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What's the Deal with Soil Health Tests?

August 26, 2020 | Stacy Zuber, State Soil Health Specialist

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What makes soil health tests different?

Soil Health

- The continued capacity of the soil to **function** as a vital living ecosystem that sustains plants, animals, and humans.



Soil Health Functions



- Produce food, feed, fiber, biofuels & medicine
- **Capture, filter, and store water**
- **Cycle and recycle nutrients**
- Resilience to drought, flood & temp extremes
- Protect plants from pathogens and stress
- Detoxify pollutants
- **Store C and moderate release of gases**
- **Resist erosive forces**



Soil Health Functions



Difficult to measure directly

Soil health tests are a proxy for measuring soil functions.



What are soil health tests?



Indicators

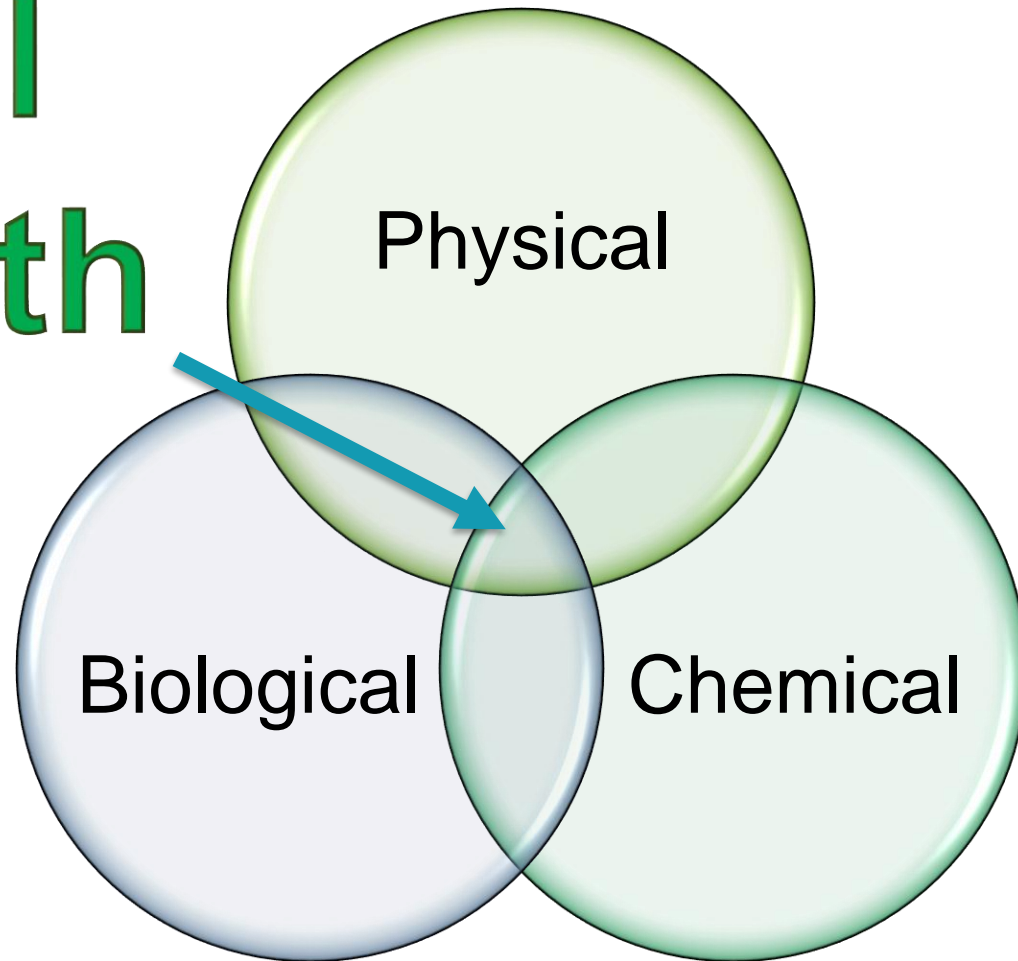
Metrics

Tests

Measurements



Soil Health



**Soil
Fertility**

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Soil Health Indicator Requirements

NRCS Tech Note 450-03

Effectiveness

- **Management sensitive**
- **Short-term sensitivity**
 - Within 1 to 3 years for significant management changes.
- **Interpretable**
 - Standalone or in combination with other tests.
- **Useful**
 - Assesses overall soil health or specific resource concerns

Commercial Readiness

Repeatability

Interpretable for agricultural management decisions



Common Soil Health Indicators



What tests are available?

Relationship to soil functions?

How should they be interpreted?

