Challenges with Soil Health Testing

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ALTA Summer Meeting
August 29, 2023—Bloomington, IL

My Background in Soil Health Testing

- University of Illinois –M.S. & Ph.D.
- Purdue University Post-Doc
  - CCSI On-Farm Research Sites
- University of Missouri-Columbia Post-Doc
  - SHAC & DNR Cover Crop Cost-Share Project
- NRCS State Soil Health Specialist

United States Department of Agriculture
National Institute of Food and Agriculture
SUSTAINABLE CORN.ORG
CROPS, CLIMATE, CULTURE AND CHANGE

PURDUE UNIVERSITY
Conservation Cropping Systems Initiative

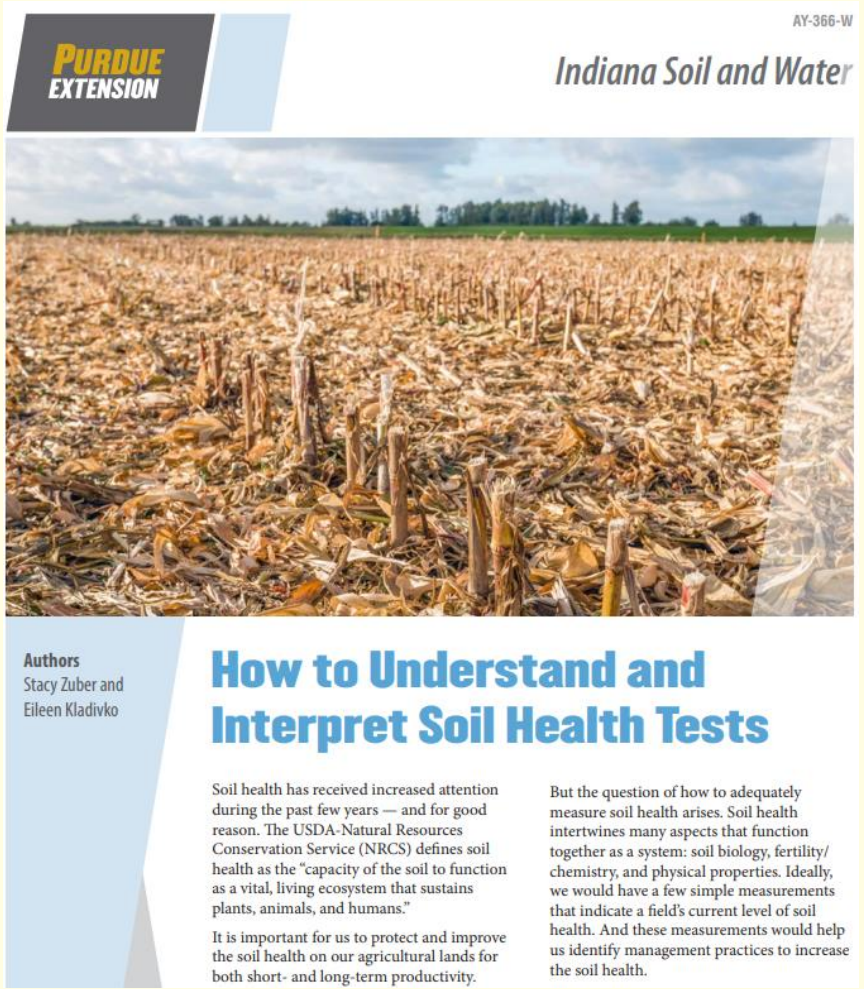
USDA United States Department of Agriculture
Natural Resources Conservation Service

University of Missouri
MISSOURI DEPARTMENT OF NATURAL RESOURCES

USDA United States Department of Agriculture
Agricultural Research Service

Resources

- Purdue Extension Publication



PURDUE EXTENSION

AY-366-W

Indiana Soil and Water

Authors
Stacy Zuber and
Eileen Kladivko

How to Understand and Interpret Soil Health Tests

Soil health has received increased attention during the past few years — and for good reason. The USDA-Natural Resources Conservation Service (NRCS) defines soil health as the "capacity of the soil to function as a vital, living ecosystem that sustains plants, animals, and humans."

