



SOIL HEALTH

— INSTITUTE —

Enriching Soil, Enhancing Life

LINKING AGRICULTURAL MANAGEMENT PRACTICES TO CARBON CYCLING TRAITS: IMPLICATIONS FOR SOIL HEALTH ASSESSMENT

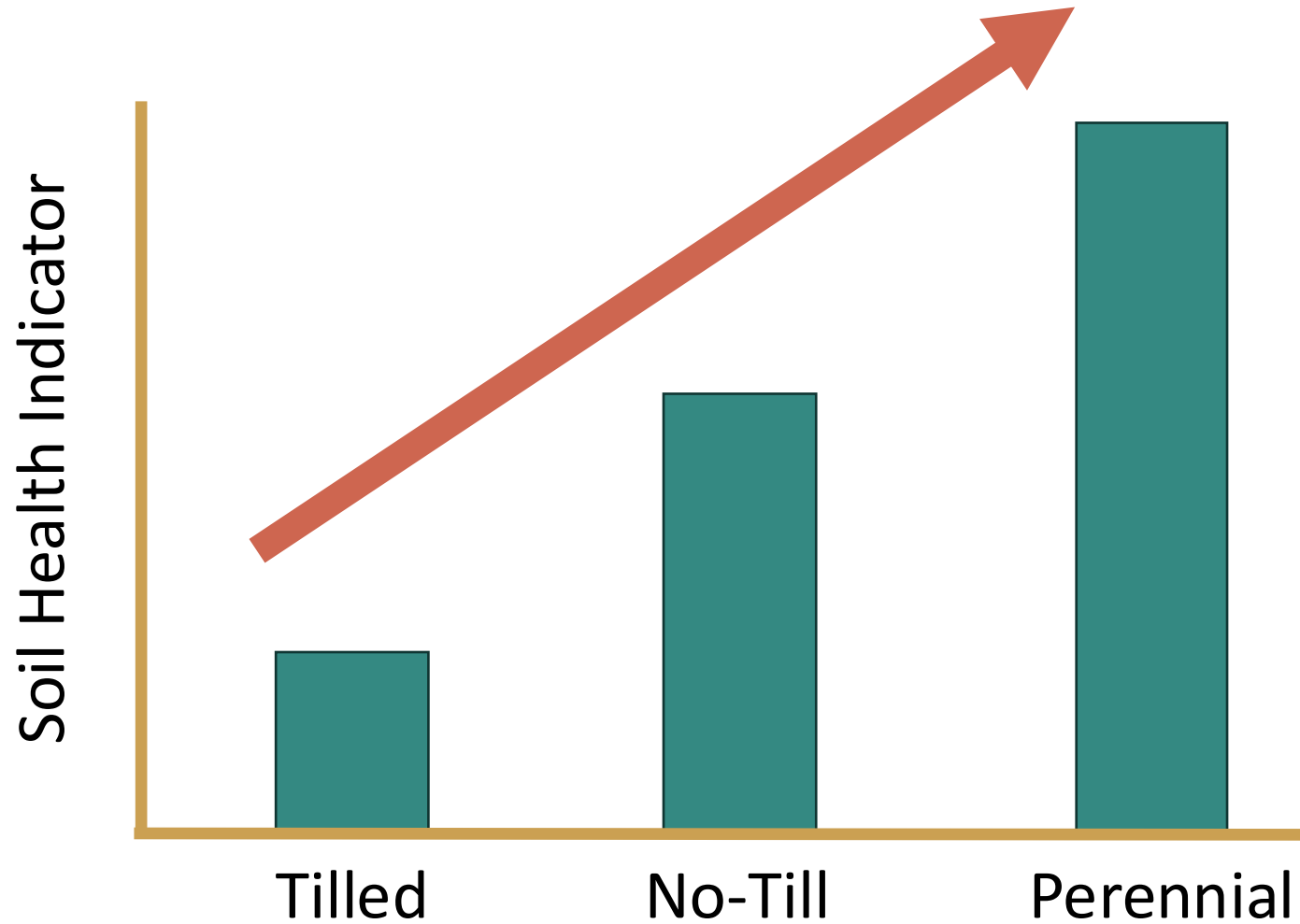
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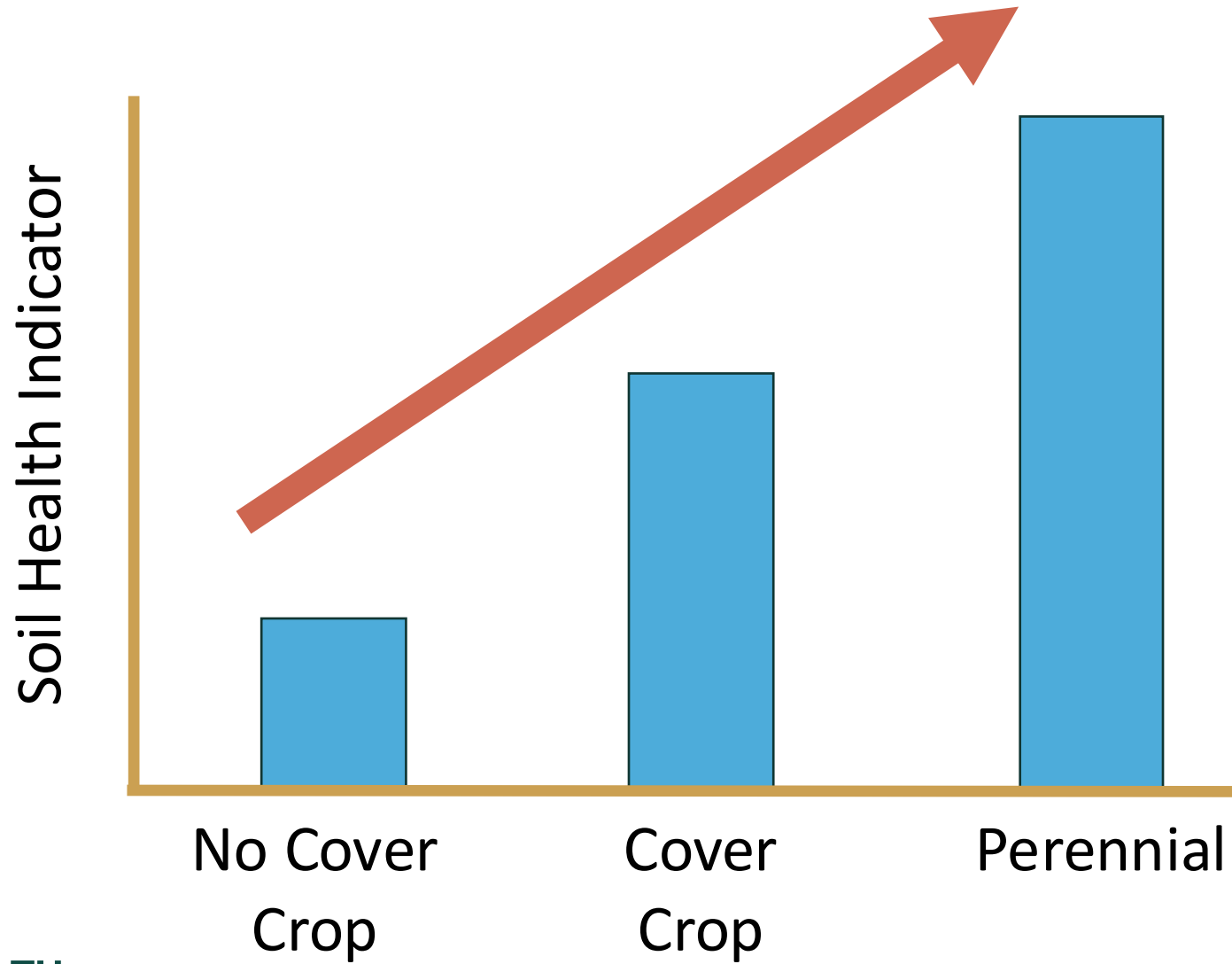
Our Science-Led Team



Expected Trends in Soil Health Indicators



Expected Trends in Soil Health Indicators



Large Gaps in Agricultural Soil Microbiome Research

- Land use change well documented
- Less known on specific management impacts
 - Few studies
 - Small geographies
 - Conflicting results