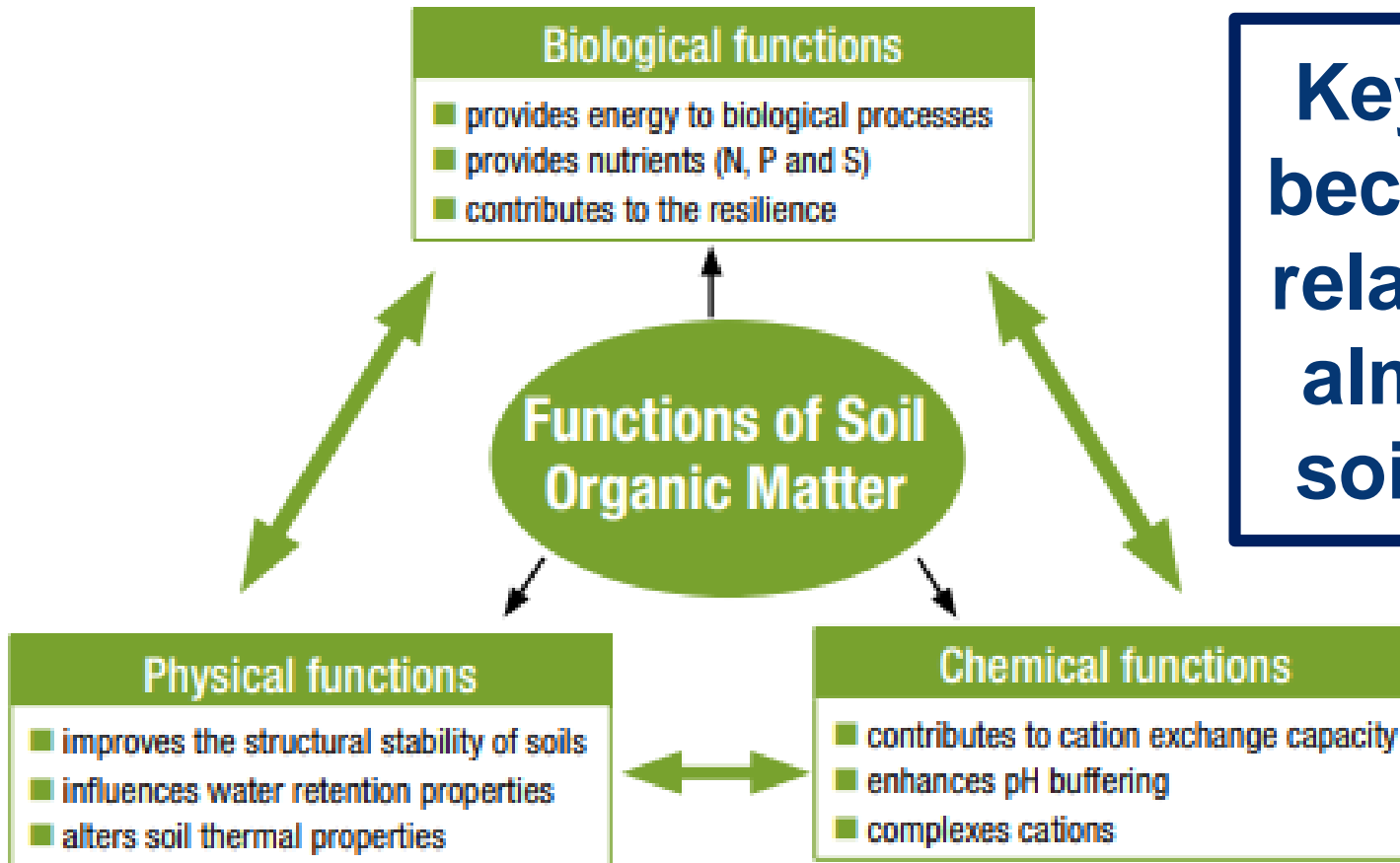
How reliable is the test?





Organic Matter Cycling & Carbon Sequestration

Soil Organic Matter/Carbon



**Key indicator
because of the
relationship to
almost every
soil function!**

GRDC, Australia

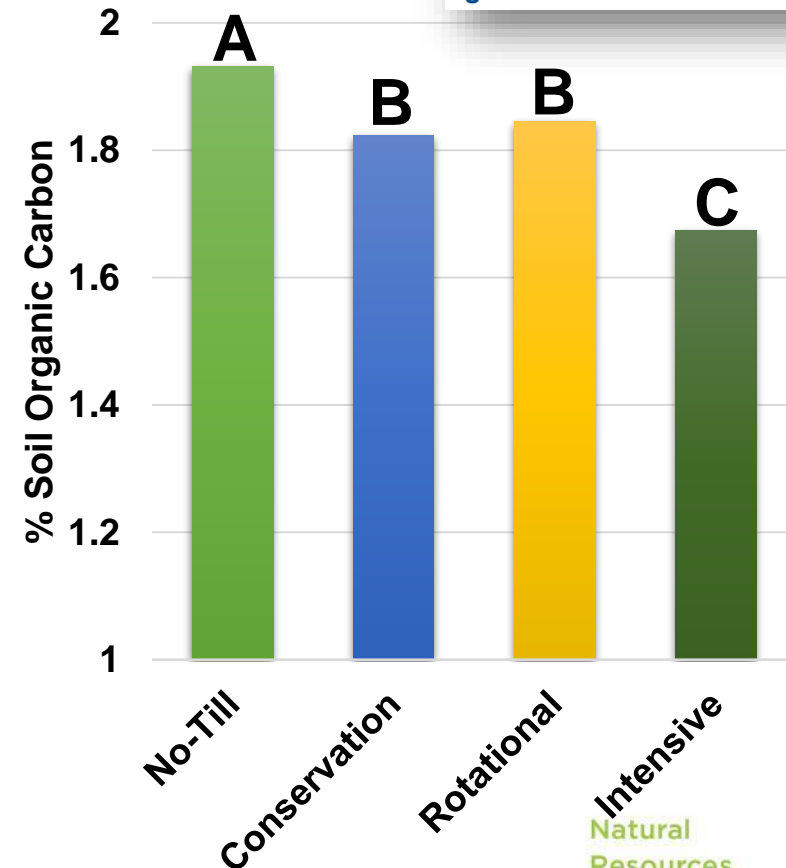
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Soil Organic Matter/Carbon

- Soil organic matter (SOM)
- Soil organic carbon (SOC)
- Often measured as SOC
- Can convert between them
 - $SOM = SOC \times 1.74$
 - But conversion rate can vary between soils so SOC is more accurate.



