

# Importance of Aggregation for Soil Health

*Dr. Abbey Wick, NDSU Extension Soil  
Health Specialist, Assistant  
Professor Soil Health*



**NDSU**

EXTENSION

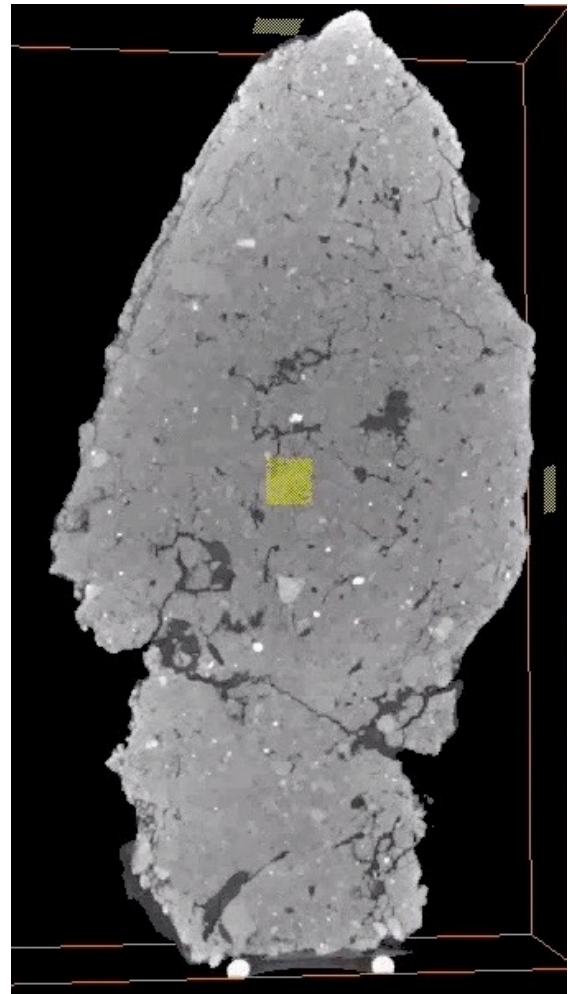
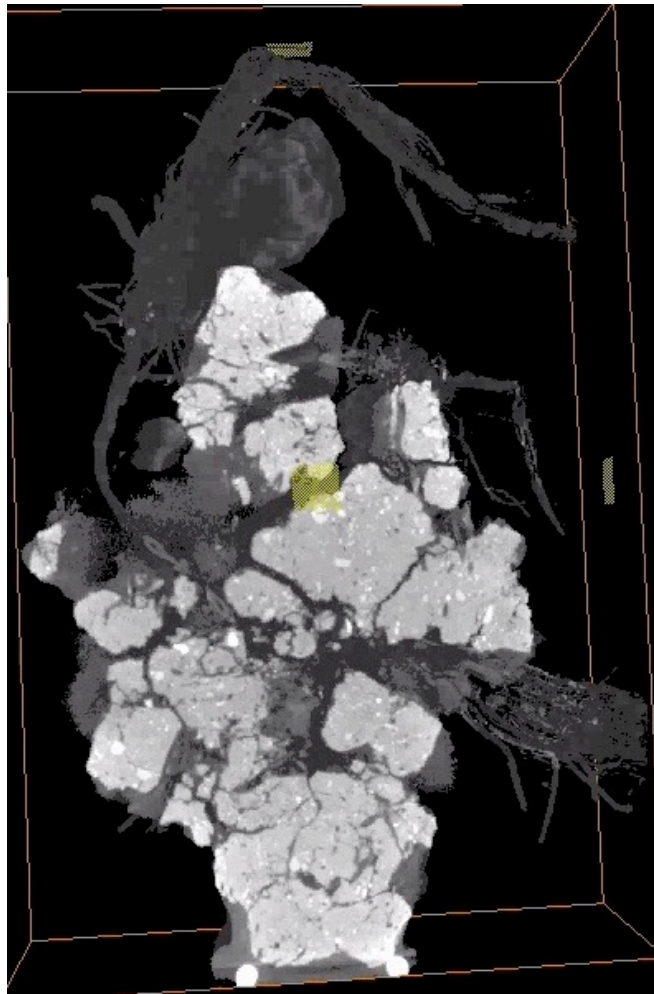