It is important for us to protect and improve the soil health on our agricultural lands for both short- and long-term productivity.

But the question of how to adequately measure soil health arises. Soil health intertwines many aspects that function together as a system: soil biology, fertility/chemistry, and physical properties. Ideally, we would have a few simple measurements that indicate a field's current level of soil health. And these measurements would help us identify management practices to increase the soil health.

Resources

- Missouri Extension Publication

Extension
University of Missouri

Getting Started With Soil Health Testing in Missouri

Recent public initiatives and USDA programs are putting a focus on producers to improve the health of their soils. Soil health is defined by the USDA-NRCS as "the continued capacity of the soil to function as a vital, living ecosystem that sustains plants, animals, and humans." Soil health encompasses the biological, physical, and chemical aspects of soil function. Improving soil health will lead to a more sustainable agricultural system by protecting the soil resource while maintaining productivity and reducing environmental degradation.

Current practices that producers can implement to improve their soil health include reduced tillage or no-till, cover crops, intercropping, manuring and more diverse crop rotations. Integration of livestock with cropping systems, such as grazing cover crops, can also boost soil health. Improving soil health may take time and will need to be monitored following appropriate sampling and testing protocols.

Several commercial soil testing laboratories offer soil health packages that measure biological, physical, and/or chemical soil characteristics. Some of these packages also provide an interpretation of the data,

Figure 1. Farmers are increasingly interested in understanding how to measure the health of their soils, especially the impact of management changes such as cover crops. (Credit: R. Myers)

from soil fertility sampling in several ways. Unlike soil fertility testing, soil health indicators are focused on soil microorganisms and their habitat. These biological and physical indicators are more sensitive to changes in management practices and environmental conditions — precisely the reason they were selected as soil health

Background on Soil Health Tests

What is soil health?

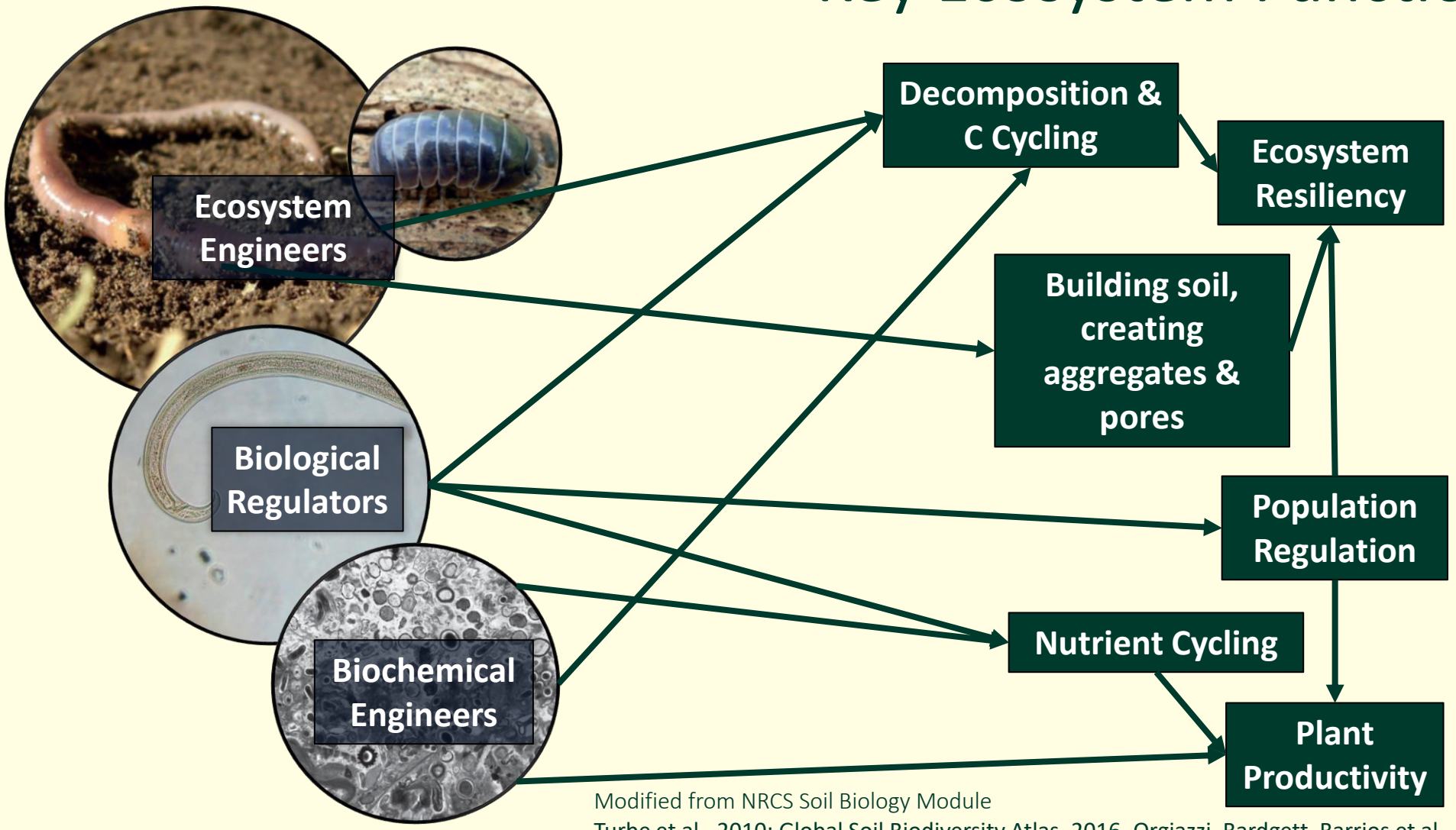
The continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals, and humans.

