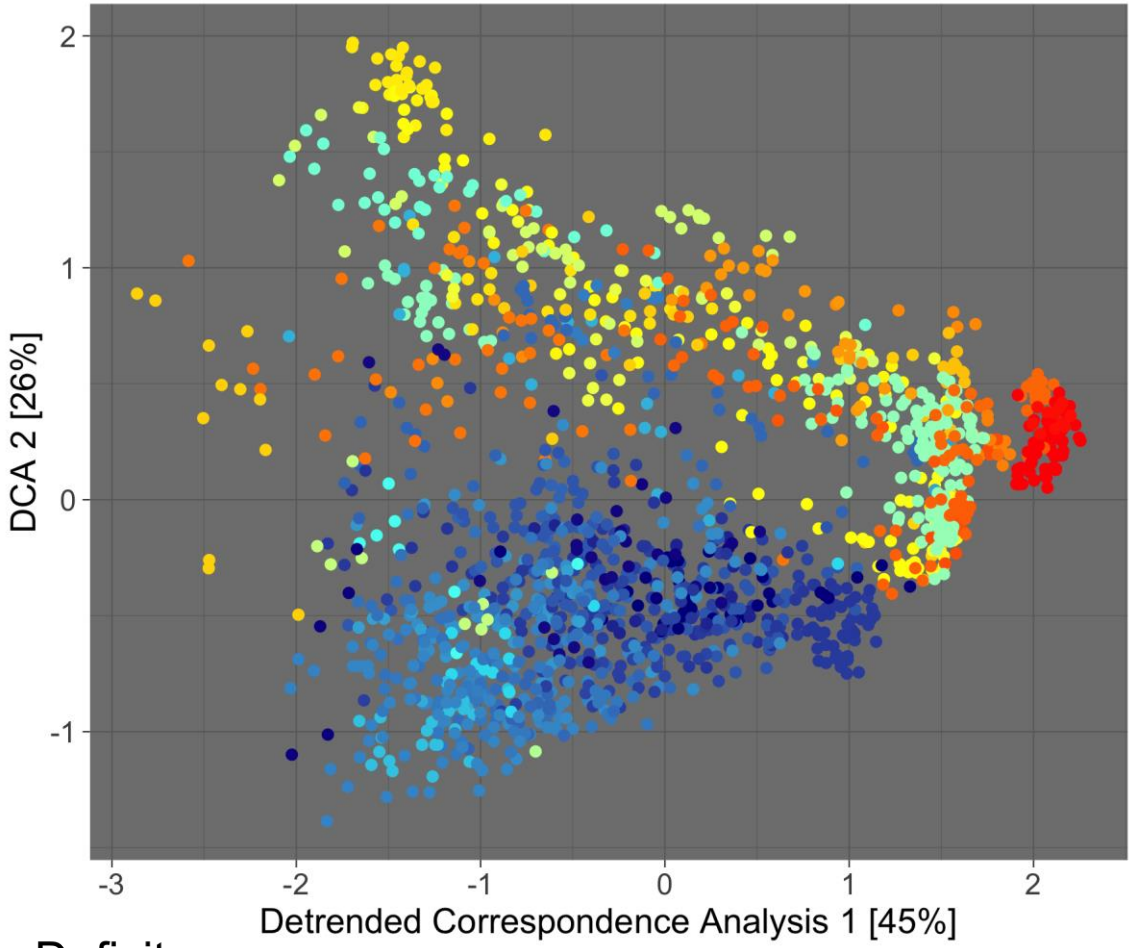
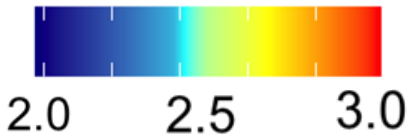
Bacterial & Archaeal Community Composition by Moisture Measurements





