Is there a better soil health test than a shovel?

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SOIL HEALTH & LAND MANAGEMENT

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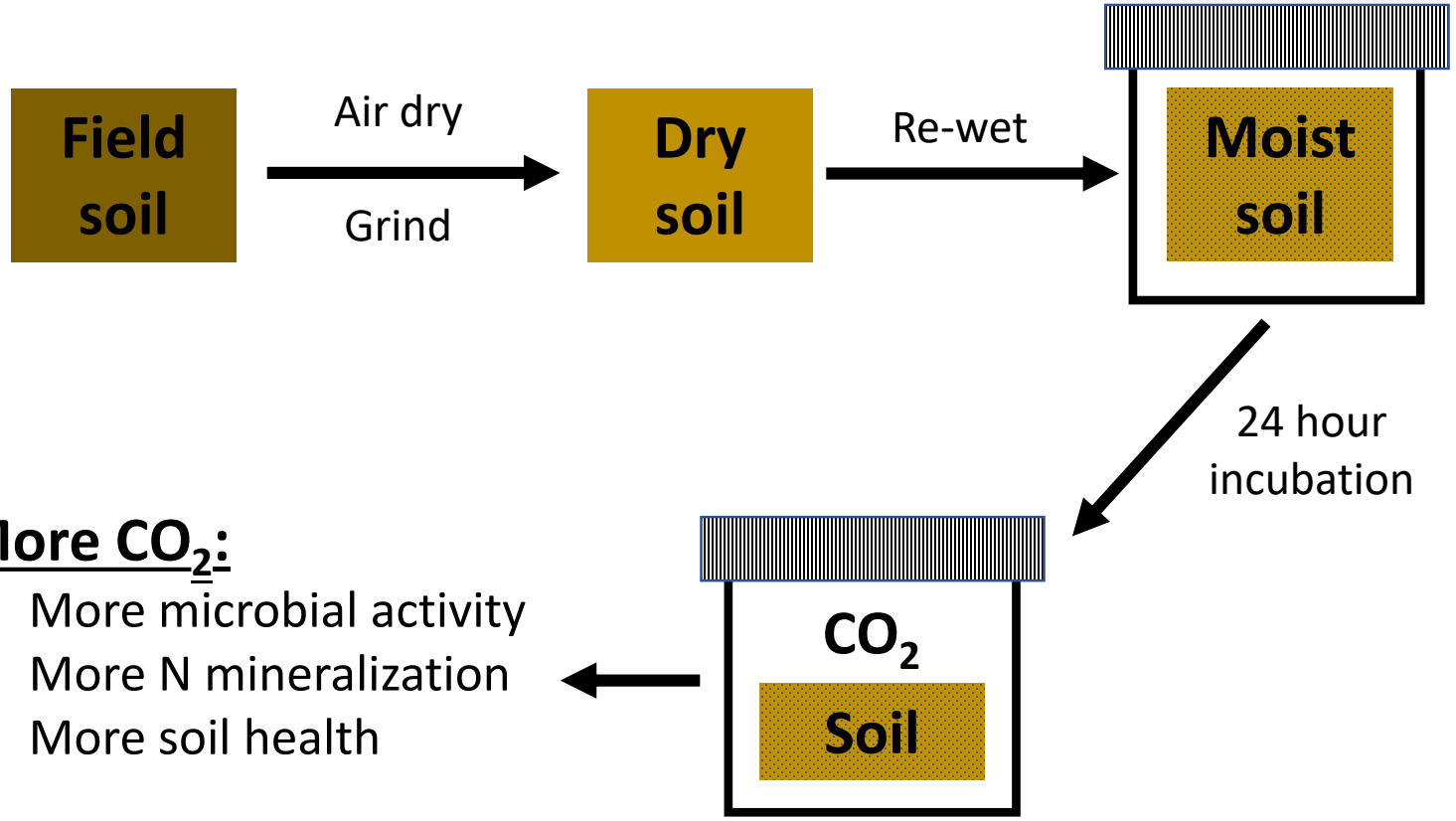
NDSU NORTH DAKOTA STATE UNIVERSITY

What is soil health?

How to measure soil health – Commercial services

- CO_2 Burst Test SOLVITA® solvita.com

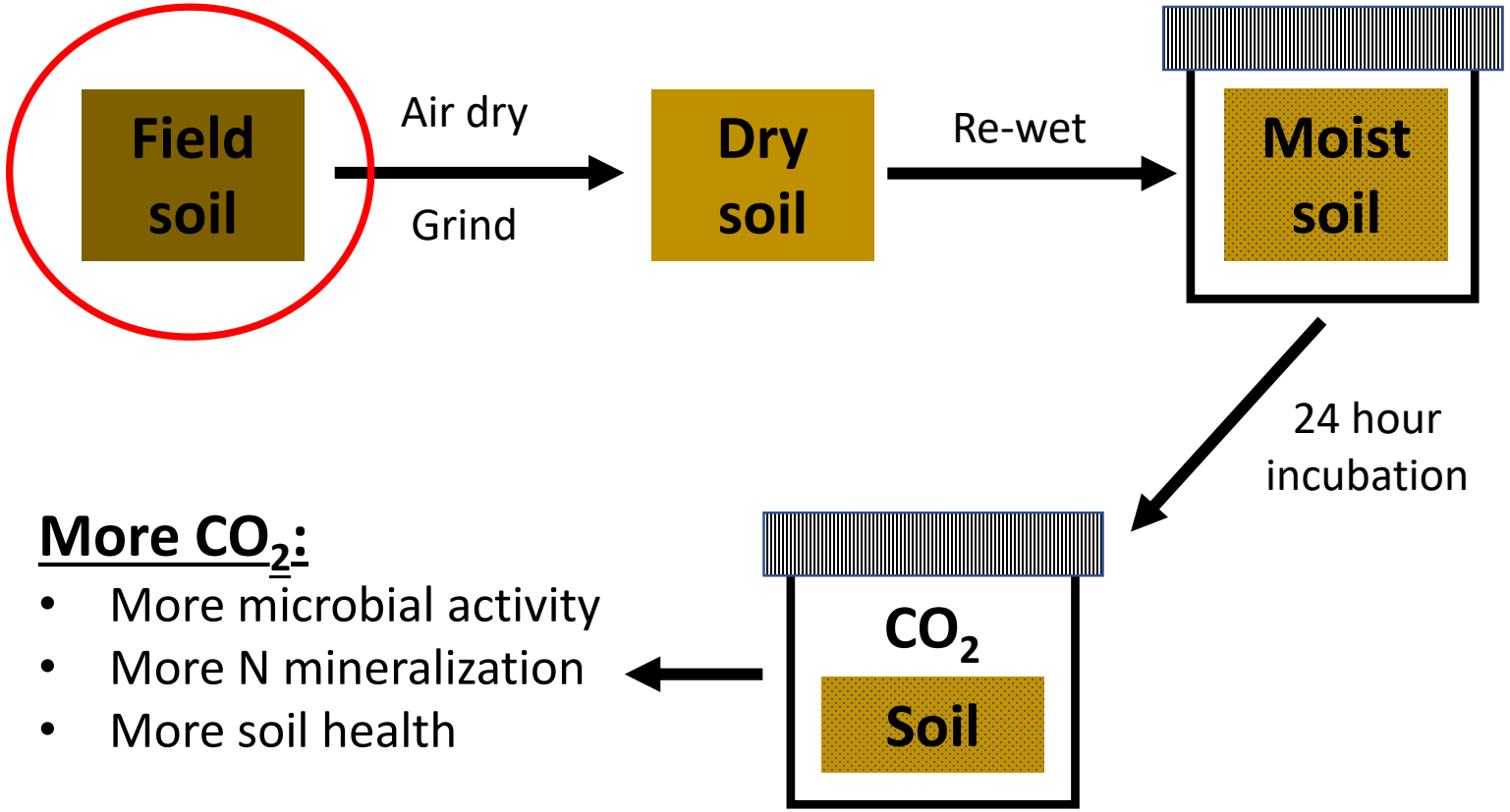


More CO_2:

- More microbial activity
- More N mineralization
- More soil health

How to measure soil health – Solvita

Sensitive to initial water and temperature conditions



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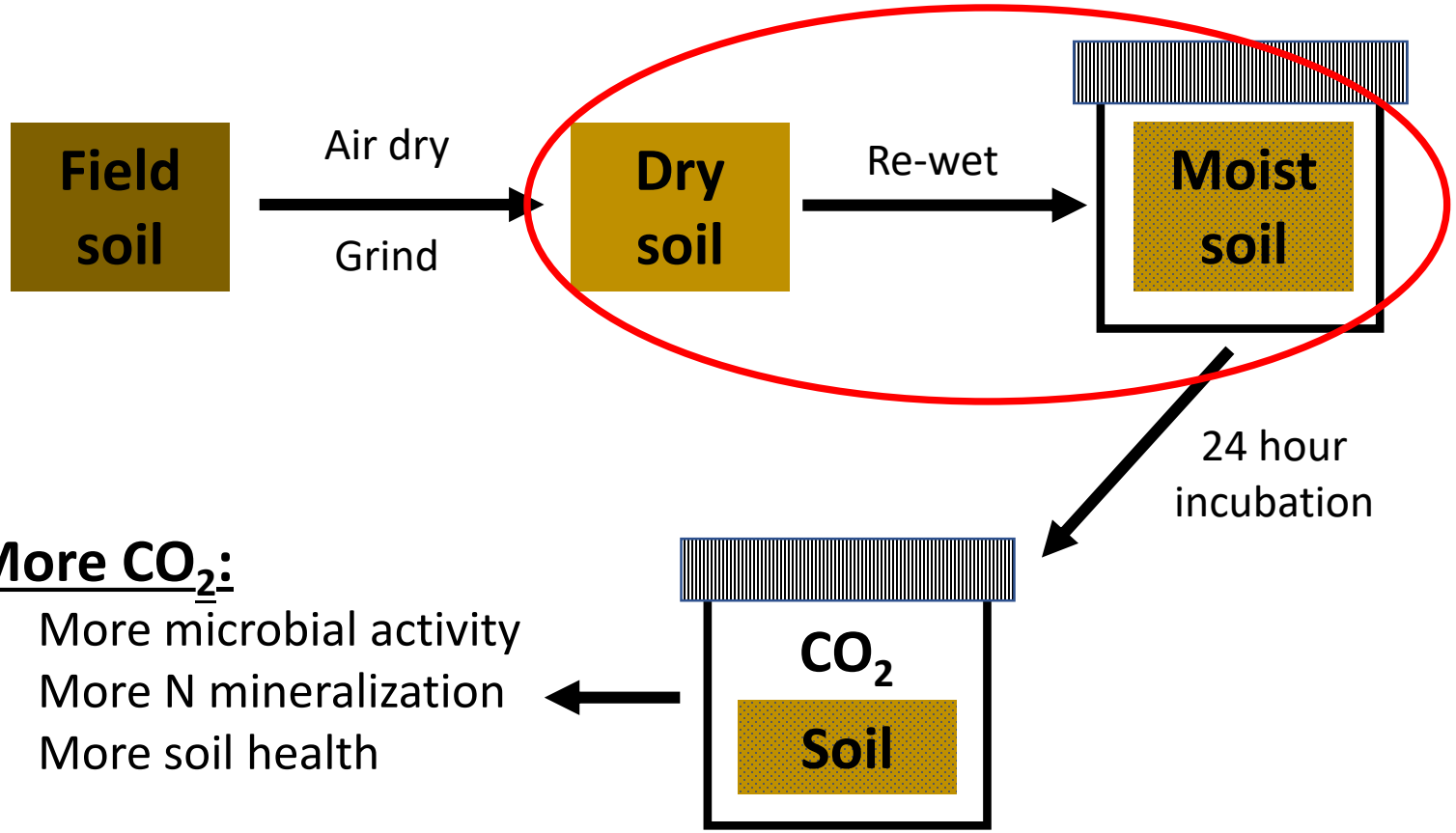
How to measure soil health – Solvita

Drying and re-wetting can kill cells and release nutrients, and can change microbial communities