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 Organisms

Key Ecosystem Functions



Modified from NRCS Soil Biology Module

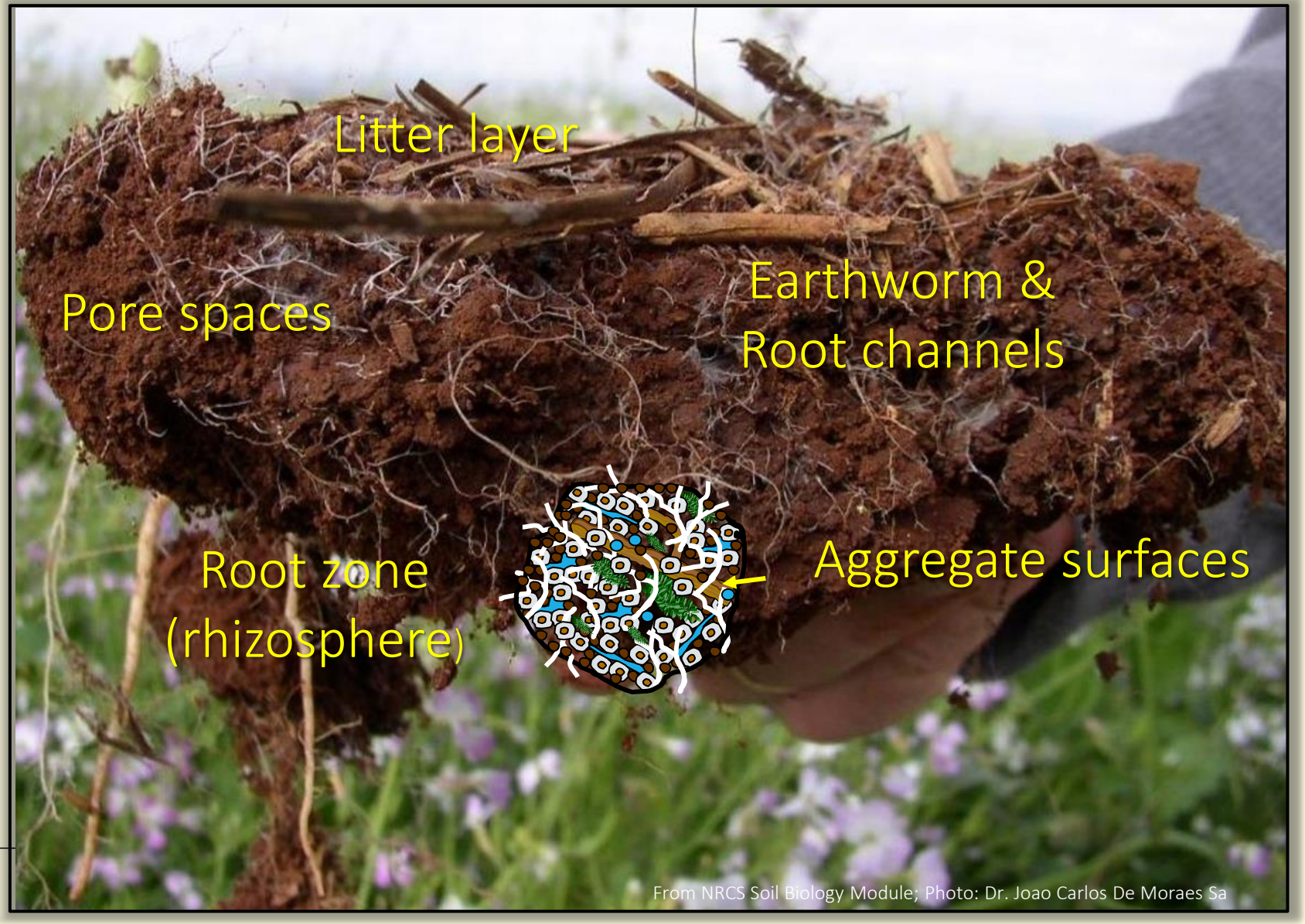
Turbe et al., 2010; Global Soil Biodiversity Atlas. 2016. Orgiazzi, Bardgett, Barrios et al.