Climate Moisture Deficit



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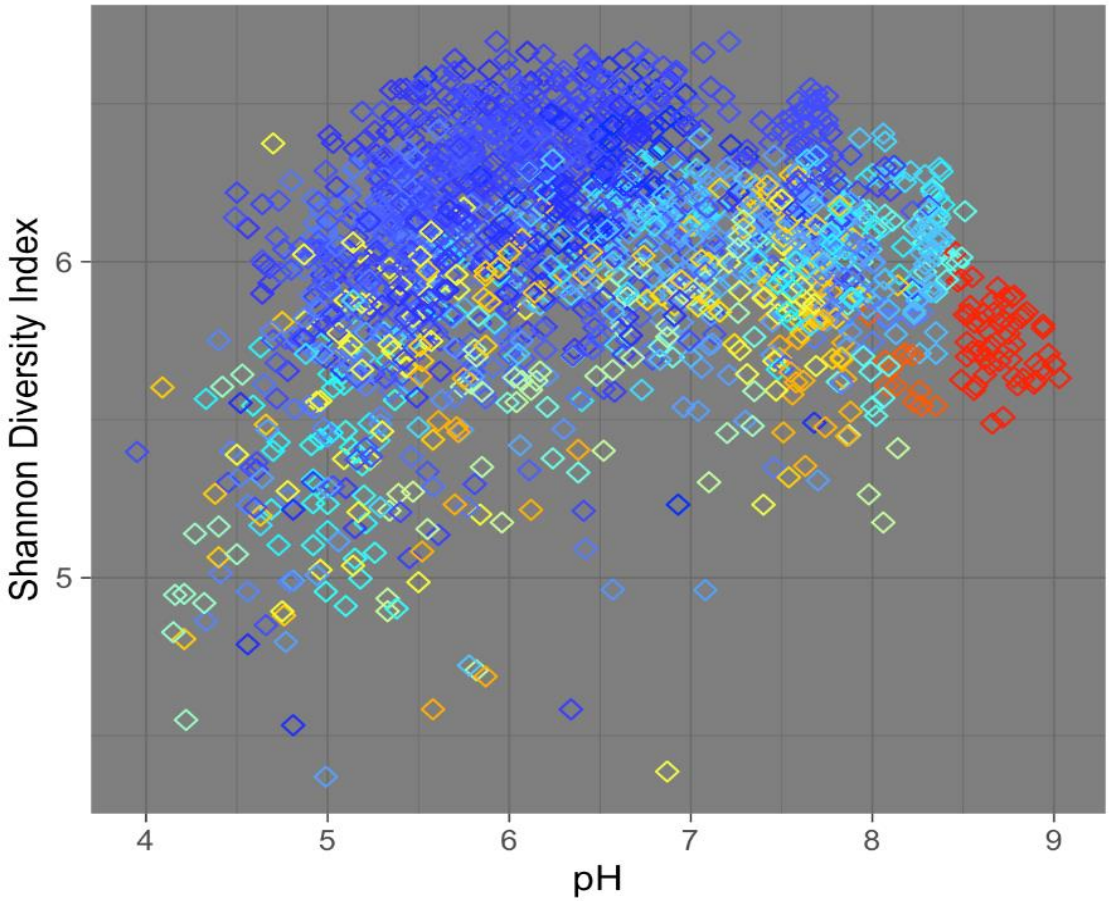
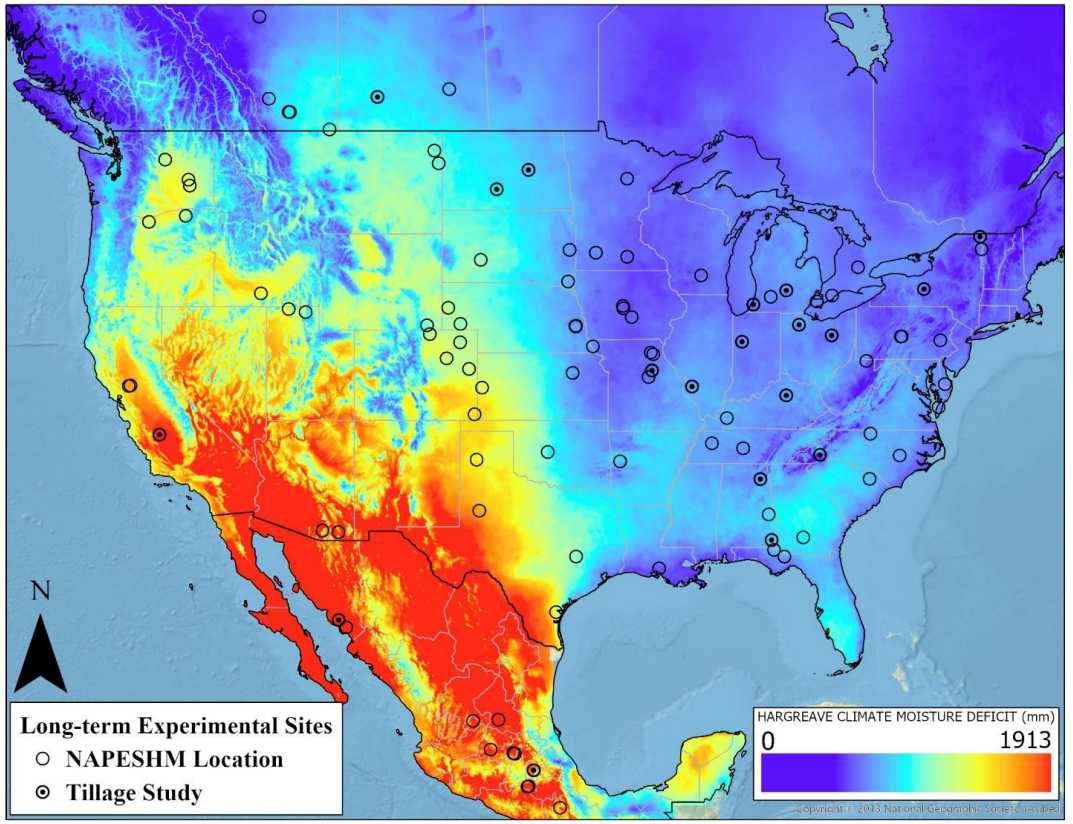
Drivers of Microbial Diversity