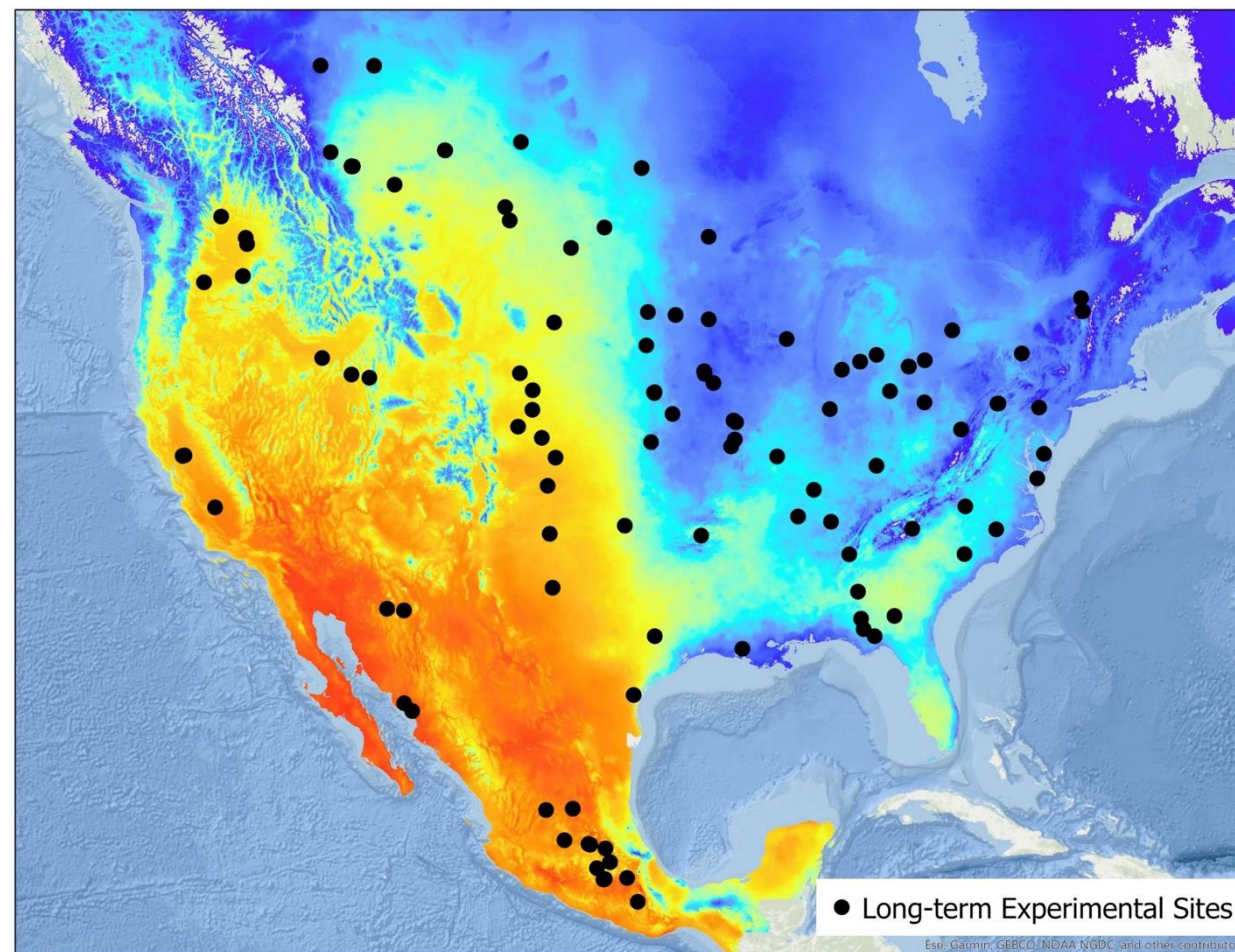
North American Project to Evaluate Soil Health Measurements

Goal: Identify most effective indicators of soil health

124 long term experimental sites

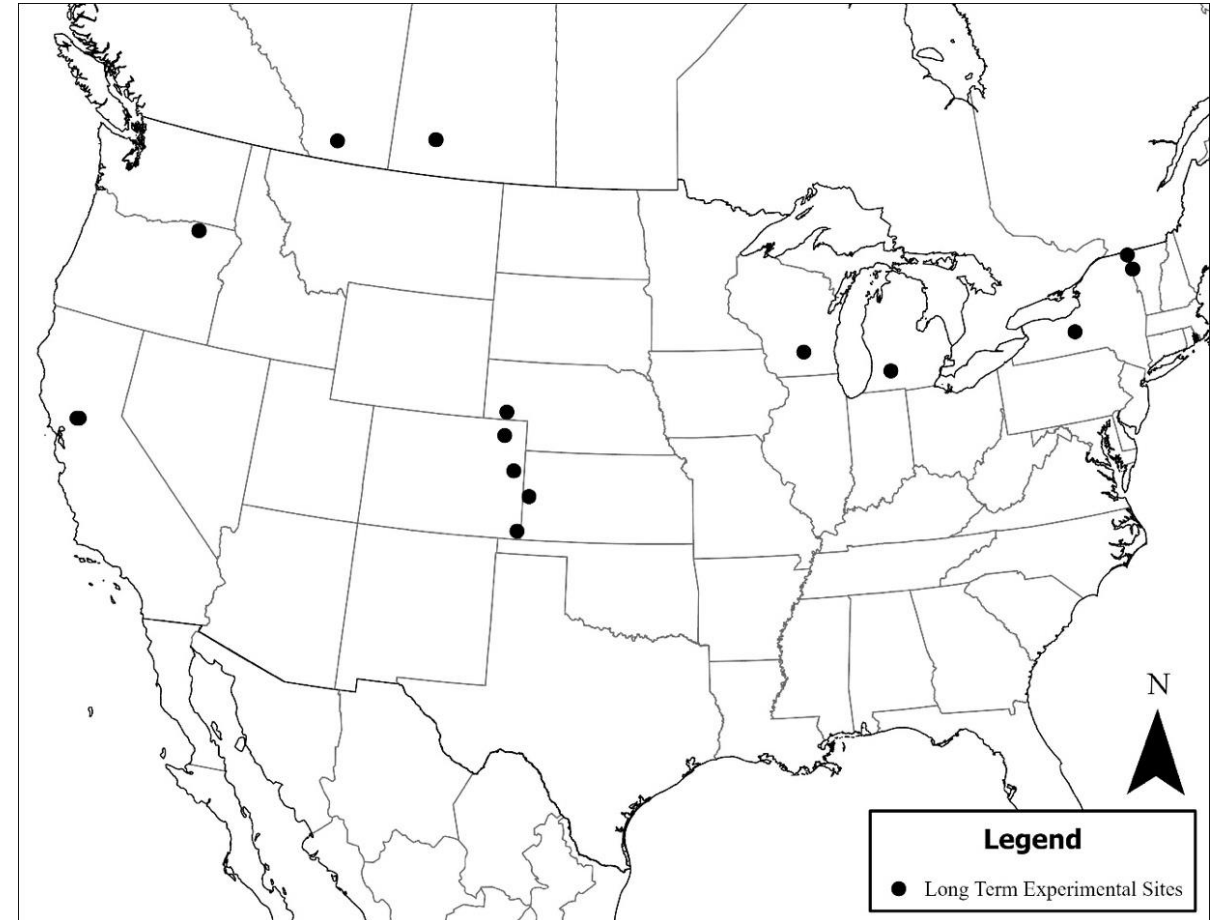
- Paired treatments- tillage, cover crops, crop rotations
- 0-15 cm depth

Over 30 current & exploratory soil health measurements



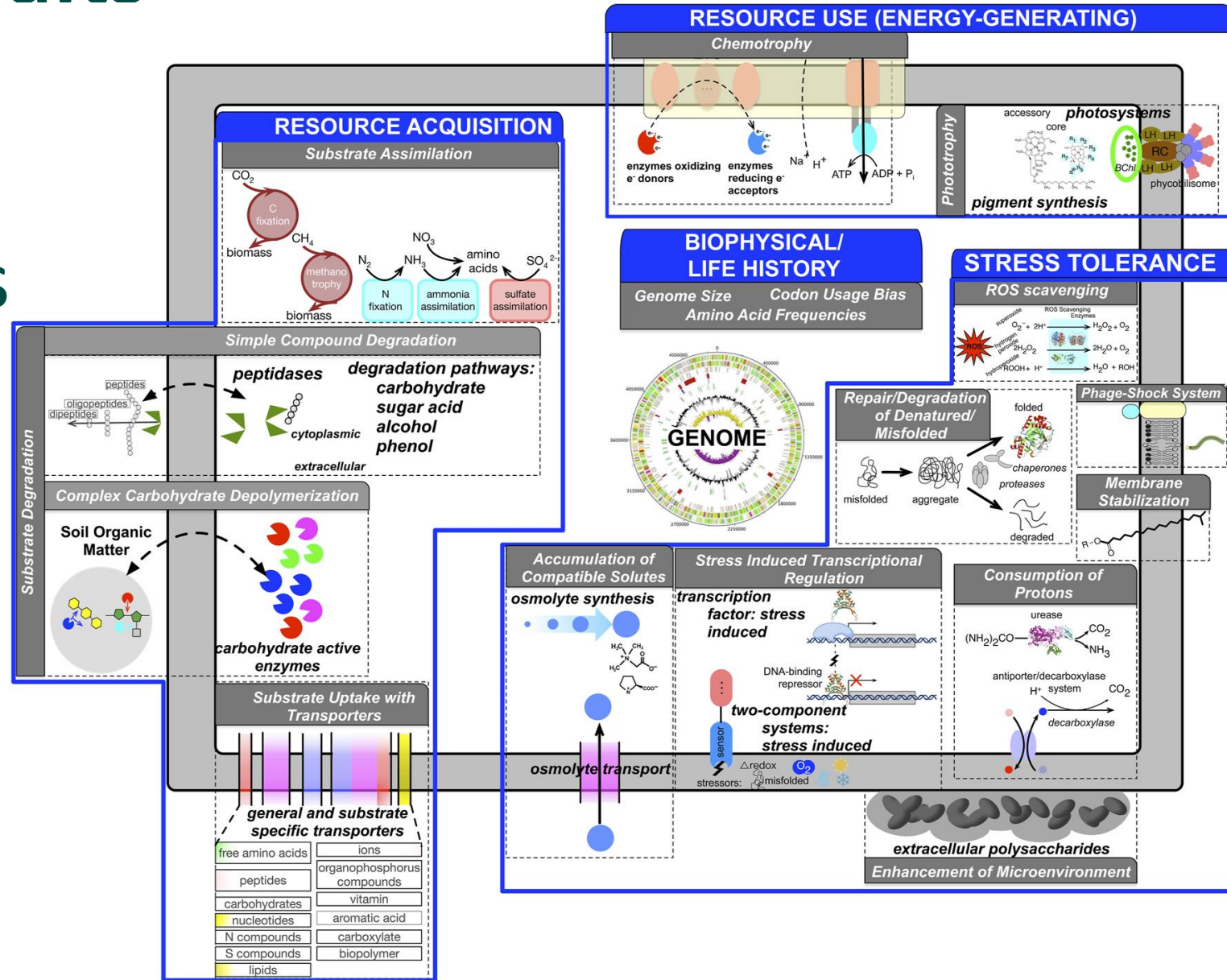
North American Project to Evaluate Soil Health Measurements