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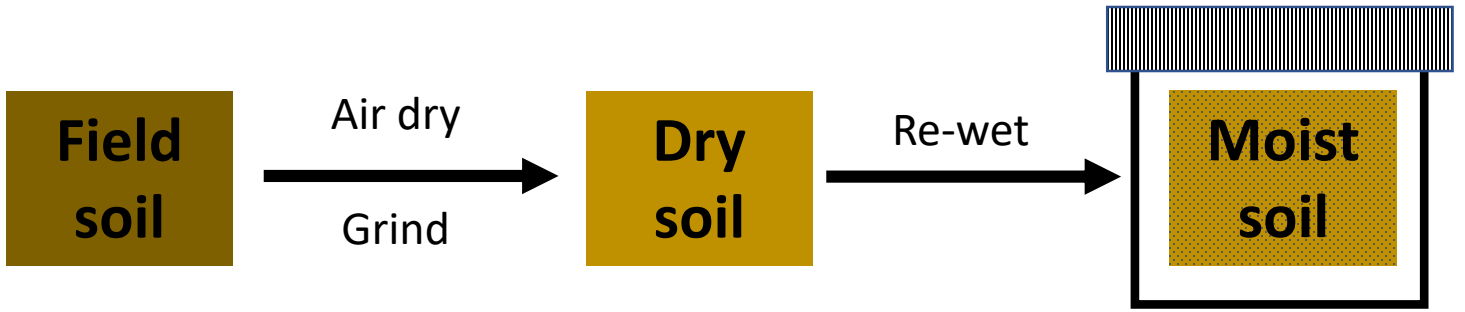
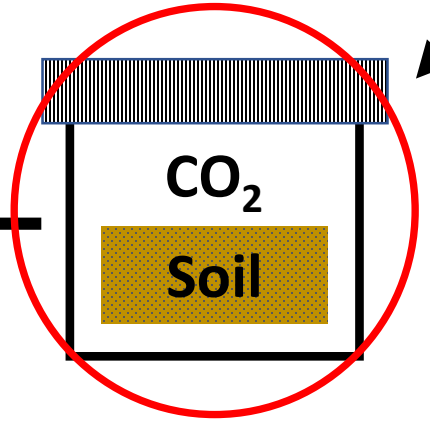
How to measure soil health – Solvita



24 hour incubation

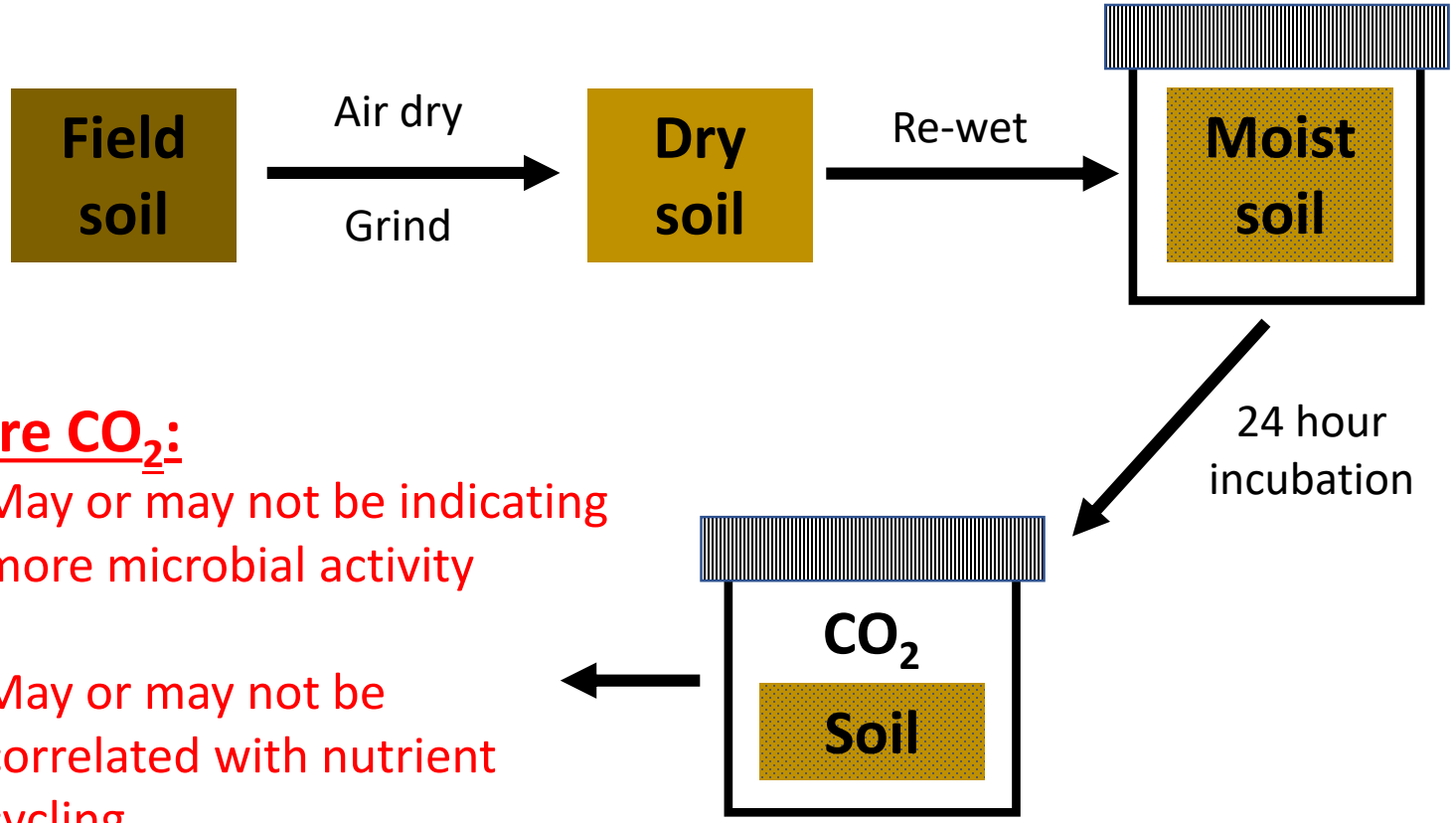


More CO_2:

- More microbial activity
- More N mineralization
- More soil health

CO_2 production is not produced only by live, active microbes

How to measure soil health – Solvita



More CO_2:

- May or may not be indicating more microbial activity
- May or may not be correlated with nutrient cycling

How to measure soil health – The Haney Test

- CO_2 Burst Test SOLVITA® solvita.com
- Water Soluble C & N
- H3A extracted N & P

Haney Test

Soil Health Score (0-50)

- Fertility recommendations
- Soil health monitoring

Approx. $50/sample

How to measure soil health – Cornell Assessment

- Cornell soilhealth.cals.cornell.edu

$60-170 ($20 a la carte)

How to measure soil health – Cornell Assessment

- Cornell soilhealth.cals.cornell.edu

Basic
- Soil pH
- OM
- P, K, micronutrients (Modified Morgan)
- Wet aggregate stability
- Soil respiration
- Penetrometer interpretation

Standard
- Basic +
- Texture
- Active carbon
- Autoclave-citrate extractable (ACE) protein test
- Available water capacity

Extended
- Basic + Standard +
- Soluble salts
- Heavy metal screening
- Root health bio-assay

$60-170 ($20 a la carte)

How to measure soil health – PLFA

- Ward Laboratories – Phospholipid fatty acid analysis
  producers.wardlab.com

PLFA Soil Microbial Community Analysis

Functional Group Biomass & Diversity

Total Living Microbial Biomass, Phospholipid Fatty Acid (PLFA) ng/g	5021.18
Functional Group Diversity Index	1.581

Total Biomass	Diversity	Rating
< 500	< 1.0	Very Poor
500+ - 1000	1.0+ - 1.1	Poor
1000+ - 1500	1.1+ - 1.2	Slightly Below Average
1500+ - 2500	1.2+ - 1.3	Average
2500+ - 3000	1.3+ - 1.4	Slightly Above Average
3000+ - 3500	1.4+ - 1.5	Good
3500+ - 4000	1.5+ - 1.6	Very Good
> 4000	> 1.6	Excellent

Functional Group	Biomass, PLFA ng/g	% of Total Biomass
Total Bacteria	**1881.75**	**37.48**
Gram (+)	**1182.99**	**23.56**
Actinomycetes	358.71	7.14
Gram (-)	**698.76**	**13.92**
Rhizobia	50.72	1.01
Total Fungi	**399.36**	**7.95**
Arbuscular Mycorrhizal	**123.64**	**2.46**
Saprophytes	**275.72**	**5.49**
Protozoa	**45.75**	**0.91**
Undifferentiated	**2694.32**	**53.66**

$60/sample

- **Active carbon**

  Permanganate-oxidizable carbon (POXC)

- **Soil protein**

  Mineralizable nitrogen

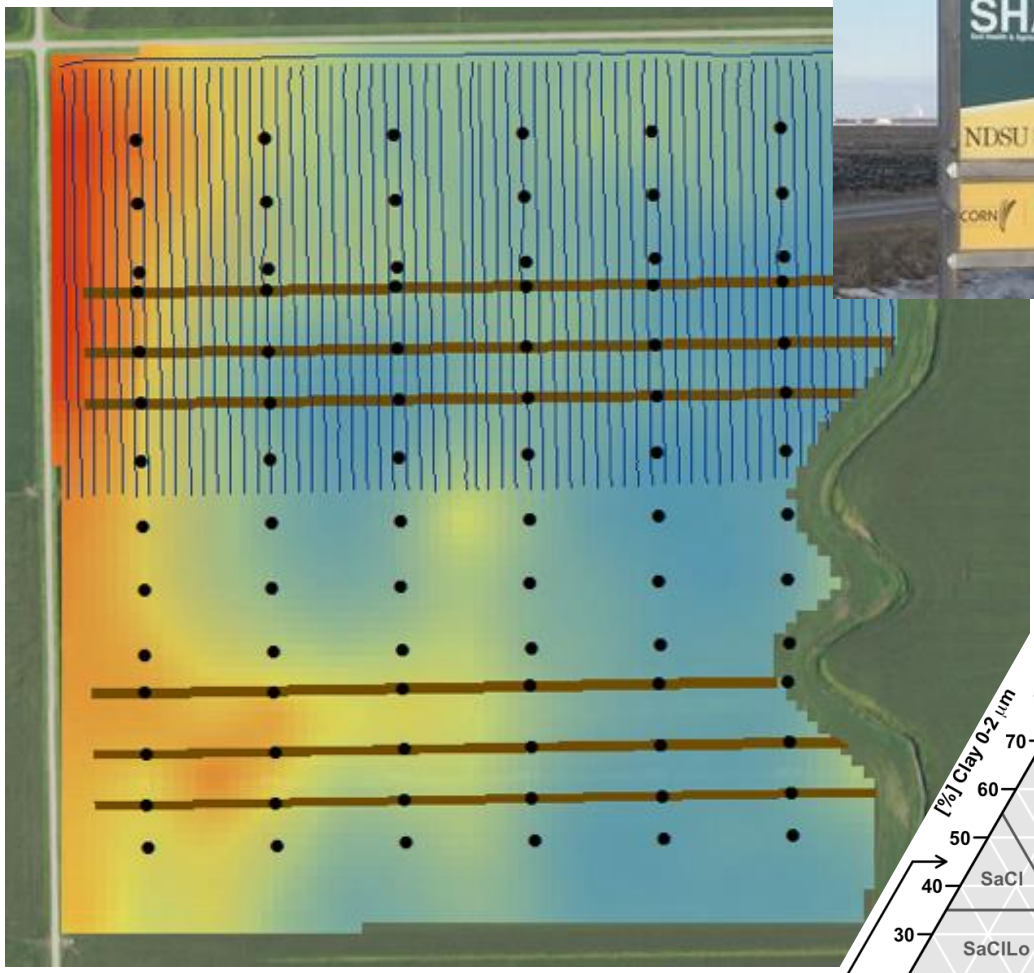
- **Aggregate stability**

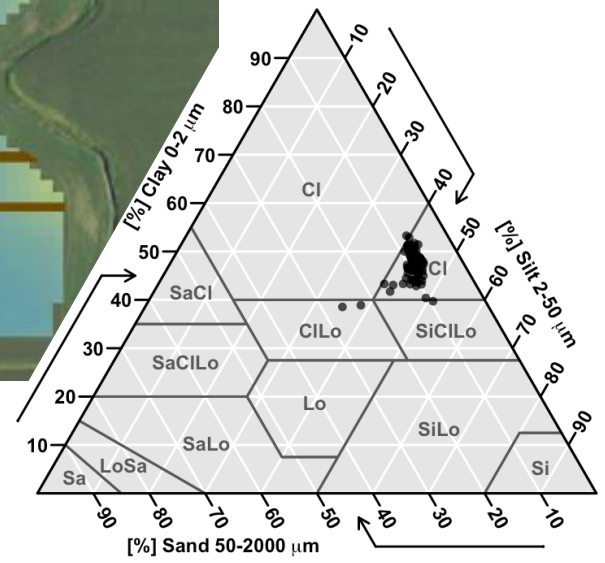
  Strength of shallow granular soil structure

Are there other commercial tests that you have encountered?