Goal

- **Link changes in soil microbial community structure from tillage to potential carbon mineralization across North America**

- **Objectives:**
  - Define tillage influence on community structure
  - Identify community members enriched under no-till systems across climates and soil types
  - Identify organisms influential in Cmin measurements

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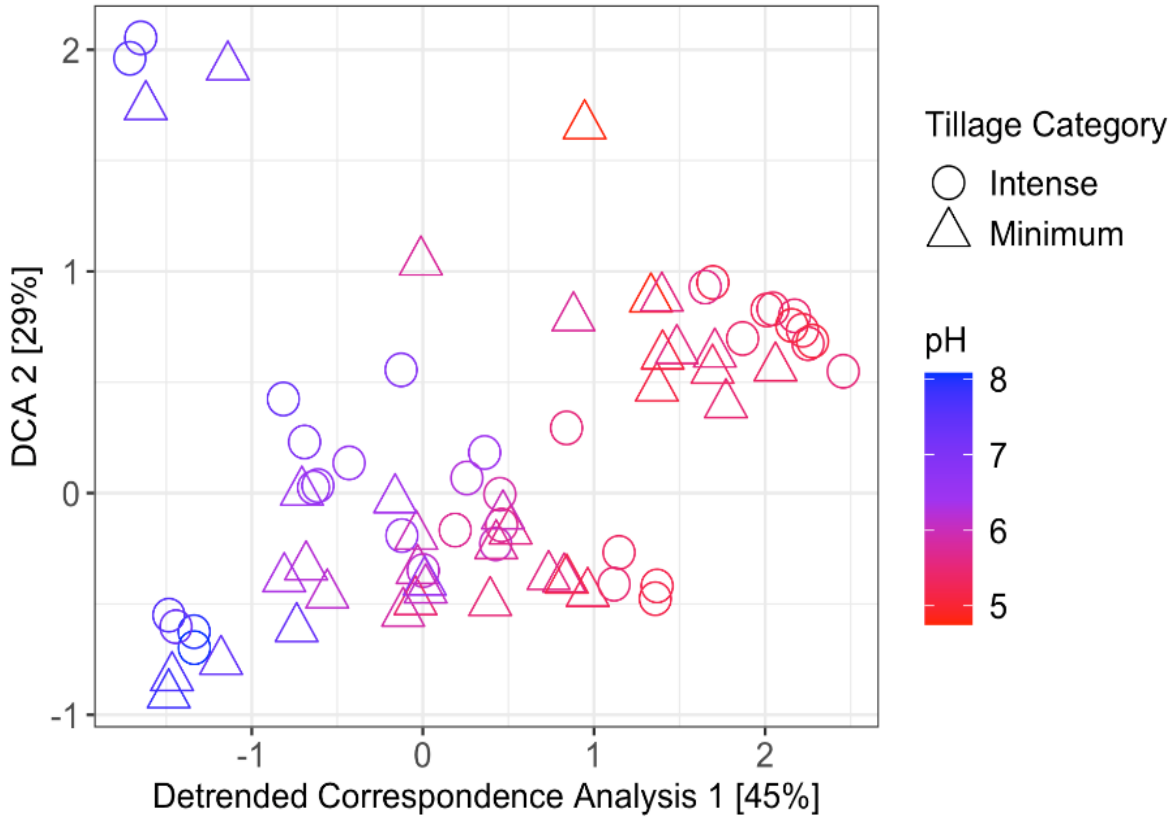
Community Structure: Minimum vs. Intense Tillage

