



# INTERPRETING CHANGES IN MANAGEMENT AT SCALE

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*Mission: safeguard and enhance the vitality and productivity of soil through scientific research and advancement*



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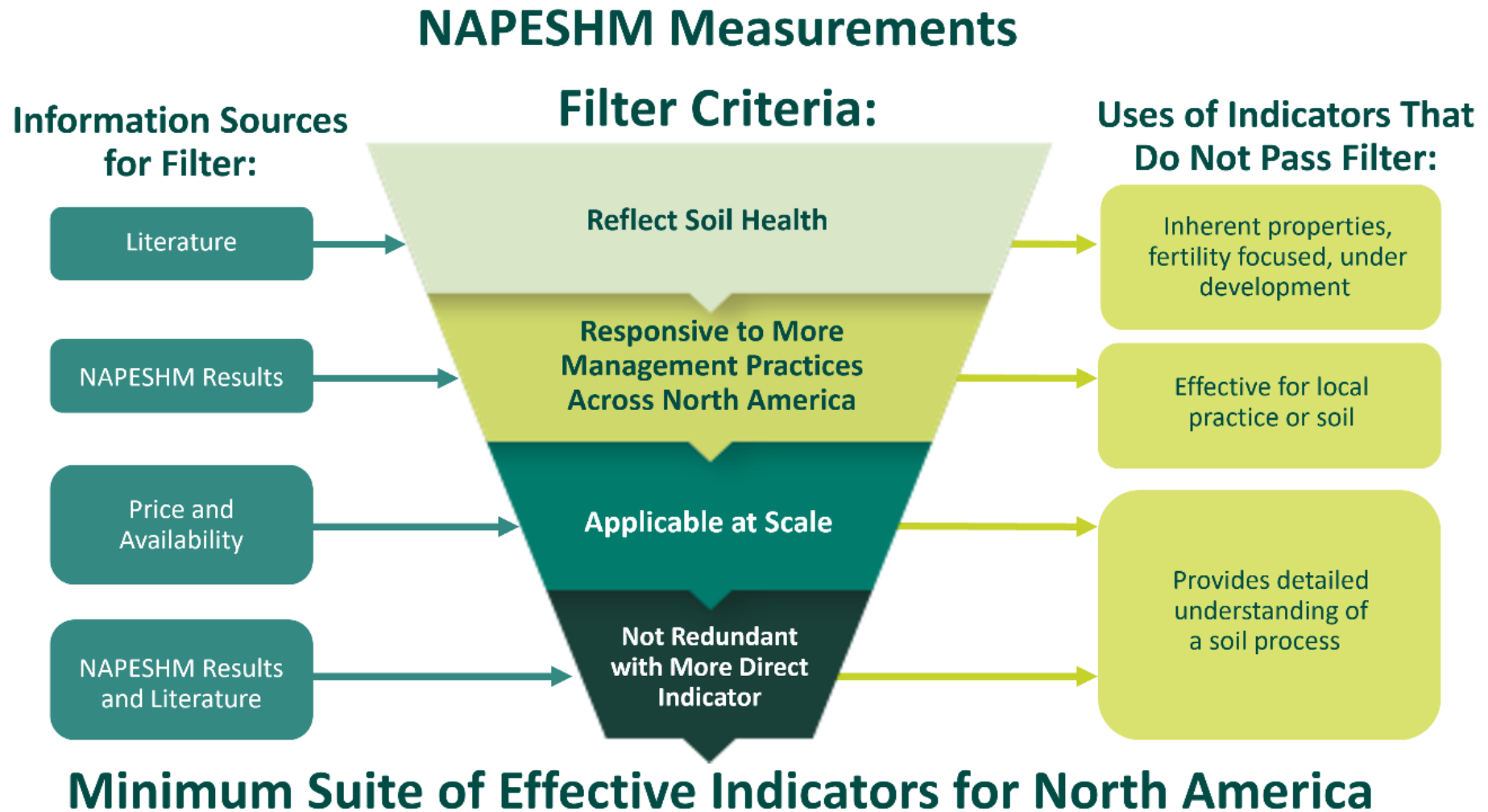