Spatial Variability

- Most soil health indicators closely related to soil biology.
- High amount of spatial variability.

Spatial Variability

- **Soil microbes tend to be concentrated in hotspots and are very sensitive to soil environmental conditions.**

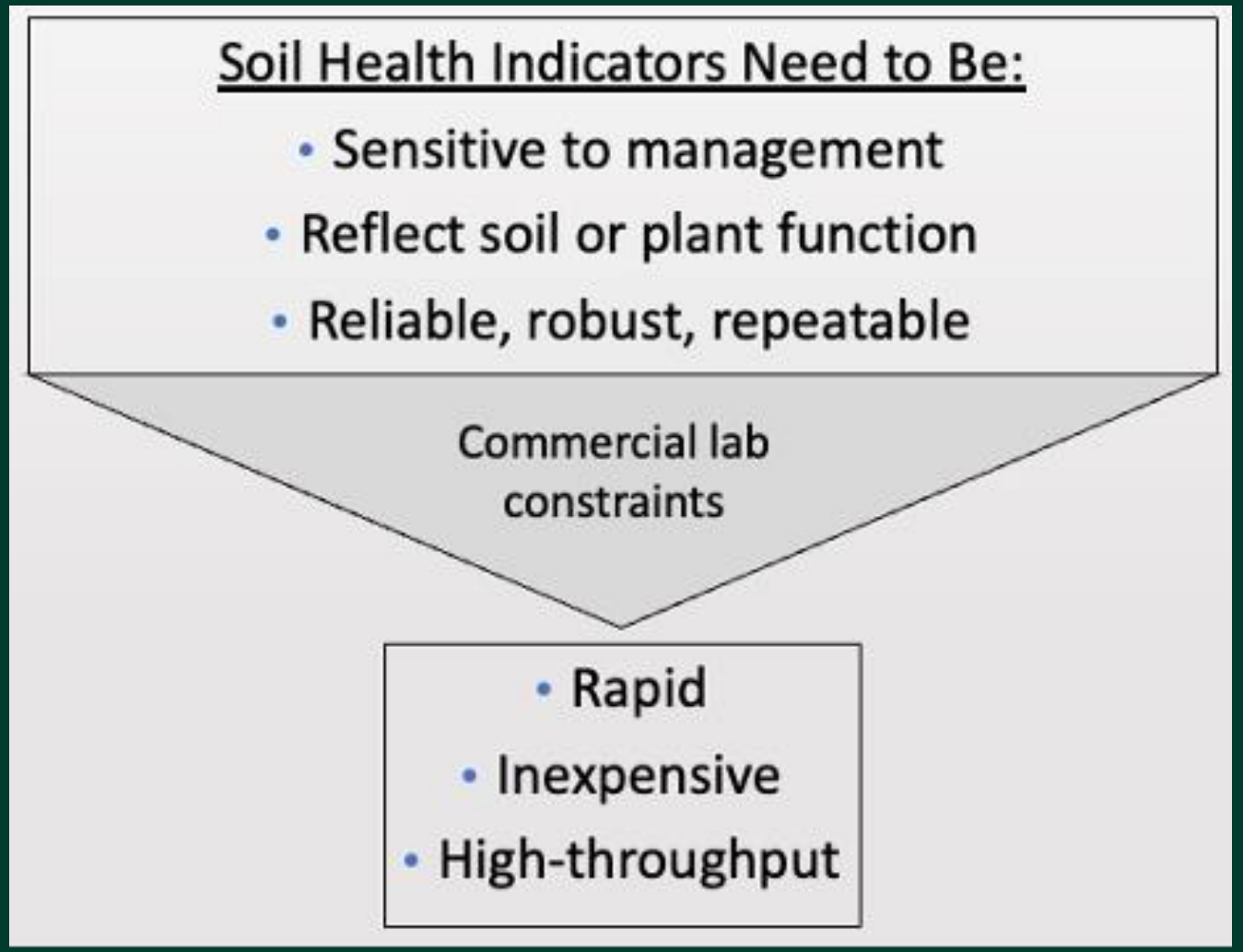


Soil Health Functions

Difficult to measure directly

Soil health tests are a proxy for measuring soil functions.

Criteria for Good Soil Health Indicators



Steve Culman, Washington State University

Soil Health Indicators

Physical

- Bulk Density
- Aggregate Stability
- Penetration Resistance
- Water Infiltration
- Water Holding Capacity
- Erosion Rating

Chemical

- Organic Carbon
- pH
- Nitrogen
- Phosphorus
- Potassium
- Micronutrients
- Cation Exchange Capacity
- Base Saturation

Biological

- Microbial Community Structure
  - Fatty Acids
  - DNA/RNA
- Soil Respiration
- Readily Available Carbon
- Bioavailable Nitrogen
- Enzyme Activities

Soil Health Institute's Minimum Suite

- Highly recommended based on SHI's large-scale project to evaluate effectiveness of soil health indicators across "different soils, climates, cropping systems and management practices."