## *What are Soil Aggregates?*





# Functional vs. Non-Functional Aggregates (x-ray scans of aggregates)



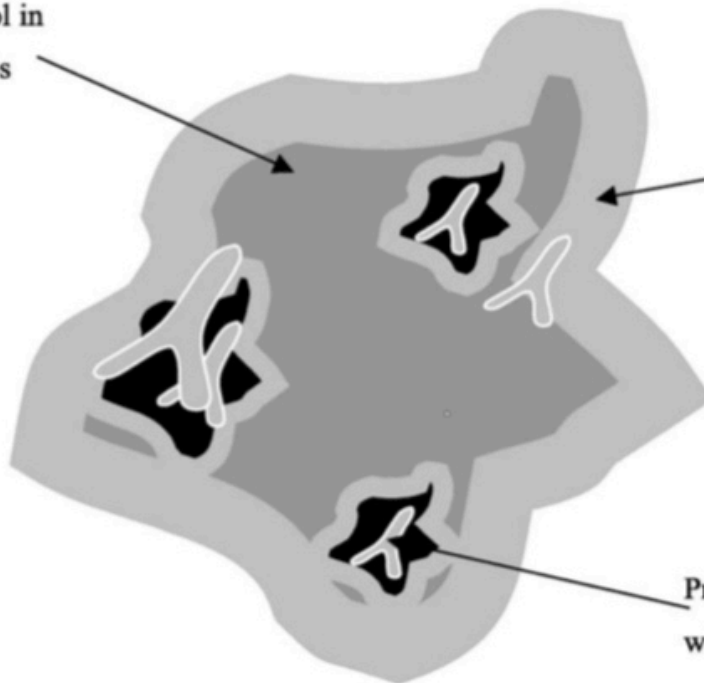


# Aggregates Based on Function

## 1) Macroaggregate

Protected C pool in  
macroaggregates

Unprotected C pool in  
macroaggregates



Small Macro: 250-2000  $\mu\text{m}$   
Large Macro: 2000-8000  $\mu\text{m}$

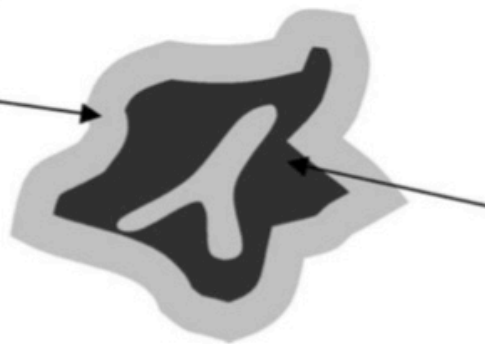
Protected C pool in microaggregates  
within macroaggregates