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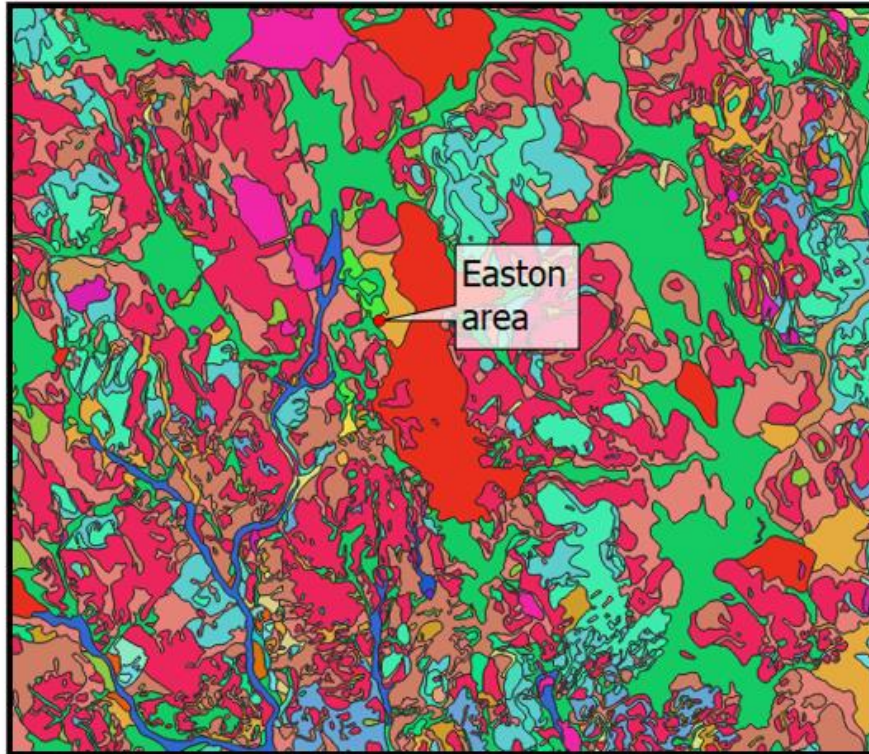
# Measuring Soil Health at Scale