1) Soil Organic Carbon Concentration
2) Carbon Mineralization Potential
3) Aggregate Stability

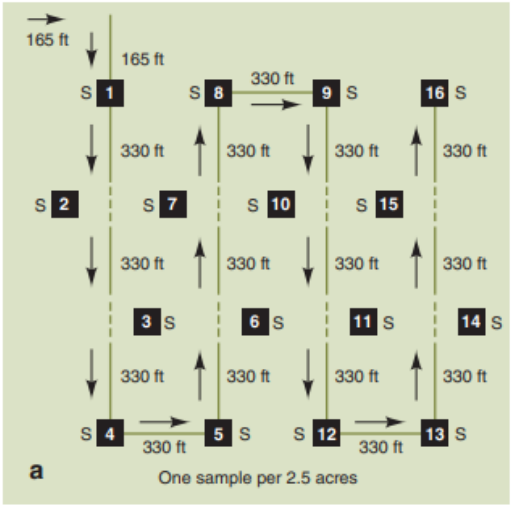
Soil Health Institute's Recommended Measurements

Measurement	Method	Reflected Outcome
Organic Carbon Concentration	Dry combustion. For calcareous soil: Total C – Inorganic C	• Nutrient cycling and retention • Stable and distinct soil structure • Available water holding capacity
Carbon Mineralization Potential	24-hr CO_2 burst resulting from rewetting air dried, sieved soil	• Carbon and nutrient cycling capacity • Strongly related to microbial biomass and activity
Aggregate Stability	10-min change in slaking via image analysis	• Resistance to wind and water erosion • Soil water infiltration and storage • Stable soil structure

Challenges & Difficulties

Soil Health Indicators vs. Soil Fertility Tests

- Instructions & Guidance
  - Fertility Tests
    - Relatively Standardized
  - Soil Health Tests
    - “BEST” method still being evaluated
    - “Be CONSISTENT!”
- Interpretation
  - Fertility Tests
    - State Land Grant University Guidance
    - Thresholds for Comparison
  - Soil Health Tests
    - ???