- 19 Sites
- 108 replicated treatments
- Inclusion of sites with perennial reference treatments
- Differences in tillage, cover cropping, and crop rotations

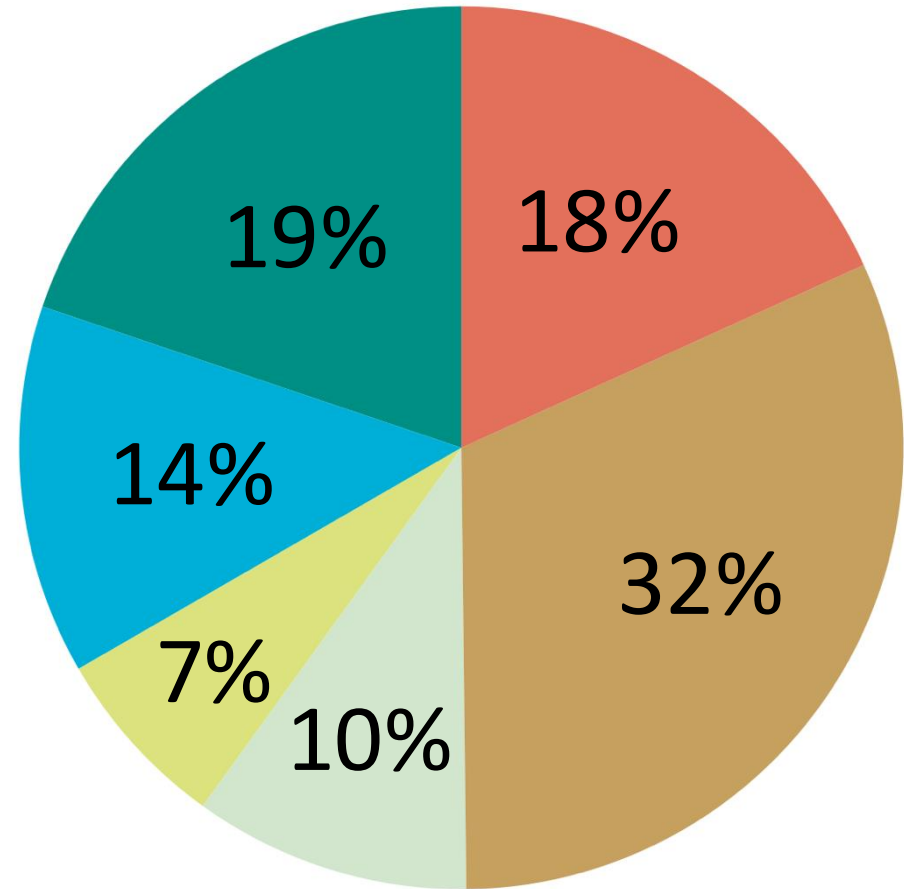
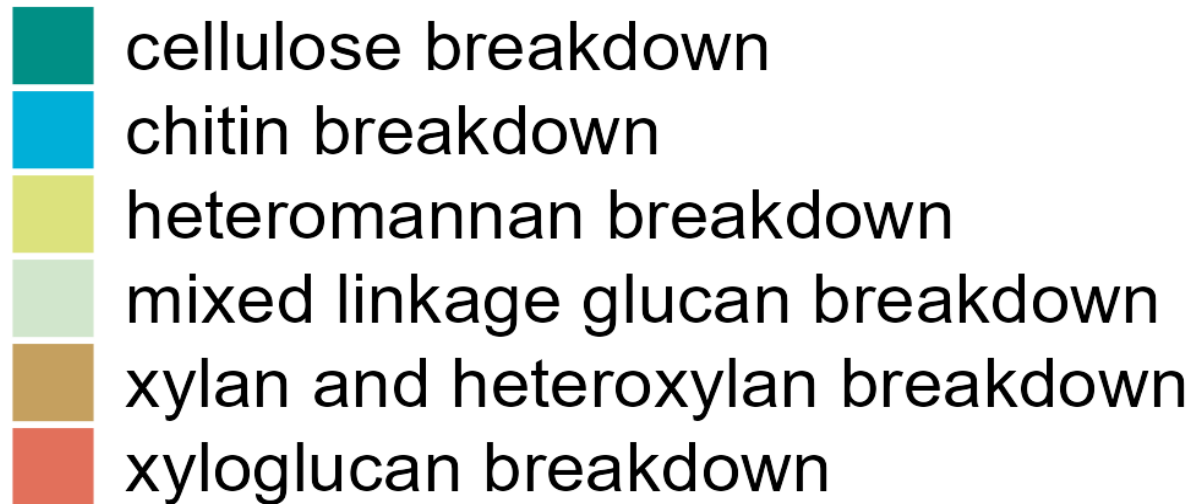