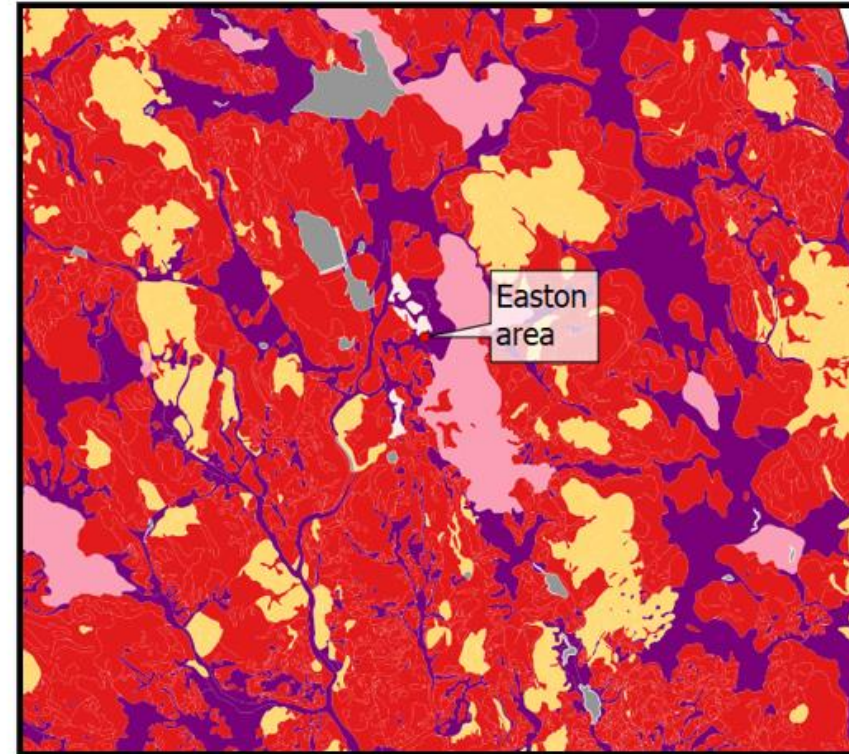


# Establishing Soil Health Targets at Scale

Soil Map Units in Easton Area



Soil strata in Easton Area



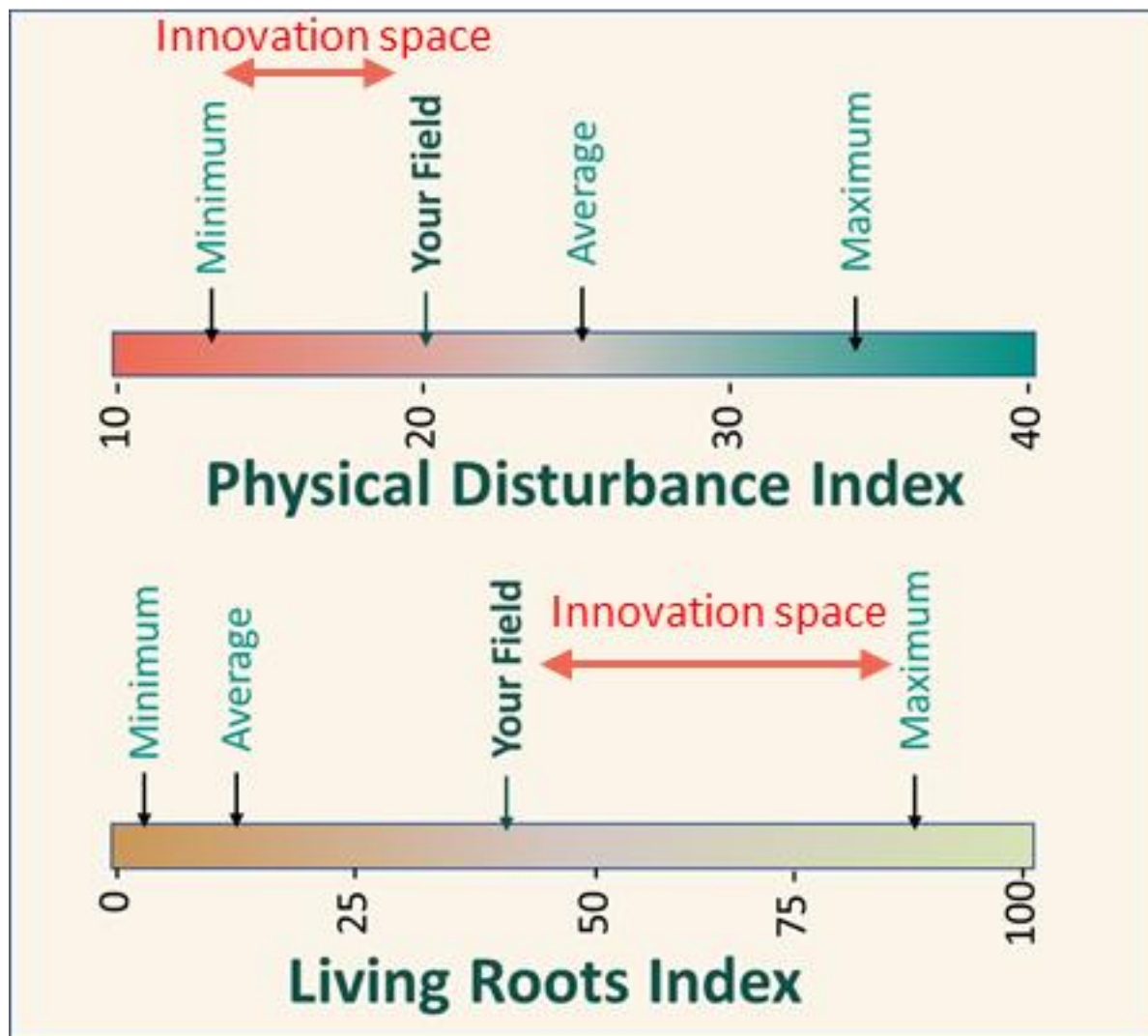
# Soil Health Institute Metrics of Interest

- ❖ **Continuous management indices**
  - ❖ Physical Disturbance Index
  - ❖ Living Roots Index
- ❖ **Predicting available water holding capacity**

## Interpreting Soil Health Data at Scale

- ❖ **Develop a simple set of continuous management indices that require a minimum amount of management data**
- ❖ **Evaluate the impact of these management indices on soil health indicators (soil organic carbon, wet aggregate stability and 24 hr C mineralization)**

# Management Targets



### ❖ What do “conventional tillage” and “no-till” mean to you?

Study	Tillage Description	Details
Corn-soybean (Illinois, USA)	Conventional tillage	Spring disc, Fall moldboard plow
Wheat-fallow (Saskatchewan, Canada)	Conventional tillage	Cultivator, field 6-12 inch sweeps (4 passes spring-summer)
Corn, soybean, wheat (Pennsylvania, USA)	No-till	Fall moldboard plow every 3rd year

**Minimum?**

**Moderate?**

**Intense?**



## ❖ Tillage Disturbance Index (Minimize Disturbance)

### Modified from NRCS Soil Tillage Intensity Rating (NRCS-STIR)

$$\text{NRCS-STIR} = D_{(\text{inches})} * A * 3.25T * 0.5S$$

D= Tillage Depth,

A = Area of soil disturbed within the operating width of the equipment

T = Tillage Type Modifier

S = Operating Speed (miles per hour)

**Tillage Type: it describes how the tillage operation mixes the soil and the associated residues. (Ferruzzi, NRCS)**

- 1.0 Inversion (moldboard plow)**
- 0.8 Mixing + some inversion (Disk, chisel plows)**
- 0.7 Mixing only (Rotary tillers)**
- 0.4 Lifting and fracturing (Subsoilers)**
- 0.15 Compression (sheep foot's rollers, cattle trampling)**

## ❖ Tillage Disturbance Index (Minimize Disturbance)

We took out the speed to obtain

General-purpose Tillage Intensity Rating (gTIR)

$$\text{gTIR} = D(\text{cm}) * A * 3.25T$$

We also took out the tillage modifier to obtain

Normalized Soil Volume Disturbed (SVD)

$$\text{SVD} = D(\text{cm}) * A$$

**We aggregated annual tillage data over 5 years in 3 ways**

- 1. Take the average within each calendar year and then average across years. ( $STIR_{mean}$ ,  $GTIR_{mean}$ ,  $SVD_{mean}$ )**
- 2. Take the sum of all values within each calendar and then average across years. ( $STIR_{sum}$ ,  $GTIR_{sum}$ ,  $SVD_{sum}$ )**
- 3. Take the maximum value within each calendar year and then average across years. ( $STIR_{max}$ ,  $GTIR_{max}$ ,  $SVD_{max}$ )**