## 2) Microaggregate

53-250  $\mu\text{m}$

Unprotected C pool in  
free microaggregates

Protected C pool in free  
microaggregates



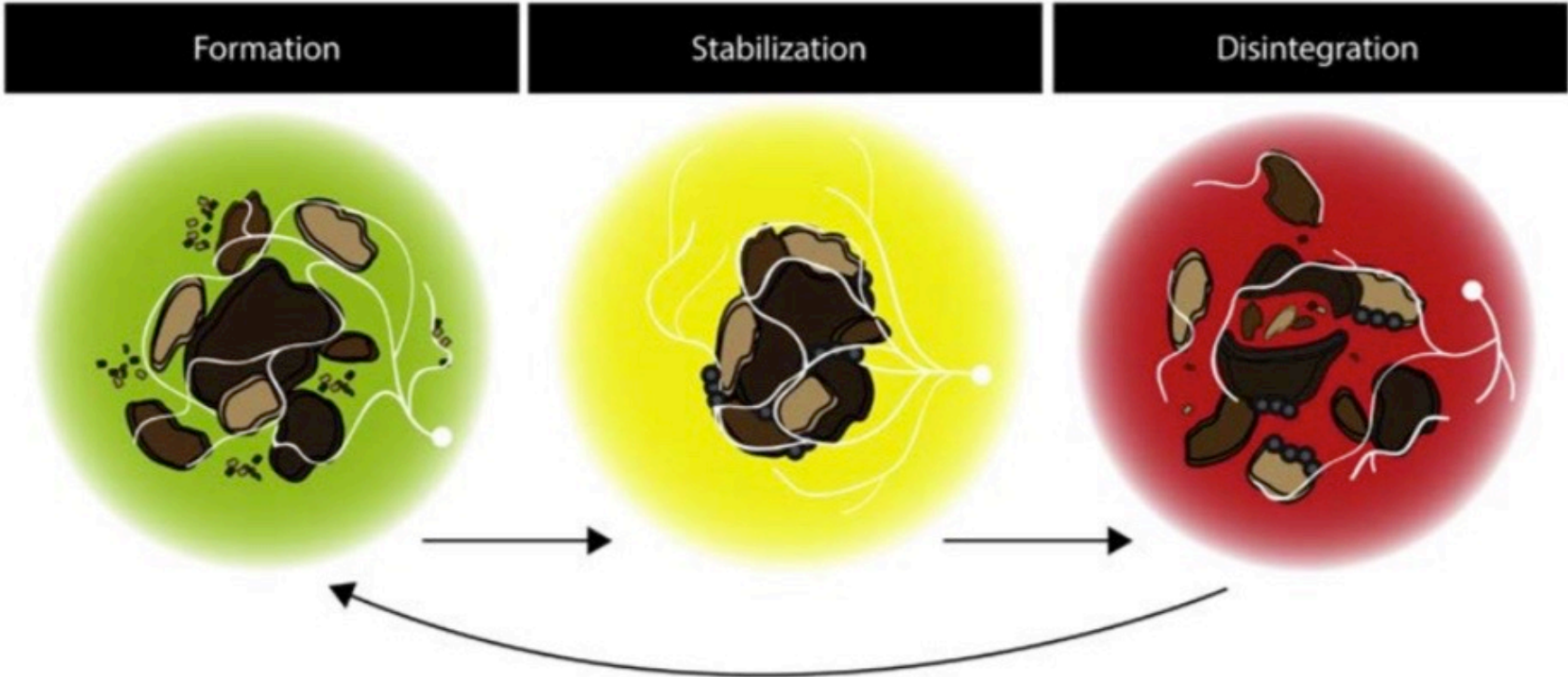


# Aggregation - Size Distribution





# Aggregate Formation, Stabilization and Disintegration



**Legend**

- primary particles
- microaggregates
- macroaggregates
- organic binding agents

Lehmann, A., E. Leifheit, M. Rillig. 2017. Mycorrhizas and Soil Aggregation. In: Mycorrhizal Mediation of Soil, Fertility, Structure and Carbon Storage, Johnson, Gehring, Jansa (Eds). Elsevier, p. 241-262.



# Aggregate Formation/Stabilization – Earthworms

Shipitalo, M., R. Le Bayon. 2004. *Quantifying the Effects of Earthworms on Soil Aggregation and Porosity*. In: *Earthworm Ecology*, p. 183-200.