Carbon Cycling Traits

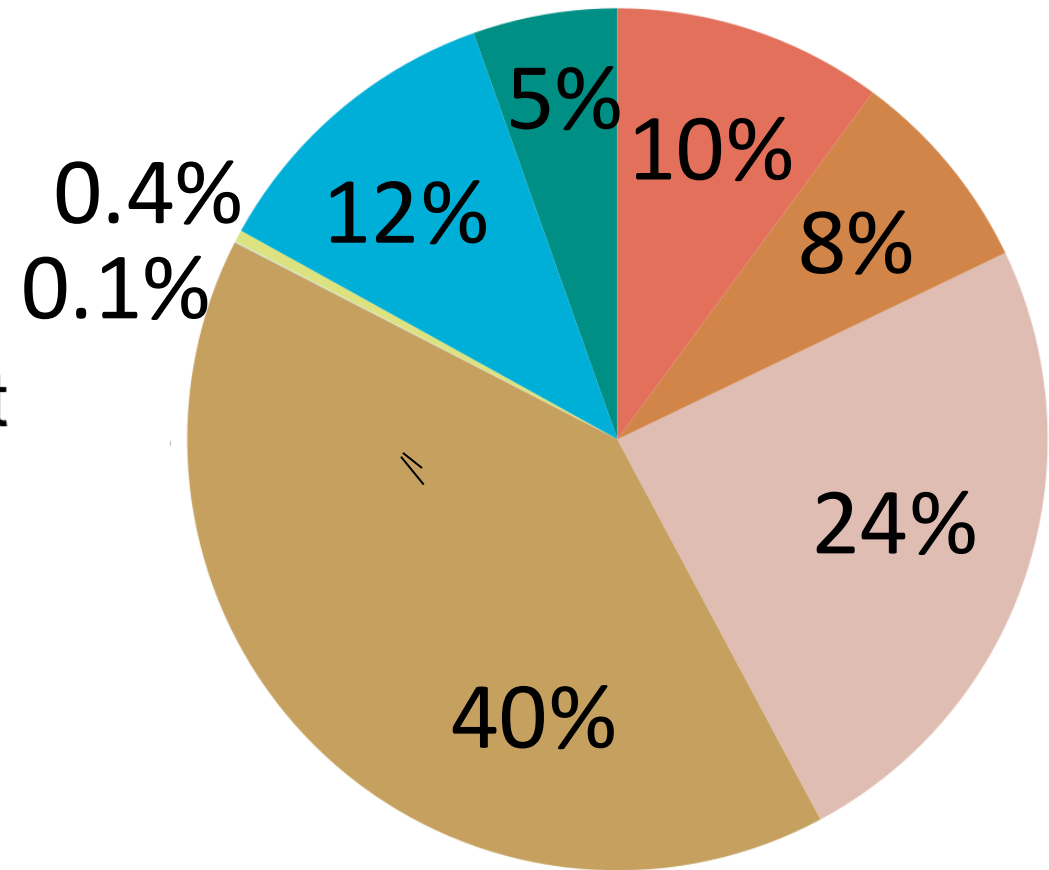
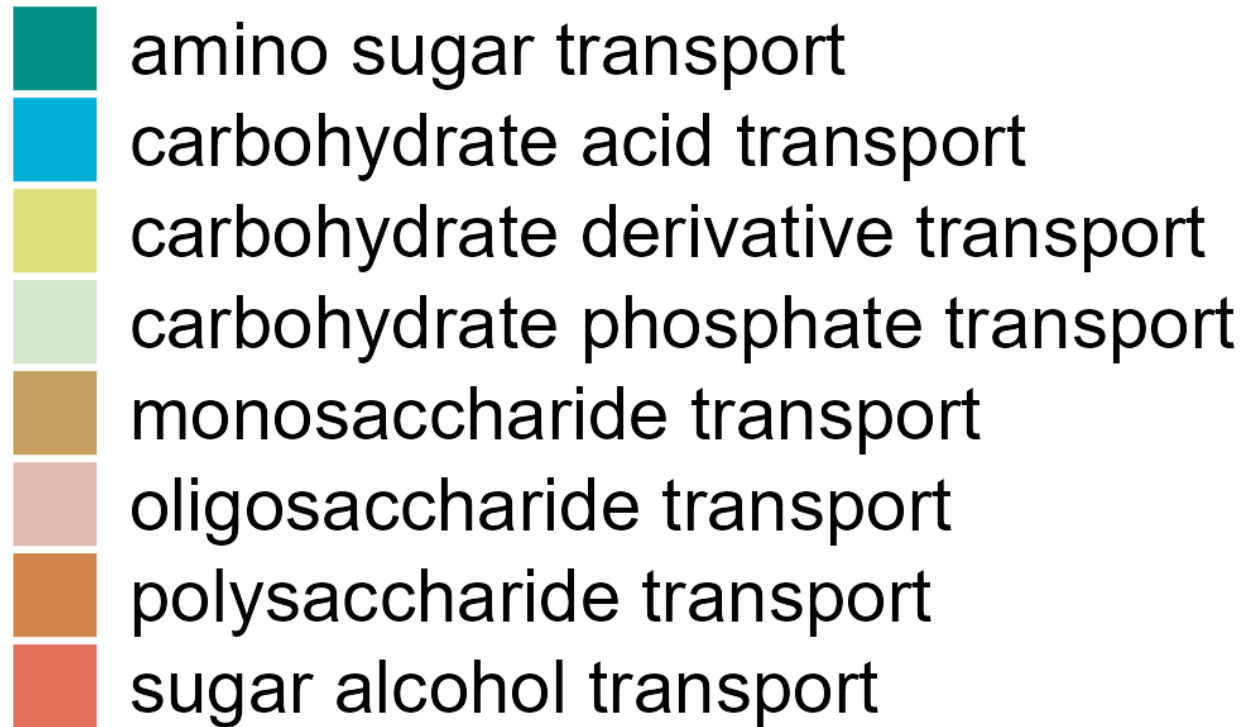
- Microtrait
- Carbon cycling traits
 - Complex carbohydrate depolymerization
 - Carbohydrate transport