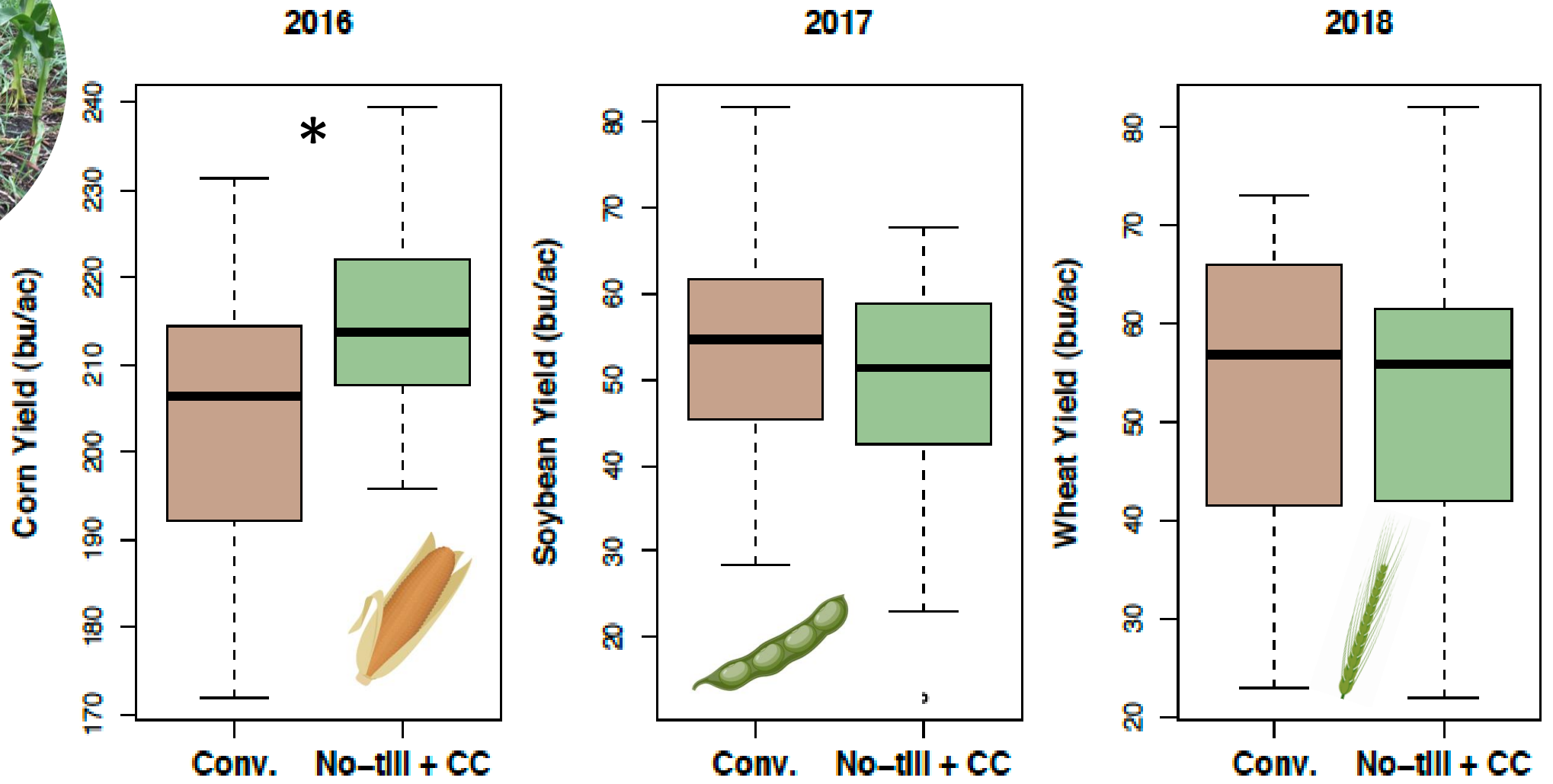
Soil Health Assessment at SHARE

2013	Inception & soil surveys (soybean)
2014	Tile drainage installed (wheat)
2015	NDAWN station installed Tillage plots installed (soybean)
2016	NCGA Soil Health Partnership Cover crops inter-seeded (corn)
2017	Expand soil health surveys Cover crops areal seeded (soybean)
2018	Bio-strip till (wheat)
2019	Cover crops inter-seeded (corn)

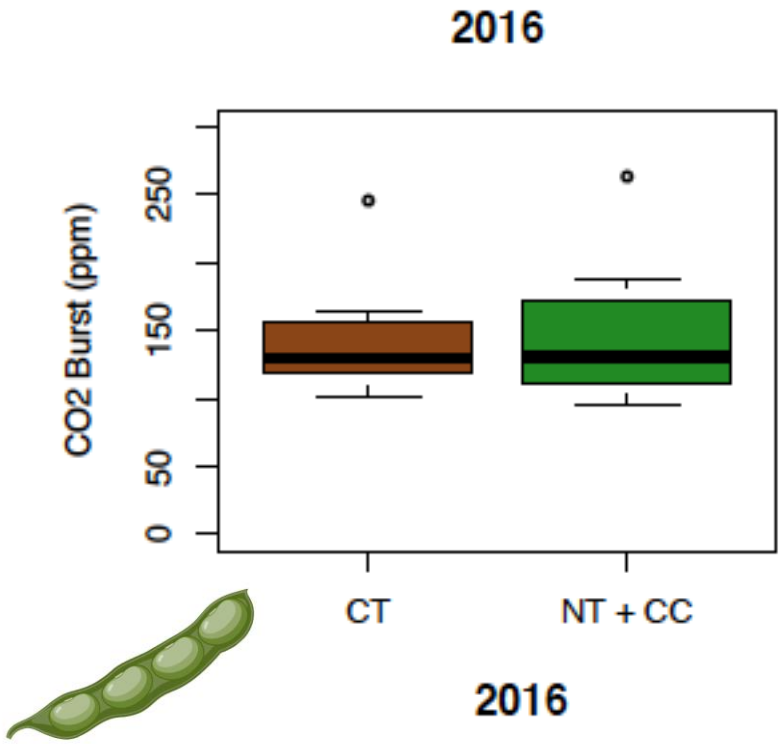


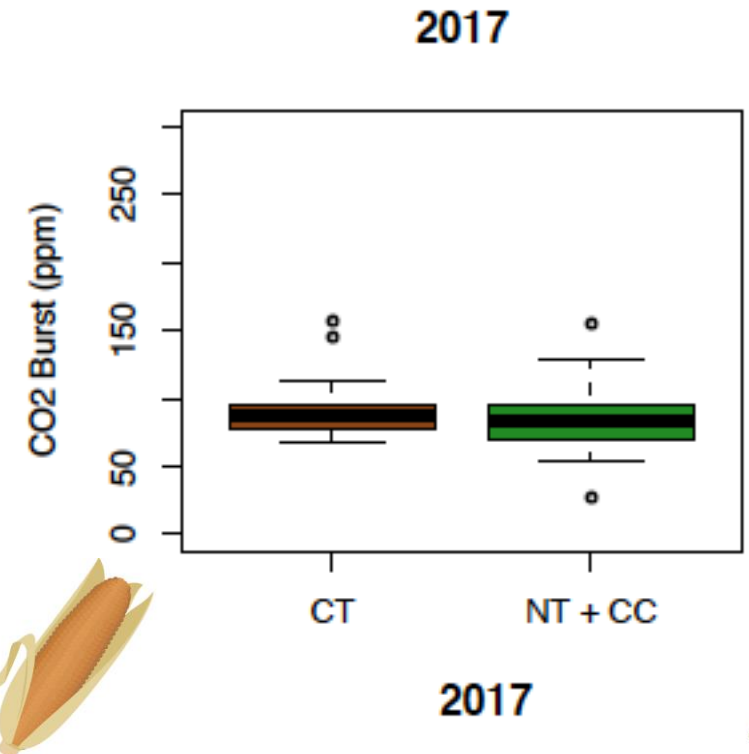


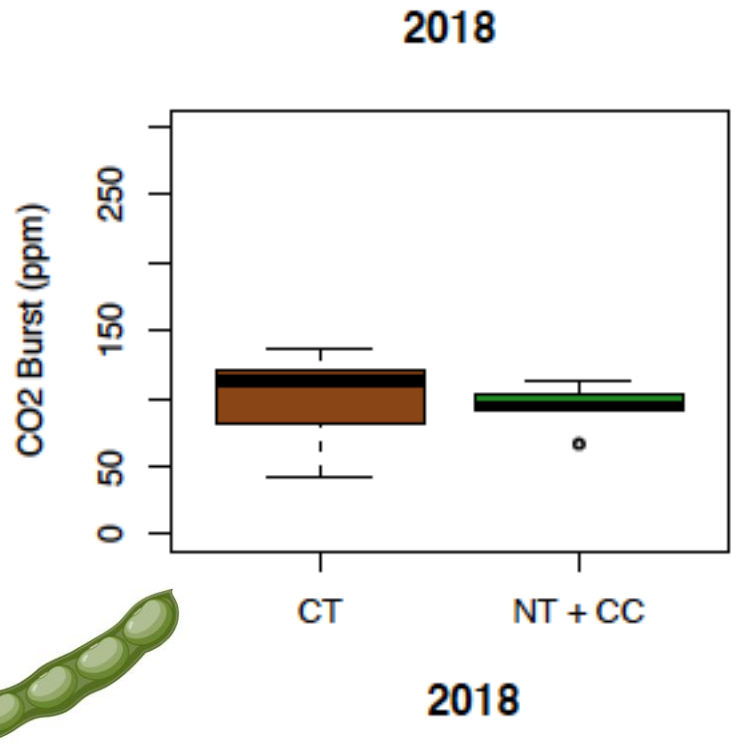
Yields

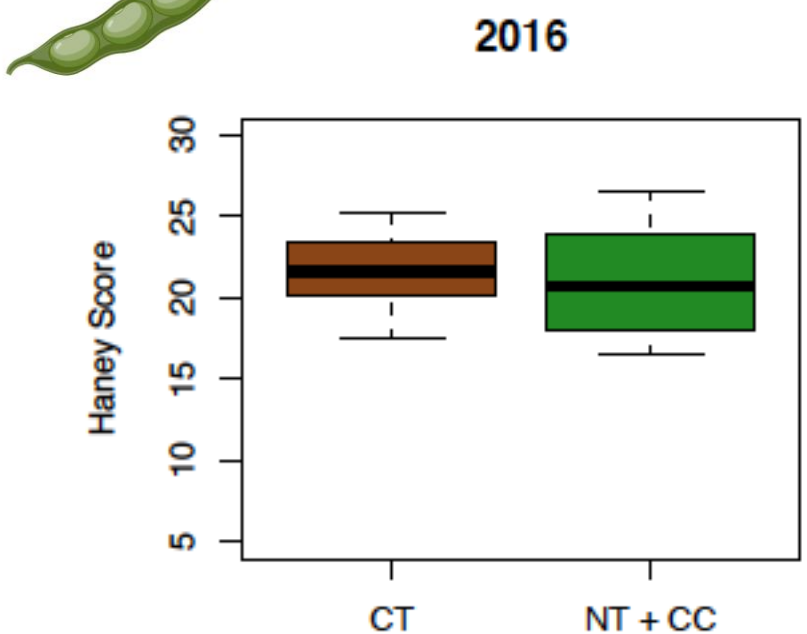

2016
2017
2018
Corn Yield (bu/ac)
Soybean Yield (bu/ac)
Wheat Yield (bu/ac)
*
Conv.
No–till + CC
Conv.
No–till + CC
Conv.
No–till + CC