- **11 of 14 sites had significantly different ($p<0.01$) community structures due to tillage**
- **3 non-significant sites were wheat-based rotations**
  - Sites represented different climates and soil properties



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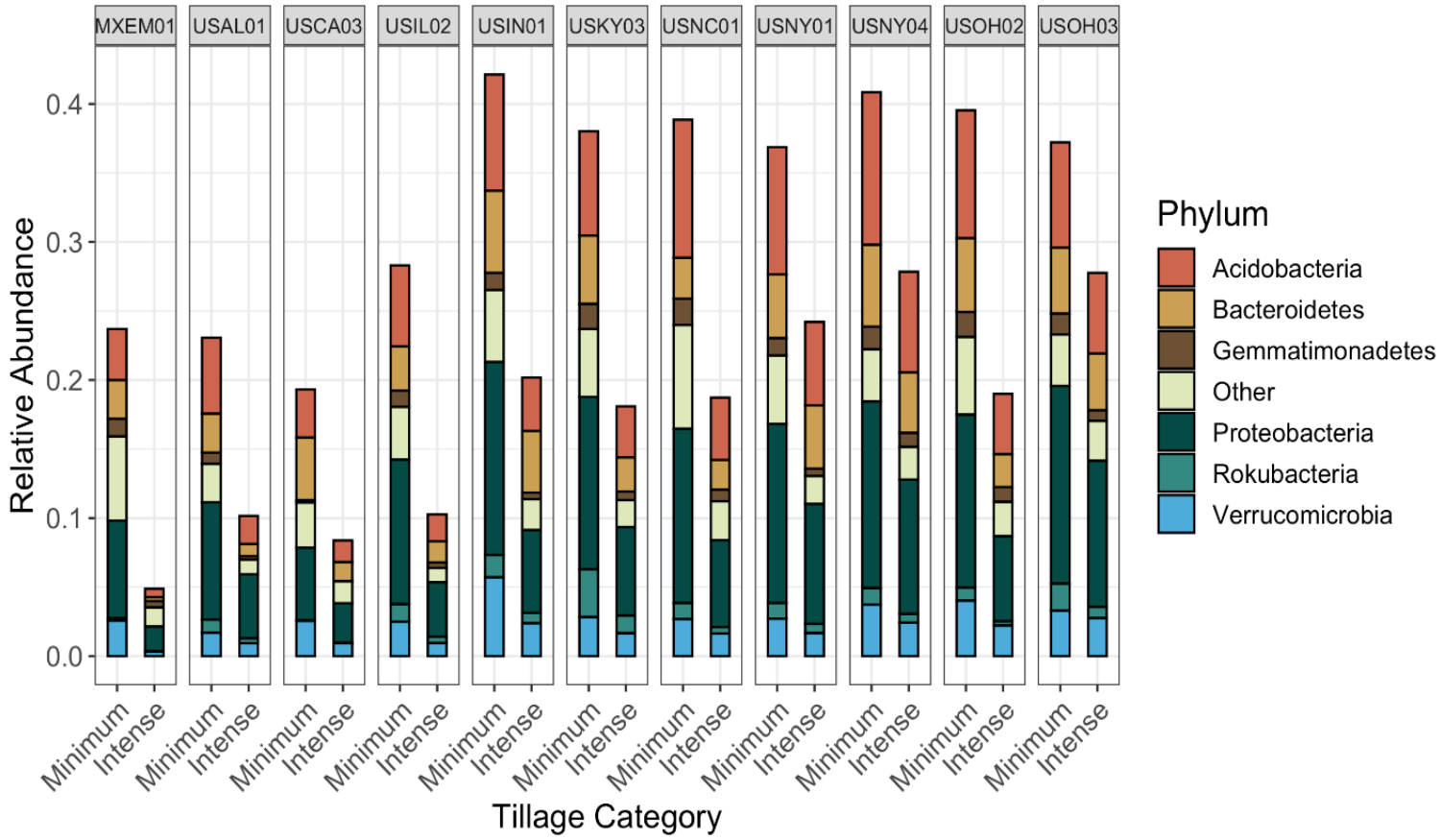
Community Structure: Minimum vs. Intense Tillage

