Measuring Soil Health

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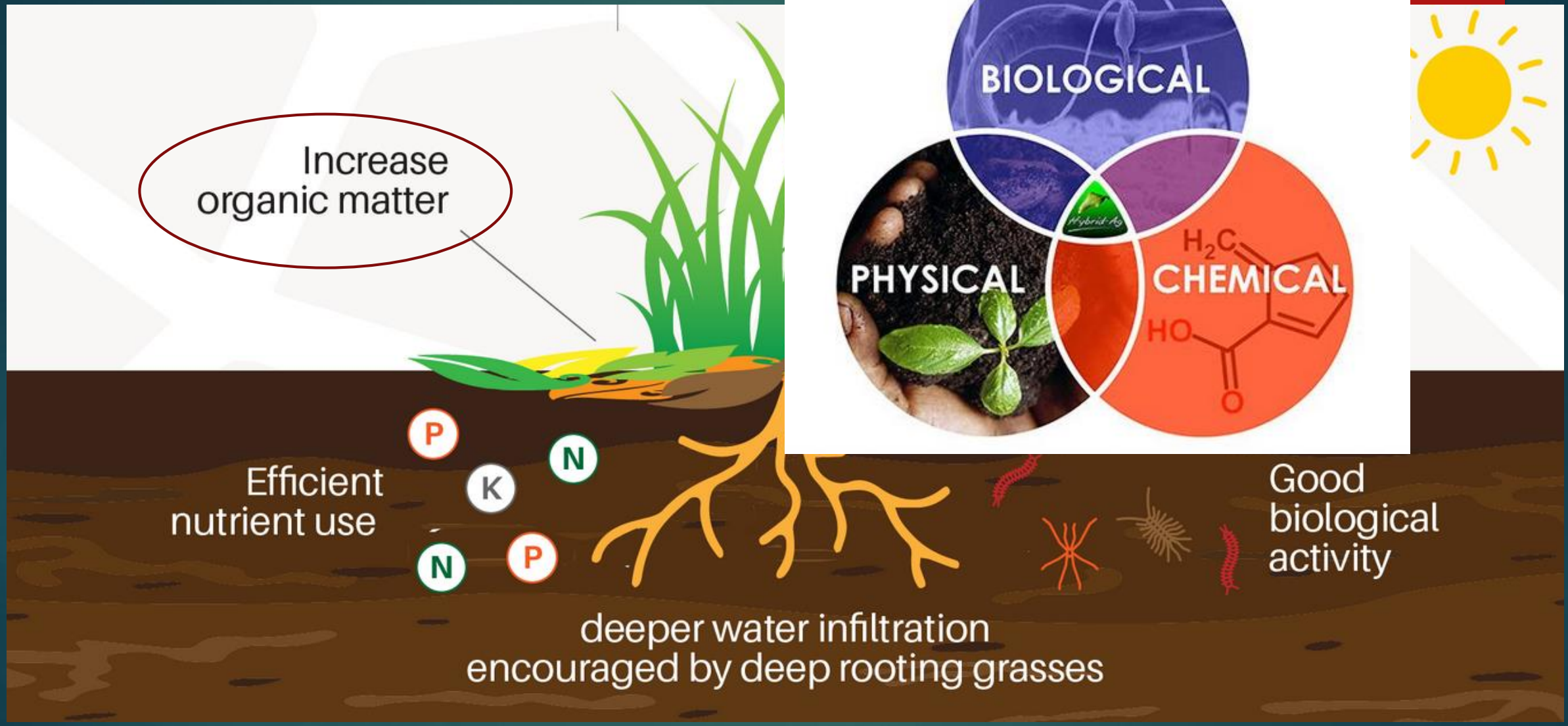
Top soil health challenges

- Erosion
- Nutrient management
- Soil compaction
- Poor crop emergence, disease
- Poor water infiltration, moisture
- Poor pore structure (no tilth)

Soil health

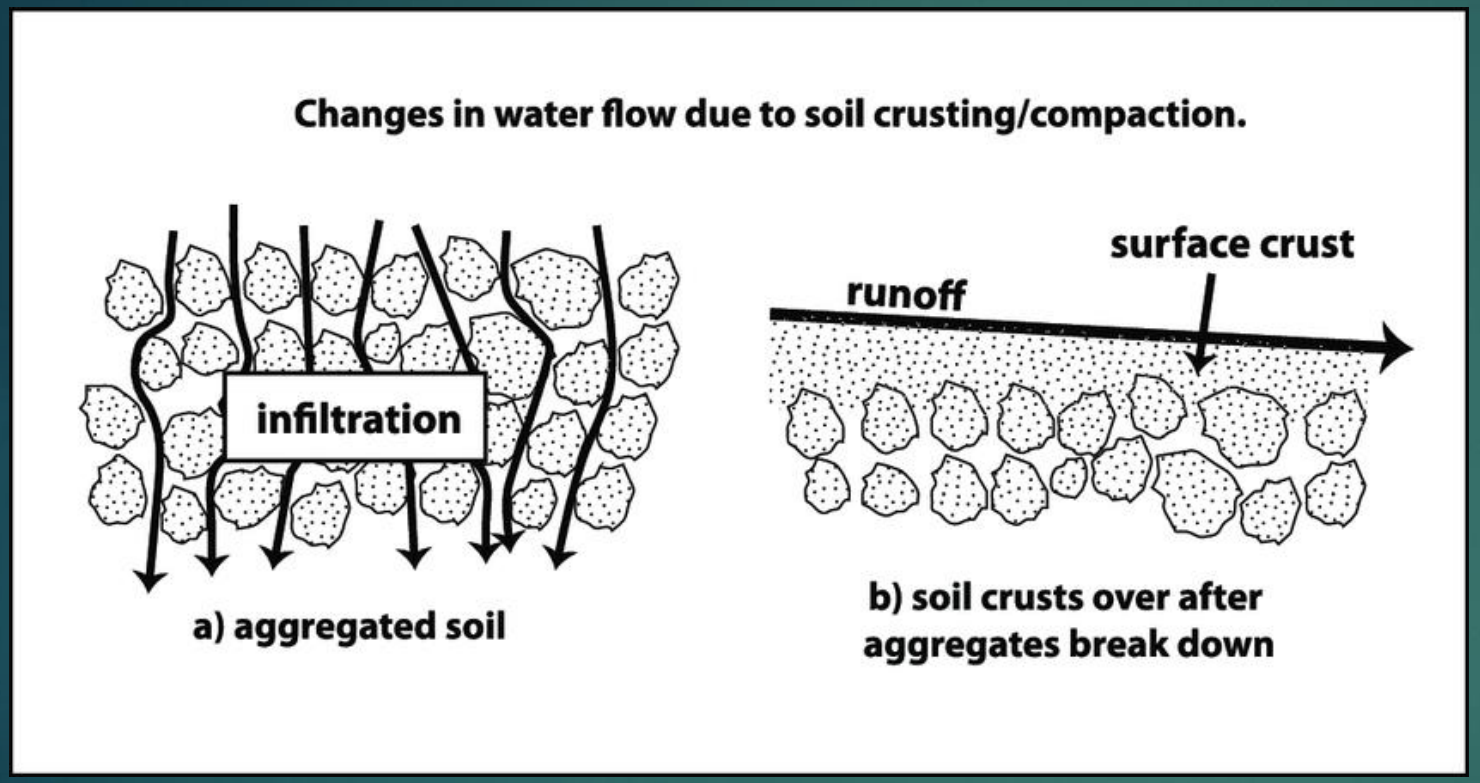
- Soil health is defined as the ability of a soil to function
  - **Crop yield** over time and high response to inputs (fertilizer, seeds)
  - **Healthy root** systems
  - **Nutrient supply** for crops
  - **Conservation**:
    - Minimal nutrient losses through leaching or volatilization
    - Minimal erosion, resilience to loss from intense rainfall,
  - **Water management**:
    - infiltration fast, water doesn't pond
    - water storage high, crop resilience to dry spells

Soil Quality Assessment Chapter 7 Snapp and Morrone 2008 Step-by-Step Field Analysis Soil Sci. Soc. Am.



https://blog.ciat.cgiar.org/how-can-we-measure-the-health-of-soil-simply

Aggregates: Soil health function



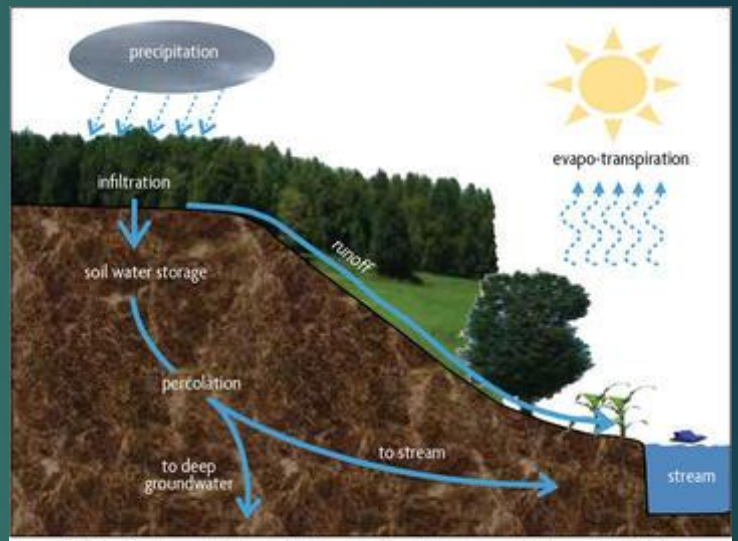


Figure 5.8. The fate of precipitation at the land surface determines whether water infiltrates or runs off the surface.