Complex Carbohydrate Depolymerization

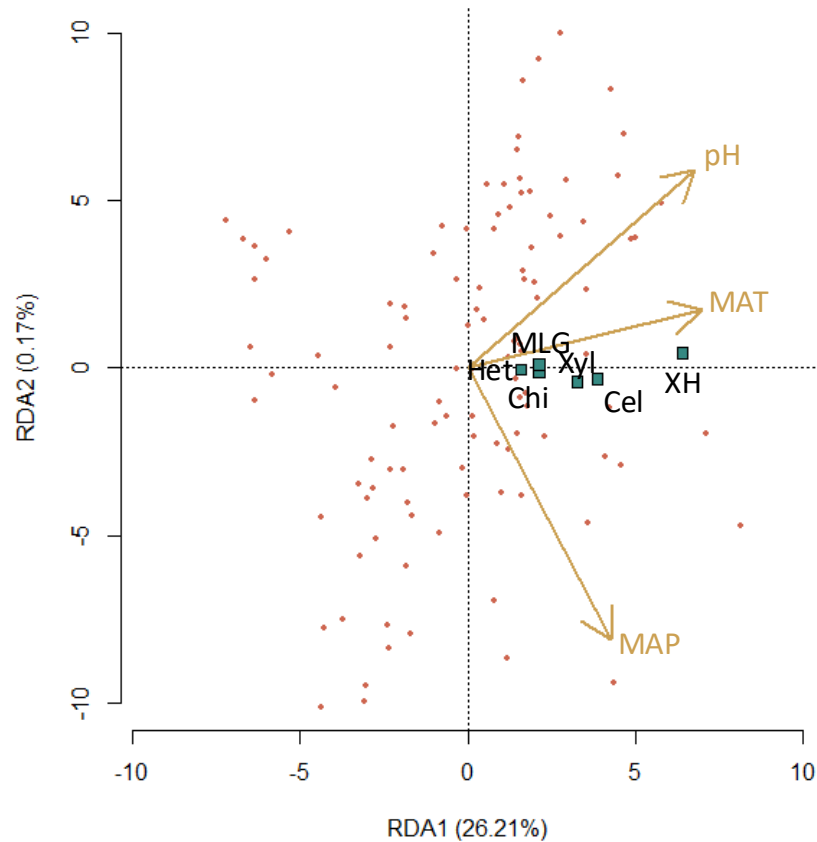


Carbohydrate Transport

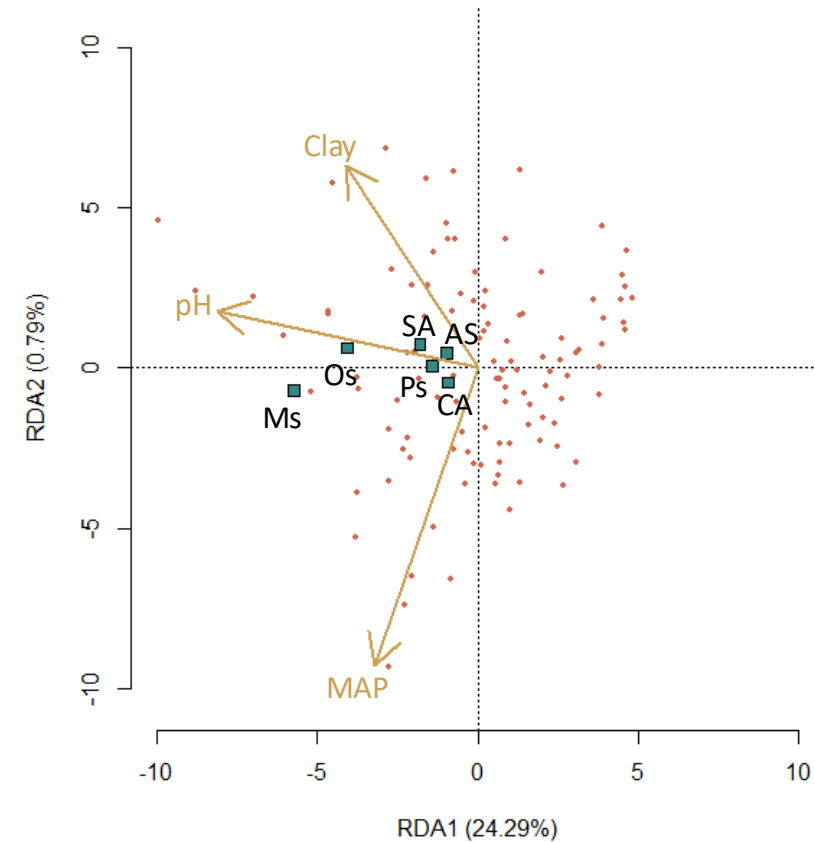


Inherent Property Influence on Carbon Cycling Traits

Complex Carbohydrate Depolymerization

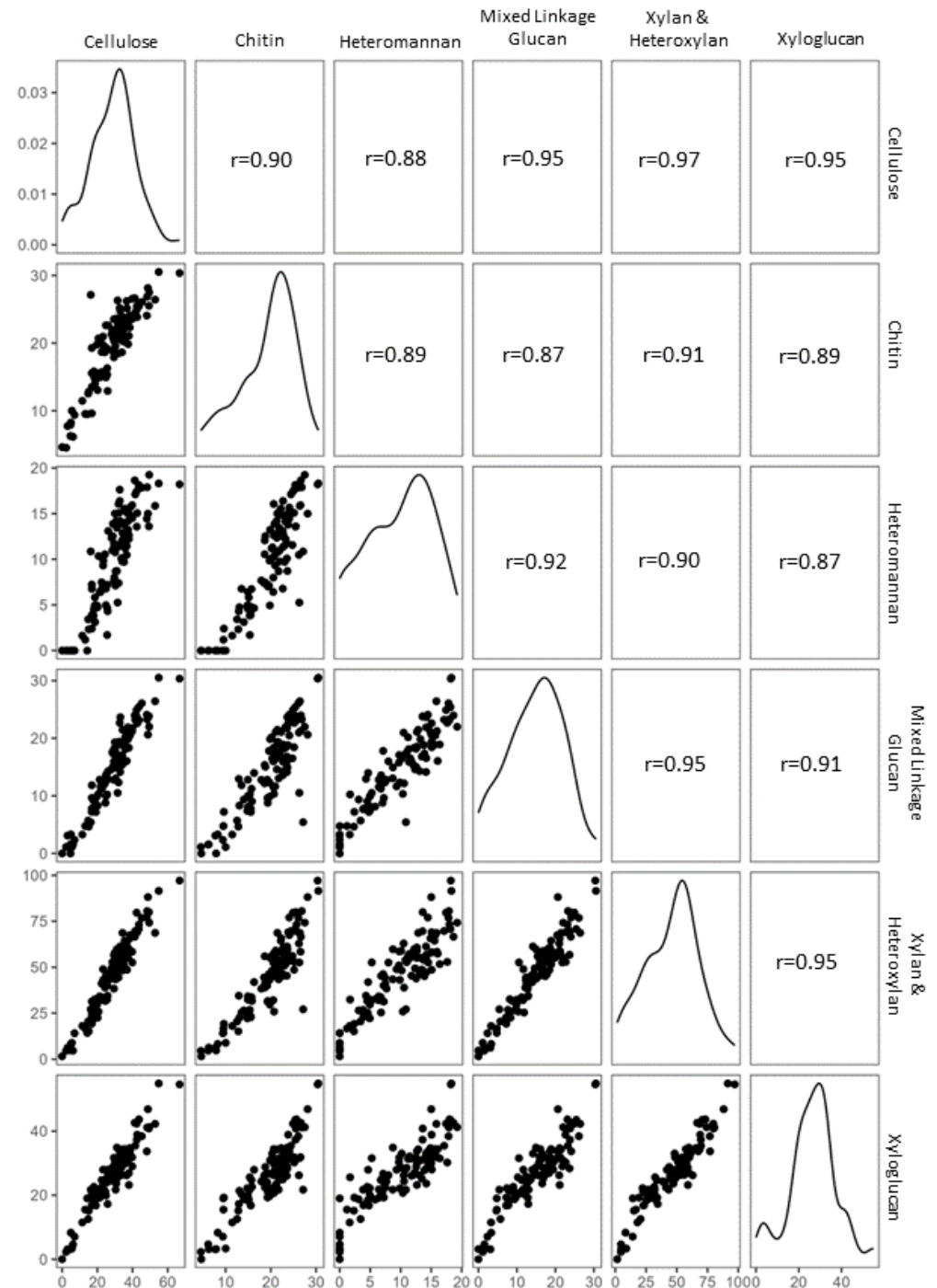


Carbohydrate Transport



Carbon Cycling Traits

- Strong correlations between traits
- Individual traits grouped together for further analysis



Impact of Living Roots on Soil

- Feeds microbes
 - Root exudates
 - Aboveground residue
- Builds soil structure
 - Increases infiltration
 - Decreases erosion



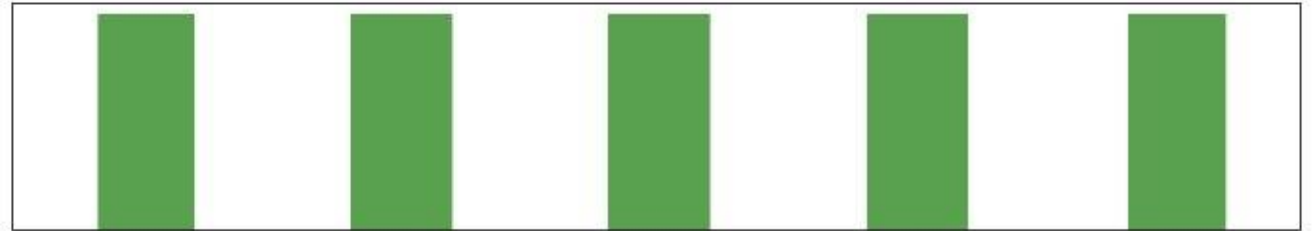
Live Roots Index (LRI)

Number of days per year with living roots

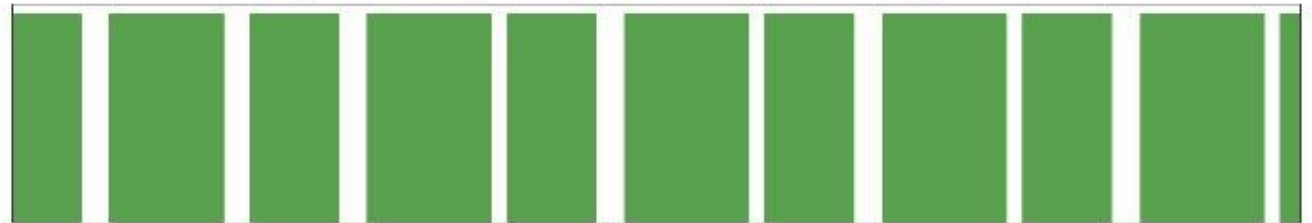
- 5-year average
- Dormant days count

Cumulative # of days between planting & harvest (or termination) ÷ 365

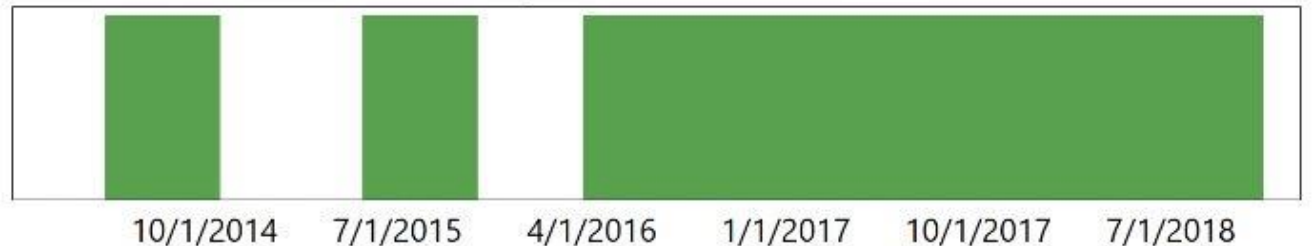
Continuous Corn, No Cover Crop (Live Roots Index = 39)



Continuous Cotton, Cover Crop Mix (Live Roots Index = 82)



Corn, Corn, 3 Years Alfalfa for Hay (Live Roots Index = 71)

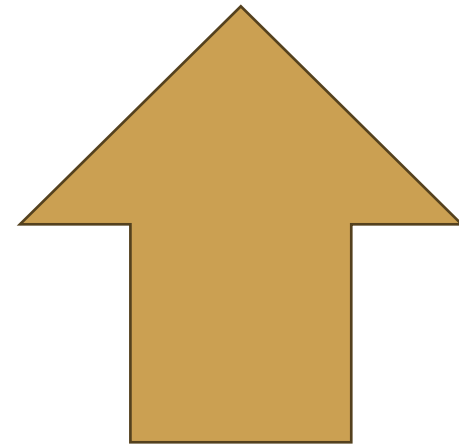


Impact of Living Roots on Soil Carbon Cycling

- Row crop only
- 7 sites, 29 treatments
- >25% relative difference in living roots
 - Cover cropping
 - Fallow periods
 - Crop termination timing
- Linear mixed models

Impact of Living Roots on Soil Carbon Cycling

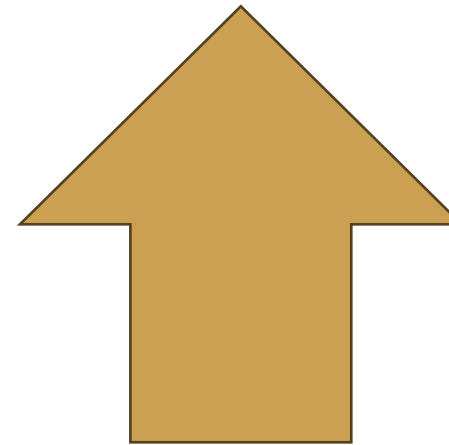
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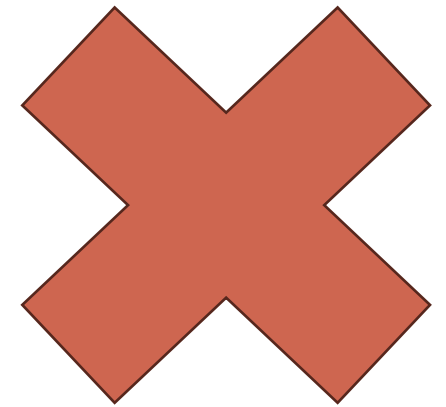
Complex
Carbohydrate
Depolymerization

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Complex
Carbohydrate
Depolymerization



Carbohydrate
Transport

Impact of Living Roots on Soil Carbon Cycling

- Living roots index likely captured increased biomass
- Less influence from root exudates
- Integrating perennials?