- **717 ASVs were enriched under minimum tillage**
- **Representing:**
  - 16% of microbes in intense tillage
  - 33% of microbes in minimum tillage



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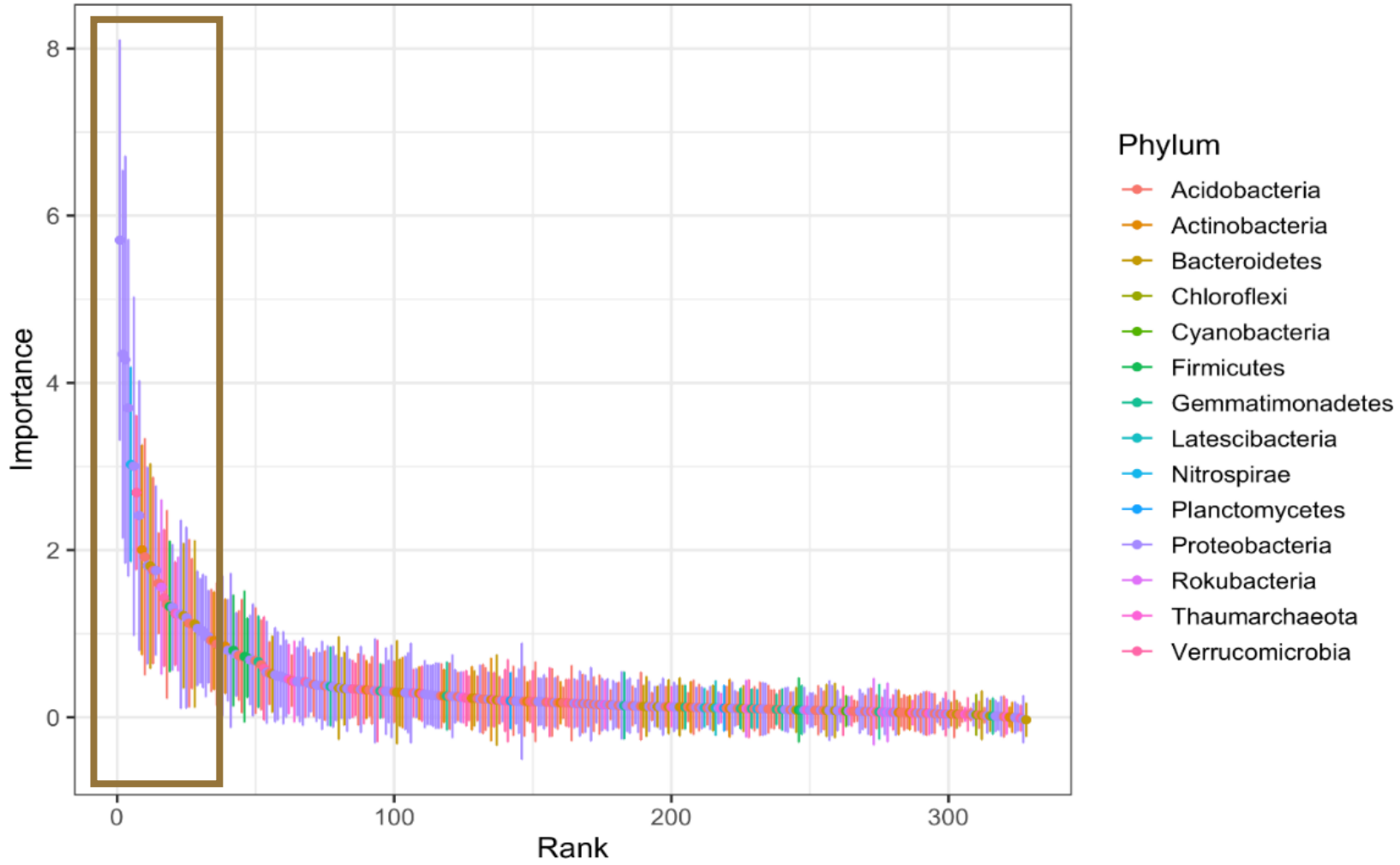
Modeling Carbon Mineralization