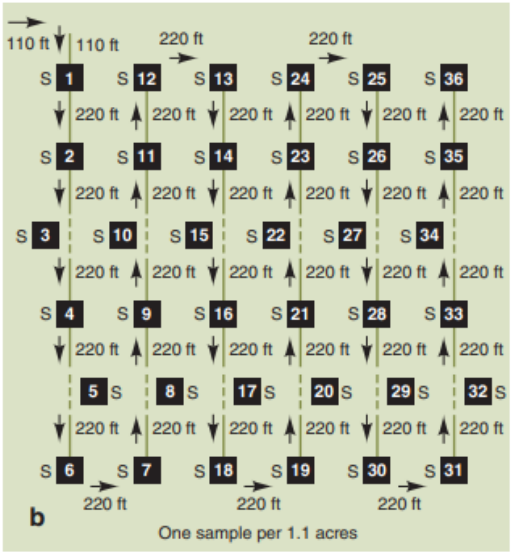


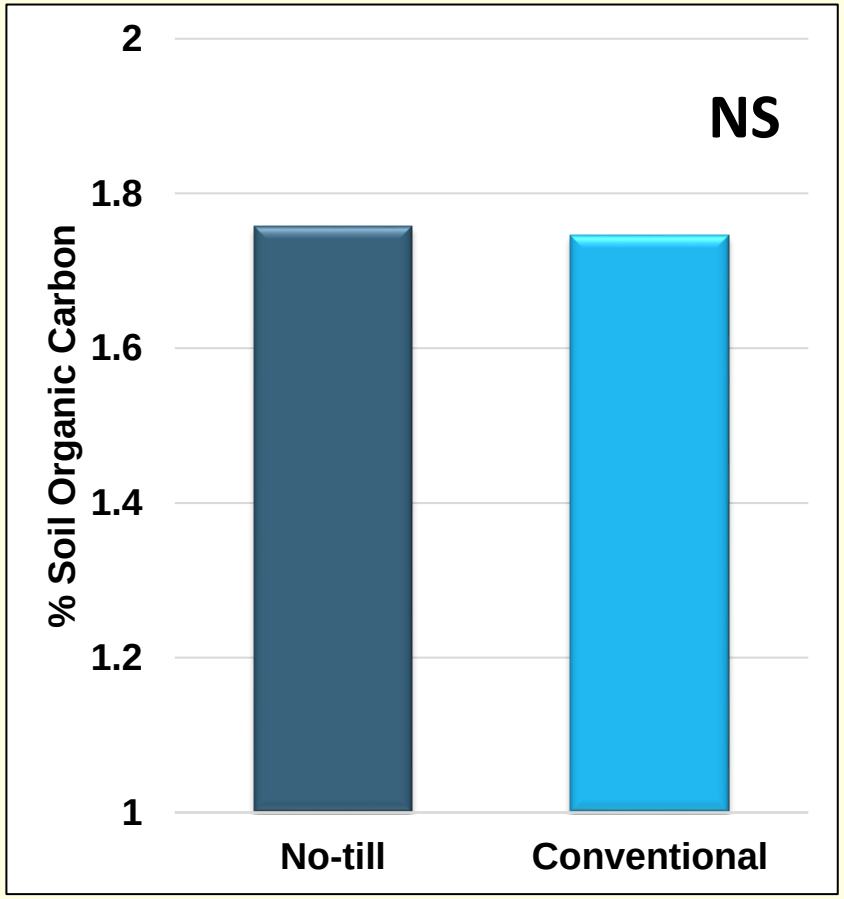
Figure 8.2. How to collect soil samples from a 40-acre field. Each sample (diagram a) should consist of five soil cores, 1 inch in diameter, collected to a 7-inch depth from within a 10-foot radius around each point. Higher frequency sampling (diagram b) is suggested for those who can use computerized spreading techniques on fields suspected of having large variations in test values over short distances.

Illinois Agronomy Handbook

How do you interpret soil health test results?