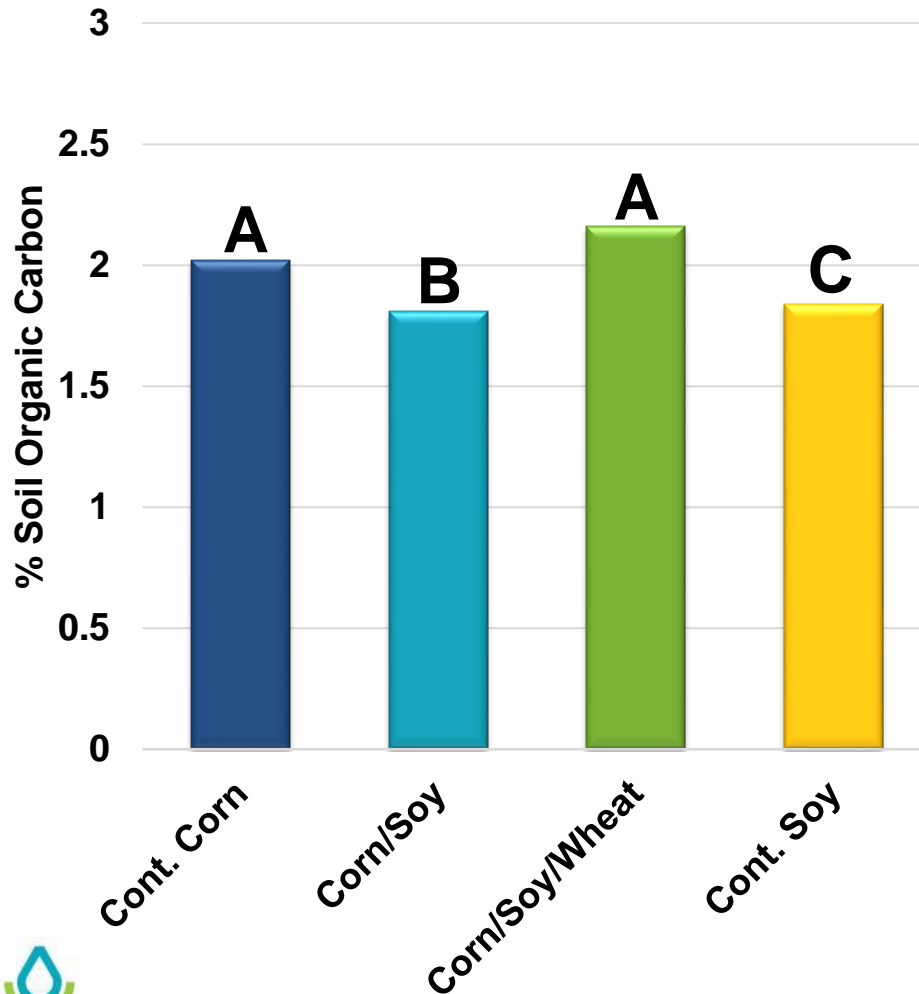
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Soil Organic Matter/Carbon