Biology: aggregates + pores formed through **soil organic matter**+roots+fungal hyphal+bacteri
Chemical: cation exchange, ion interaction, nutrient availability
Physical: Soil particle size (texture) influences pore size and aggregate formation

Soil Health: aggregates protect **soil organic matter, provide a home for microorganisms**

Finney et al., 2017 JSWC

Soil organic matter and soil carbon

- Soil organic matter is closely related to soil organic carbon
- Soil organic matter also includes hydrogen, oxygen and nitrogen and is commonly measured by ignition in a very hot oven (loss = burned up organic material)
- Soil organic carbon = Combustion or Walkley Black hot acid method Multiply soil carbon X 1.72:

Organic matter (%) = Total organic carbon (%) x 1.72

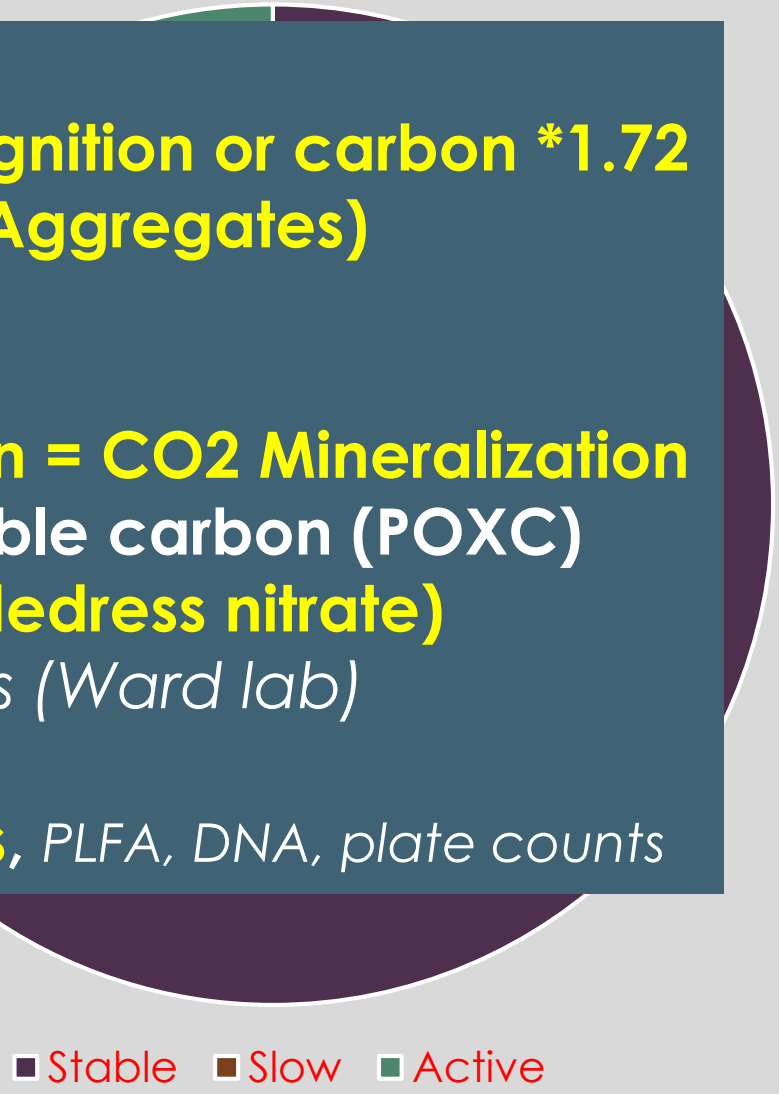
http://www.soilquality.org.au/factsheets/organic-carbon

Soil Organic Matter Pools

Soil Organic Matter:
Standard test: Loss on ignition or carbon *1.72
(related: CEC, soil pH, Aggregates)

Active organic matter:
Indicated by respiration = CO2 Mineralization
Permanganate oxidizable carbon (POXC)
Nitrogen supply (presidedress nitrate)
Soil protein, Haney tests (Ward lab)

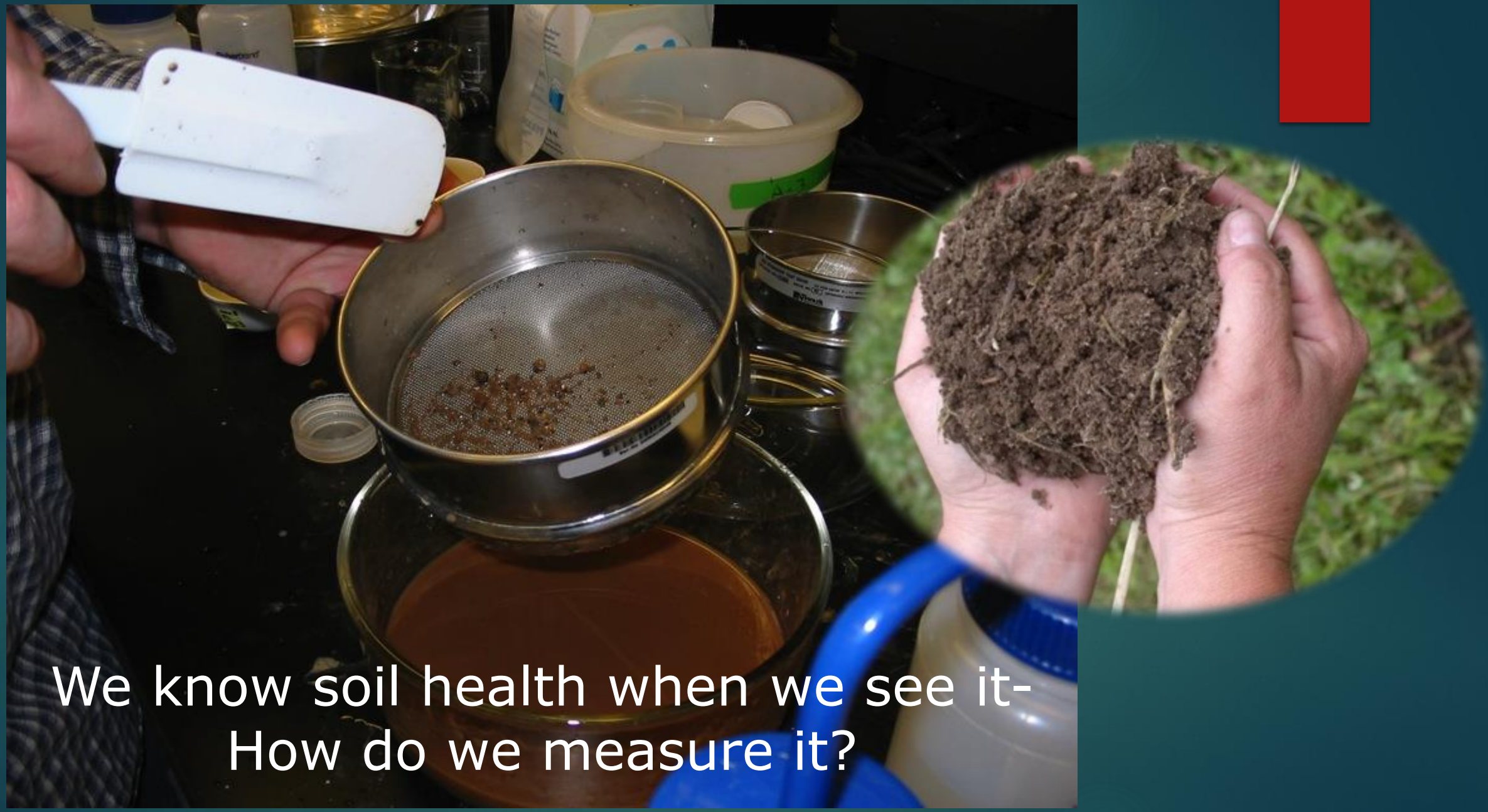
Organisms: Earthworms, *PLFA, DNA, plate counts*



ACTIVE: Recent OM inputs and soil organisms

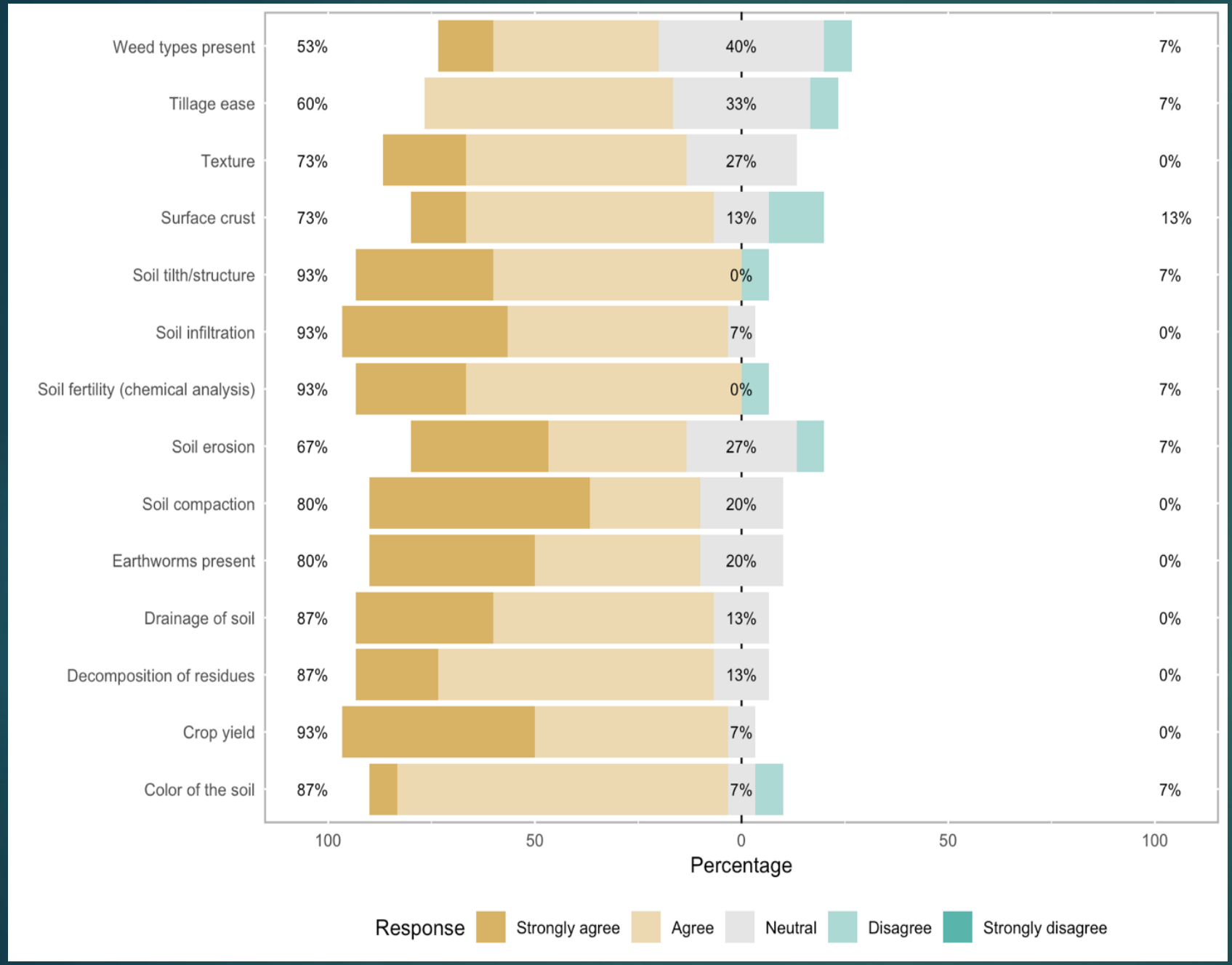
SLOW: Organic compounds derived from active pool, protected

STABLE: Physically protected humus, extremely recalcitrant Charcoal



We know soil health when we see it-
How do we measure it?