## Tillage indices

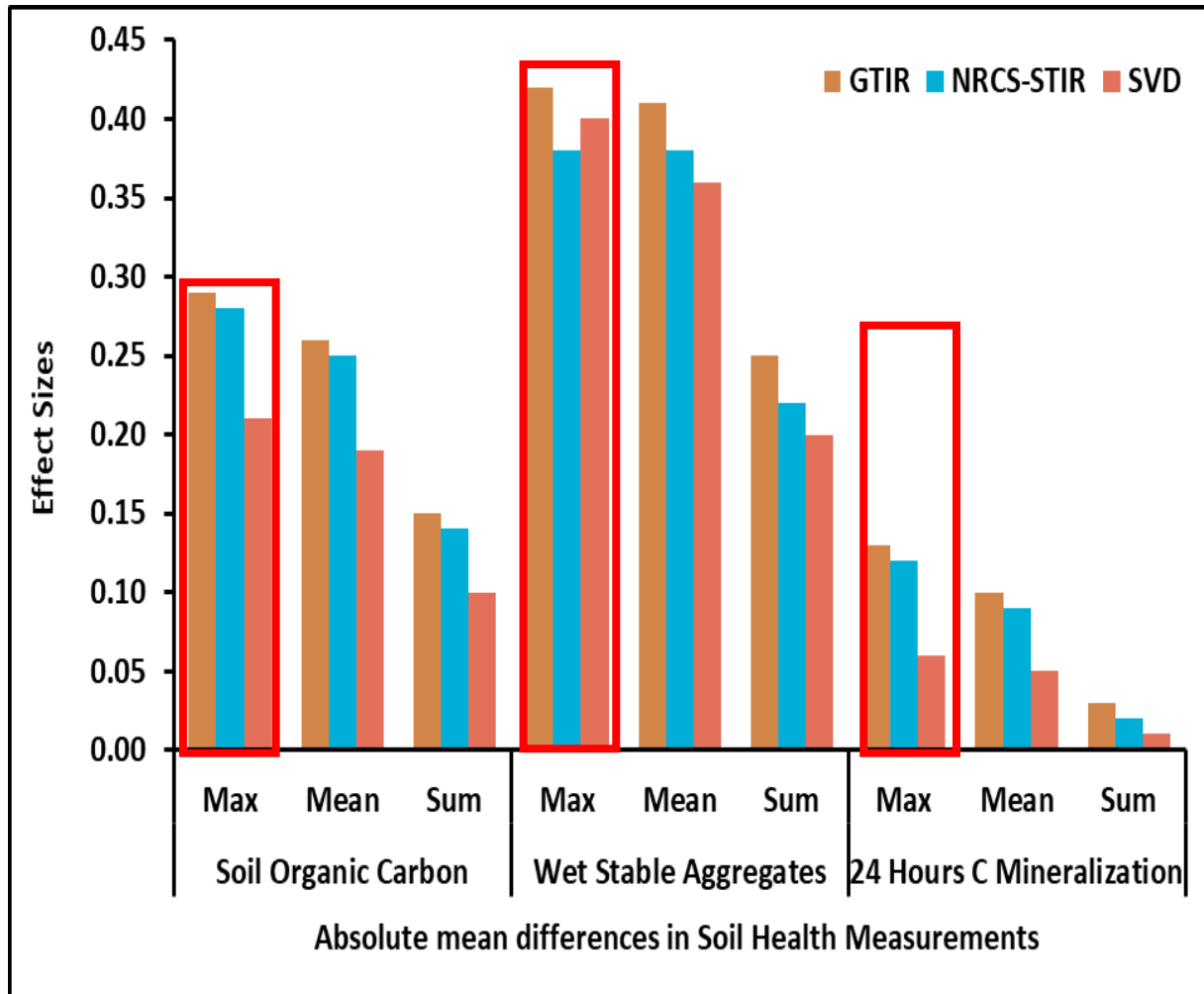


Fig 2. Univariate effect sizes of the relationship of within-trial mean differences in soil health measurements to within-trial differences in tillage disturbance indices.

- Annual Mean Maximum is the most efficient aggregation method
- gTIR and NRCS-STIR are comparable- gTIR requires less parameters
- gTIRmax showed strong effect size for the soil health indicators