Can Management Mimic Natural Systems?

- Perennial systems minimize physical disturbances while maximizing living roots
- Cover cropping alone not enough to mimic carbohydrate uptake in perennial systems
- Test integrating perennials

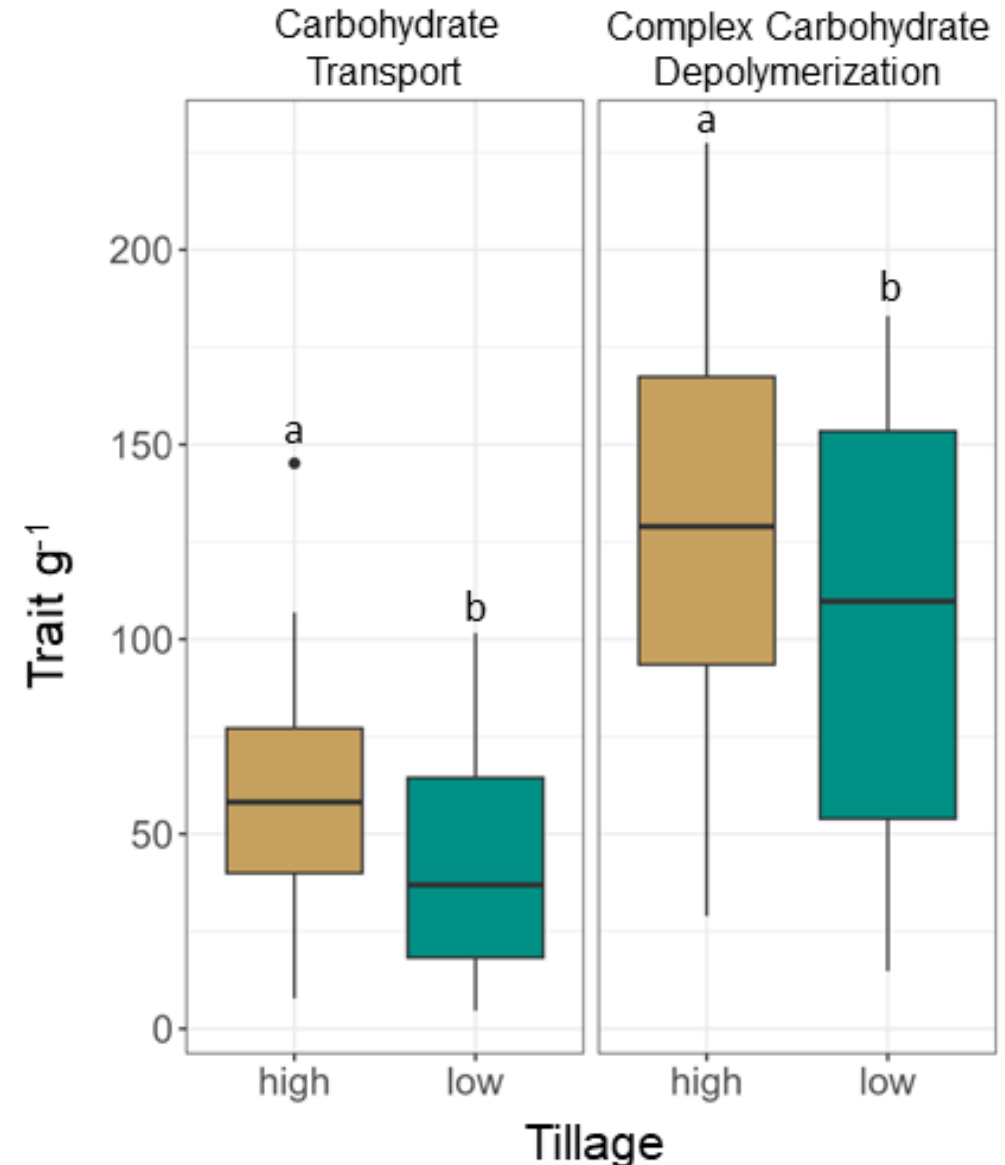
Impact of No-Till on Soil

- Builds soil structure
- Compartmentalizes microbes
- Aboveground residue breaks down on soil surface

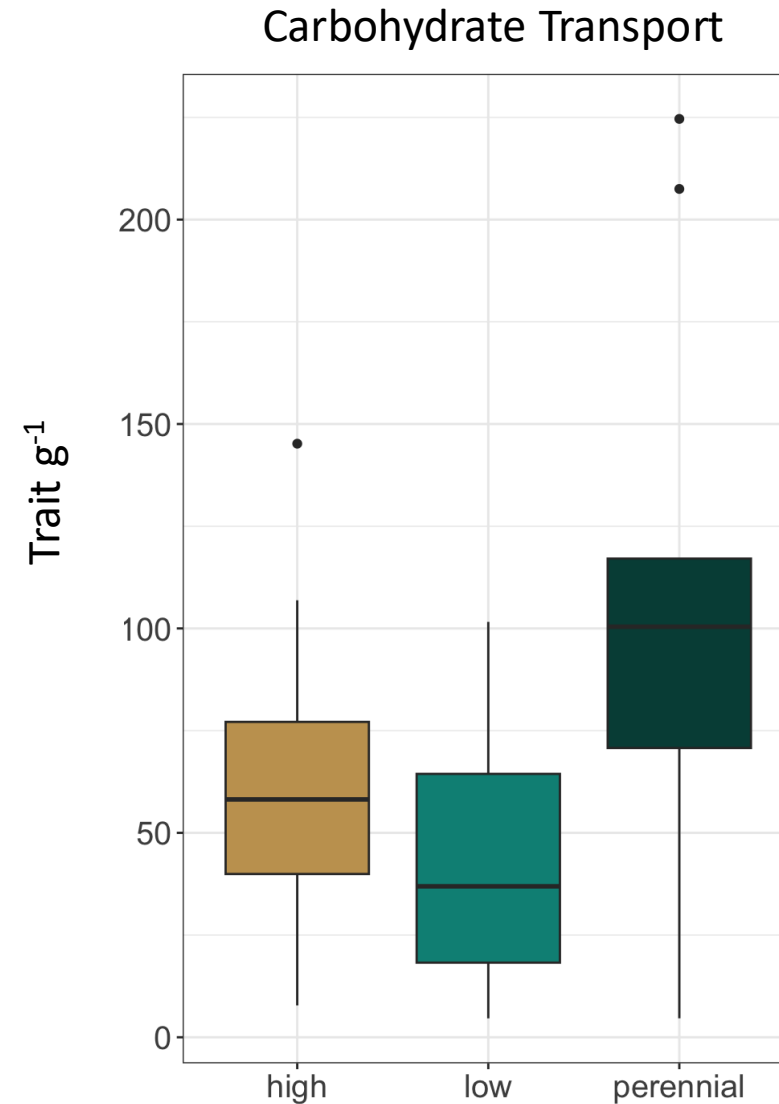
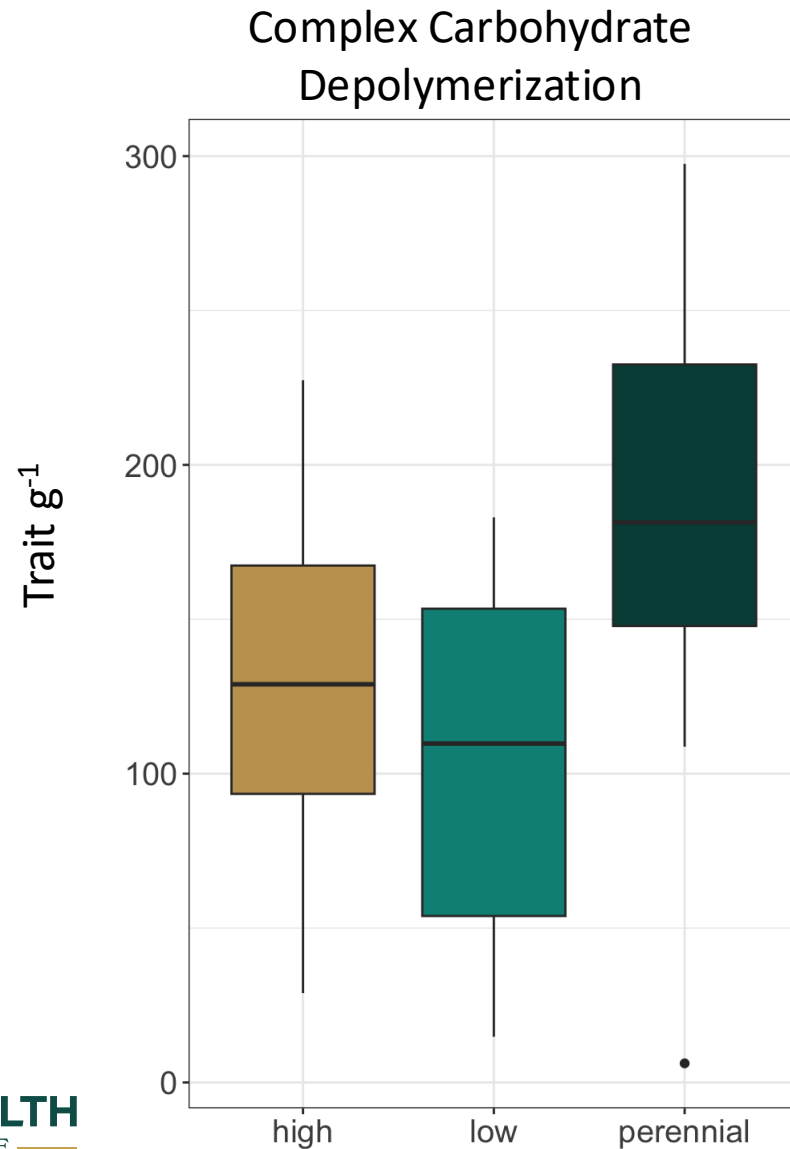