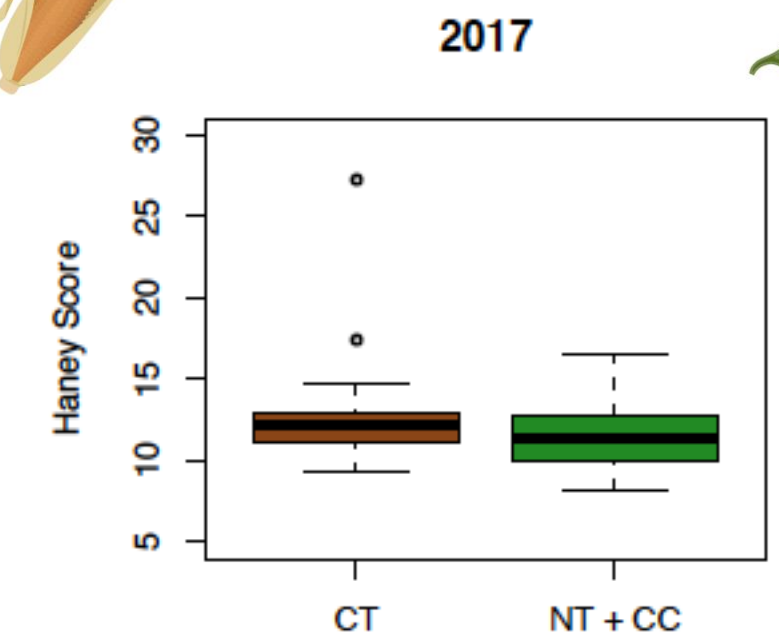
The Haney Test

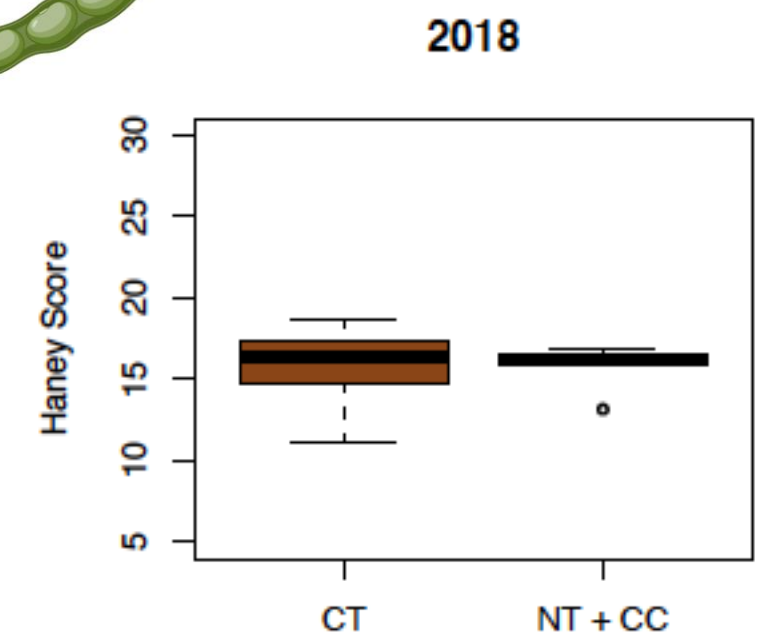












Comprehensive Assessment of Soil Health

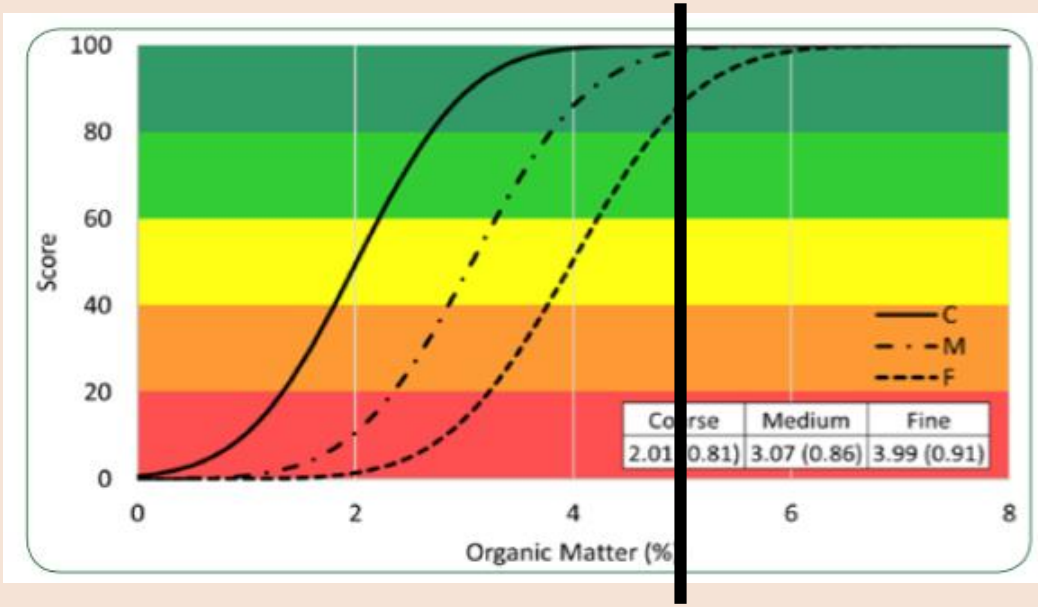
From the Cornell Soil Health Laboratory, Department of Soil and Crop Sciences, School of Integrative Plant Science, Cornell University, Ithaca, NY 14853. http://soilhealth.cals.cornell.edu

Group	Indicator	Value	Rating	Constraints
physical	Available Water Capacity	0.27	95	
physical	Surface Hardness			Not rated: No Field Penetrometer Readings Submitted
physical	Subsurface Hardness			Not rated: No Field Penetrometer Readings Submitted
physical	Aggregate Stability	59.2	89	
biological	Organic Matter	4.9	84	
biological	ACE Soil Protein Index	5.4	43	
biological	Soil Respiration	0.3	19	Soil Microbial Abundance and Activity
biological	Active Carbon	474	30	
chemical	Soil pH	6.2	89	
chemical	Extractable Phosphorus	2.2	64	
chemical	Extractable Potassium	417.4	100	
chemical	Minor Elements Mg: 1279.8 / Fe: 1.7 / Mn: 5.3 / Zn: 0.3		100	

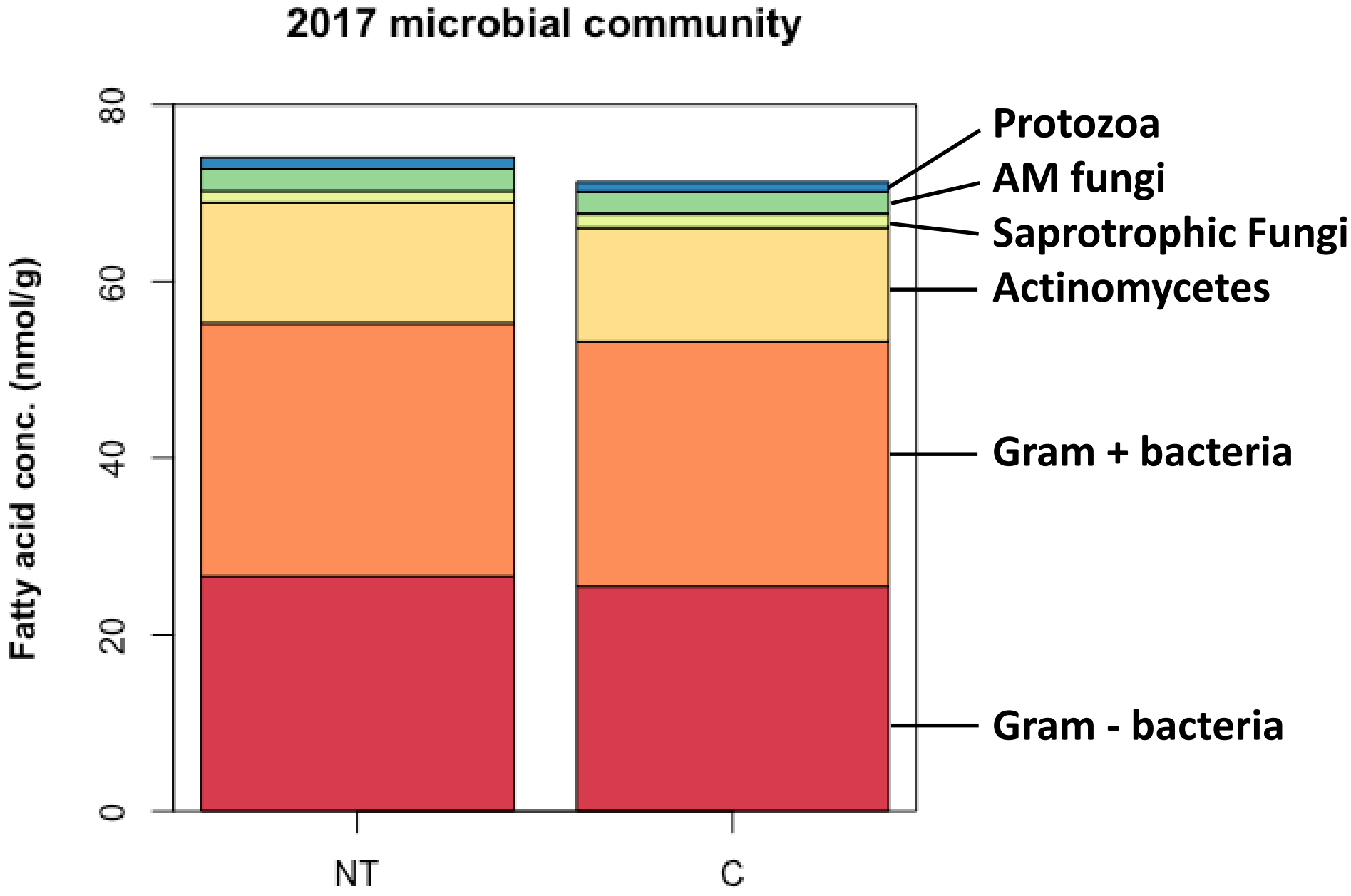
Overall Quality Score: **71** / Excellent

Cornell soil health (2016):