- Average sequence importance averaged over 30 model runs



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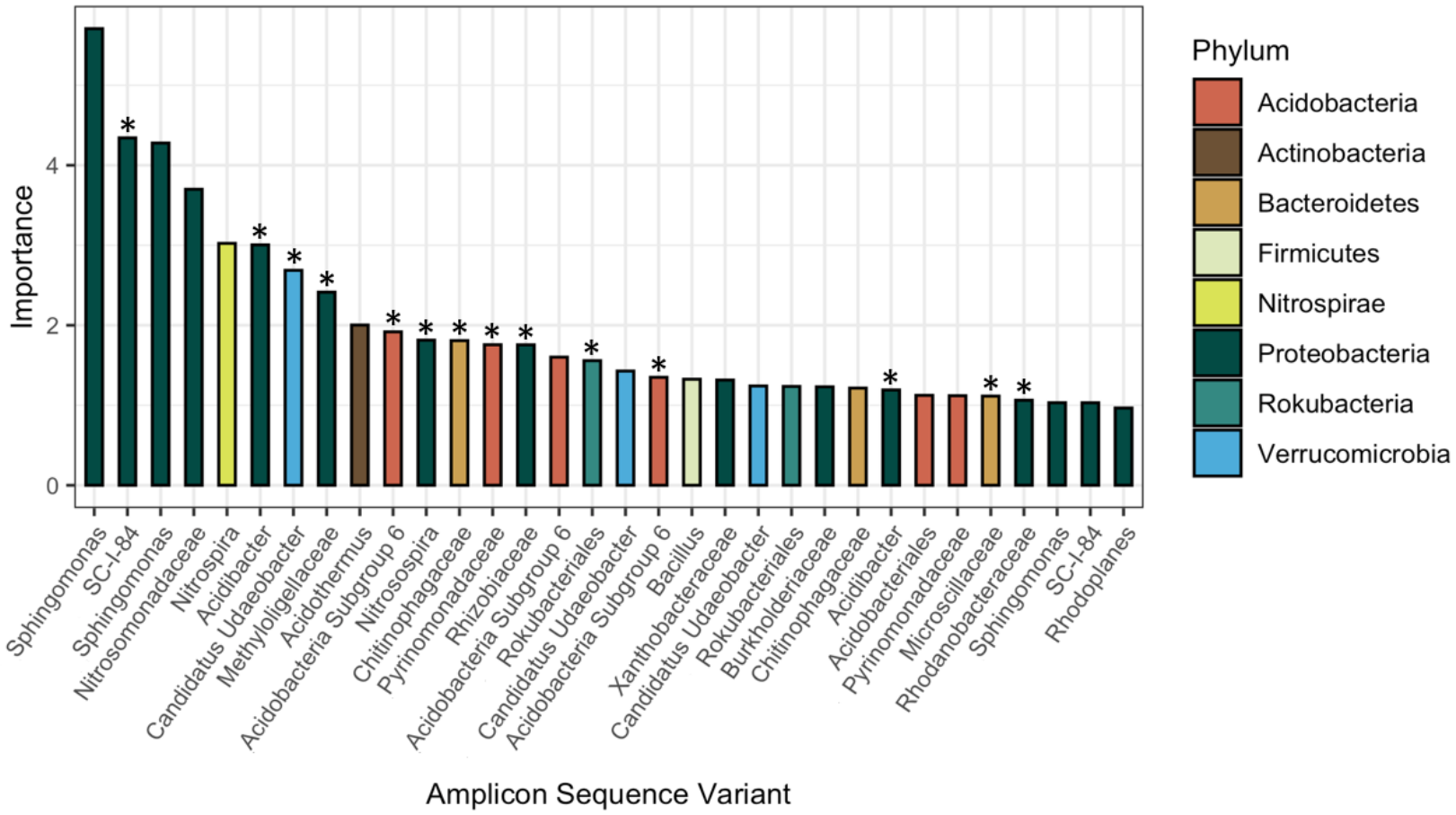
Modeling Carbon Mineralization