## Tillage Index

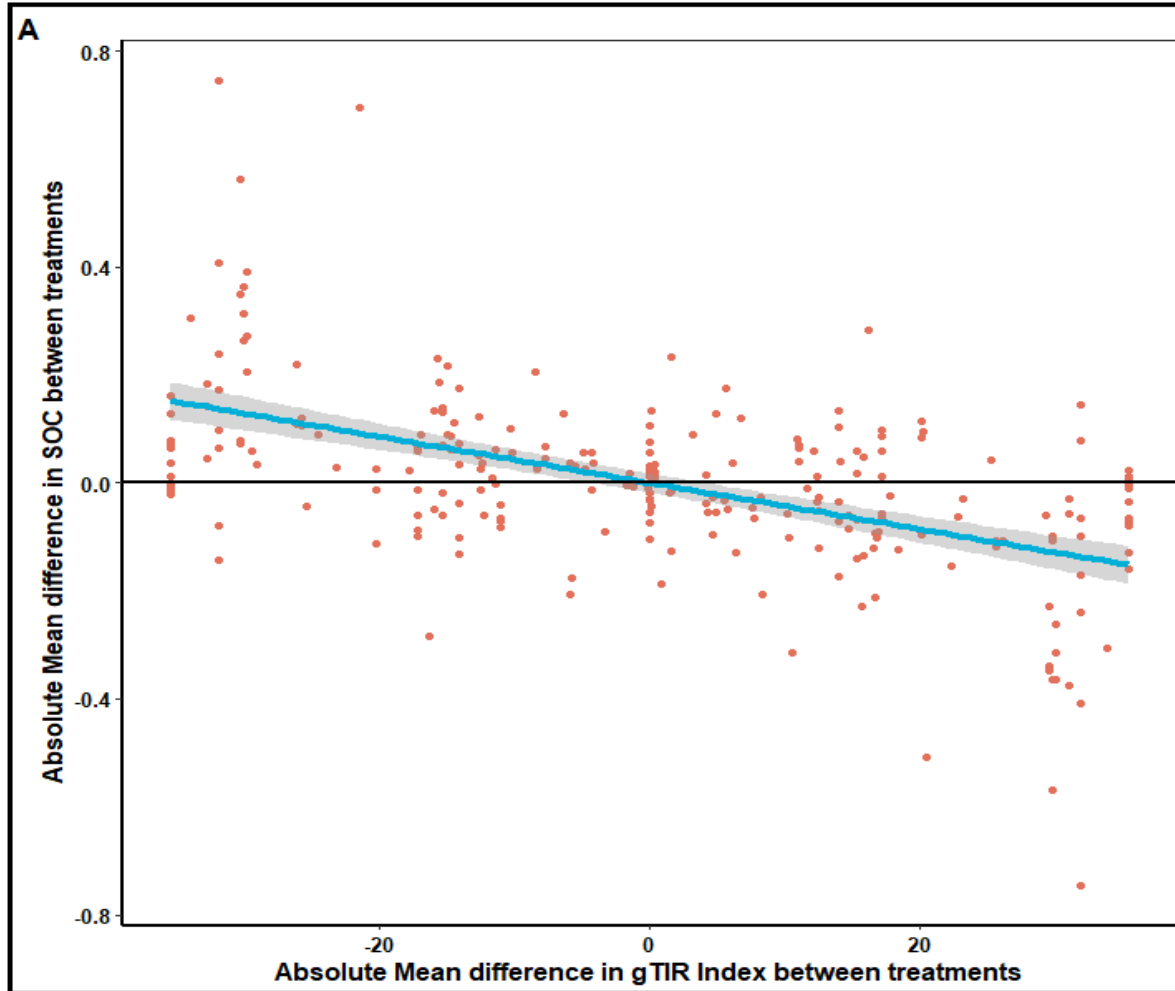


Figure 3. Responses of differences in soil organic carbon (SOC) concentration to differences in gTIRmax between paired tillage treatments.

- Negative relationship between gTIRmax and SOC
- Increase in intensity of tillage decreases SOC concentration.

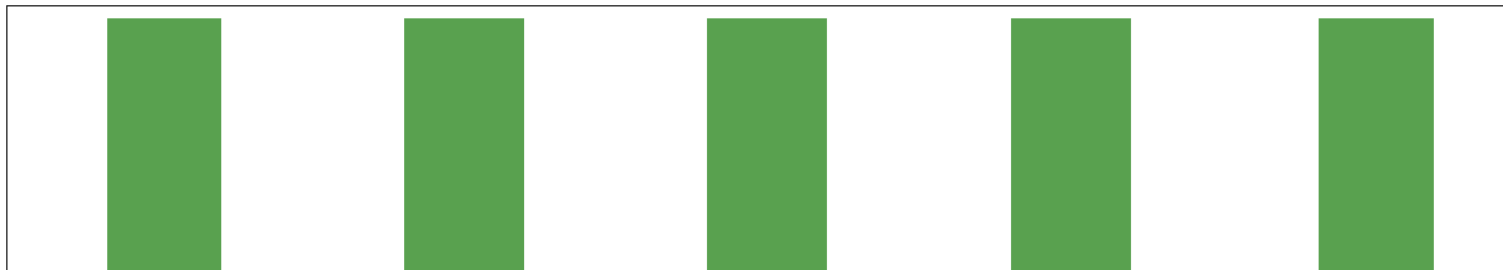
# What does cover cropping mean to you?