Aggregates (Cornell Soil Health)



Xinyi Tu, unpublished MI farmers focus groups

Poll: What soil measures do you use?

Soil monitoring FIELD:

Field observations:

Earthworms

Tea bag decomposition

Penetrometer (sub-surface, flag)

LandPKS (soil profile characterization)

Aggregates* (Rainfall simulator – MSUE Soil Health team)

Solvita

*Aggregates can also be measured at the Cornell Soil Health lab ~$12 per sample

LandPKS Apps

5. SOIL OBSERVATIONS

The Soil Obvservations screen is used to indicate whether deep VERTICAL
cracks occur when the soil is dry, and whether salt has accumulated
on the surface. Deep vertical cracks occur with certain types of clay and can limit growth of some plants. Salt accumulation limits growth of most plants.

Choose from two categories identifying cracked or not cracked and salty or not salty soil.

5 Easy Steps!

LandPKS

ANDROID APP ON Google play

Download on the App Store

Step 1

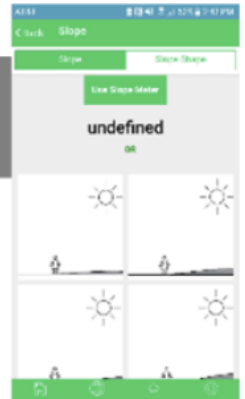
Download the app and register a Gmail address (so you can find your data on the Data Portal)

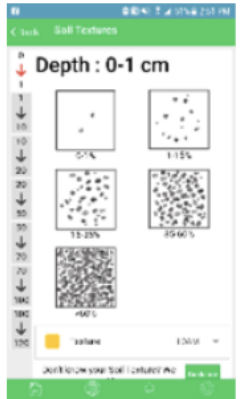
Step 2

Click the + to start a new site; then name your site and obtain the GPS

Step 3

Enter your LandInfo and/or LandCover data under the Data Input tab





Soil monitoring LAB: goals and timeframe

- What is the primary goal?
  - Crop health?
  - Conservation of soil water and nutrients, efficient use of inputs?
  - Environmental protection?
- What is the timeframe?
  - Soil organic matter (organic carbon) requires five or more years to measure change accurately!
  - Crop yield varies with weather and may take five or more years to detect trends, increasing or decreasing
  - Pests and diseases: variable occurrence

Monitor your soil: make a plan

- Observe crops above and BELOW ground
- Notice how crops respond by zone not just the field
- Test your soil the same time each year
- Set goals and build your soil

Presque Isle County, Michigan (MI141)

Presque Isle County, Michigan (MI141)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
2	Lupton muck, 0 to 1 percent slopes	2.0	10.0%
31B	Mancelona loamy sand, 2 to 6 percent slopes	0.1	0.5%
31C	Mancelona loamy sand, 6 to 15 percent slopes	0.2	0.9%
37A	Gladwin loamy sand, 0 to 3 percent slopes	2.7	13.9%
52A	Hagensville fine sandy loam, 0 to 2 percent slopes	10.8	54.6%
73A	Omena fine sandy loam, 0 to 2 percent slopes	4.0	20.1%
Totals for Area of Interest		19.7	100.0%

Zonal sampling of soil important

- Look up soil types

https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

- Walk the field
- Define zones to sample

(use your knowledge,

soil maps, yield monitor)

- Sample a reference site:
- Fence row,
- natural areas

Soil Quality Assessment Chapter 7 Snapp and Morrone 2008 Step-by-Step Field Analysis Soil Sci. Soc. Am.

Choose a reference benchmark site

- **Fence row or natural area:** Goal to aim for!
- **Shows soil health obtainable** for your soil parent material and location, check soil type
- https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
- Or SoilWeb https://casoilresource.lawr.ucdavis.edu/gmap/

Soil health: sample CONSISTENTLY & DIG DEEP

- **Sample at the same time of year, use same tests over time**
- **Less frequent, many samples better practice** (once every ~four years comprehensive and include deeper soils, fence rows and multiple zones)
- **Combine five or more samples** - shovel or auger samples in a bucket per zone sampling, mix well and subsample
- **Take samples from plow layer, plus deep** subsoil samples
- Dig a pit and make observations, or use a fence posthole

Rules of thumb for measuring soil health

- **Set your goals** (nutrient supply, root health, soil organic matter, which is most important?)
- **Be Consistent** (sample same zones, same time of year spring or fall, use same soil health tests, same laboratory)
- **Be Patient** (often takes four or more years)
- **Use Benchmarks** (fence rows, natural areas)

https://www.no-tillfarmer.com/articles/9167-tips-for-soil-health-test-sampling

Be Consistent!

Choose Your Lab and Test(s), Then Stick with It

Different labs use different methods, and you will not be able to gauge progress if you switch to a different lab (Figure 5).

PLFA Measurements	2015 Ward Laboratories (ng/g)	2017 Missouri Soil Health Assessment Center (nmol/g)
Total Microbial Biomass	1,790	103.8
Total Bacteria	1,083	58.7
Total Fungi	101	1.78
Mycorrhizal Fungi	23	4.35
Protozoa	8.4	0.71

Different units
Different results
Biology of soil health is complex!

Zuber and Kladivko, ag.purdue.edu/AGRY

Soil health tests – context matters

- **Soil health is influenced by biology**
- **Soil respiration** for example estimates how active soil micro organisms are - this depends on temperature range (**80-105° F** is ideal for most) and sufficient moisture (**55-78%** soil moisture preferred), so when sample matters!
- Spring before tillage or fall after harvest consistent time to sample (pre-sidedress N = late spring)

Active Carbon: mineralization test

Solvita (respiration in the field) provides a very rough estimate – Highly variable due to soil moisture

Soil samples are moistened, then incubated in a jar and the carbon dioxide that is mineralized is measured, this provides a measure of soil activity (respiration of carbon dioxide). Cornell Soil Health Lab

Active carbon = soil biology supports decomposition

Tea bag decomposition
(soil microorganism activity)

Benchmark!

Tea bag test in Iowa
Practical Farmers of Iowa & ISU McDaniel

ttps://iowalearningfarms.wordpress.com/2018/08/16/tea-bags-tell-story-of-soil-health/

Active Carbon POXC test

The test tubes shown here are laboratory standards for the POXC measurement, showing the range of values possible with permanganate oxidizable carbon (POXC). The lighter color is where more active carbon was oxidized, from a soil with more active carbon.

Cornell Soil health lab

Culman Snapp et al., 2012 SSSA

Application of soil health measurements

MSU Living Field Laboratory (LFL) trial in SW Michigan at Kellogg Biological Station

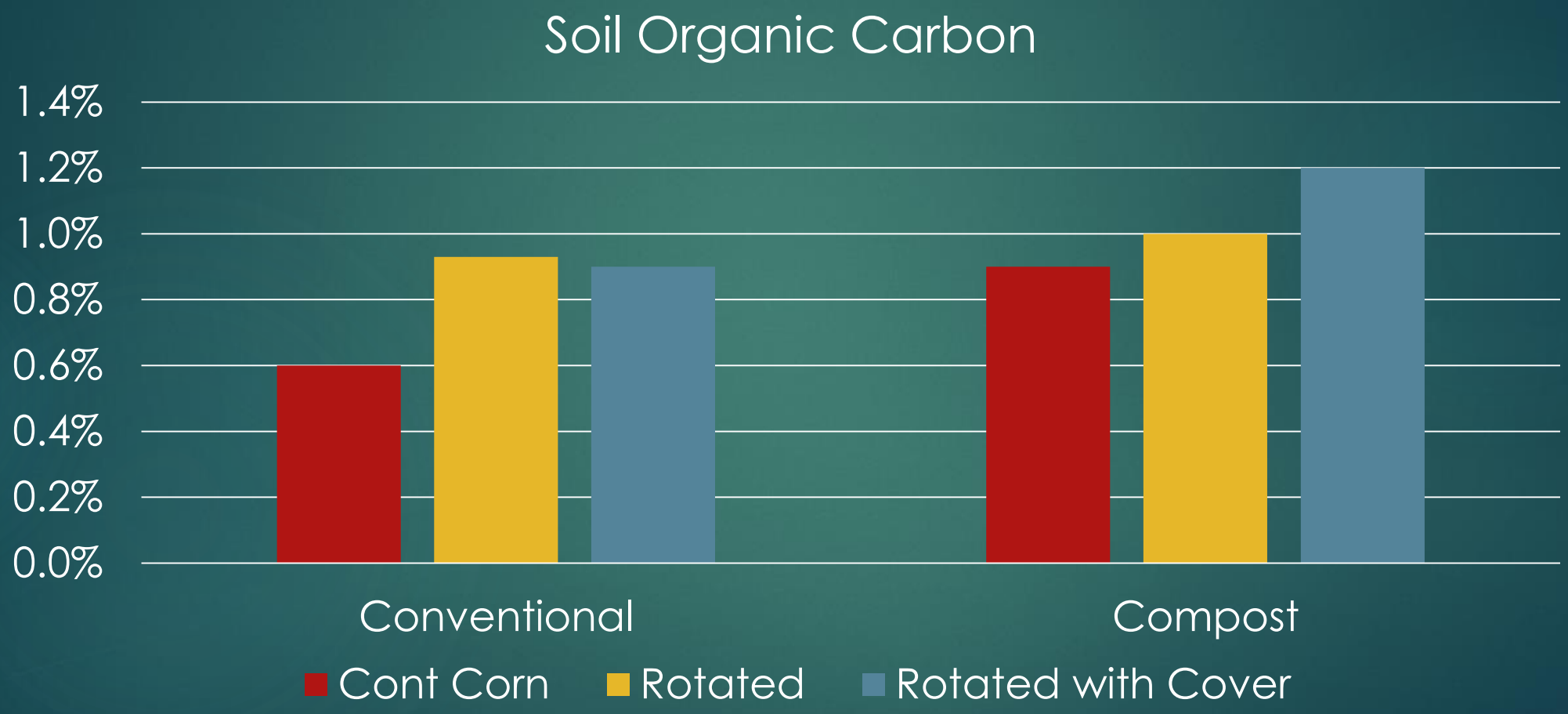
Four management systems:
(Conventional, integrated, compost and organic)

Field crop rotation:
Continuous corn
Vs. corn-corn-soybean-wheat

Organic N inputs:
Dairy Compost, Crop residues
Cover crops (rye, red clover)