- **Proteobacteria contributed the most**
- **44% of sequences of model ASVs enriched under minimum tillage**



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Modeling Carbon Mineralization

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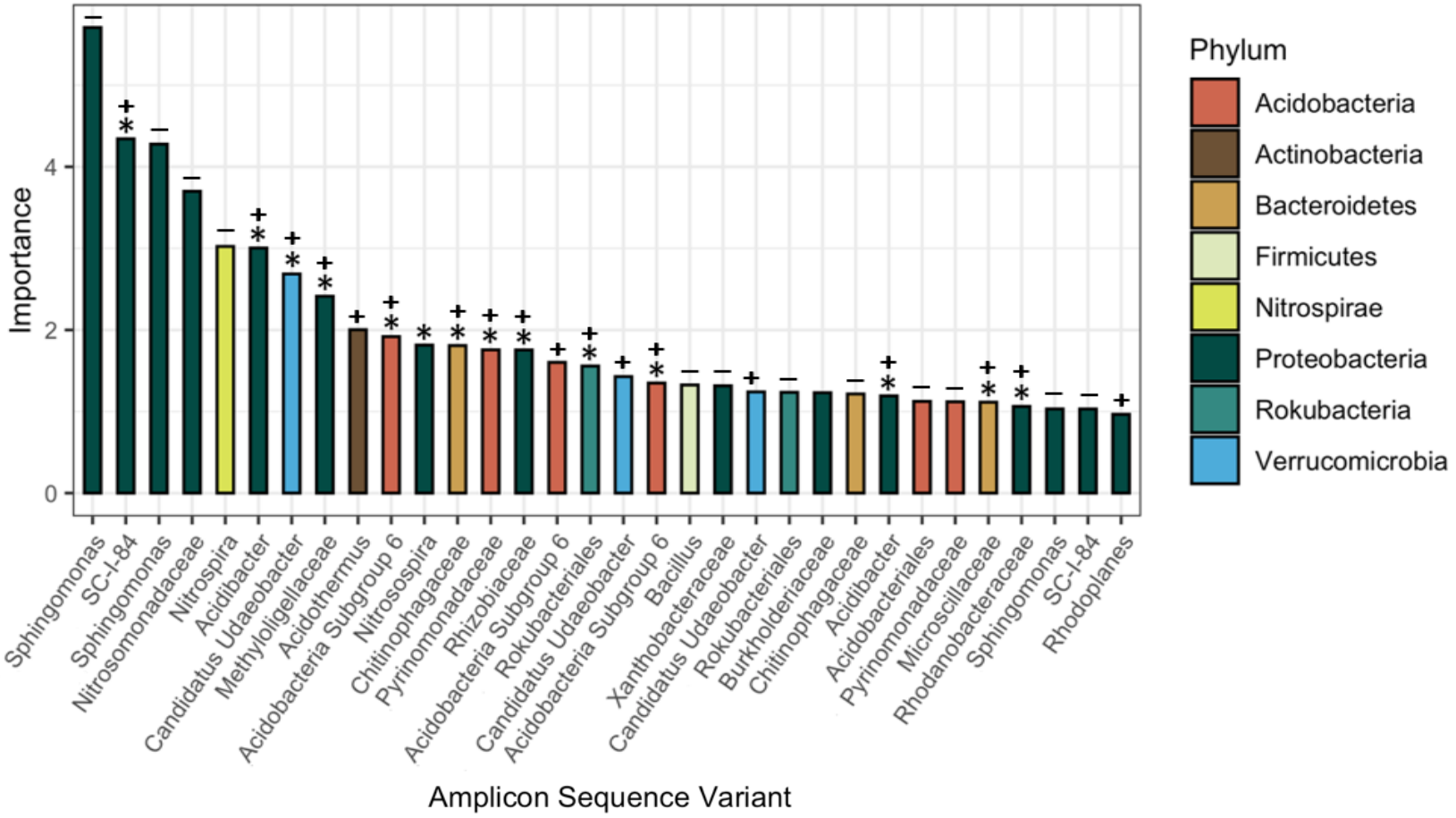