Study	Cover Crop Description	Details
Corn, snap bean, acorn squash (Michigan, USA)	Rye-Vetch or Vetch	Planted early fall, terminated following spring (every year)
Corn, soybean, wheat (Ontario, Canada)	Red Clover	Inter-seeded in winter wheat in spring, terminated in fall (every 4th year)

**Cover Crop?****No Cover Crop?**

# Live Roots Index (Continuous live roots)

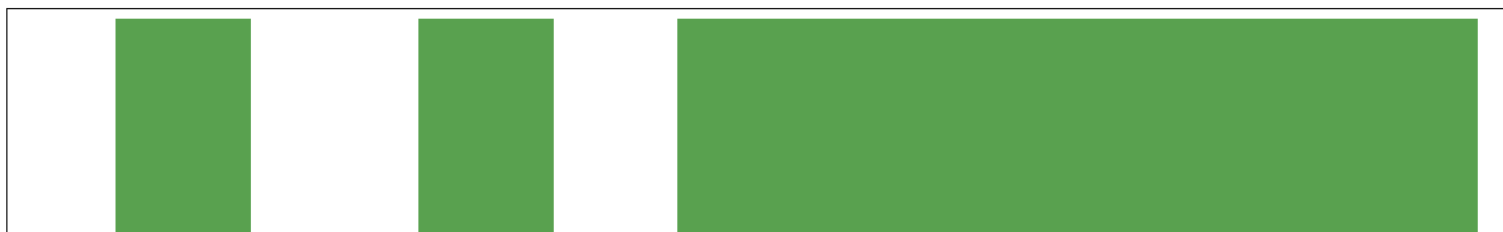
**Continuous Corn, No Cover Crop**



**Continuous Cotton, Cover Crop Mix**



**Corn, Corn, 3 Years Alfalfa for Hay**



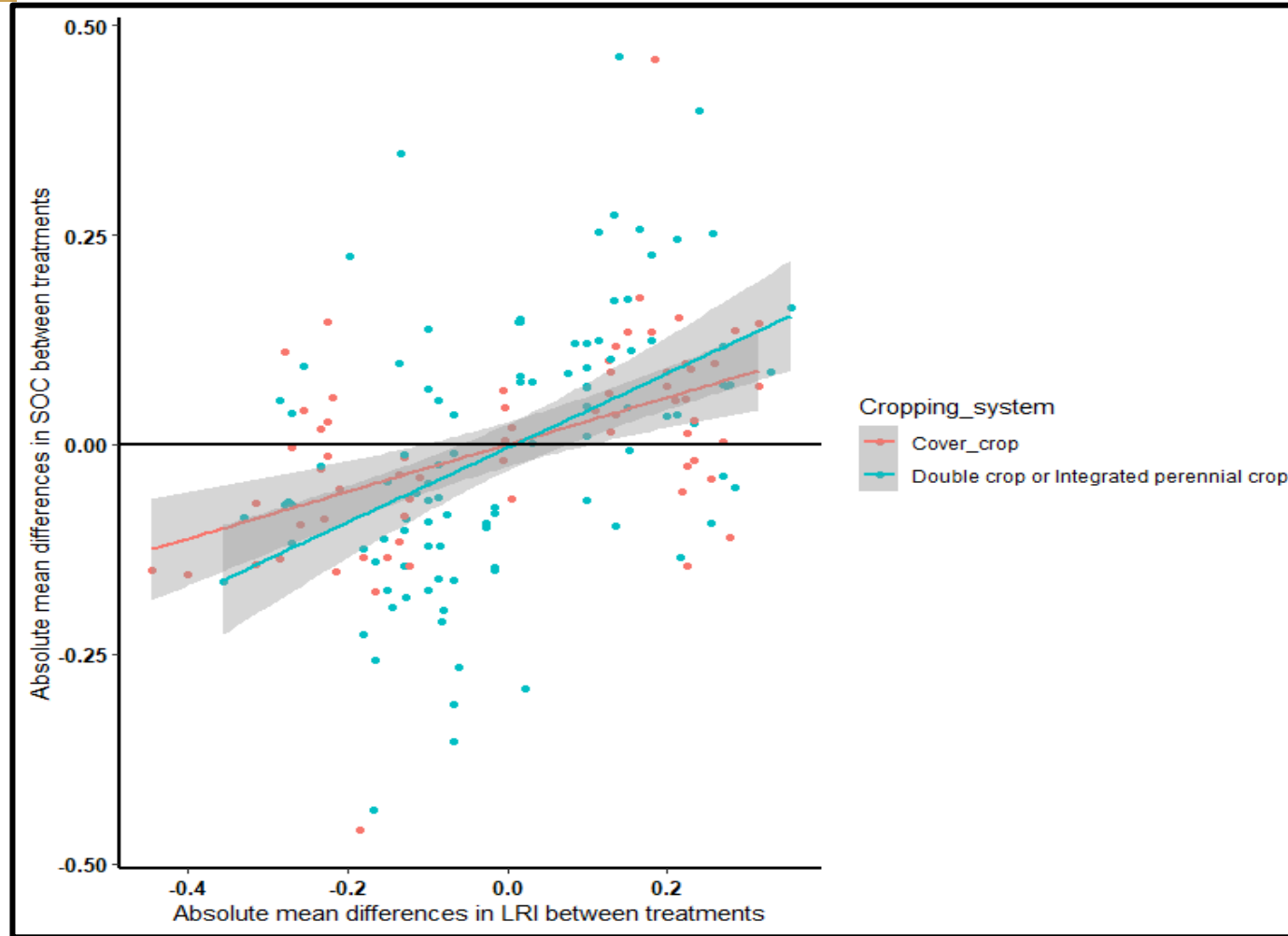
10/1/2014 7/1/2015 4/1/2016 1/1/2017 10/1/2017 7/1/2018

## Live Roots Index (Continuous live roots)

It is simply conceptualized as the total number of days per year when living roots are present in the soil.