Perry, IL—Alfisol



**May take 3 to 5
years to show
appreciable change.**

**Could take longer in
soils with higher
inherent SOM.**





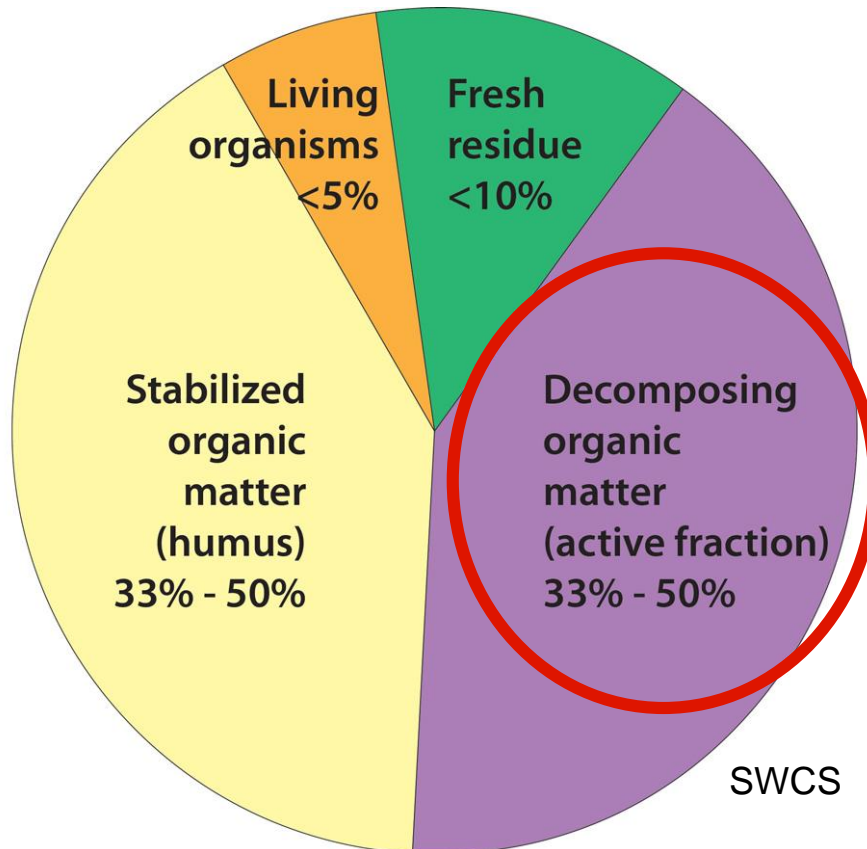
Readily Available Carbon Food Source



Readily Available Carbon



Soil Organic Matter Composition



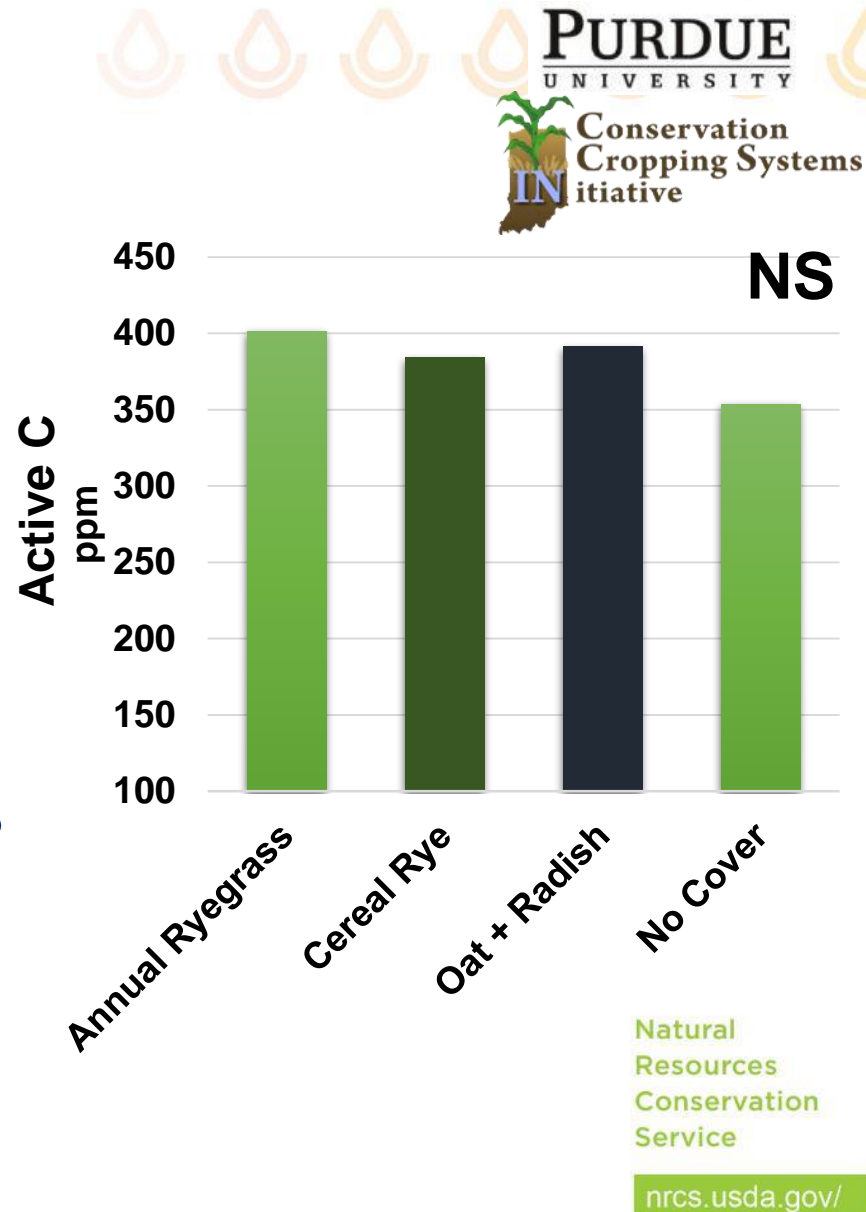
Microbial food source

Also called labile fraction



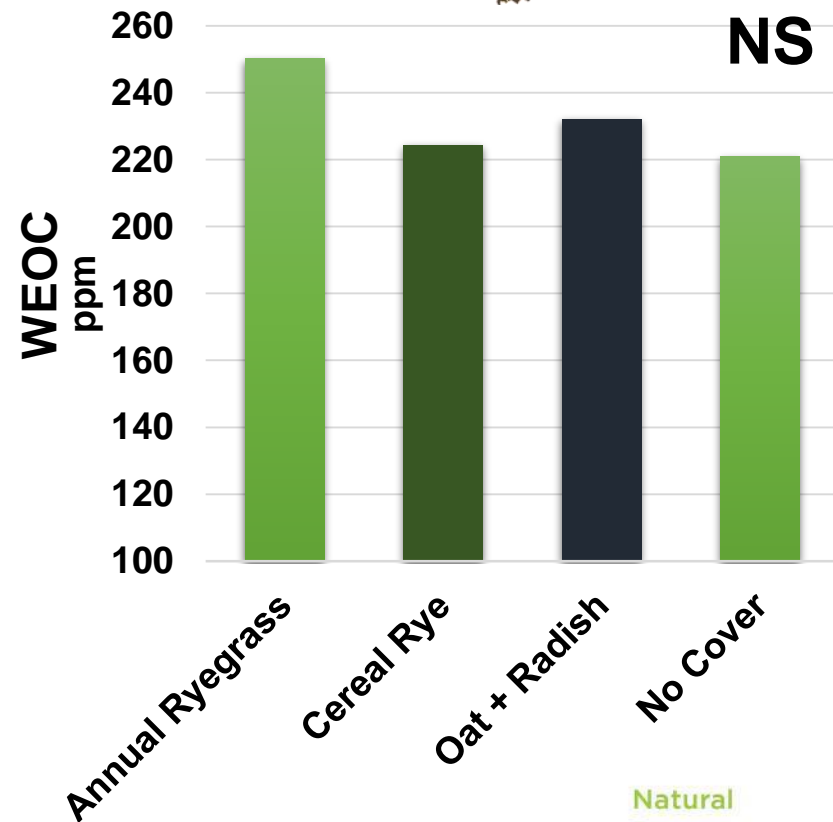
Active Carbon

- Permanganate oxidizable carbon (POXC)
- Useful indicator of long-term C sequestration.
- More sensitive to changes in crop and soil management than SOC.



Water Extractable Organic C

- Cold-water extractant
- Used in Haney Test
- Rationale is that C that can dissolve in water is most available to microbes.



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Nitrogen Cycling

ACE Soil Protein



- **ACE=Autoclaved Extractable**
- **Majority of N in soil organic matter is in proteins.**
- **Indicates amount of organic N that is cycling through microbial biomass and may be released in plant-available forms.**



Potentially Mineralizable Nitrogen

- Also, represents amount of organic N that may be converted to plant-available form
- Plus gives an indication of size and activity of microbial community
- Most common method is 7-day incubation.
- Since more time consuming, it is not as commonly available from commercial labs.