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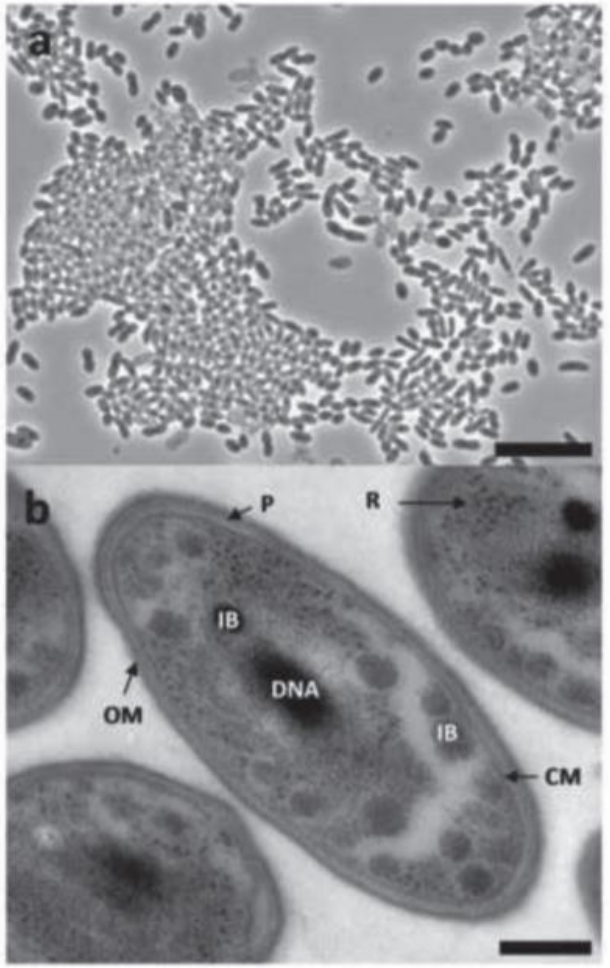
Results- *Acidobacteria Subdivision 6*

- Enriched under no-till and important in predicting Cmin
- *Acidobacteria* present in wide range of soils
- Slow growing
- Adaptive to low nutrient concentrations
- Produces uncharacterized extracellular polymeric substances



Huber et al. 2016

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Soil Biology and Biochemistry
Volume 168, May 2022, 108618

Linking soil microbial community structure to potential carbon mineralization: A continental scale assessment of reduced tillage

Elizabeth L. Rieke [a], Shannon B. Cappellazzi [a], Michael Cope [a], Daniel Liptzin [a], G. Mac Bean [a], Kelsey L.H. Greub [a], Charlotte E. Norris [a], Paul W. Tracy [a], Ezra Aberle [b], Amanda Ashworth [c], Oscar Bañuelos Tavarez [d], Andy I. Bary [e], R.L. Baumhardt [f], Alberto Borbón Gracia [g], Daniel C. Brainard [h], Jameson R. Brennan [i], Dolores Briones Reyes [g], Darren Bruhjell [j] ... C. Wayne Honeycutt [a]

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