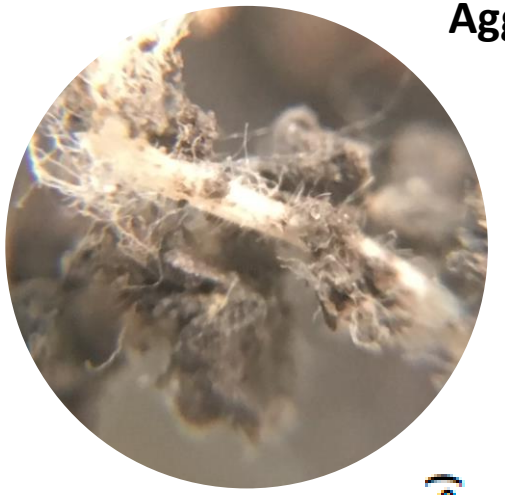
72/100 = Excellent

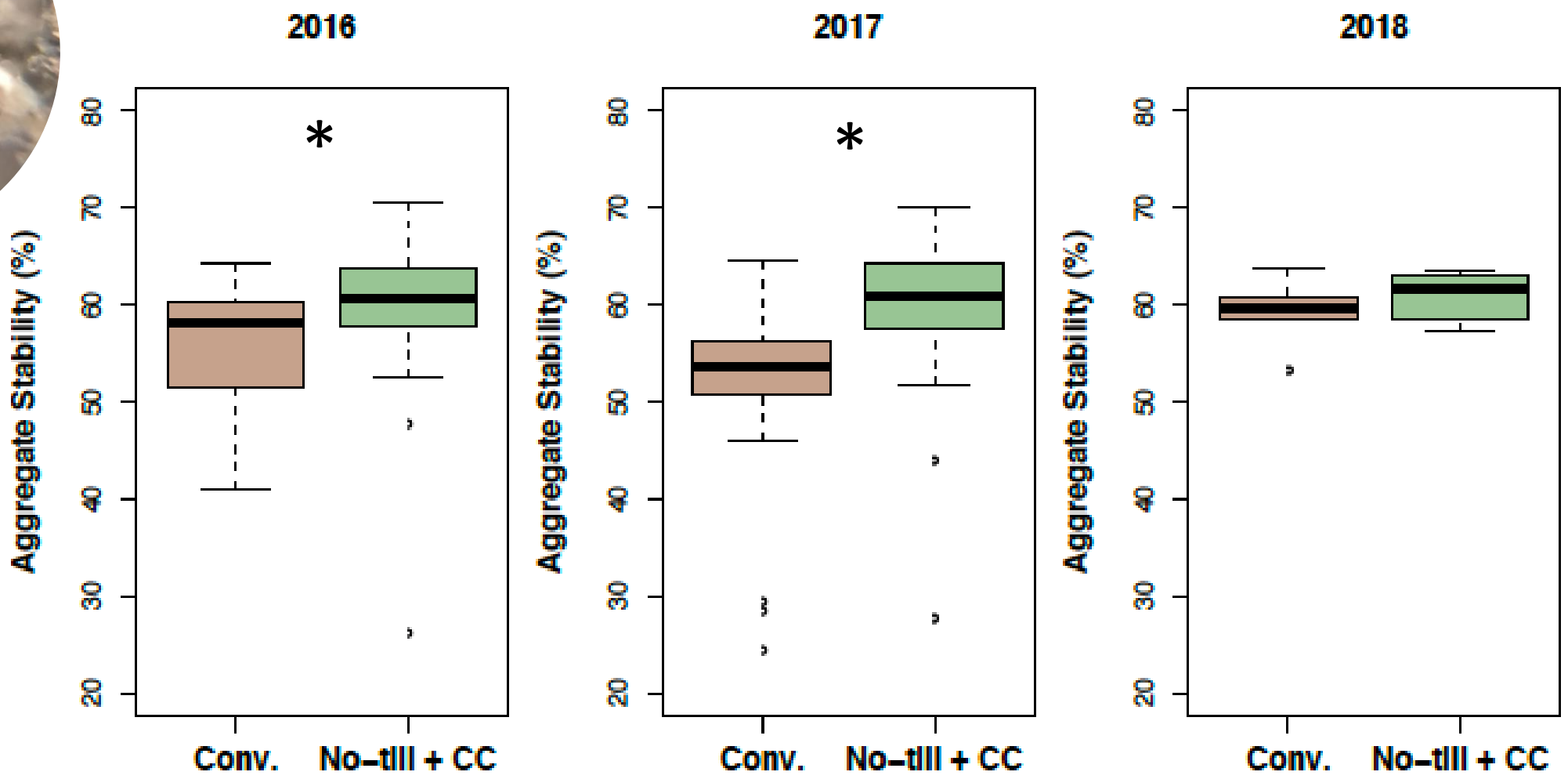


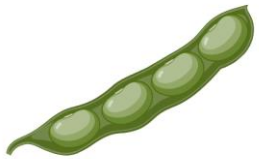
PLFA

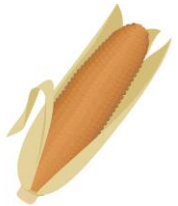

2017 microbial community
Fatty acid conc. (nmol/g)
0
20
40
60
80
NT
C
Protozoa
AM fungi
Saprotrophic Fungi
Actinomycetes
Gram + bacteria
Gram - bacteria

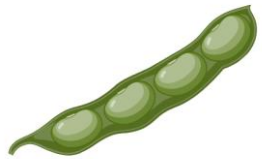
Aggregate Stability

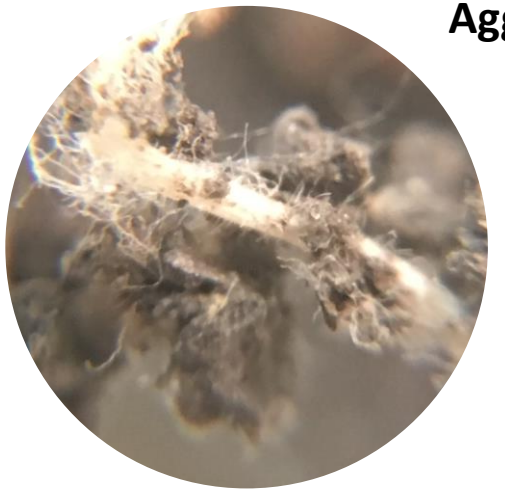












Aggregate Stability

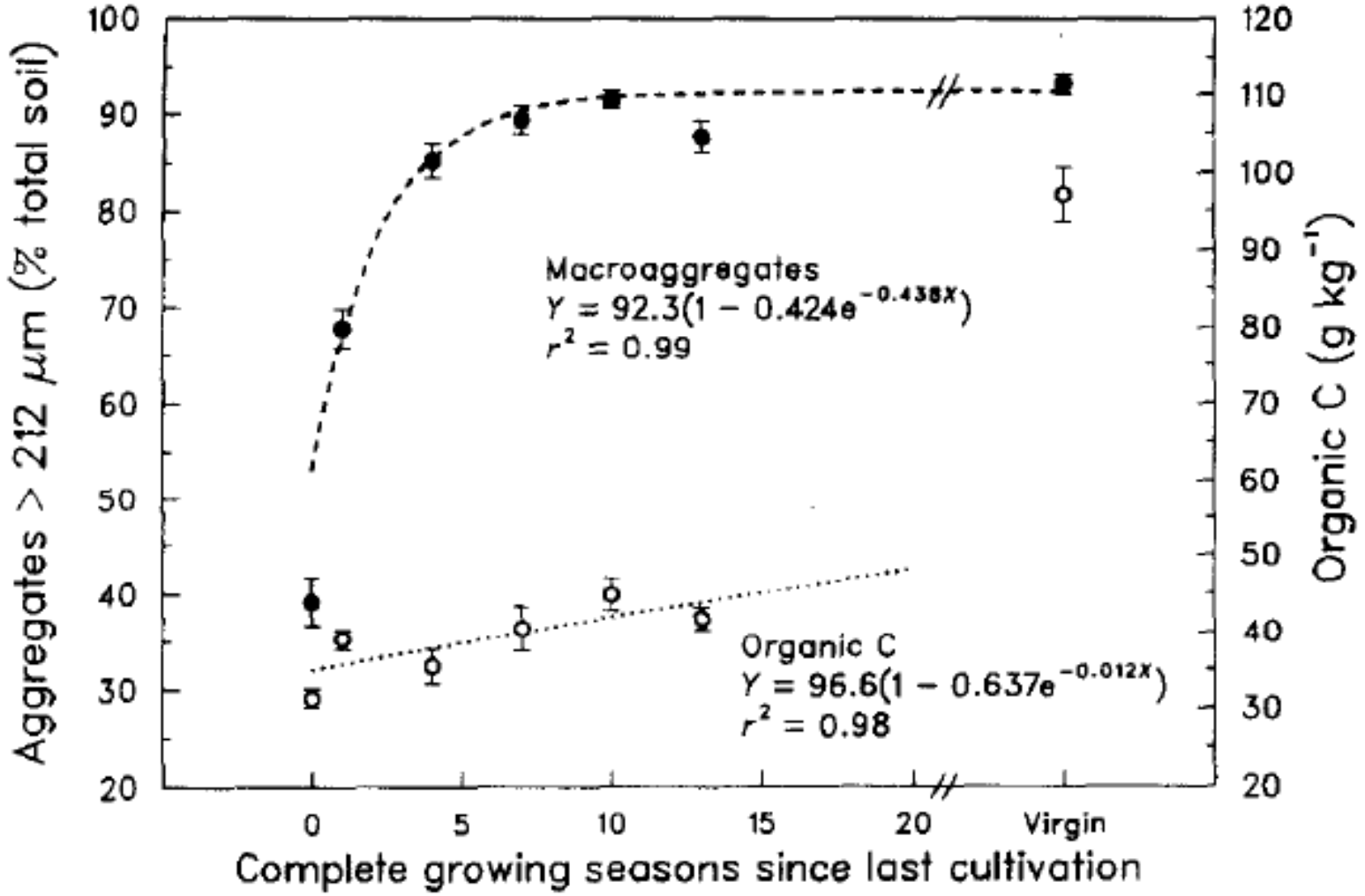
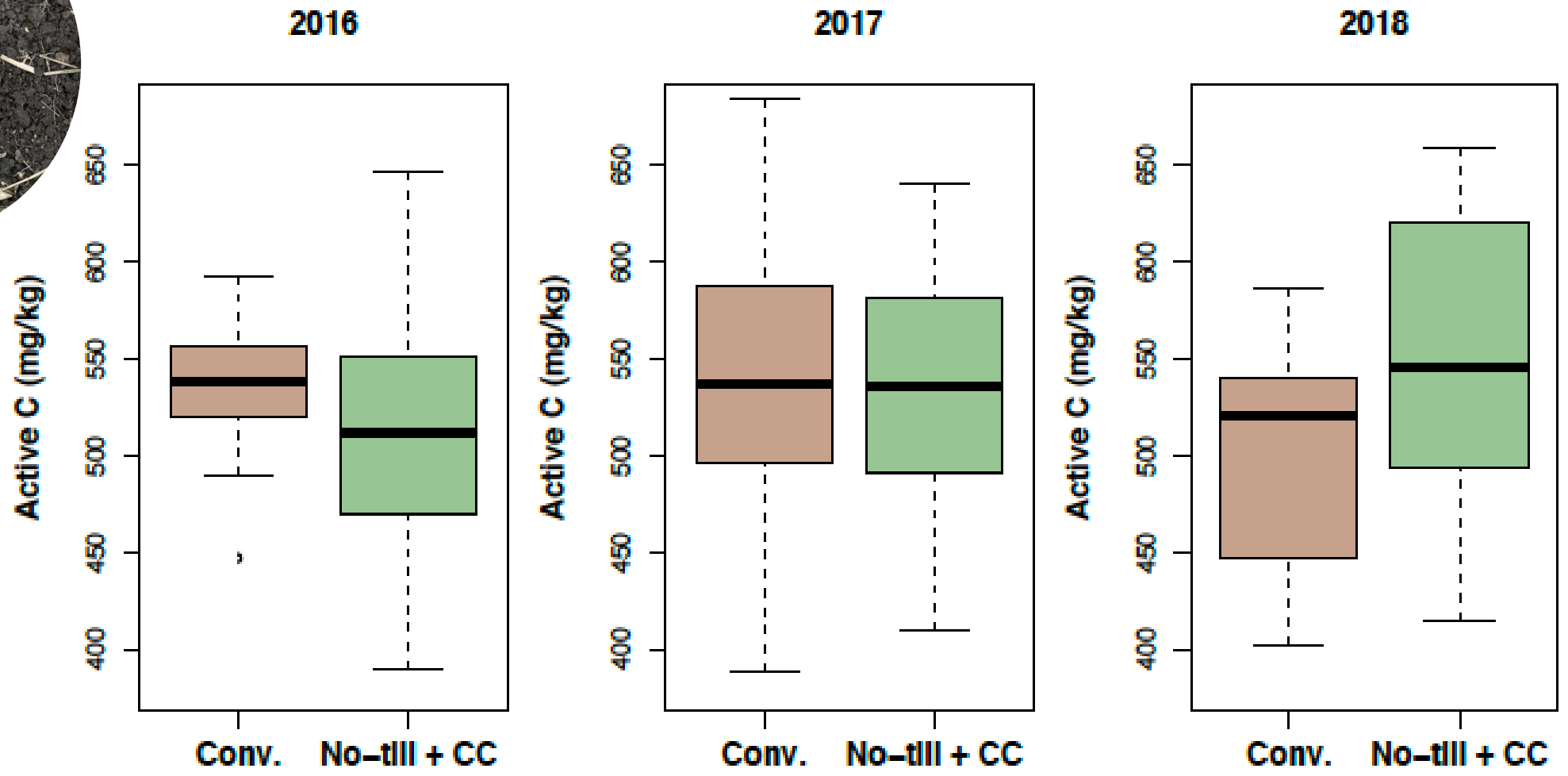
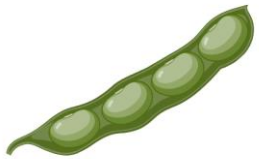


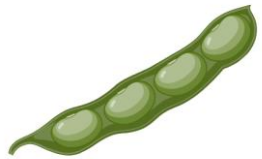
Fig. 1. Changes in percentage of macroaggregates and accumulation of whole-soil organic C with time since cultivation. Error bars indicate standard errors ($n = 10$).