Planting and Harvesting dates

$$\text{Living Roots Index (LRI)} = \frac{\text{Number of days with living plant/roots}}{\text{Number of days in a year (365)}}$$



**Figure 4.** Univariate effect sizes of the relationship of within-trial absolute mean differences in soil health measurements to within-trial differences in continuous living root index.

- **Positive relationship between LRI and soil health measurements**
- **Cover crops increased the SOC concentration**
- **Practices that increase LRI such as double cropping and inclusion of perennial crops also increased SOC**



# Indices Under Development



Soil armor



Plant diversity



Grazing

# Indices Summary

- Tillage Disturbance Index developed from STIR inputs- only need to know most disruptive implement from each year
- Living Roots Index calculated based on planting & termination data
- Results to be submitted for peer review by Dada et al.

# Soil Health Institute Metrics of Interest

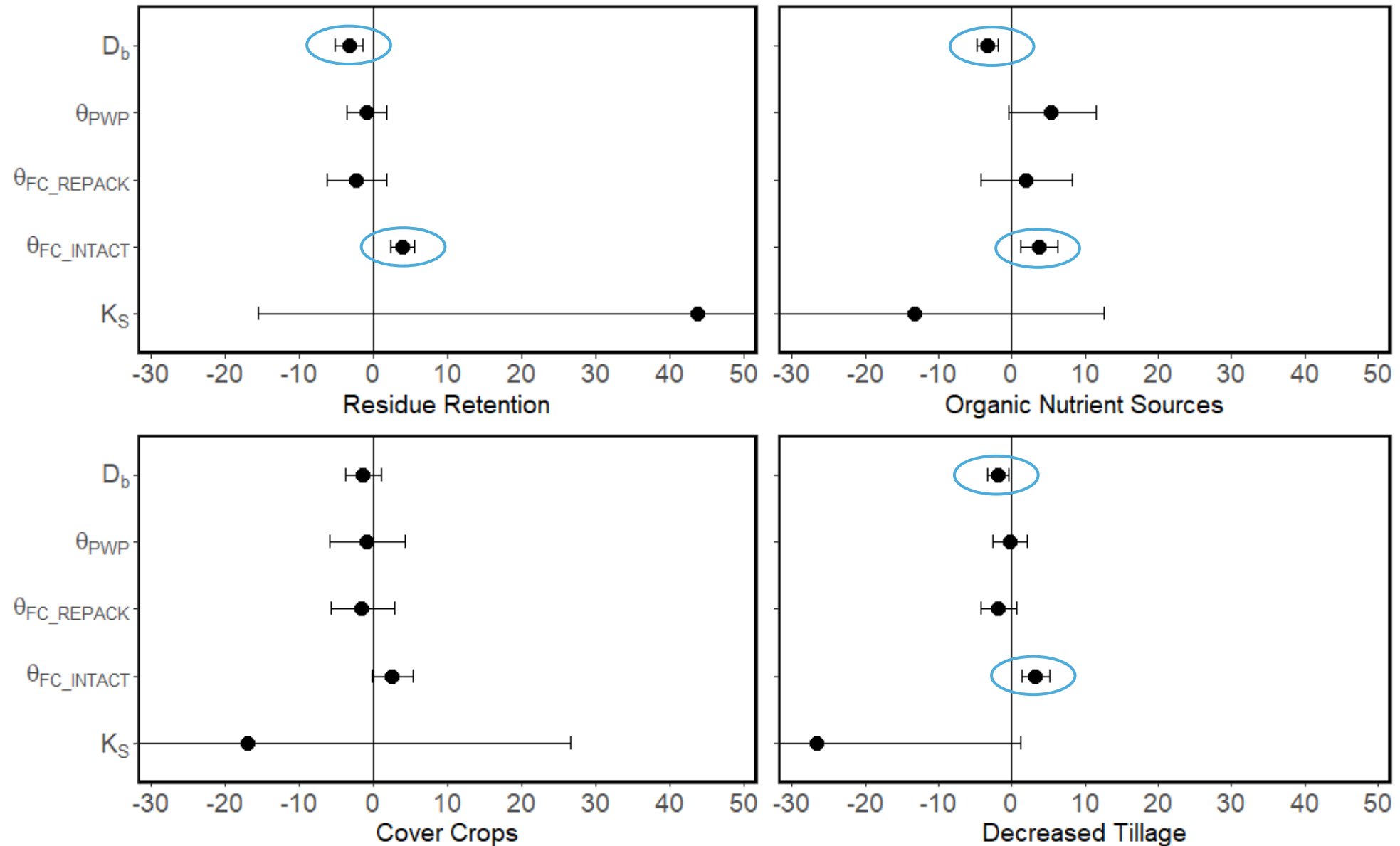
- ❖ Continuous management Indices
- ❖ **Predicting available water holding capacity**