# Aggregate Formation/Stabilization – Fungal Hyphae

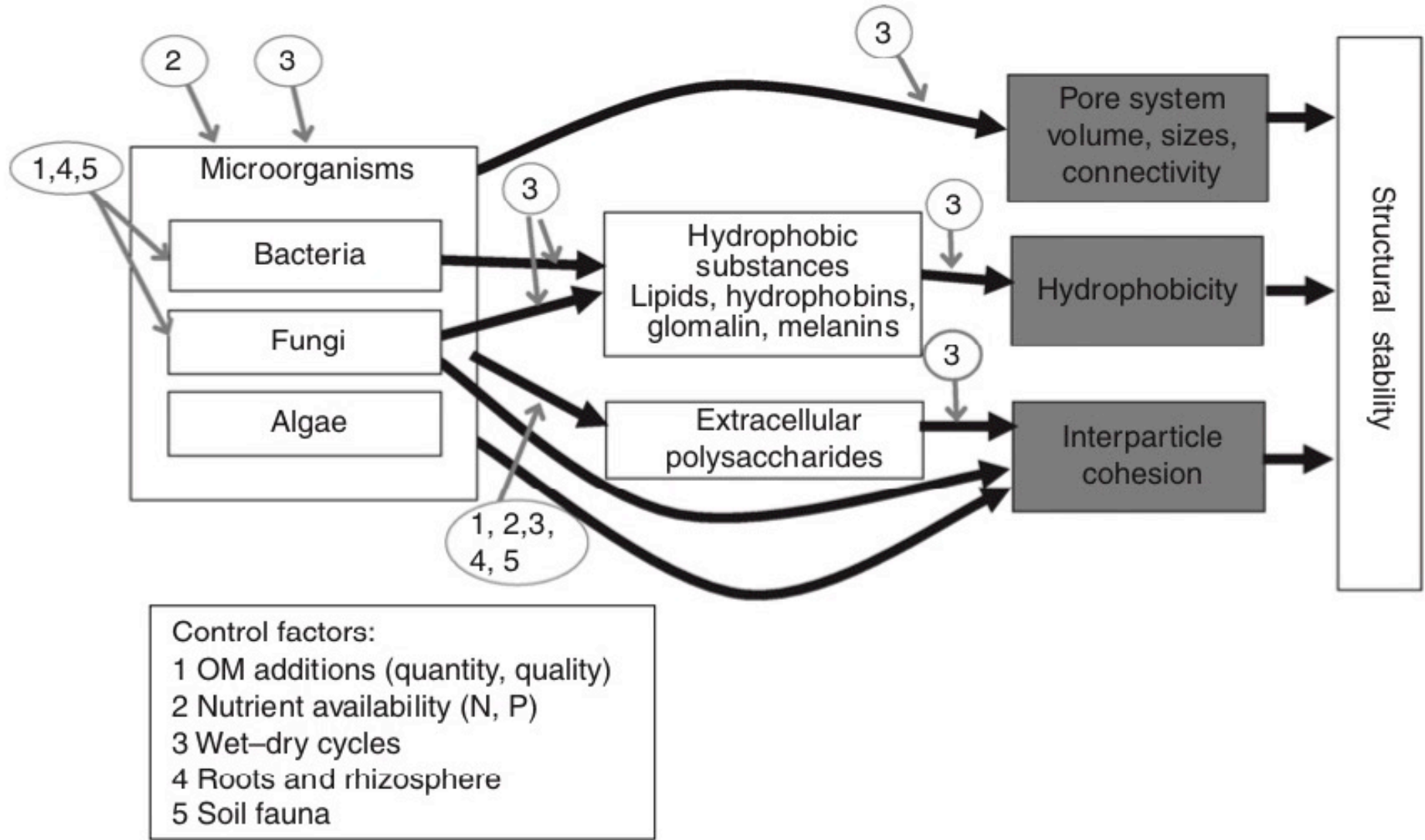


Lehmann, A., E. Leifheit, M. Rillig. 2017. Mycorrhizas and Soil Aggregation. In: Mycorrhizal Mediation of Soil, Fertility, Structure and Carbon Storage, Johnson, Gehring, Jansa (Eds). Elsevier, p. 241-262.