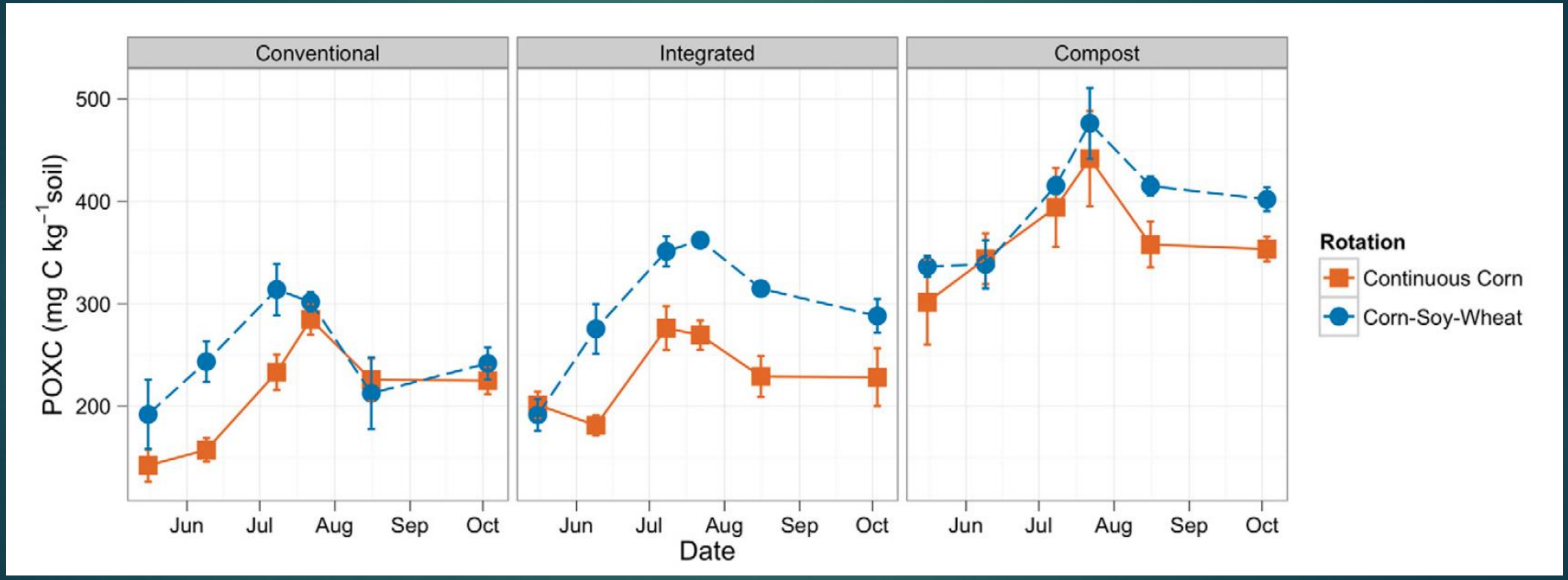
Dr Dick Harwood initiated 1992; Snapp led since 2006

Living Field Laboratory (KBS @ MSU)



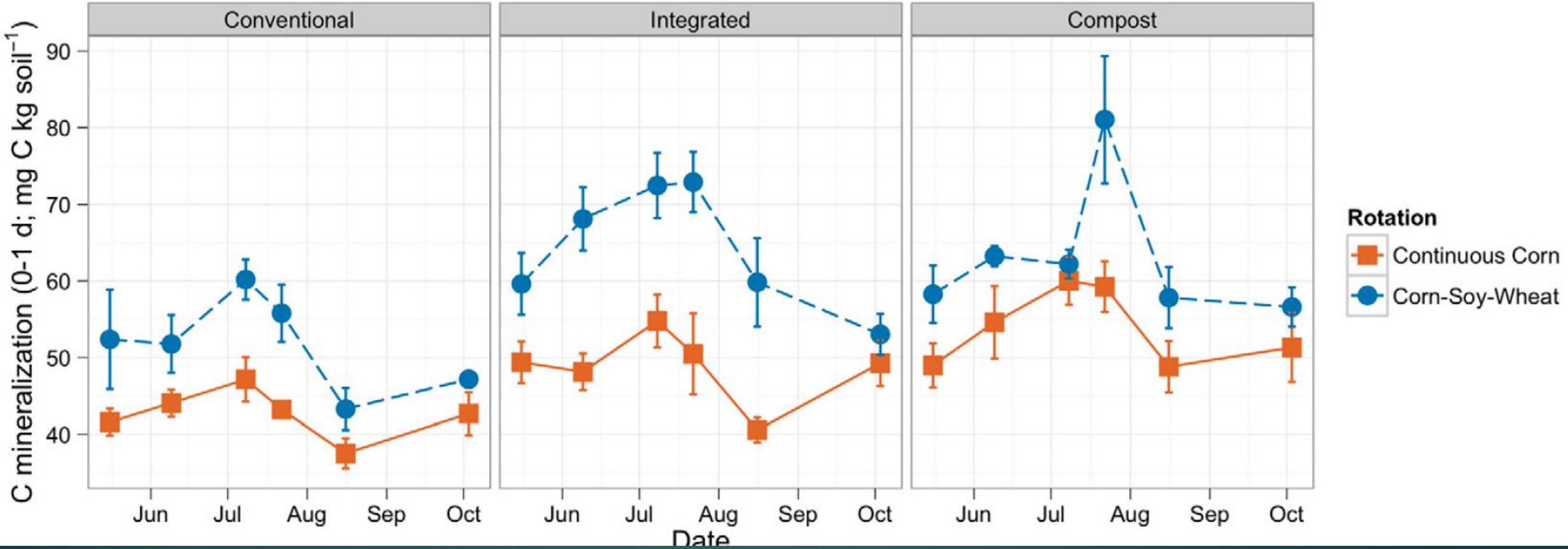
Snapp et al., 2010

Living Field Laboratory (KBS @ MSU)
Active carbon (POXC)



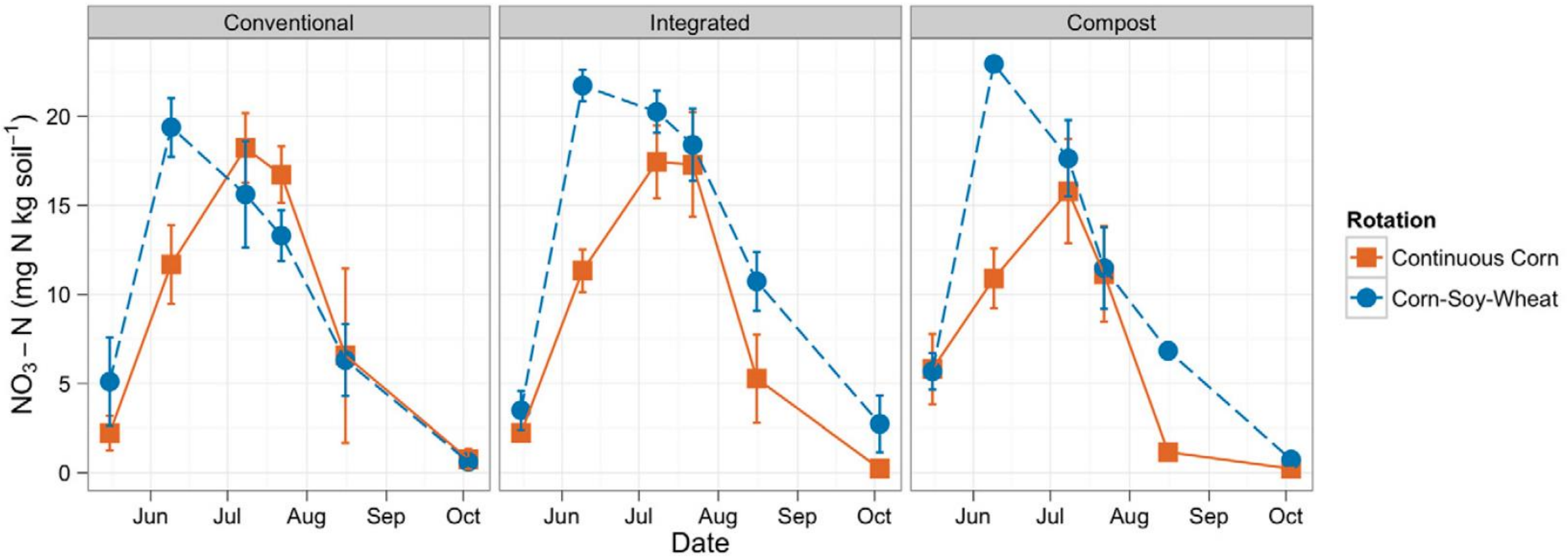
Culman, Snapp et al., 2013 Agronomy Journal

Living Field Laboratory (KBS @ MSU)
CO2 Mineralization



Culman, Snapp et al., 2013 Agronomy Journal

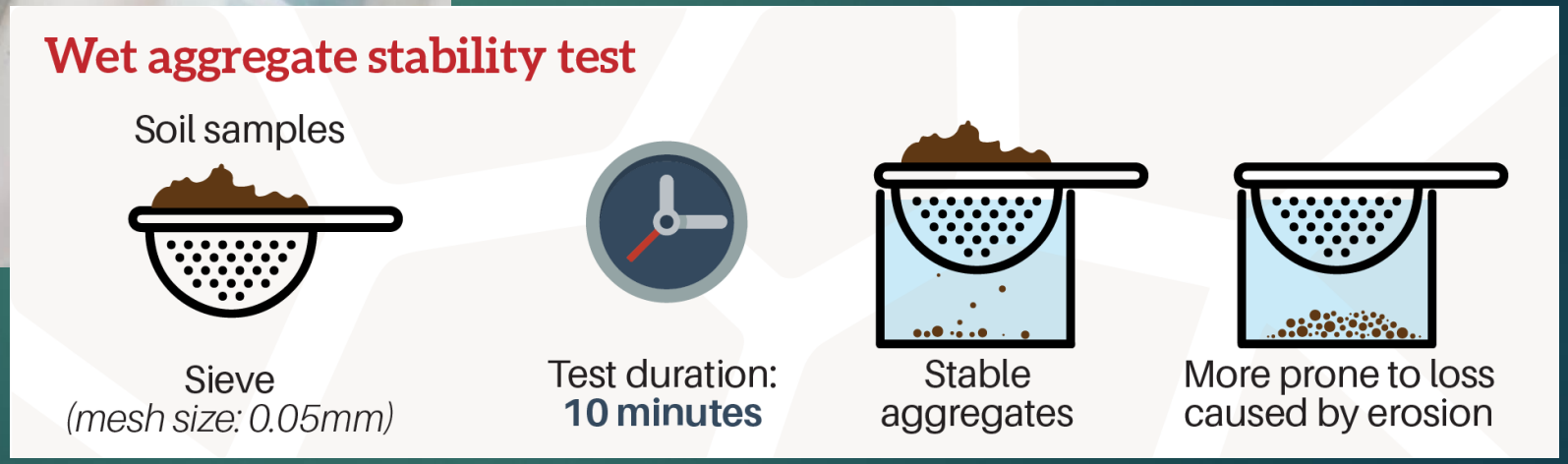
Living Field Laboratory (KBS @ MSU)
Soil Nitrate (Pre-sidedress)