Jastrow, 1996, *Soil Biology and Biochemistry* 28: 665

Active Carbon







Active Carbon

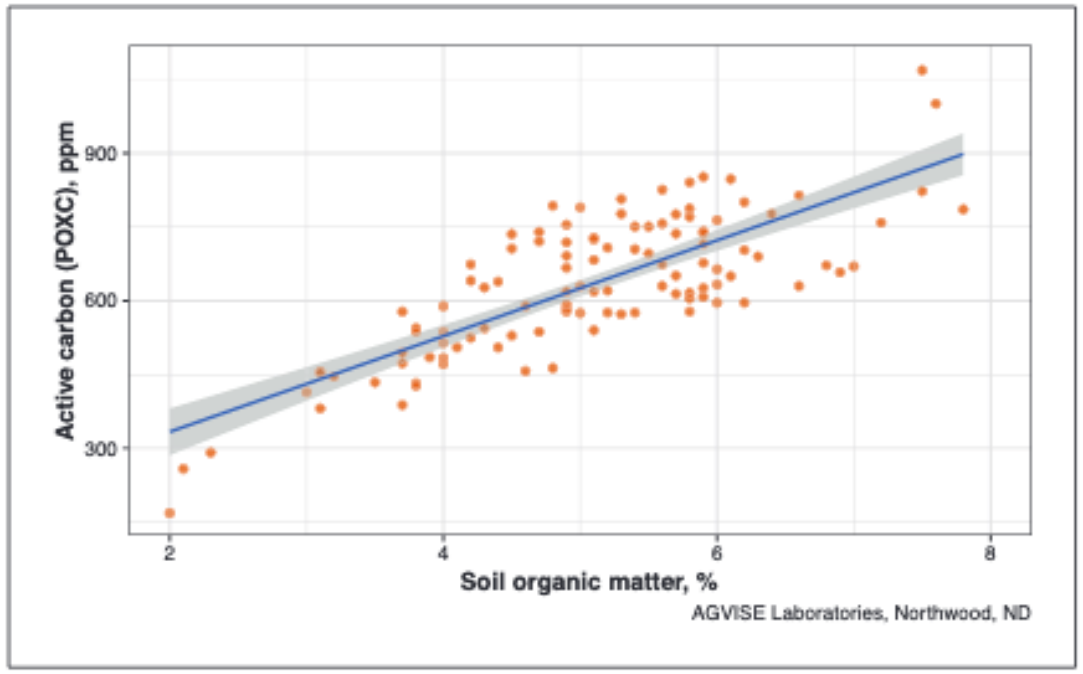


Figure 2. Active carbon (POXC) is one component of total soil organic matter (AGVISE, 2019).

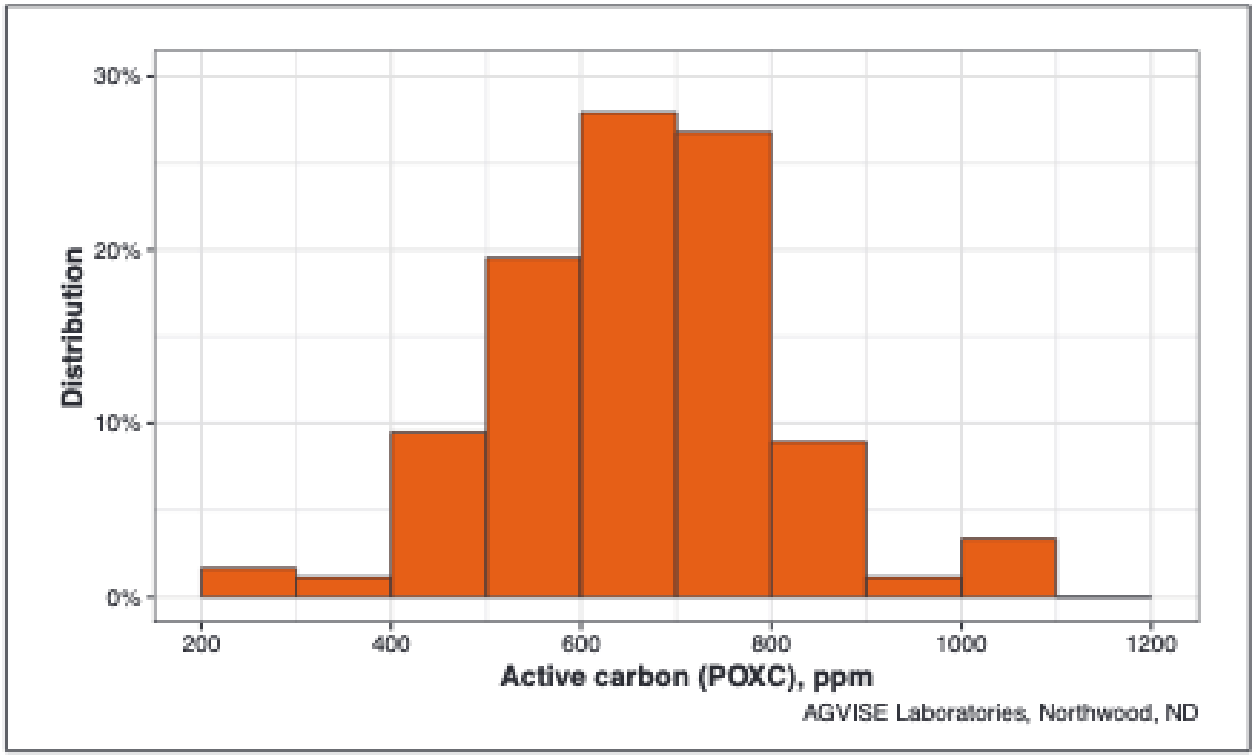
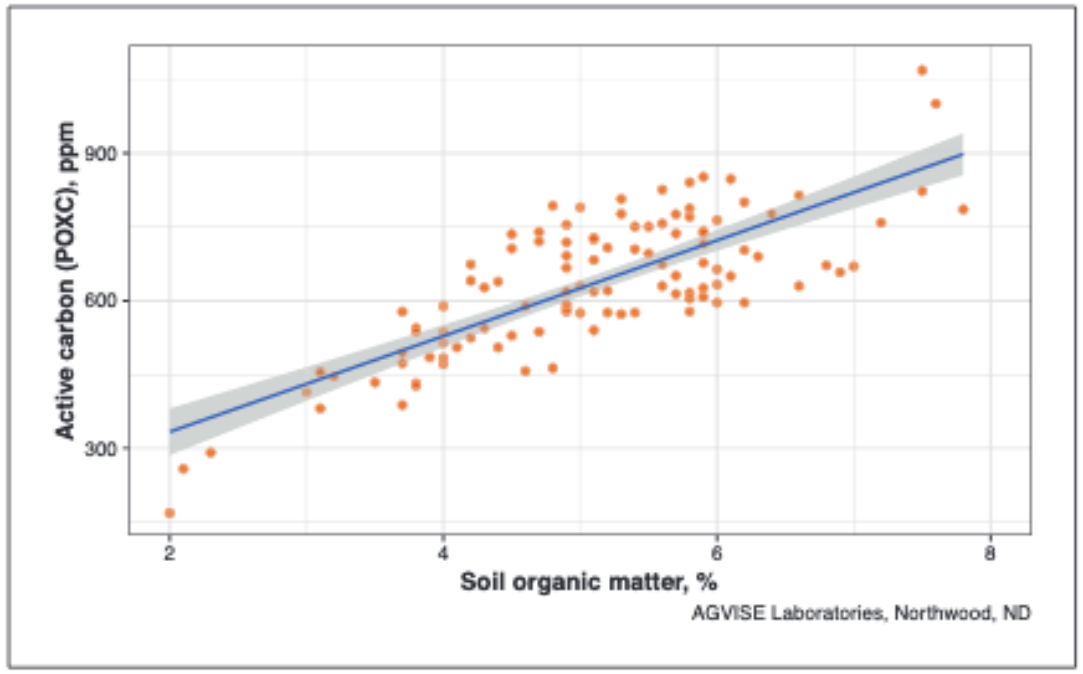


Figure 3. Active carbon (POXC) distribution among agricultural soils of the upper Midwest and northern Great Plains (AGVISE, 2019).