# Aggregate Stabilization - Microorganisms





# Aggregate Stabilization - Fungi or Bacteria?

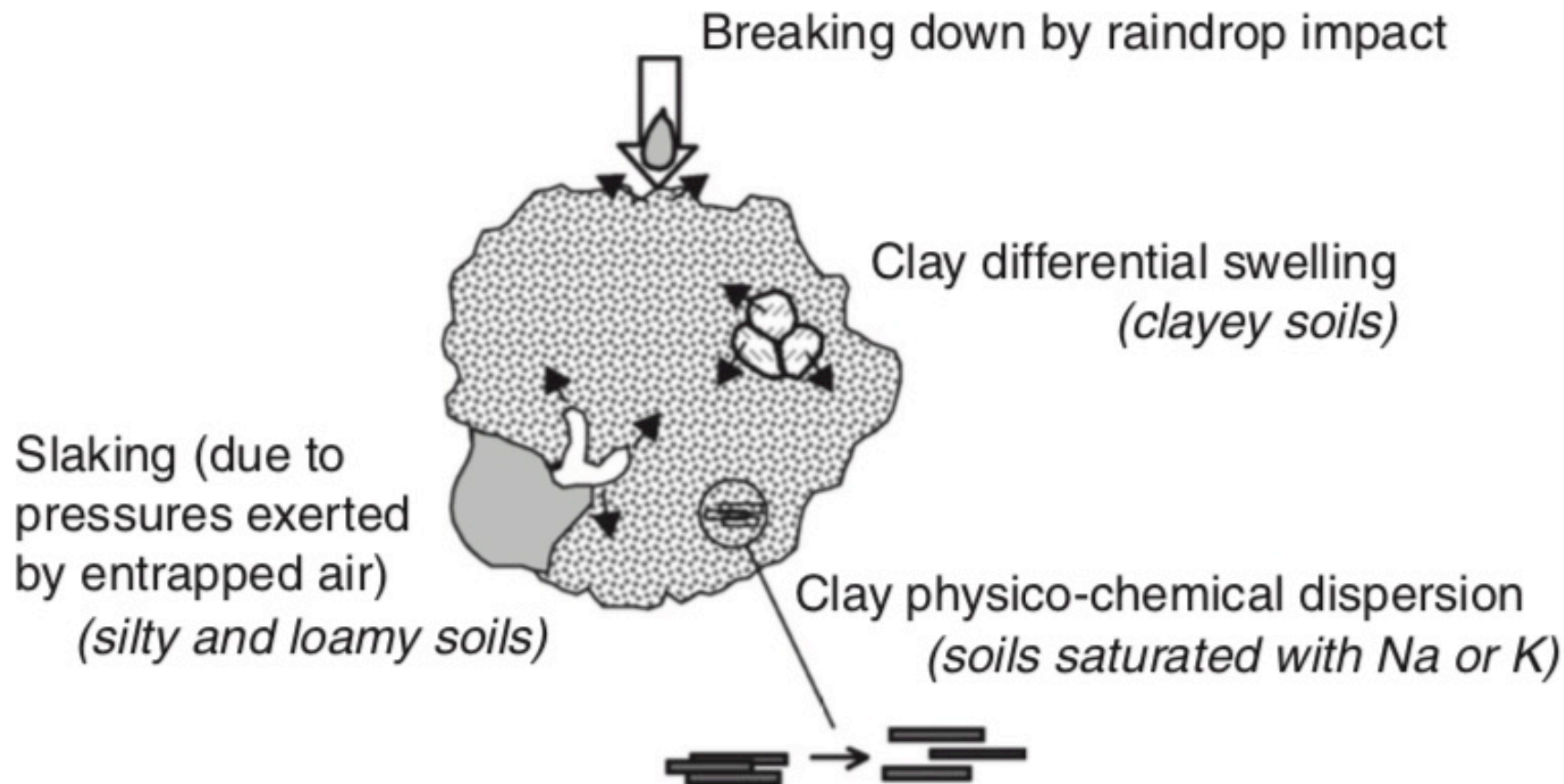
---

Aggregating agent	Residence/ lifetime (days)	Conditions	Reference(s)
Live hyphae	3–5		Staddon <i>et al.</i> (2003)
Dead hyphae	160	1-point data, calculation assuming first-order kinetics	Steinberg and Rillig (2003)
Extracellular polysaccharides	20	Bacterial polysaccharide luvisol, 24°C	Cohen (2002)
	5–10	Bacterial polysaccharide	Andreyuk <i>et al.</i> (1986)
Glomalin	240	1-point data, calculation assuming first-order kinetics	Steinberg and Rillig (2003)