Culman, Snapp et al., 2013

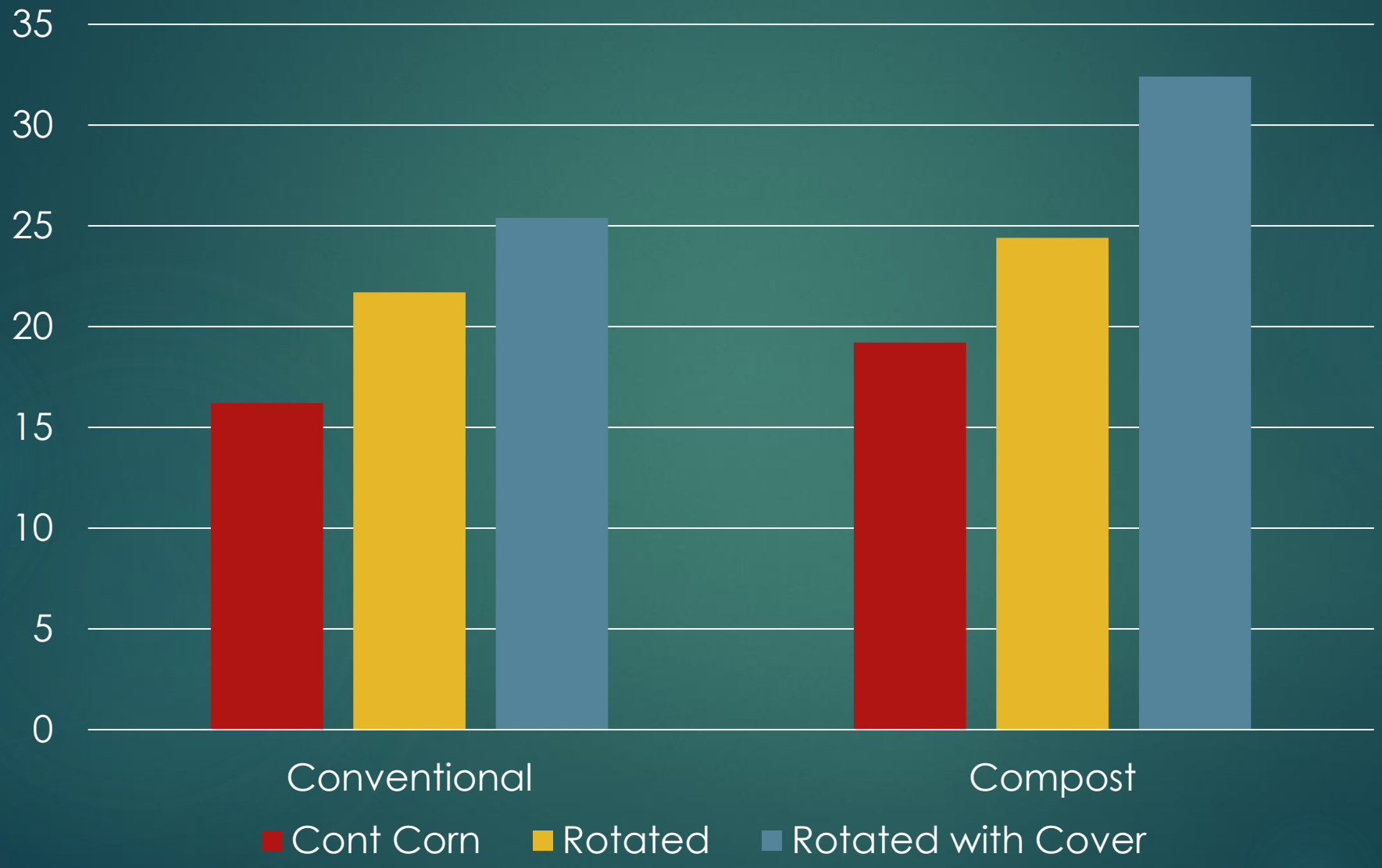
Measuring aggregates: soil health

Soil aggregates stable to sieving

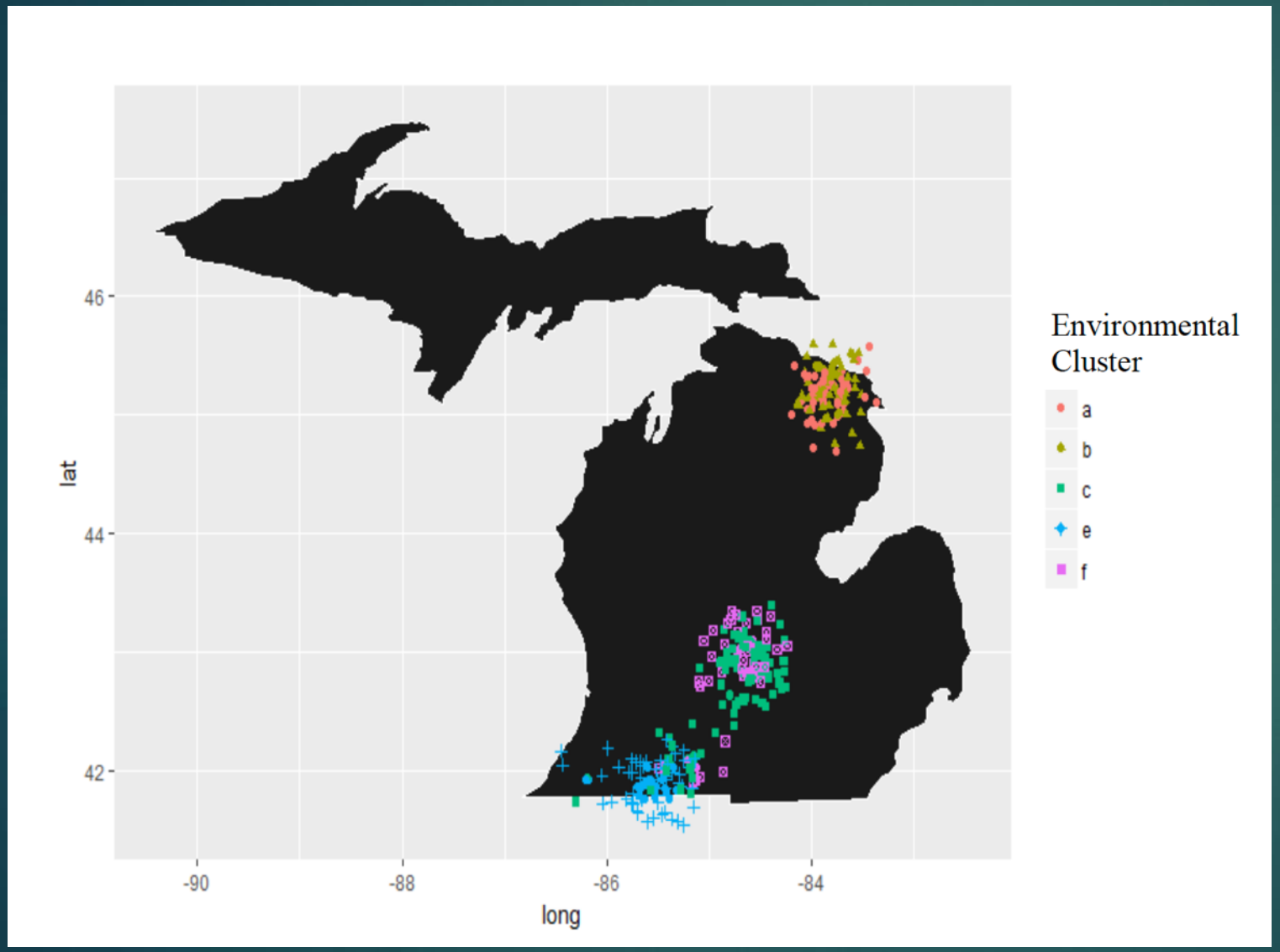


/blog.ciat.cgiar.org/how-can-we-measure-the-health-of-soil-simply-and-cheaply/

LFL Soil aggregates (macro g/100g soil)



Application of soil health measurements: On Michigan soybean farms (Jumpstart project)

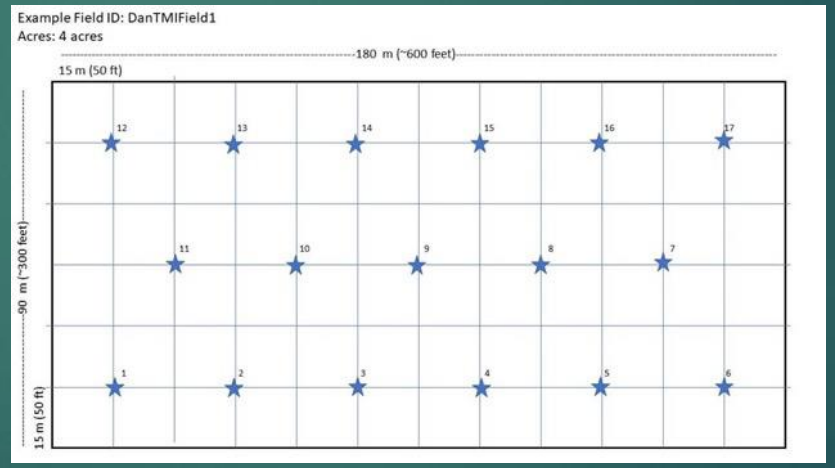


Dedecker, Thelen, Anderson MSUE
Snapp and Tu, Dept PSM, MSU

Measuring soil health by zone

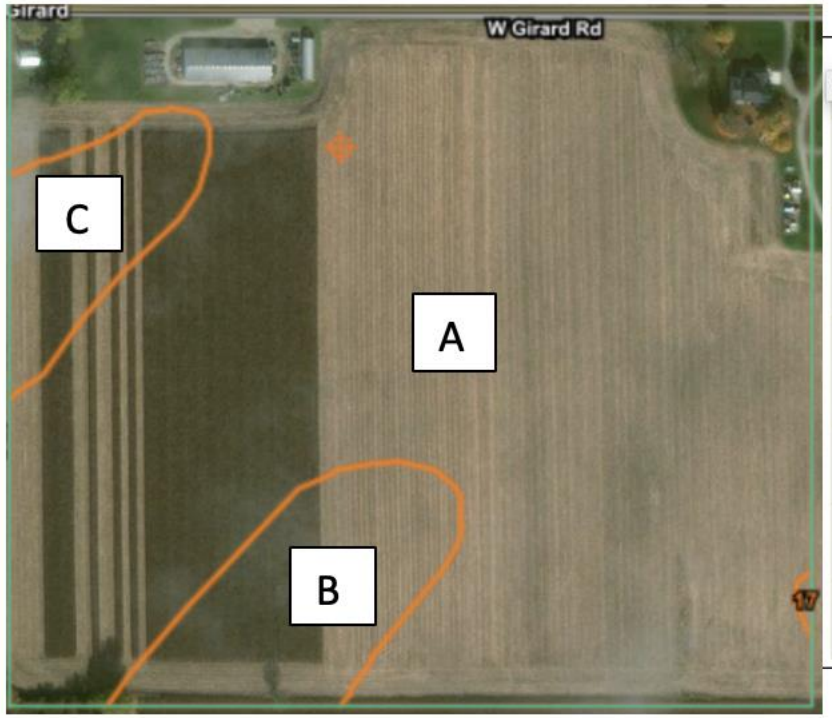
Soil sampling supplies:

- Small spade
- Bags for samples (can be paper or plastic)
- Marker to label bags
- Bucket to carry soil samples
- Device to identify GPS coordinates



Application of soil health measurements: On Michigan soybean farms (Jumpstart project)

- Three Chosen Soil types
  - A. Locke fine sandy loam
  - B. Hillsadle-Riddles fine sandy loams
  - C. Sebewa Loam

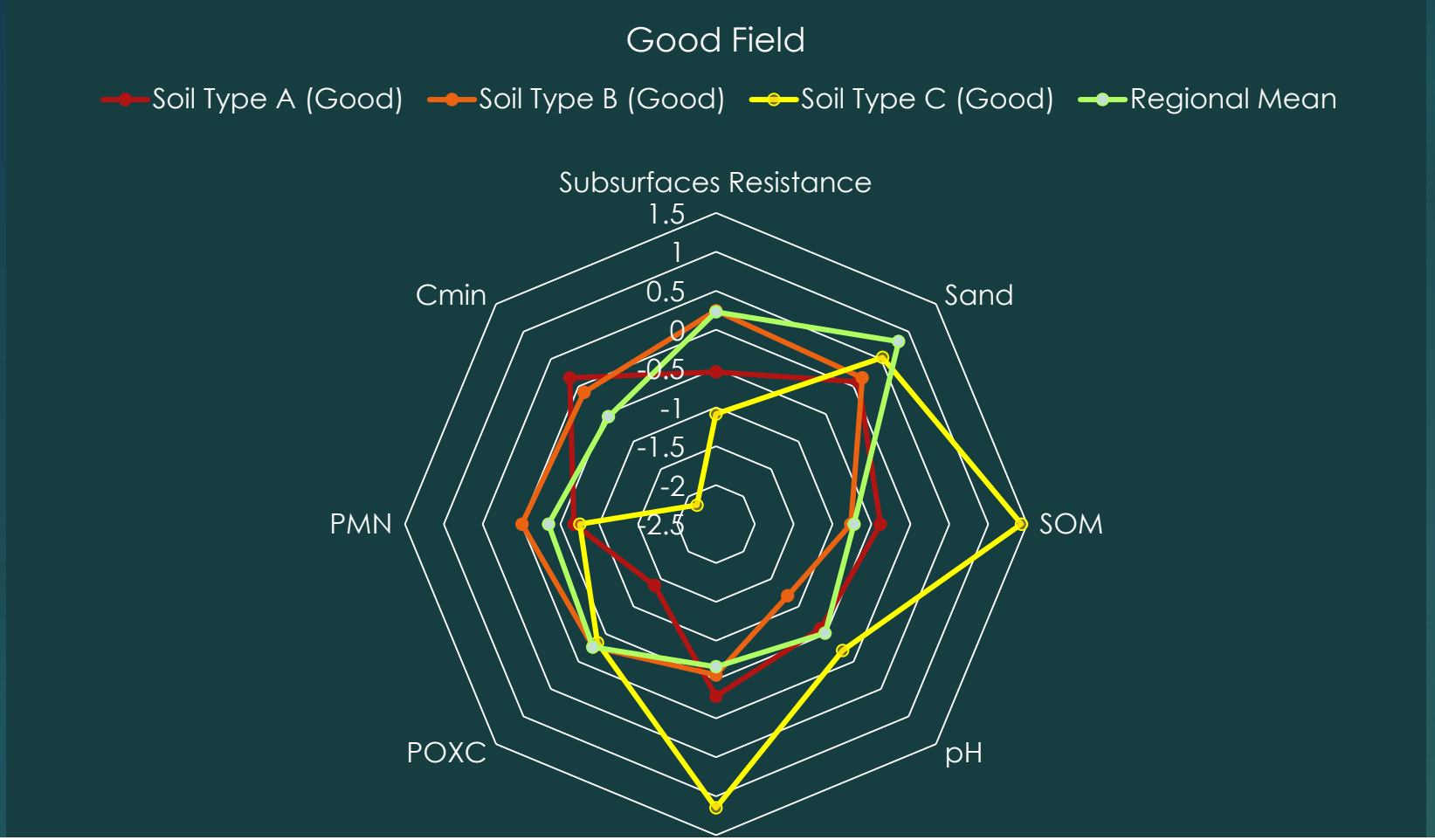


Branch County, Michigan (MI023)

Display map unit description

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
5B	Hillsdale-Riddles fine sandy loams, 2 to 6 percent slopes	4.2	8.8%
15B	Locke fine sandy loam, 1 to 4 percent slopes	40.6	85.6%
17	Barry loam, 0 to 2 percent slopes	0.1	0.1%
24	Sebewa loam, 0 to 2 percent slopes	2.6	5.5%
Totals for Area of Interest		**47.4**	**100.0%**

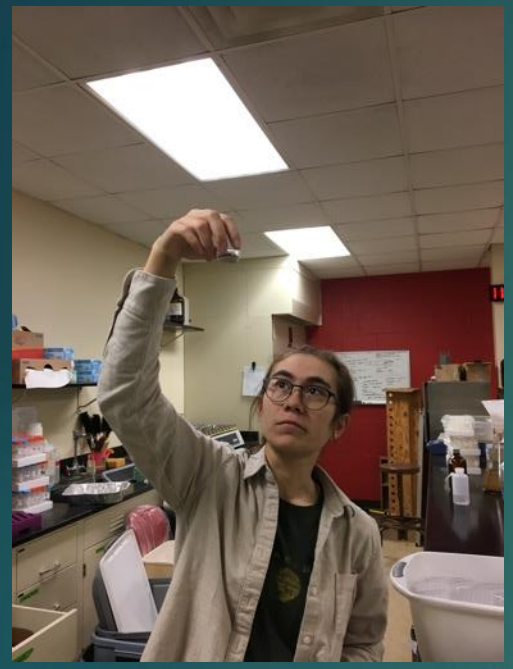
Dedecker, Thelen, Anderson MSUE
Snapp and Tu, Dept PSM, MSU

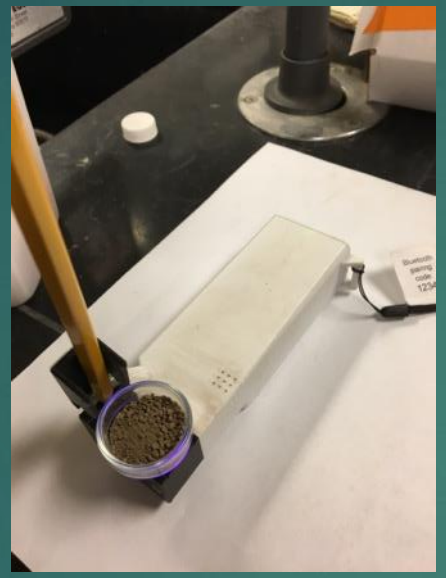


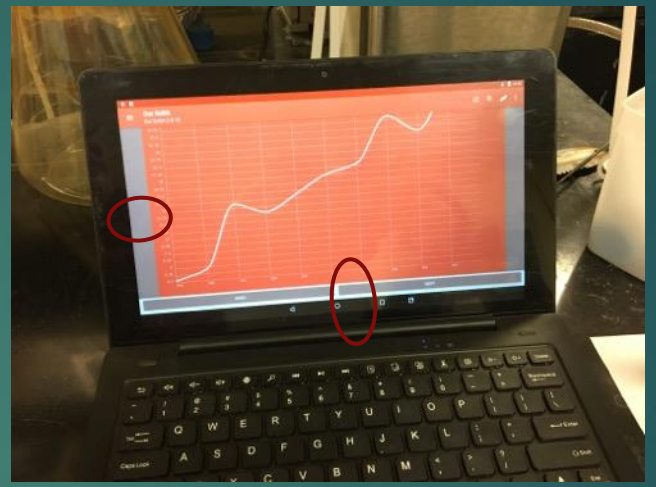
3. Biological and Chemical Properties

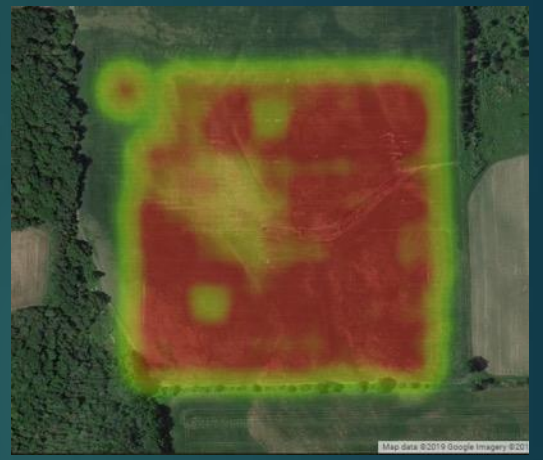
Soil type	Permanganate Oxidizable Carbon (ppm)	Nitrate (ppm)	Ammonium (ppm)	Potential Mineralizable Nitrogen (ppm)	Carbon Mineralization (ppm/hr)
A	257.92	13.76	1.47	4.27	1.44
B	468.39	13.66	1.65	5.83	1.28
C	453.34	14.38	1.58	4.10	0.09
Mean	**466.16**	**10.15**	**1.77**	**5.07**	**1.01**