AGVISE winter newsletter, 2019

Active Carbon



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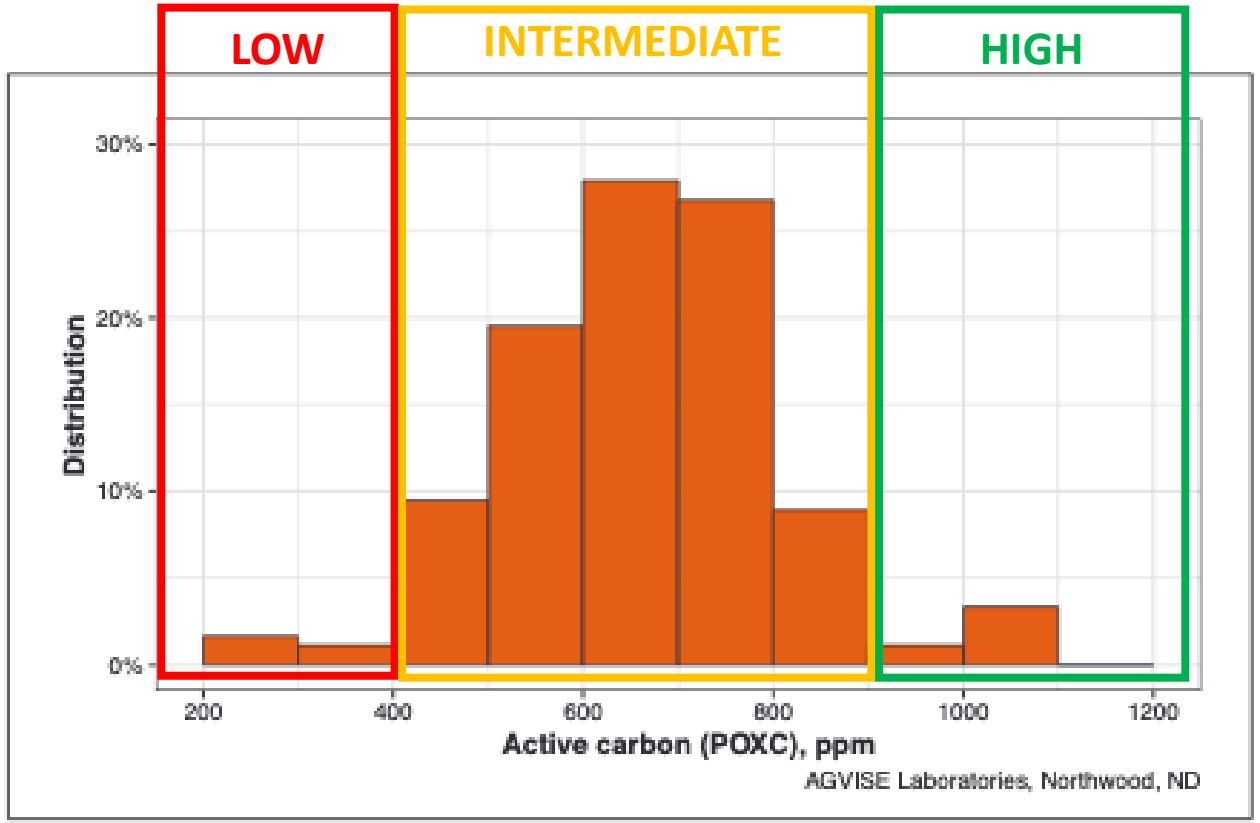
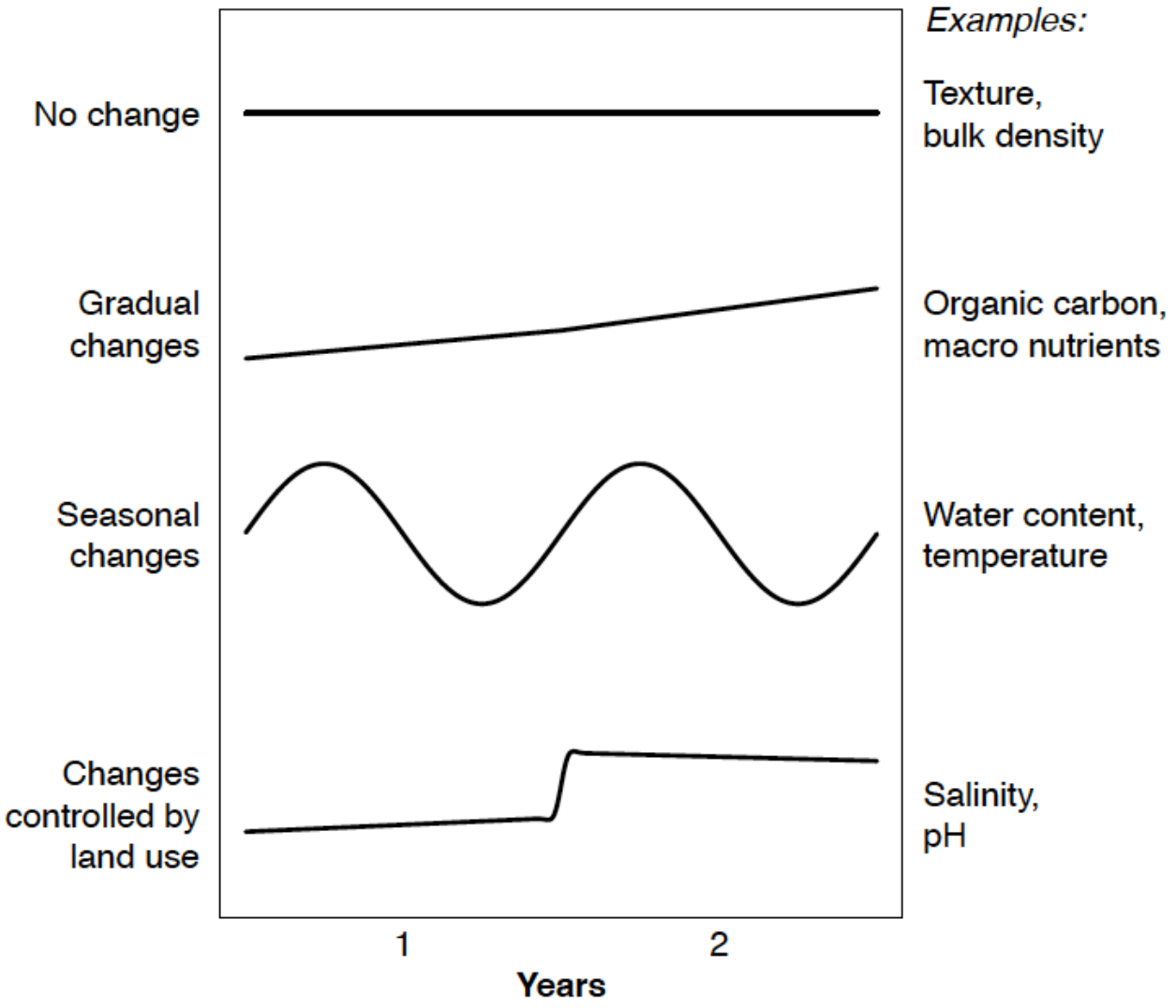
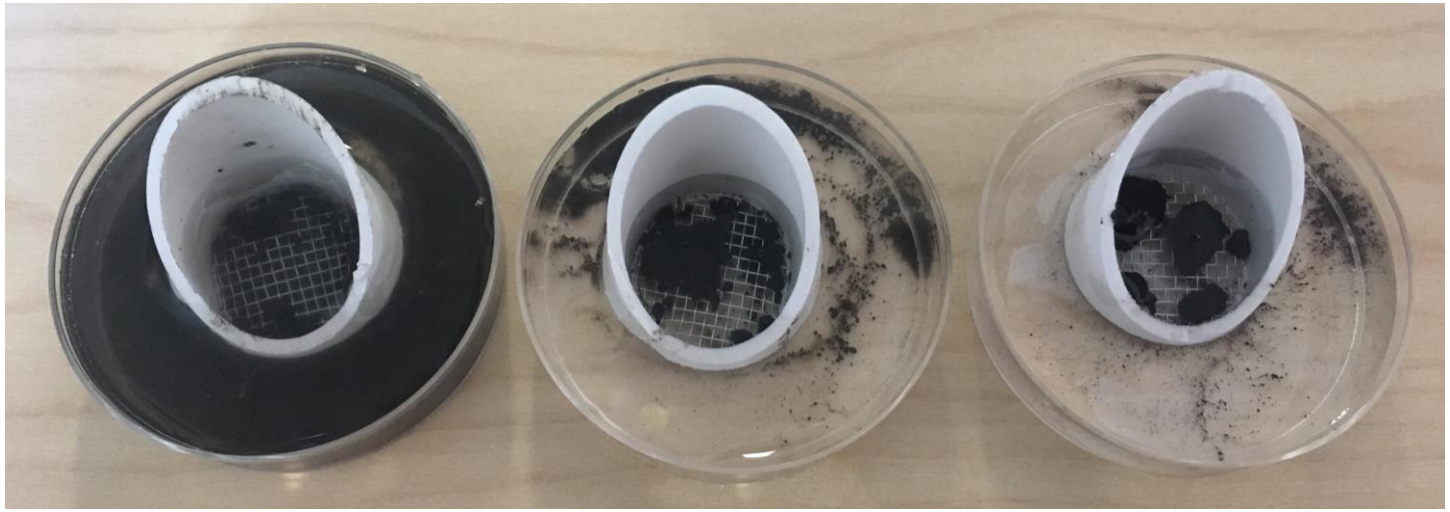


Figure 3. Active carbon (POXC) distribution among agricultural soils of the upper Midwest and northern Great Plains (AGVISE, 2019).

AGVISE winter newsletter, 2019

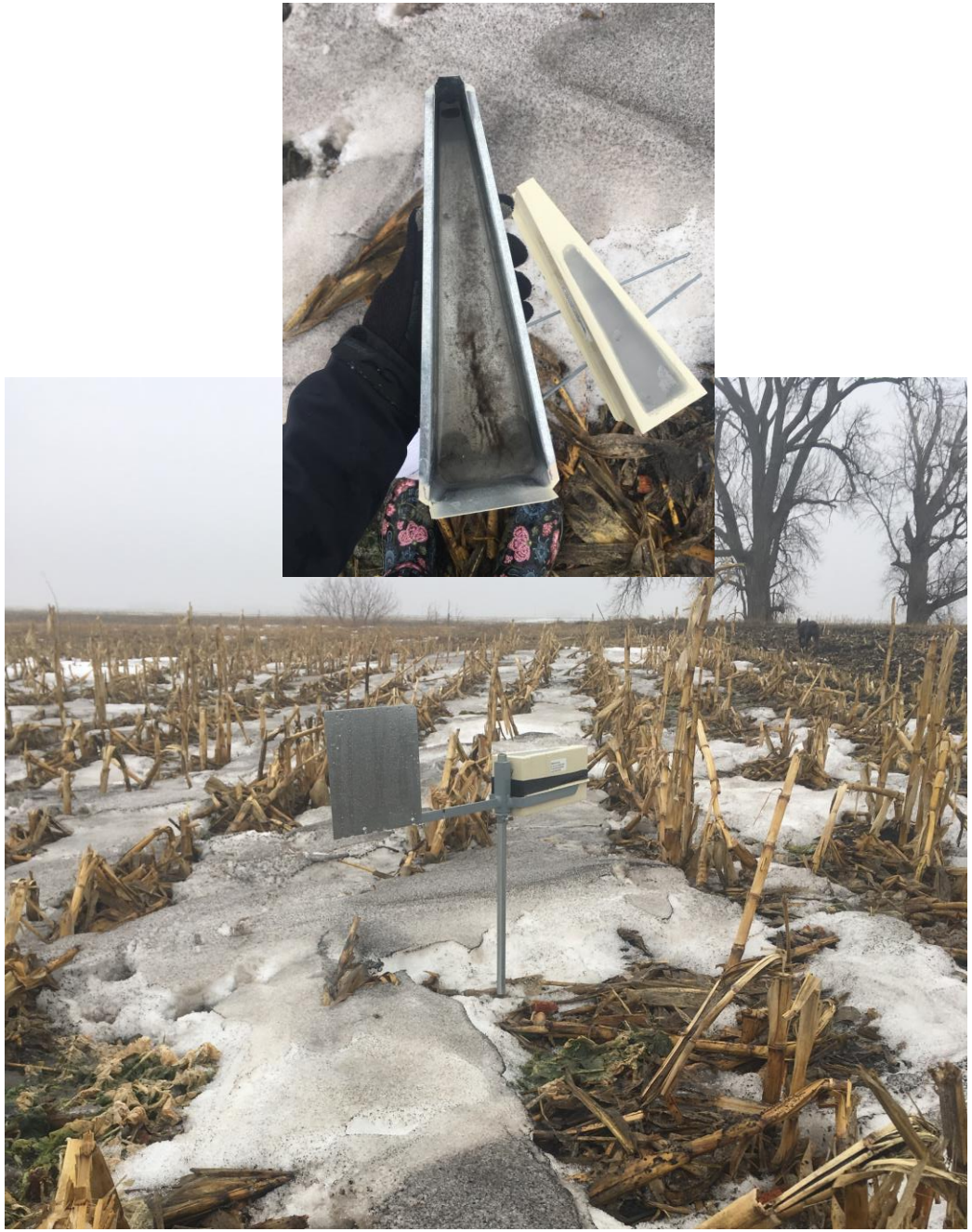
How to measure soil health – Temporal considerations