Water Extractable Organic N

- **Part of Haney Test**
- **Same as WEOC.**

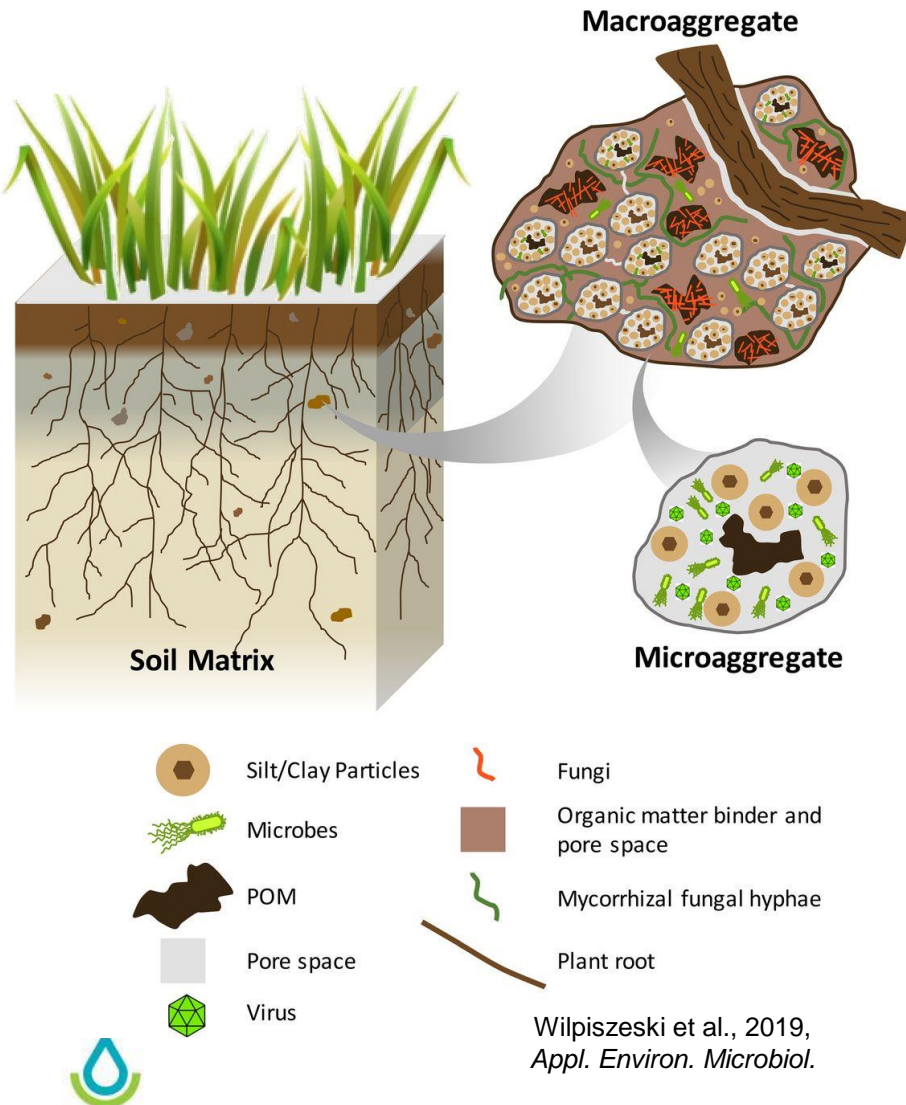


Soil Structure

Infiltration

Resistance to Erosion

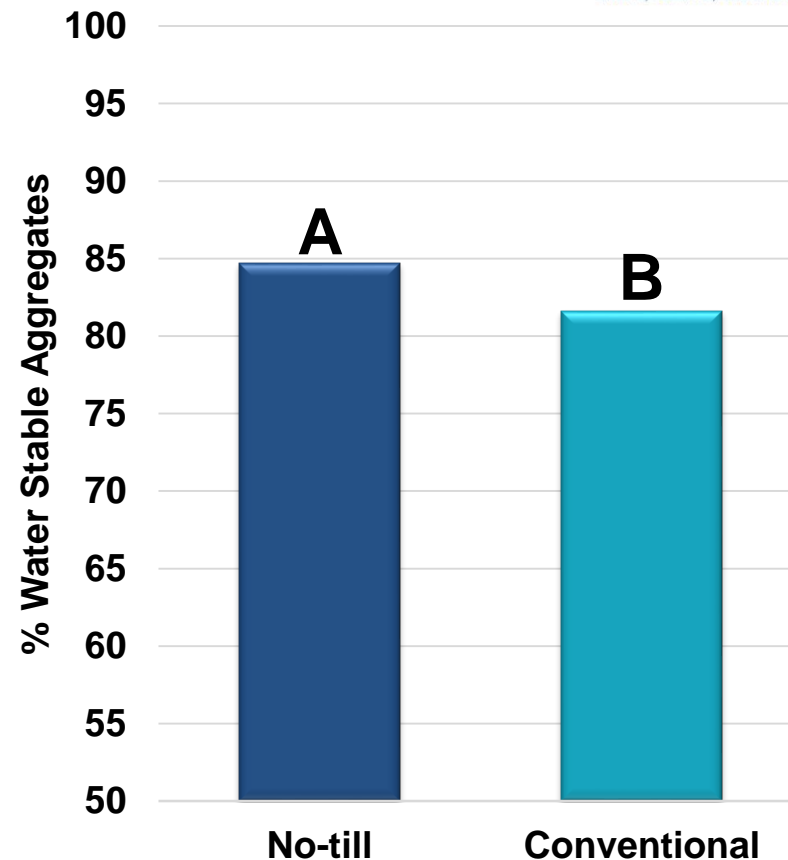
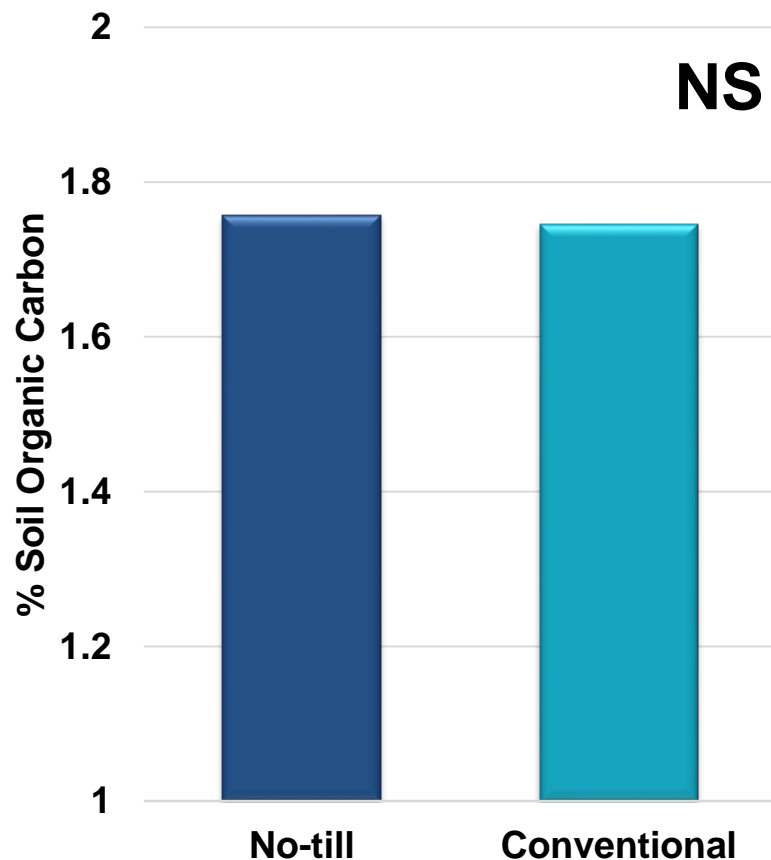
Aggregate Stability