Impact of No-Till on Carbon Cycling Traits

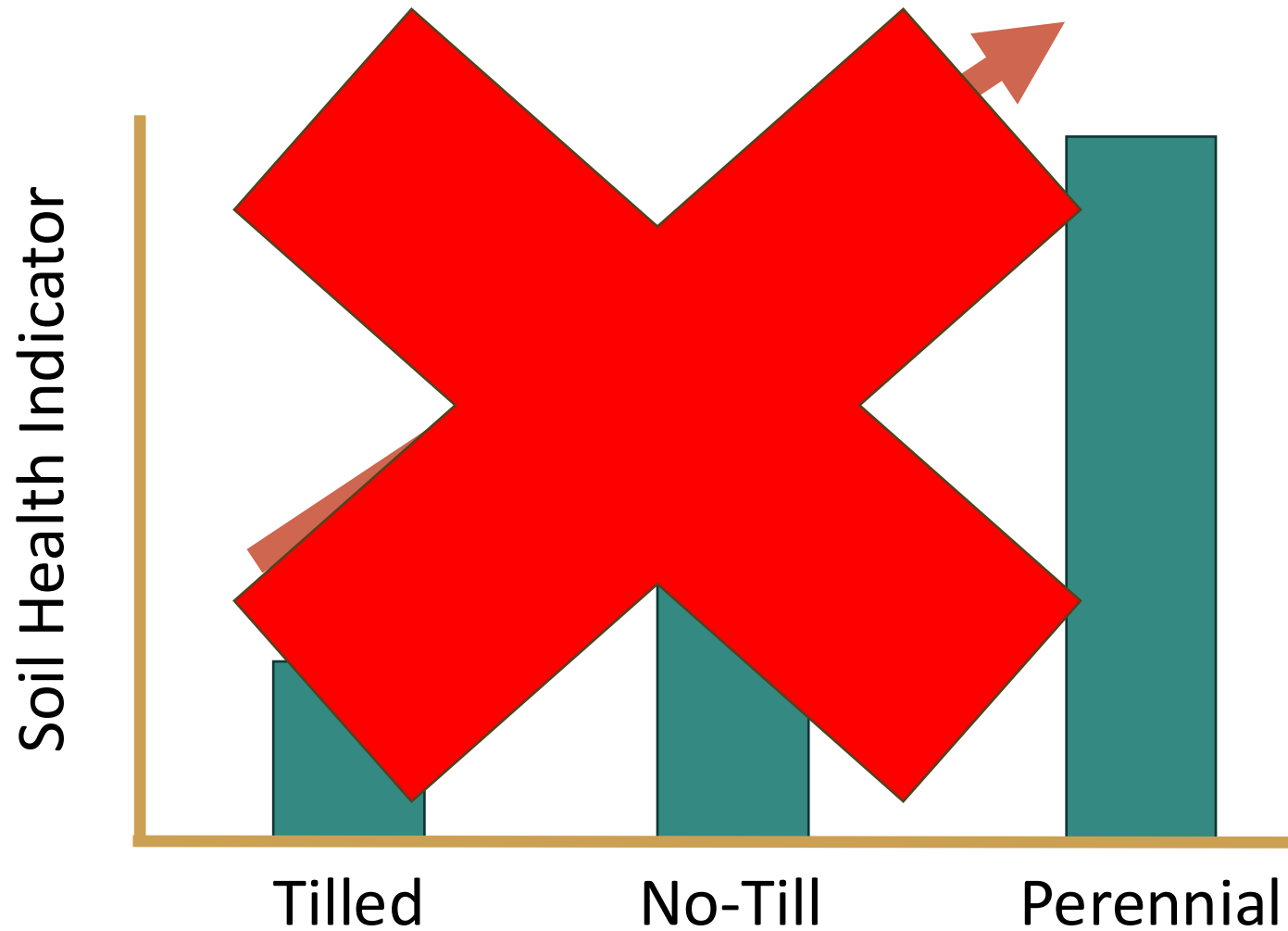
- 12 direct treatment comparisons
- Both greater in tilled systems
- Increased contact with aboveground residues



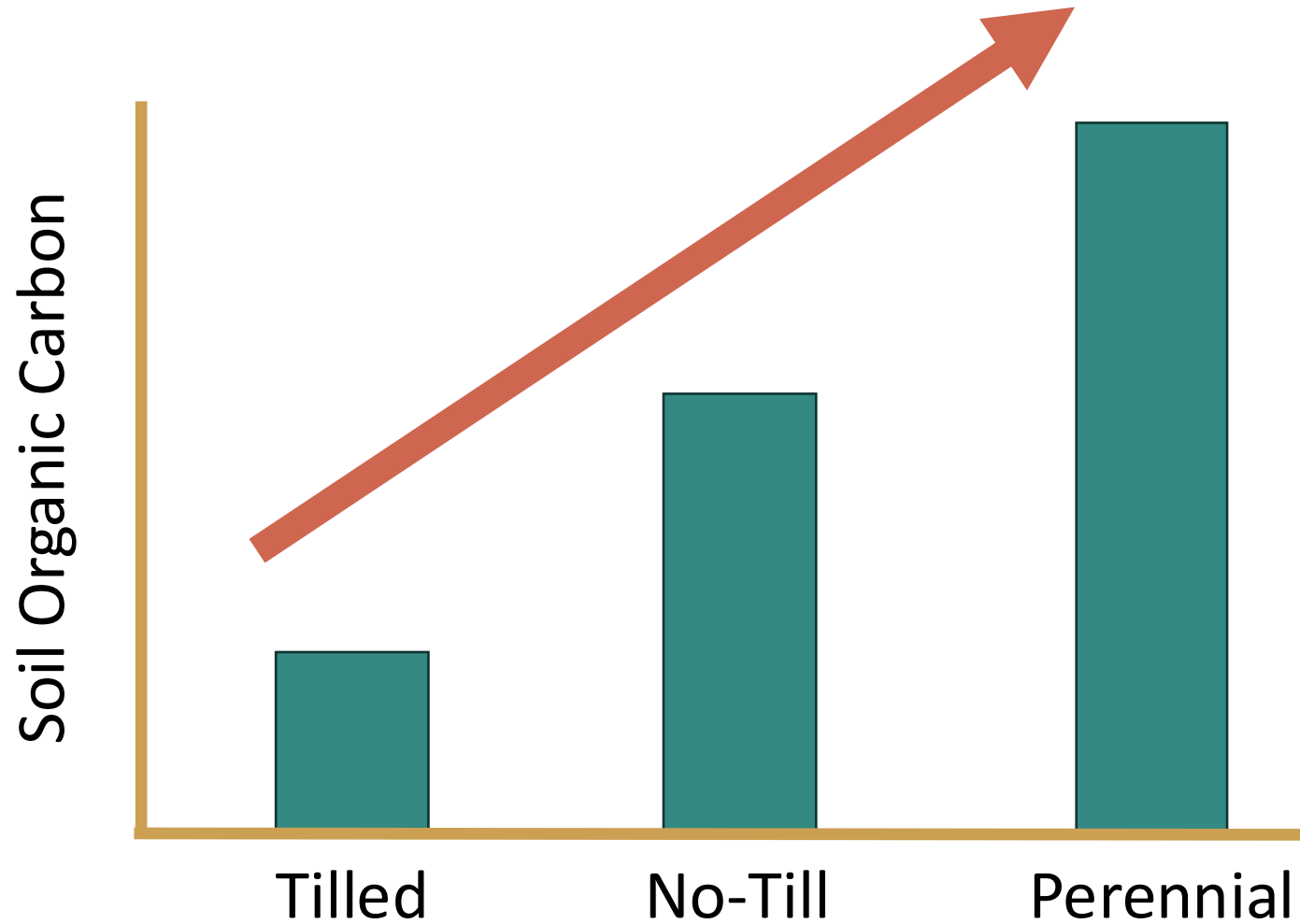
Impact of No-Till on Carbon Cycling Traits