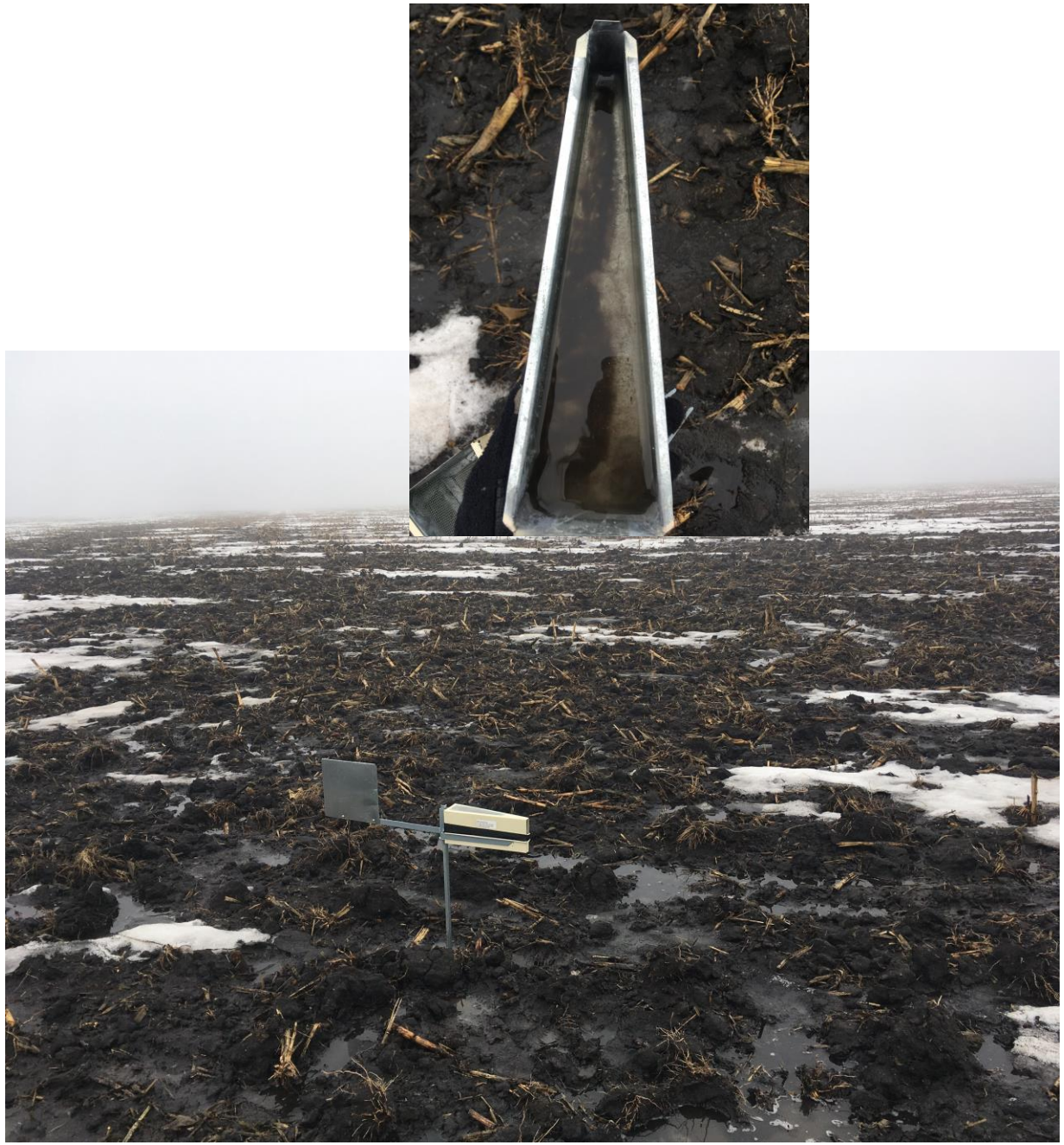




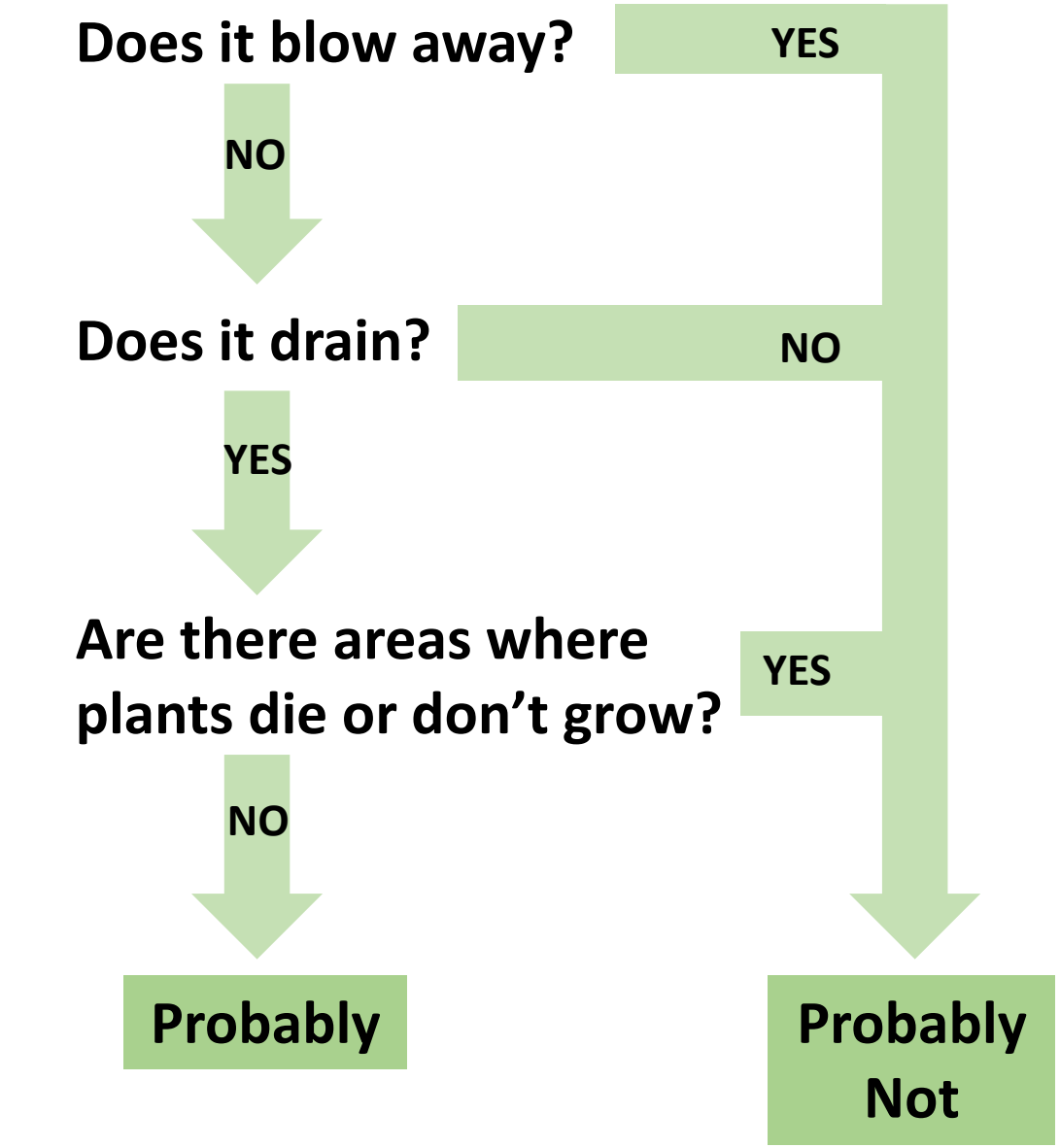
Stability class	Criteria for assignment to stability class (for Standard Characterization)[a]
1	**50%** of structural integrity lost within **5 seconds** of insertion in water OR too unstable to sample (falls through sieve)*.
2	**50%** of structural integrity lost **5–30 seconds** after insertion.
3	**50%** of structural integrity lost **30–300 seconds** after insertion or <10% of soil remains on sieve after 5 dipping cycles.
4	**10 - 25%** of soil remains on sieve after 5 dipping cycles.
5	**25 - 75%** of soil remains on sieve after 5 dipping cycles.
6	**75 - 100%** of soil remains on sieve after 5 dipping cycles.

From: Interpreting Indicators of Rangeland Health, 2005, Dept. of Interior





Is the soil healthy?

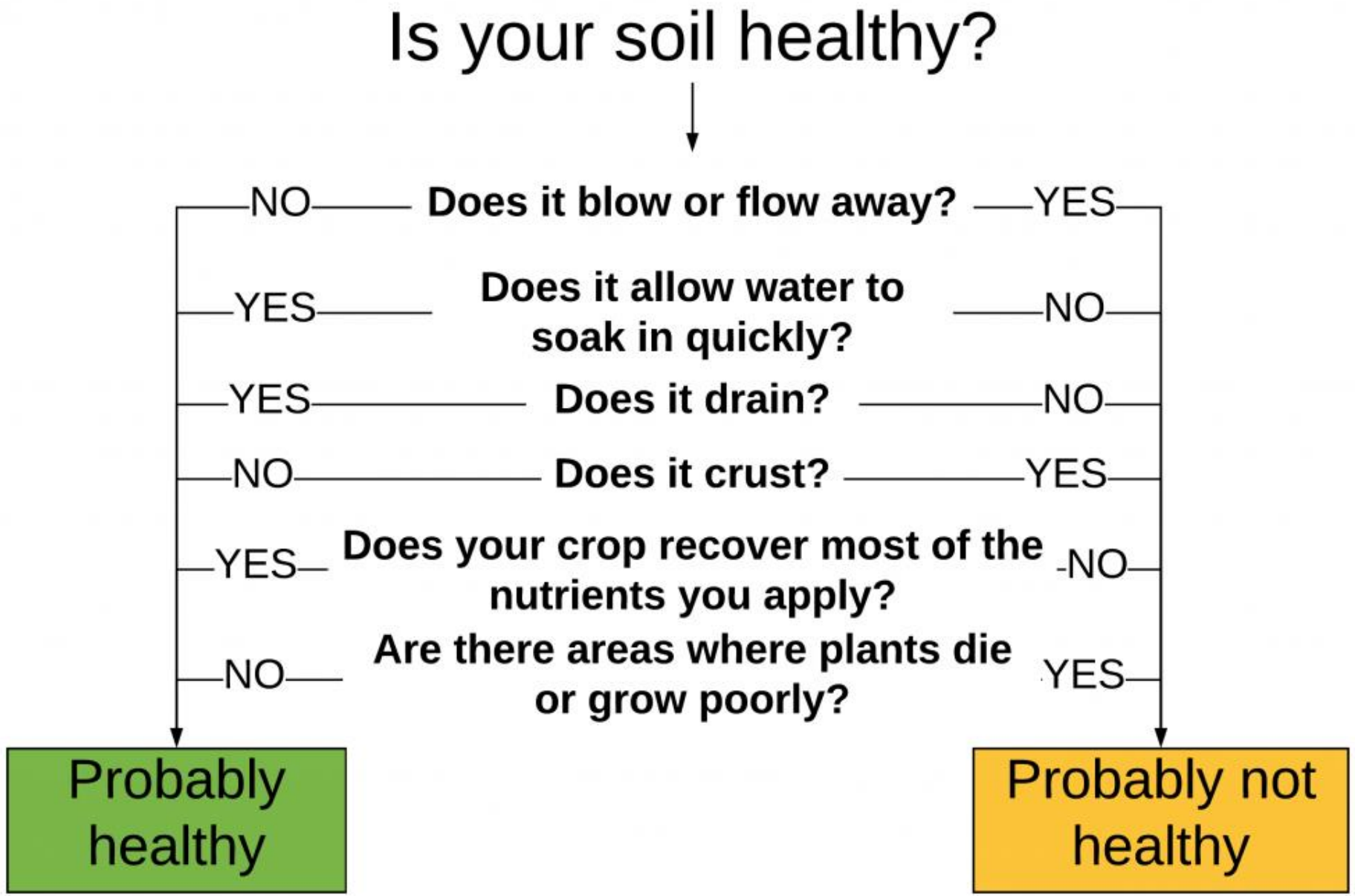


Practices you can change:

- Rotation and covers
- Tillage type and frequency
- Disease and pest control
- Manure, compost, livestock

To meet these goals:

- Protect and improve soil structure
- Combat disease and pest problems
- Increase fertility efficiencies
- Encourage beneficial biological activity



Andy McGuire, WSU Extension

How to measure soil health – Some recommendations

- Identify the problem (understand the management system)
- Soil tests for a specific concern
  (salinity, symbionts, pathogens, etc.)
- Develop a monitoring plan with appropriate metrics
- Develop a management plan for your soil health target(s)
- Common sense and patience

Thank you

Abbey Wick
Frank Casey
Ken Johnson Farms
Joel Bell
Luke Ressler
Nate Derby
Rodney Utter
Kevin Horsager
Chandra Langseth

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SOIL HEALTH & LAND MANAGEMENT

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