- Strongly related to water infiltration & ability to resist erosion.
- Different methods available, but usually reported as %.
 - What % of aggregate hold together?



Aggregate Stability





Microbial Activity

Soil Respiration

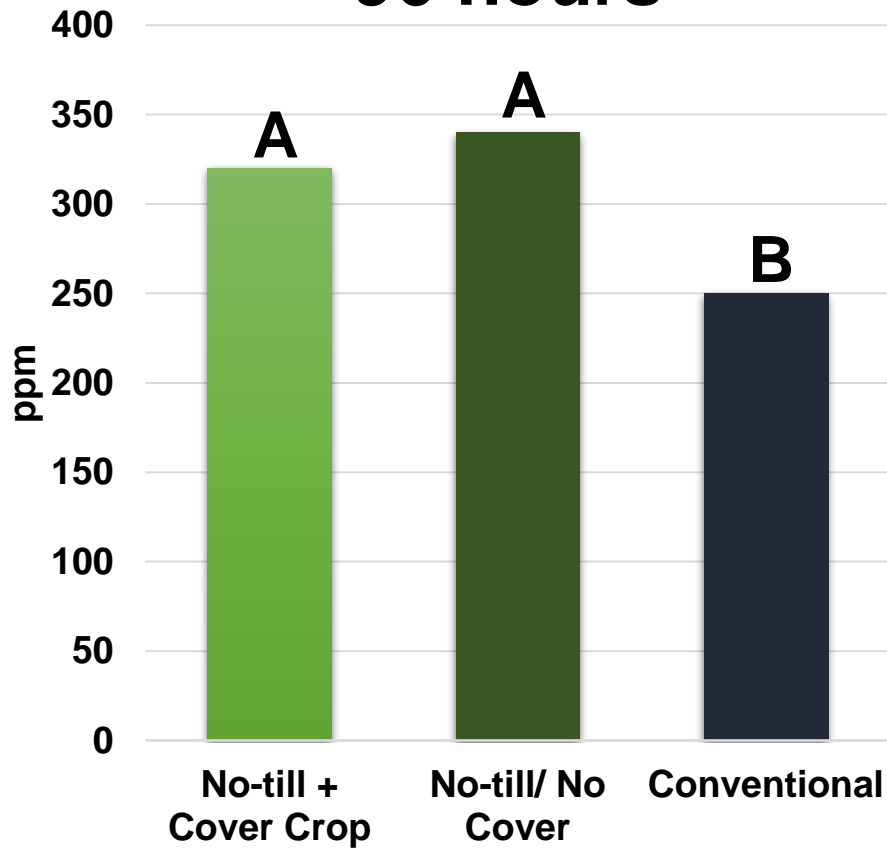


- **Rewetting dried soil then incubated**
- **Measures CO₂ release over certain # of hours**
 - Commonly either 96 hrs or 24 hrs
- **Provided indication of how much the microbes are eating and how active they are.**
- **Also called “Short-term C mineralization”**