Measuring soil organic matter
New tools - Reflectometer









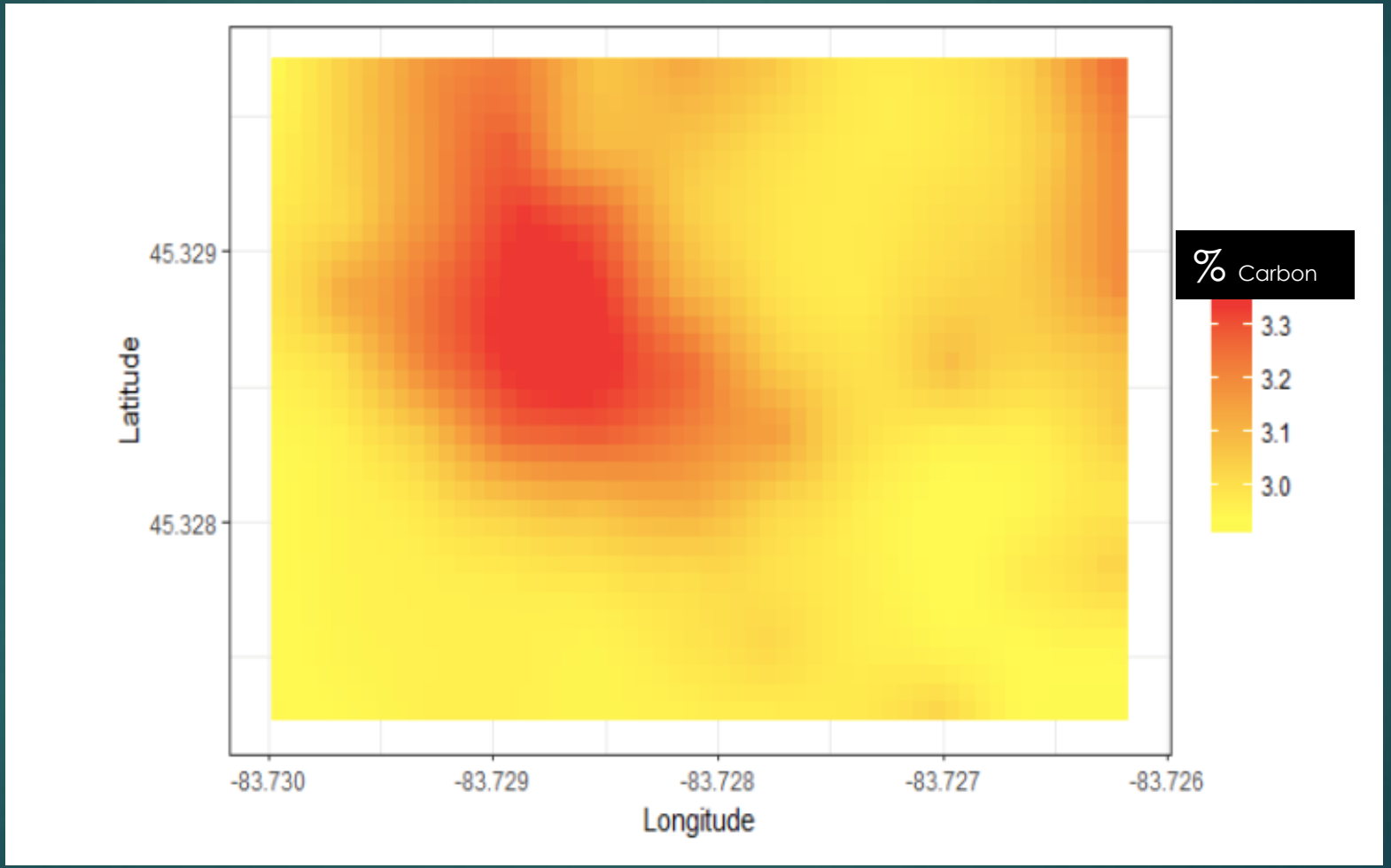
Yellow = low reflection/high OM

Red = high reflection/low OM

The reflectometer measures reflected light. Greater reflection correlates with less organic matter. The reflectometer automatically uploads the scanned data to a website, to overlay the reflection values of different samples over a map to visualize organic matter across a field.

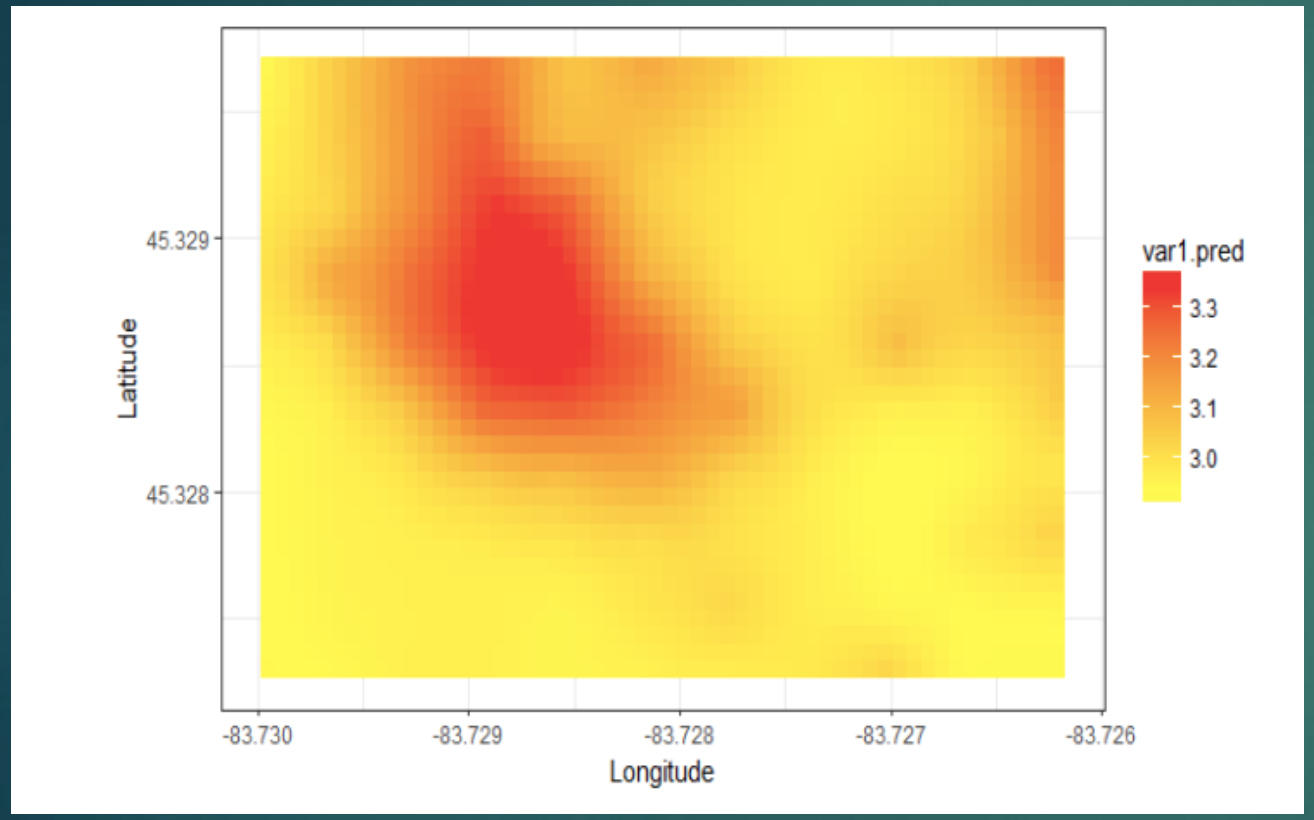
Jumpstart project underway Snapp lab MSU with Our-Sci.net

Soil Carbon % Across a Field: reflectometer

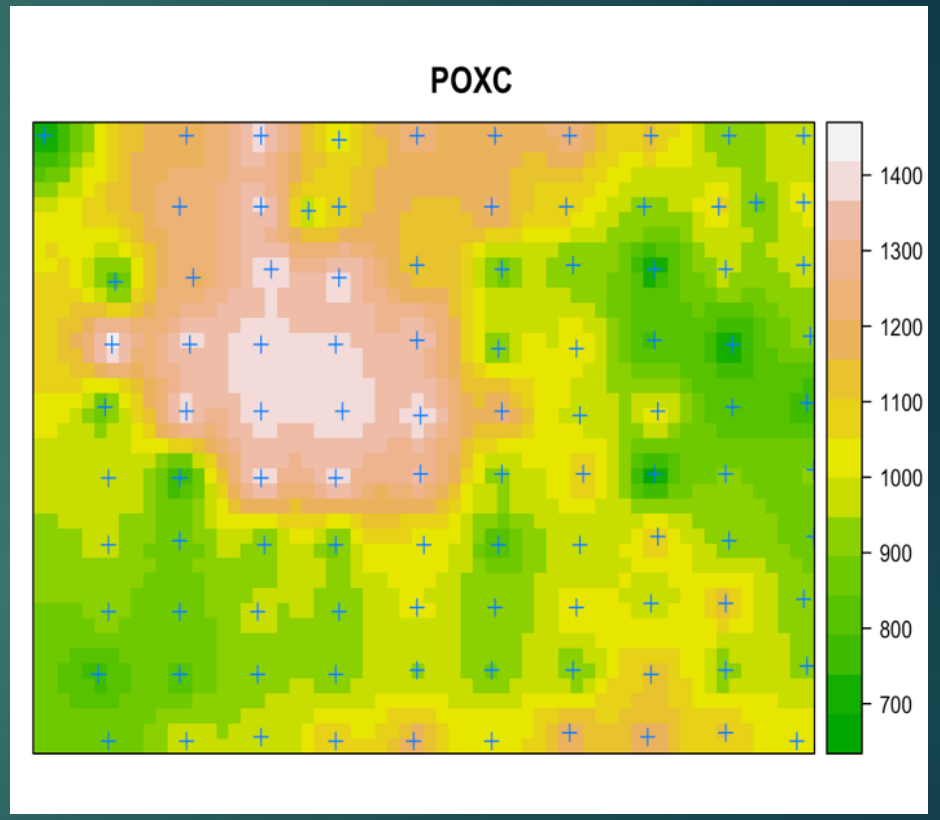


Jumpstart project underway Snapp lab MSU with Our-Sci.net

Application of soil health measurements:
On Michigan soybean farms (Jumpstart project)