# Indicators of soil water cycle

- Indicators assessed:
  - Bulk density ( $D_b$ )
  - Permanent wilting point ( $\theta_{PWP}$ )
  - Field capacity measured on repacked ( $\theta_{FC\_REPACK}$ ) and intact ( $\theta_{FC\_INTACT}$ ) cores
  - Saturated hydraulic conductivity ( $K_s$ )



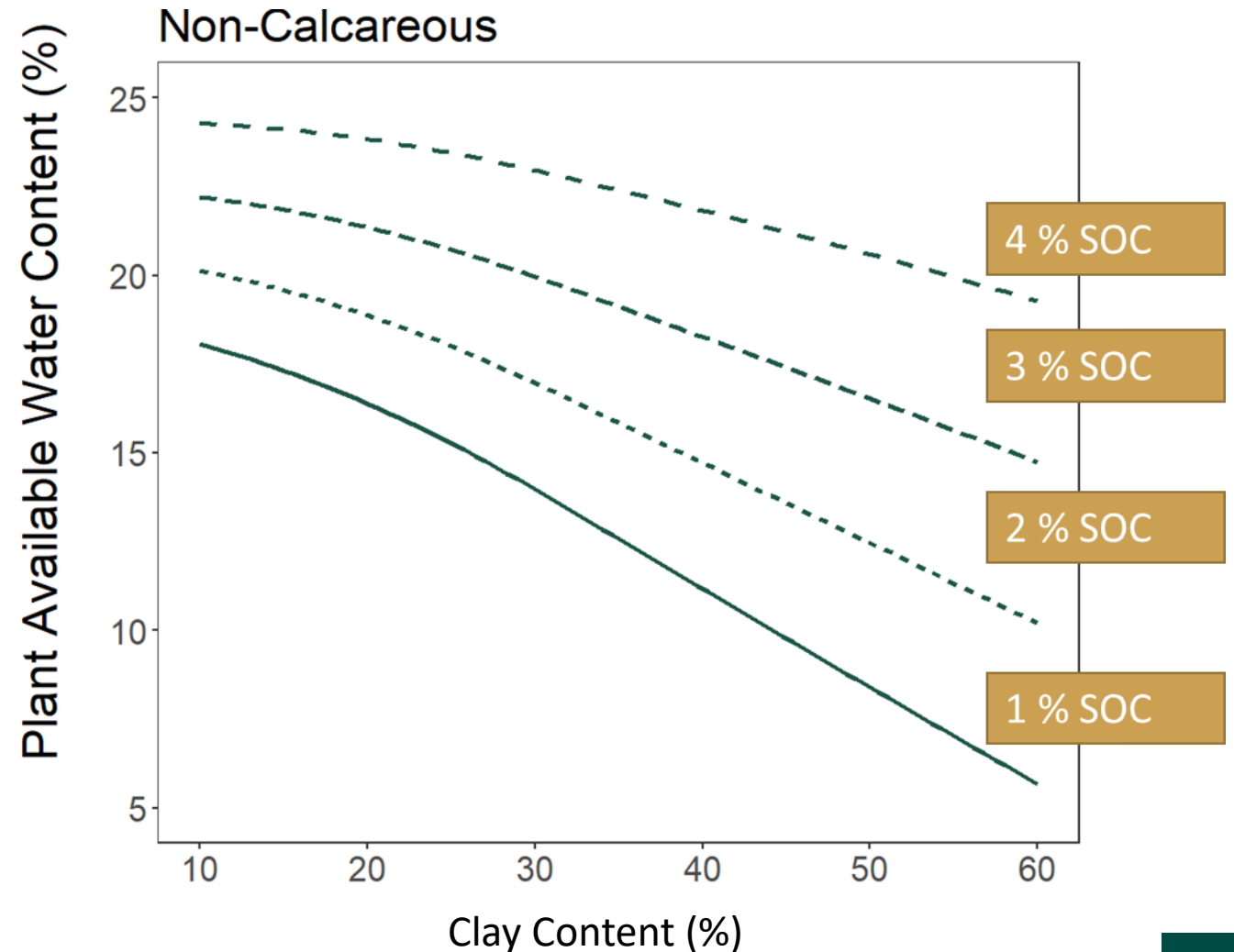
# Response to management practices





# Predicting Available Water Holding Capacity

- Current pedotransfer functions show a small effect of soil organic C plant available water
- Used NAPSHEM data with intact field capacity
- Differences represent changes in soil health management through soil organic C



## Predicting Available Water Holding Capacity- Summary

- Field capacity must be measured on intact cores to identify management induced changes- costly & not widely available!
- SHI pedotransfer function available on website:  
<https://soilhealthinstitute.org/our-work/initiatives/measurements/#resources>

# Questions?