- **Few or no thresholds on soil health tests.**
  - **<u>Must have a relative comparison.</u>**
- **Almost all tests are more is better, but limited by soil's potential for improvement.**
  - Depends on inherent soil characteristics and forming factors.

Do Soil Health Tests Work?



- Need to be more sensitive than Soil Organic Carbon.

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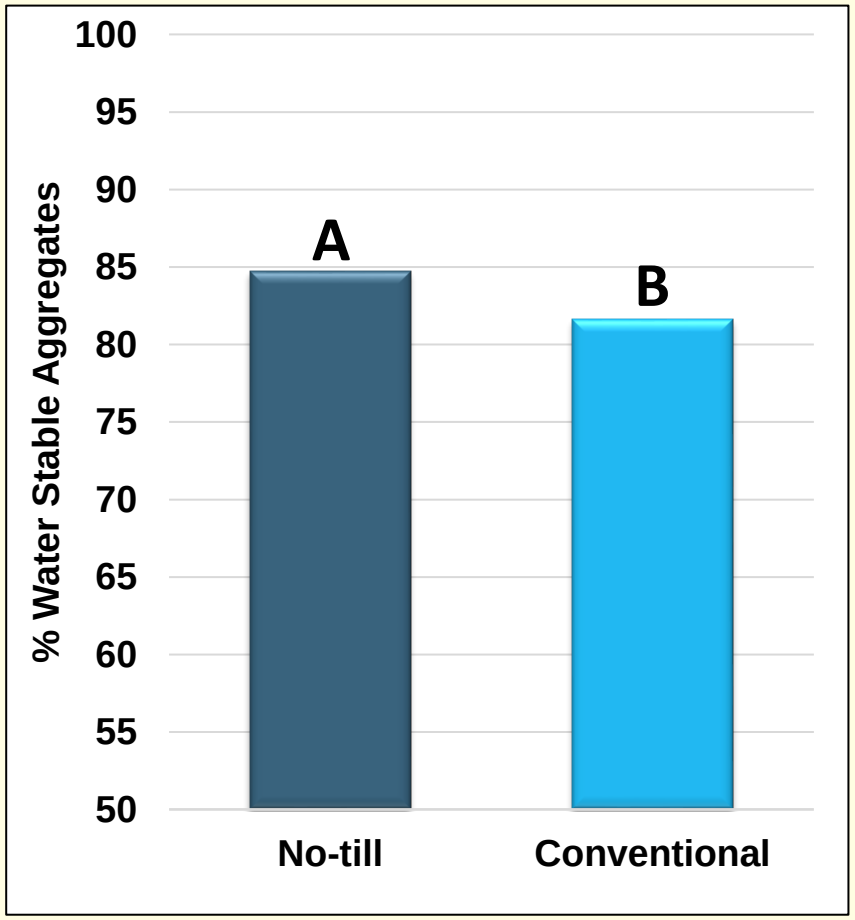

- Need to be more sensitive than Soil Organic Carbon.