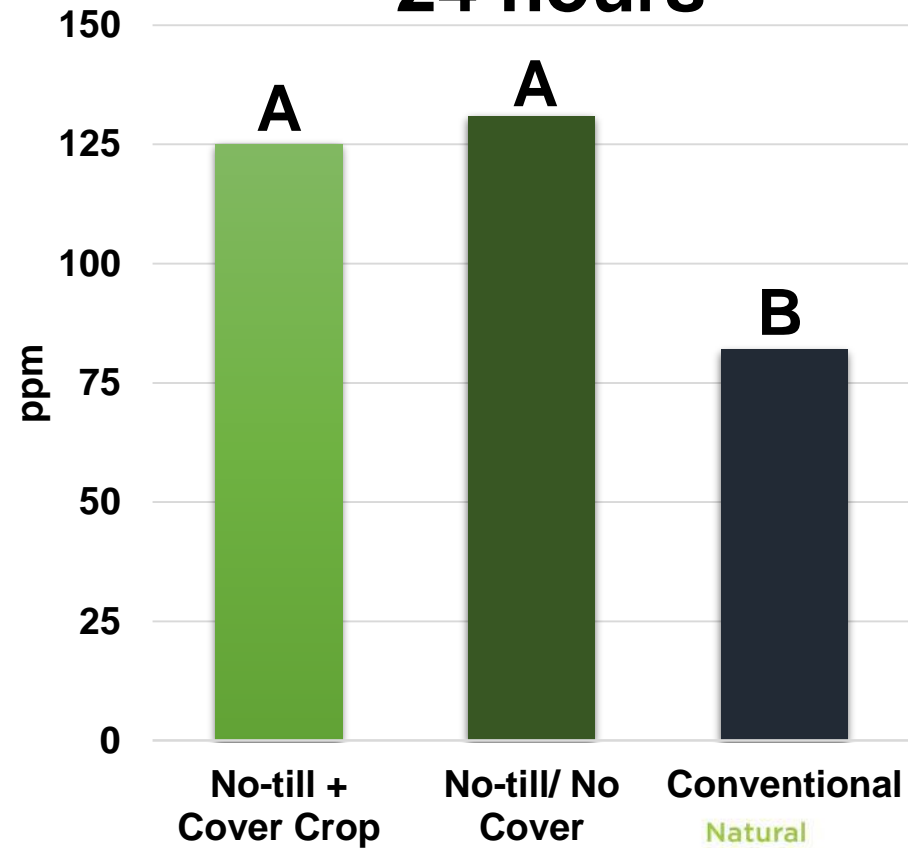


Soil Respiration

96 hours



24 hours



Enzyme Activities



- **Reflect potential for microbes to convert and cycle nutrients.**
- **Enzymes are the metabolic protein keys for breaking up larger molecules.**
 - Cellulose, DNA, lipids, chitin, proteins
- **Recommended:**
 - β -glucosidase (BG) for C
 - N-acetyl- β -D-glucosaminidase (NAG) for N & C
 - Arylsulfatase for S
 - Acid/alkaline phosphatase for P

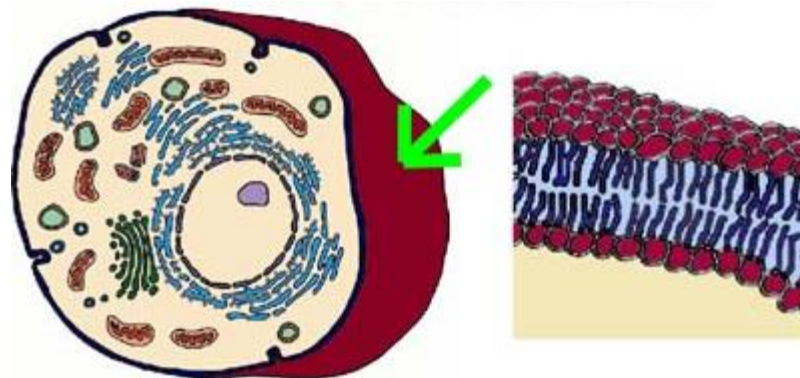




Microbial Diversity

Phospholipid Fatty Acids (PLFA)

- Biochemical marker in cell membranes.
- Unique to broad classifications in soil biology.
- Provides an indication of relative abundance of microbial groups and total microbial biomass.

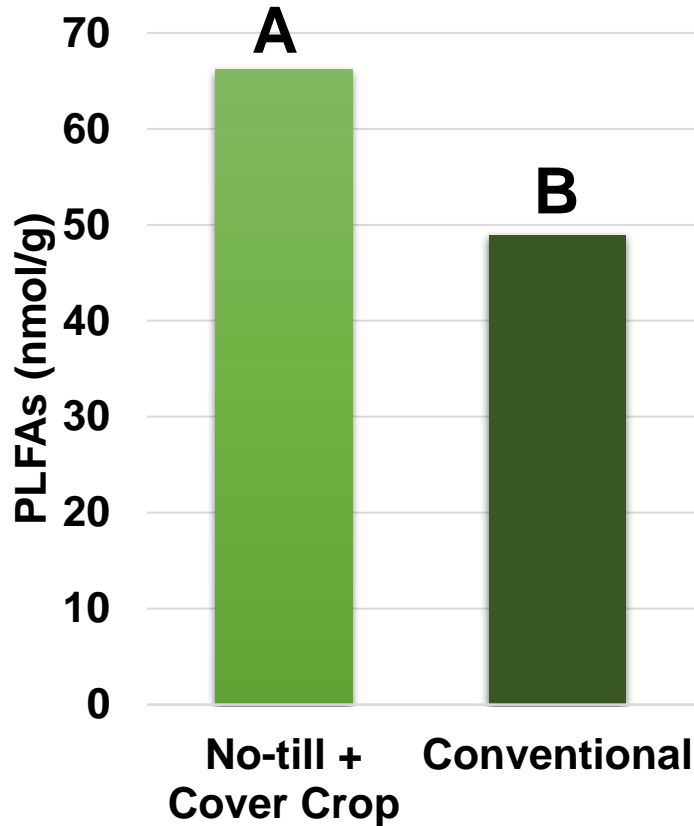


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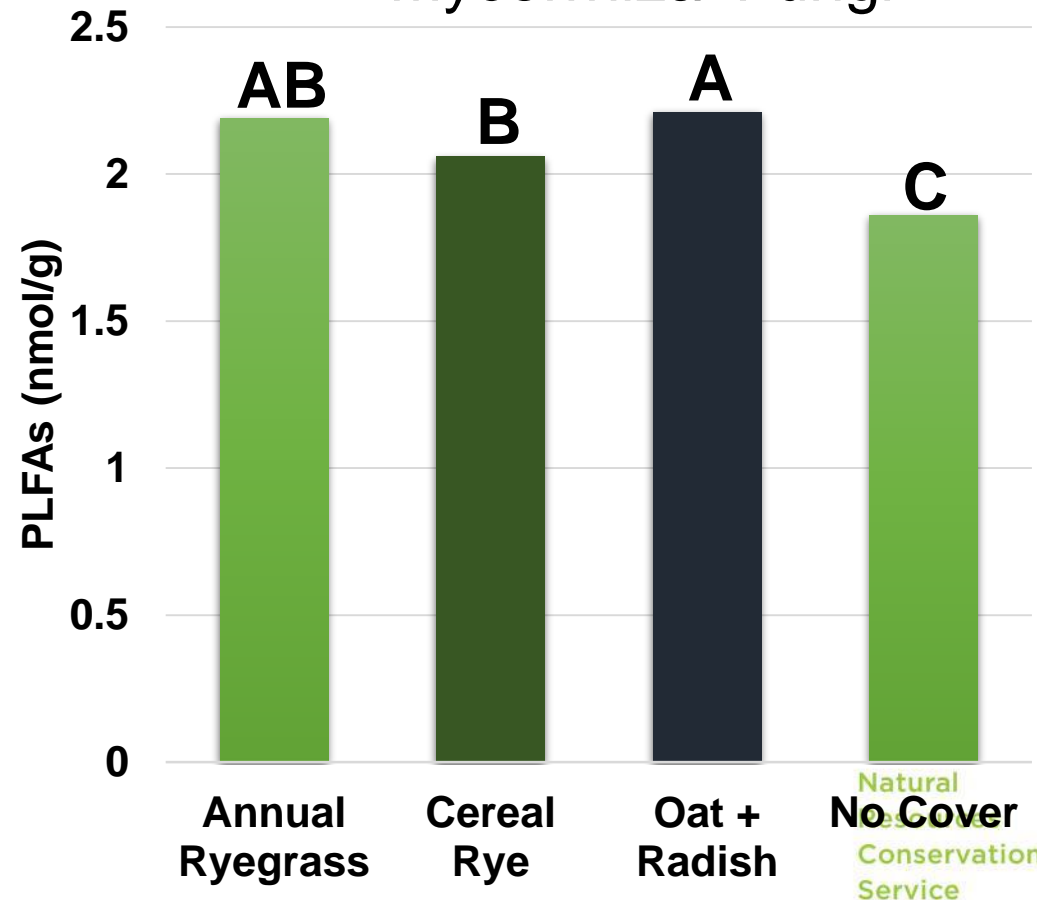