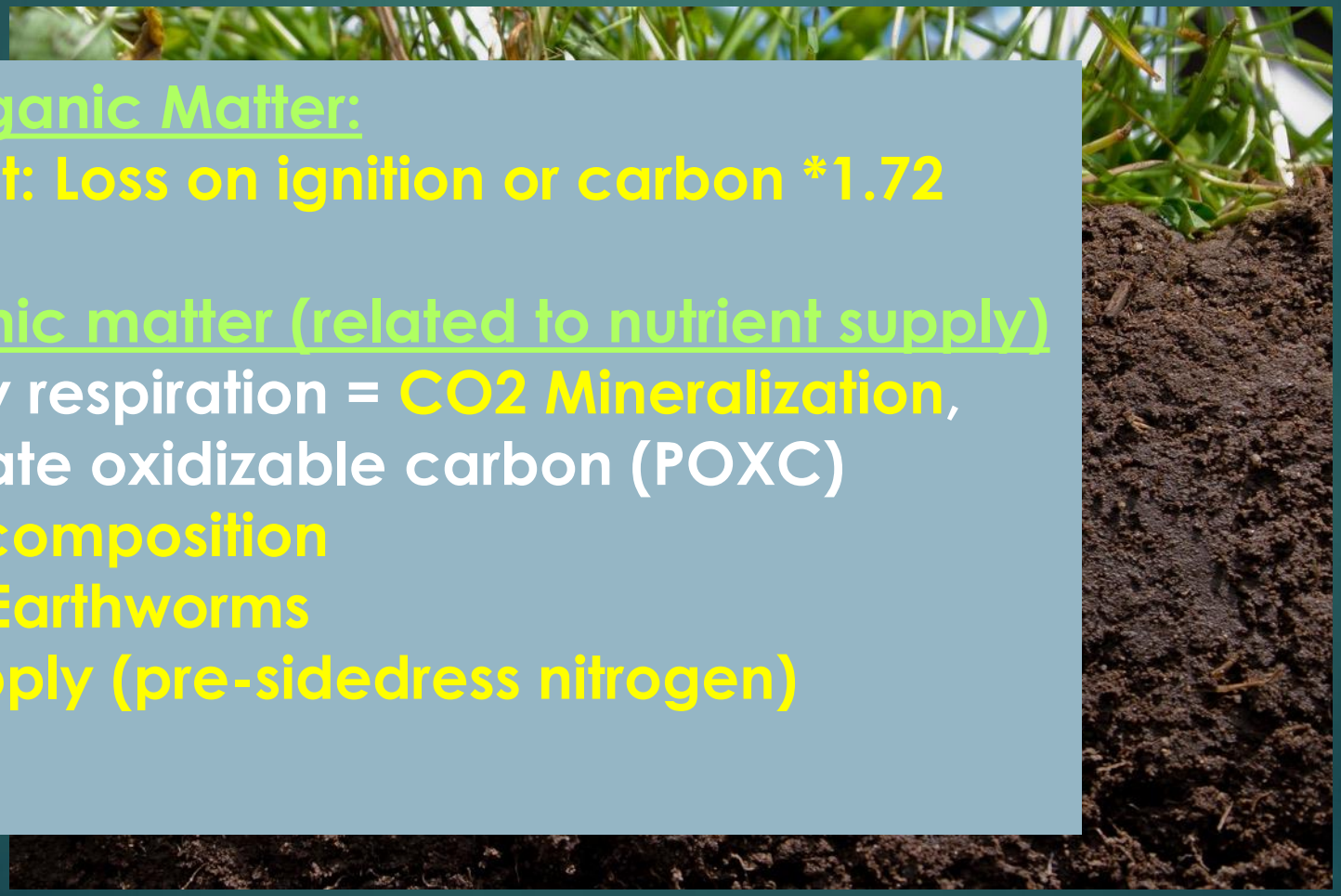


Grid sampling of soil organic matter



Grid sampling of active soil carbon

Soil health function conundrum How to build soil organic matter while releasing nutrients?



Total Soil Organic Matter:

Standard test: Loss on ignition or carbon *1.72

Active organic matter (related to nutrient supply)

Indicated by respiration = CO2 Mineralization,

Permanganate oxidizable carbon (POXC)

Tea bag decomposition

Organisms: Earthworms

Nitrogen supply (pre-sidedress nitrogen)

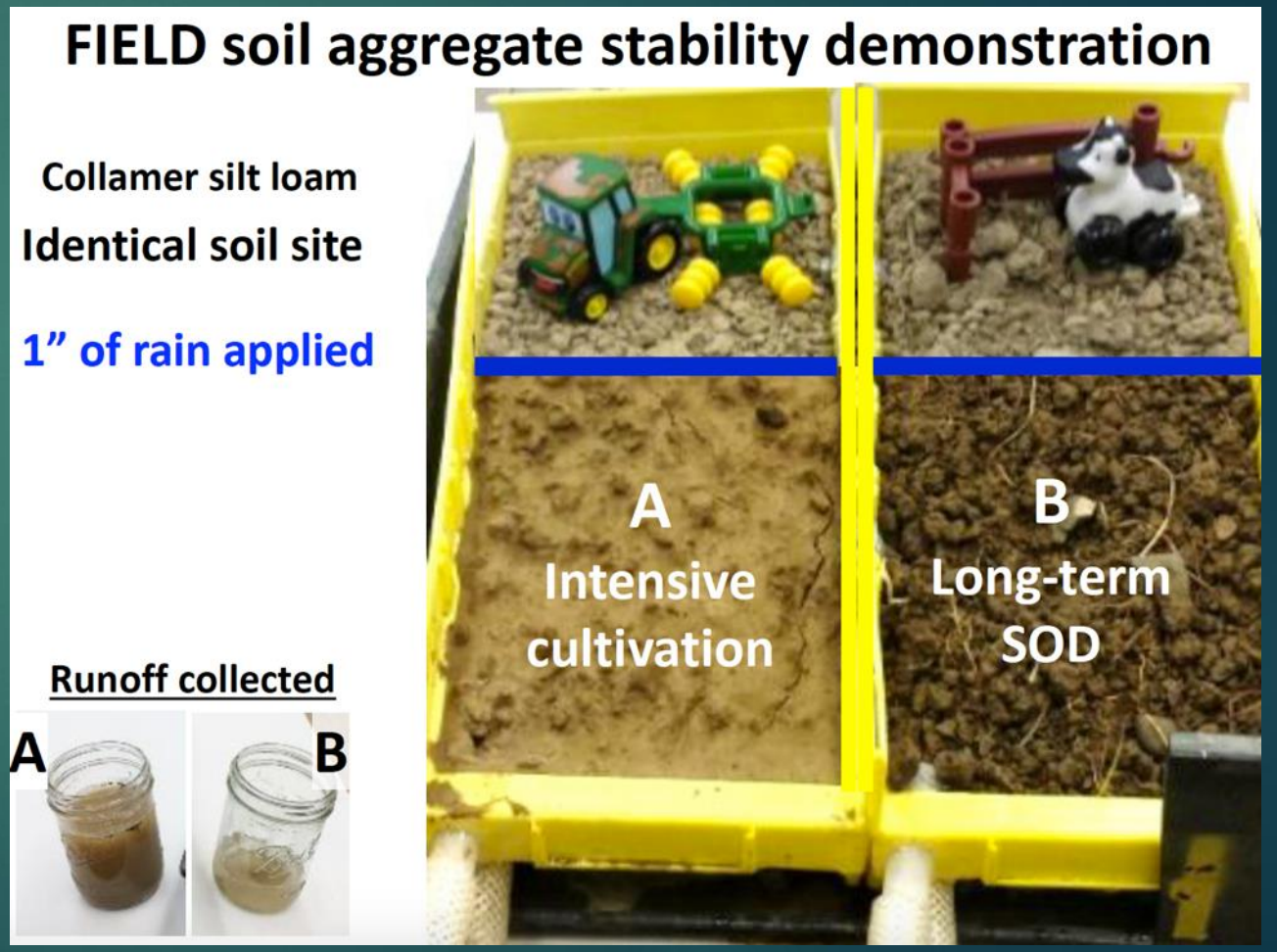
Build up soil organic matter to meet short and long-term goals

- **Historic:** Soil organic matter built up from past organic inputs, judicious tillage. TEST: SOM

- **Recent:** Legumes and compost provide active organic matter (carbon) and supply N. TEST:
  - Active soil C, CO_2 mineralization, teabag, pre-sidedress nitrogen

Soil health function conundrum

How to increase water infiltration AND water storage



Soil health function conundrum
How to increase water infiltration AND water storage

TESTS:

- Penetrometer or marking flag to identify hard-pans
- Aggregates (Cornell soil health, or rain simulator or Field observations - soil aggregates placed carefully in jar, moisten and let sit)
- Observe water infiltration after a storm, observe earthworms
- Use LandPKS to assess texture and water holding capacity

Extension resources

Extension Bulletin E-3137 • New • January 2011

Advanced Soil Organic Matter Management

MICHIGAN STATE UNIVERSITY | Extension

Managing Soils

Soil organic matter (SOM) is the foundation for productive soil. It promotes healthy crops, supplies resources for microbes and other soil organisms, and regulates the supply of water, air and nutrients to plants. SOM can deliver over half of the nitrogen and a quarter of the

Practices that influence SOM include crop rotation, tillage, residue management, cover crops and targeted use of manure or compost (see Fig. 1). A wide range of management tools exist to reduce soil disturbance and promote living plant cover, both of which conserve SOM and protect against erosion.

Soils with sufficient SOM typically have an increased

MSUE James Dedecker, UP Michigan

Rules of thumb for measuring soil health

- **Set your goals** (nutrient supply, root health, soil organic matter, which is most important?)
- **Be Consistent** (sample same zones, same time of year spring or fall, use same soil health tests, same laboratory)
- **Be Patient** (often takes four or more years)
- **Use Benchmarks** (fence rows, natural areas)

https://www.no-tillfarmer.com/articles/9167-tips-for-soil-health-test-sampling

Summary: Recommended tests, labs and field

Soil Organic Matter (A&L, any standard lab $8):
Standard test: Loss on ignition or carbon *1.72 = Soil organic matter
(related: CEC, soil pH)

Active organic matter:
Indicated by respiration = CO2 Mineralization (Cornell soil health, $12-$100)
Nitrogen supply (pre-sidedress nitrate, A&L, any standard lab $10)
Teabag decomposition (Iowa State Univ)

Field Observations (free): Earthworms, Penetrometer, LandPKS App, Aggregates* with MSUE Soil health team, Water infiltration

*Aggregates Cornell Soil Health Lab $15

What will you do?

ANDROID APP ON Google play

Download on the App Store

LandPKS Apps

MSUE Paul Gross, Rumely Michigan