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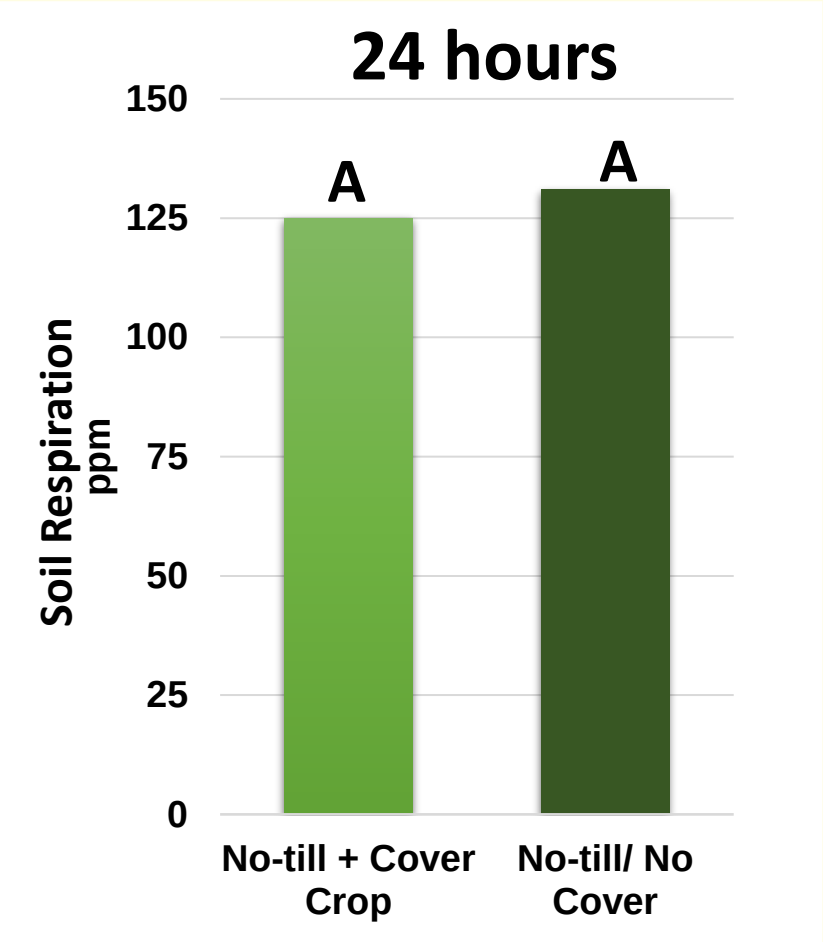
Do Soil Health Tests Match Up with Farmer Experience and In-Field Assessments?



- Often do NOT match up!
- Farmers have frequently mentioned that they have noticed a difference between their fields that is NOT appearing in the soil health test results.
- Leads to perception that they are a waste of money!
- Recommend In-Field Tests at same time.

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How Can We Make Soil Health Tests More Effective

Farmer Guidance

Decide on Sampling Strategy

- What is the goal?
- What questions are you trying to answer?
  - Do you want to compare the current soil health indicators of different management practices or of different zones within your field?
  - Do you want to monitor the soil health changes after implementing new practices?

Farmer Guidance

Comparisons or Monitoring

- Comparisons—Management
- Make sure soil types and landscape position are similar
  - Don’t compare **apples** to **oranges**.
- Monitoring over time
- Sample every 3-5 years
  - Consider crop rotation-sample in the same phase.
- Consider evaluating different zones or taking a reference sample when you take your baseline
  - Undisturbed area, fence row, long-term pasture, etc.

Farmer Guidance

How many samples per field?

- Soil health tests (~$50-120) are more expensive than fertility tests (<$10) per sample.
  - Can focus on sampling zones of field based on soil type, yield map, etc.
- Likely only want to sample 1-3 locations per field to monitor.

Farmer Guidance

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 (row vs inter-row)
  - Soil moisture & temperature
  - Date of sampling
  - Tillage
  - Amendments—manure, lime, NPK, etc.

Farmer Guidance

Sampling Procedures

- Be CONSISTENT!
- When to sample?
  - Same time every year, but for nutrient component, aim for pre-sidedress—shows what soil can still provide.
- Use same lab and tests to provide consistency
  - Methods & handling of samples may vary.
- Emphasize following lab instructions for sampling procedures & shipping!
  - Slice method vs. soil probe (aggregate stability)
  - Next-day shipping or ice (PLFA, enzymes, etc.)

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Soil Testing Laboratories

Better Messaging & Instructions

- Too often treated the same as soil fertility tests.
- Need better and more detailed instructions.

- Results can be overwhelming to majority of farmers.
  - Lots of numbers, what are they looking at?
  - Clear explanations and interpretations needed
    - Massive challenge because even researchers who have been working on these indicators for decades are not always sure.
    - Remember it’s only a snapshot!

Soil Health Tests

- These recommendations can help to minimize variability and maximize usefulness of the tests.

- **MUST be realistic!**
- These tests are more sensitive, but small changes may still not be detectable.
    - Use in-field assessment as well!

- Tests are expensive, make sure clients take the time to do them right on their end!

Resources

- Purdue Extension Publication
  - How to Understand and Interpret Soil Health Tests (AY-366-W)
- Missouri Extension Publication
  - Getting Started with Soil Health Testing in Missouri
- Soil Health Institute
- NRCS Soil Health Division

Thank You

ILLINOIS SOYBEAN ASSOCIATION

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