Phospholipid Fatty Acids (PLFA)

Total Microbial Biomass



Mycorrhizal Fungi



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Other Methods



Genetic Analysis of Soil Microbiome—DNA, RNA Biolog Assays

- **Not widely available on commercial level.**
- **Can provide high level of detail about microbial community diversity.**
- **Complicated to interpret.**



Soil Health Test Packages

- **Becoming more widely available from commercial soil testing labs.**
- **Sometimes include overall rating of soil health, integrating several metrics together.**



Comprehensive Assessment of Soil Health

Measured Soil Textural Class: **silt loam**

Sand: 7% - Silt: 66% - Clay: 26%

**Percentile ratings
based on soils in
the CASH database.**

Group	Indicator	Value	Rating	Constraints
physical	Available Water Capacity	0.27	94	
physical	Surface Hardness	148	57	
physical	Subsurface Hardness	241	70	
physical	Aggregate Stability	15.2	19	Aeration, Infiltration, Rooting, Crusting, Sealing, Erosion, Runoff
biological	Organic Matter	3.2	58	
biological	ACE Soil Protein Index	4.2	23	
biological	Soil Respiration	0.3	18	Soil Microbial Abundance and Activity
biological	Active Carbon	499	49	
chemical	Soil pH	6.6	100	
chemical	Extractable Phosphorus	4.3	100	
chemical	Extractable Potassium	164.4	100	
chemical	Minor Elements Mg: 538.9 / Fe: 4.0 / Mn: 8.3 / Zn: 0.4		100	

Scores between:

- 0 - 20 → very low (red)
- 20 - 40 → low (orange)
- 40 - 60 → medium (yellow)
- 60 - 80 → high (light green)
- 80 - 100 → very high (dark green)

Overall Quality Score: 66 / Excellent

Haney Test



- **Package available from many commercial labs**
- **Nitrogen and nutrients component**
 - N release
- **Soil Health Measurements**
 - Water Extractable Organic C & N
 - 24 hour Soil Respiration/ CO₂ Burst



Haney Soil Health Calculation

$$\text{Soil Health Calculation} = \frac{\text{CO}_2(24\text{hr})}{10} \times \frac{\text{WEOC}}{100} \times \frac{\text{WEON}}{10}$$

$\text{CO}_2(24\text{hr}) \rightarrow$ Soil Respiration/ CO_2 Burst

WEOC \rightarrow Water Extractable Organic Carbon

WEON \rightarrow Water Extractable Organic Nitrogen

- No specific goal threshold, but look for increase over time.



A la Carte



Start with:

- **Soil organic carbon**
- **Activity carbon**
- **Soil protein**
- **Aggregate Stability**



Comparisons or Monitoring

Comparisons

- **Make sure soil types and landscape position are similar**
 - Don't compare **apples** to **oranges**.

Monitoring over time

- **Consider taking a reference sample when you take your baseline**
 - undisturbed area, fence row, long-term pasture, etc.
- **Sample every 3-5 years**
 - Consider crop rotation-sample in the same phase.



Spatial Variability



- **Most soil health indicators closely related to soil biology.**
- **Lots of spatial variability.**
- **Soil microbes tend to be concentrated in hotspots and are very sensitive to soil environmental conditions.**



Sampling Procedures



Be CONSISTENT!

- **If monitoring over time, take detailed notes to match up conditions for the next time:**
 - GPS coordinates
 - Sample depth
 - Residue on the soil surface
 - Proximity to plant roots
 - Soil moisture
 - Date of sampling
 - Tillage
 - Amendments—manure, lime, NPK, etc.



Consistency with Lab and Tests Too!

Be CONSISTENT!

- **Methods may vary between labs.**
 - Aggregate Stability
 - PLFA
- **How samples are handled may differ**
 - Air-drying, sieving, etc.



Sampling Procedures



- 15 to 20 cores to a depth of 6"
- Or can go shallower (0-4", 0-2") particularly for aggregate stability.

Sampling pattern

- Can focus on sampling zones of field based on soil type, yield map, etc.
 - 15 – 20 foot area
- Or consistent sampling across entire field.

Again, most important thing is to BE CONSISTENT!



Shipping Samples



Check into what your lab recommends

- **Most commercial lab tests and packages use air-dried samples –no special requirements.**
- **BUT, soil biological measurements may require next-day shipping or shipping on ice.**
 - PLFA
 - Enzymes



Soil Health Tests



- Follow these recommendations to minimize variability and maximize usefulness of the tests.
- These tests are more sensitive, but small changes may still not be detectable.
- Tests are expensive, make sure you take the time to do them right!





Thank You!

Questions?

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