Expected Trends in Soil Health Indicators



Expected Trends in Soil Health Indicators



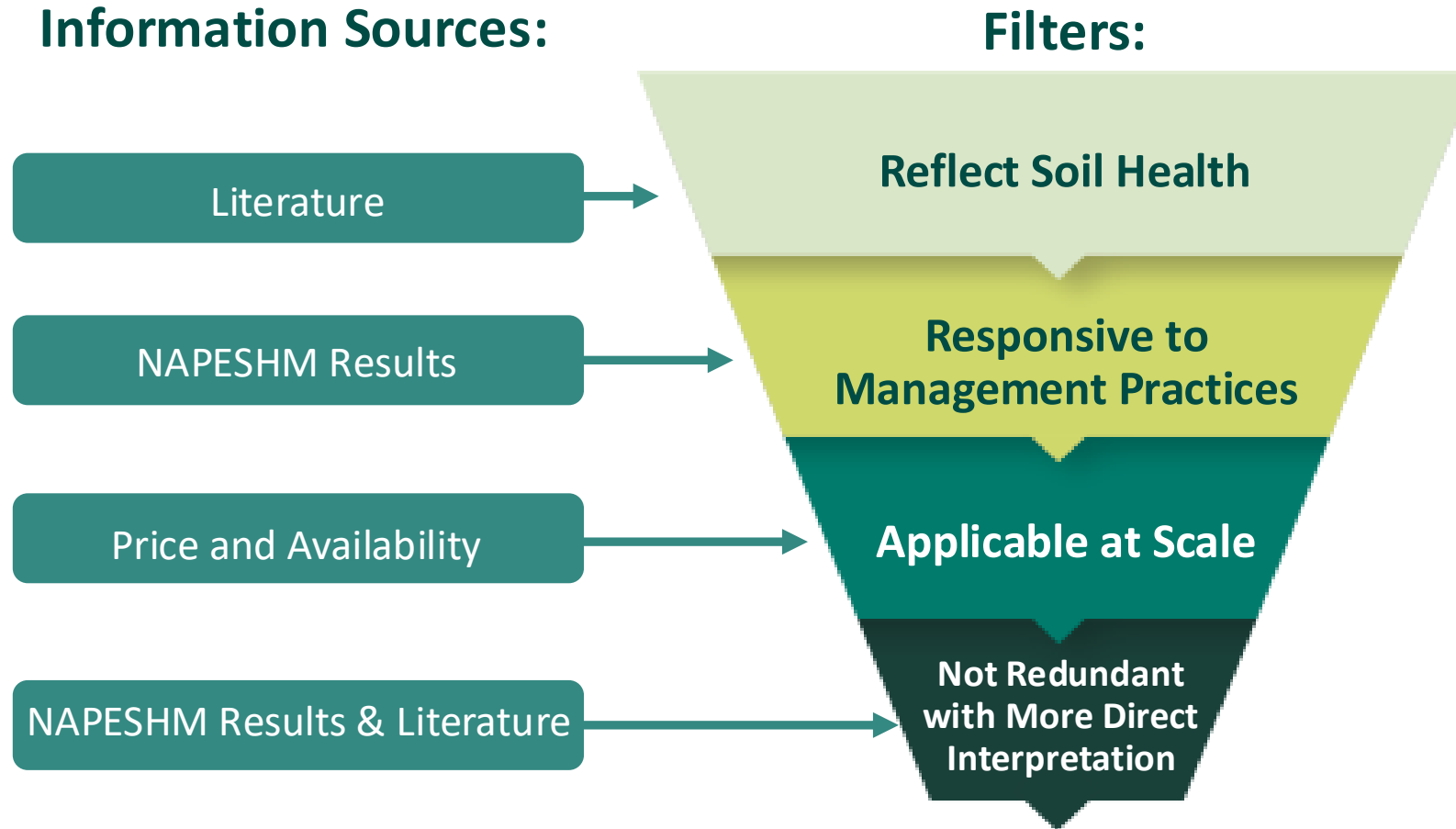
Key Takeaways

- Less clear trends complicate interpretation of genetic traits
- More carbon cycling traits does not equal more carbon storage
- Push boundaries of soil health practices to mimic natural systems

How Can We Utilize Genetic Information for Soil Health?

- Less clear trends complicate interpretation of genetic traits
- In conjunction with physical indicators of soil health
 - Tell more complete story
- Explanatory variables for common, cheaper soil health indicators
 - Enhancing interpretation of scalable measurements

Essential Indicators of Soil Health



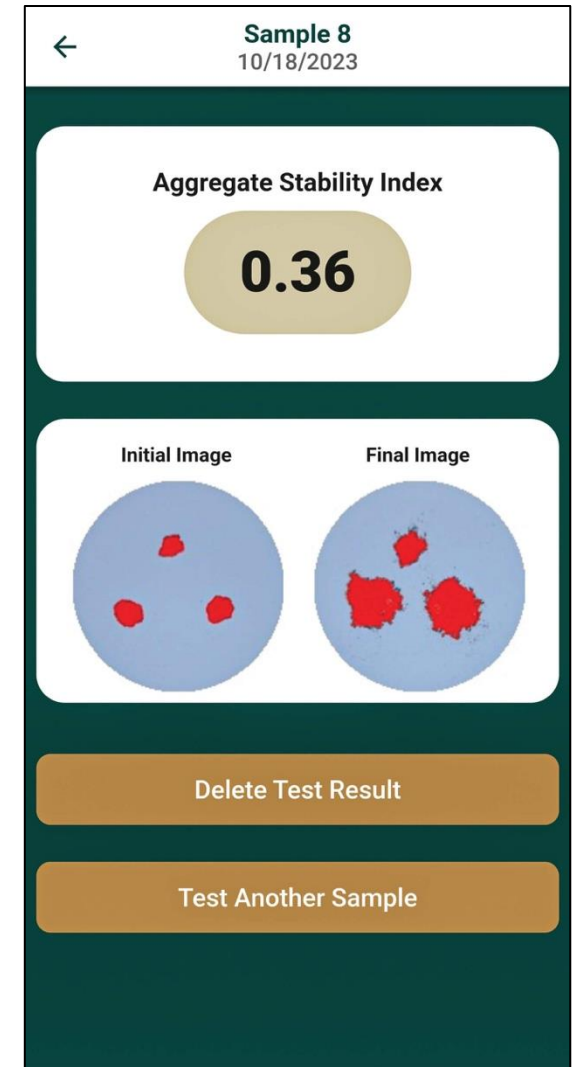
Minimum Suite of Effective Indicators for North America

Essential Indicators of Soil Health

INDICATOR	MEASUREMENT	REFERENCE
Organic Carbon	Dry combustion For calcareous soil: (Total C – Inorganic C)	Nelson and Sommers, 1996
Potentially Mineralizable C	24-hr CO ₂ burst resulting from rewetting air dried, sieved soil	Zibilske, 2018
Aggregate Stability	10-min change in slaking via image analysis	Fajardo et al., 2016
Plant Available Water	organic carbon texture	Bagnall et al., 2022

Combining Trait Data with Traditional Indicators

- Aggregate stability provides indication of soil structure
- Both soil structure and active community needed for carbon storage to reach potential
- Combine slakes results with carbon cycling potential



Strengthening Interpretation of Scalable Indicators

- Most indicators empirically linked to soil function
- Some misrepresented (e.g. poxC)
- SOC is a driver of lots of soil function
- Can changes in SOC and carbon cycling traits better predict other indicators?

Strengthening Interpretation of Scalable Indicators

Indicator	SOC R ²	SOC + Complex Carbohydrate Degradation R ²	SOC + Carbohydrate Transport R ²
Microbial Biomass	0.51	0.61	0.59
Carbon Mineralization Potential	0.61	0.63	0.65
Aggregate Stability	0.23	0.31	0.32

Key Take Aways

- Lots of redundancy in individual carbon cycling traits
- Genetic information not a stand-alone soil health indicator
 - Use in conjunction with other indicators
- Understanding traits provide foundational knowledge for scalable indicators

THANK YOU

Present and Former SHI Staff

GM Bean
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SB Cappellazzi
M Cope
KLH Greub
CW Honeycutt
CLS Morgan
CE Norris
EL Rieke
S Shafer
PW Tracy

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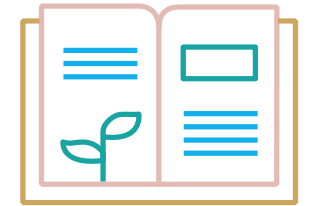
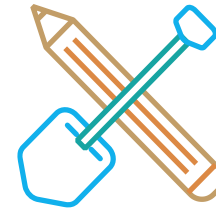
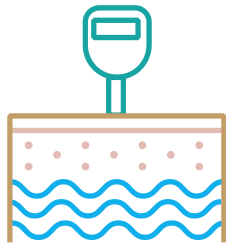
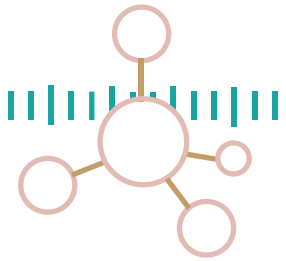
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