---

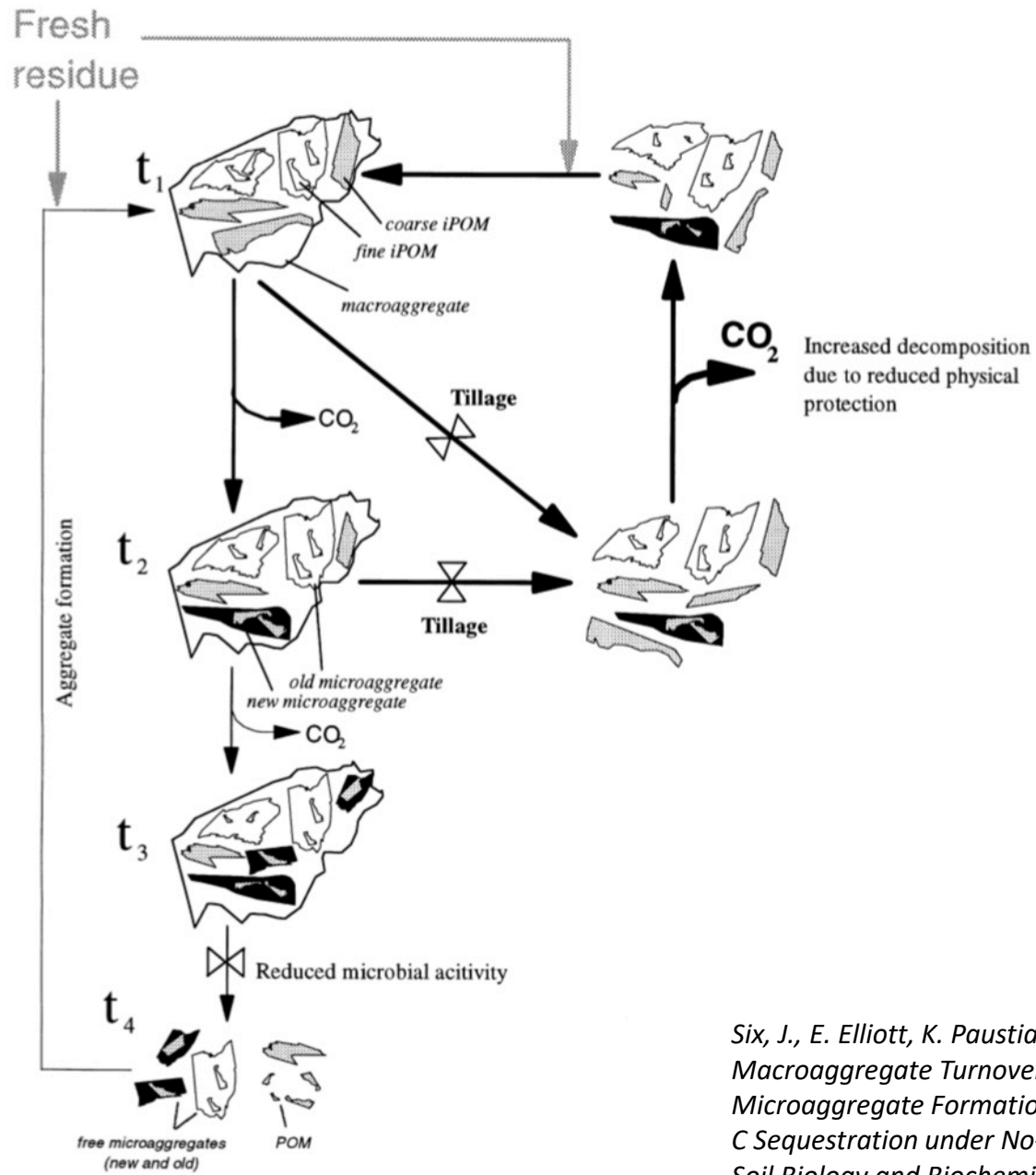


# Aggregate Disintegration/Disruption - Slaking





# Aggregate Disintegration – Tillage, Natural Turnover



Six, J., E. Elliott, K. Paustian. 2000. Soil Macroaggregate Turnover and Microaggregate Formation: A Mechanism for C Sequestration under No-Tillage Agriculture. *Soil Biology and Biochemistry* 32:2099-2103.



## Setting Expectations: *Aggregated Clayey Soil (long-term)*





# *Aggregated Clayey Soil (newly transitioned)*





## *Aggregated Sandy Soil (long-term)*





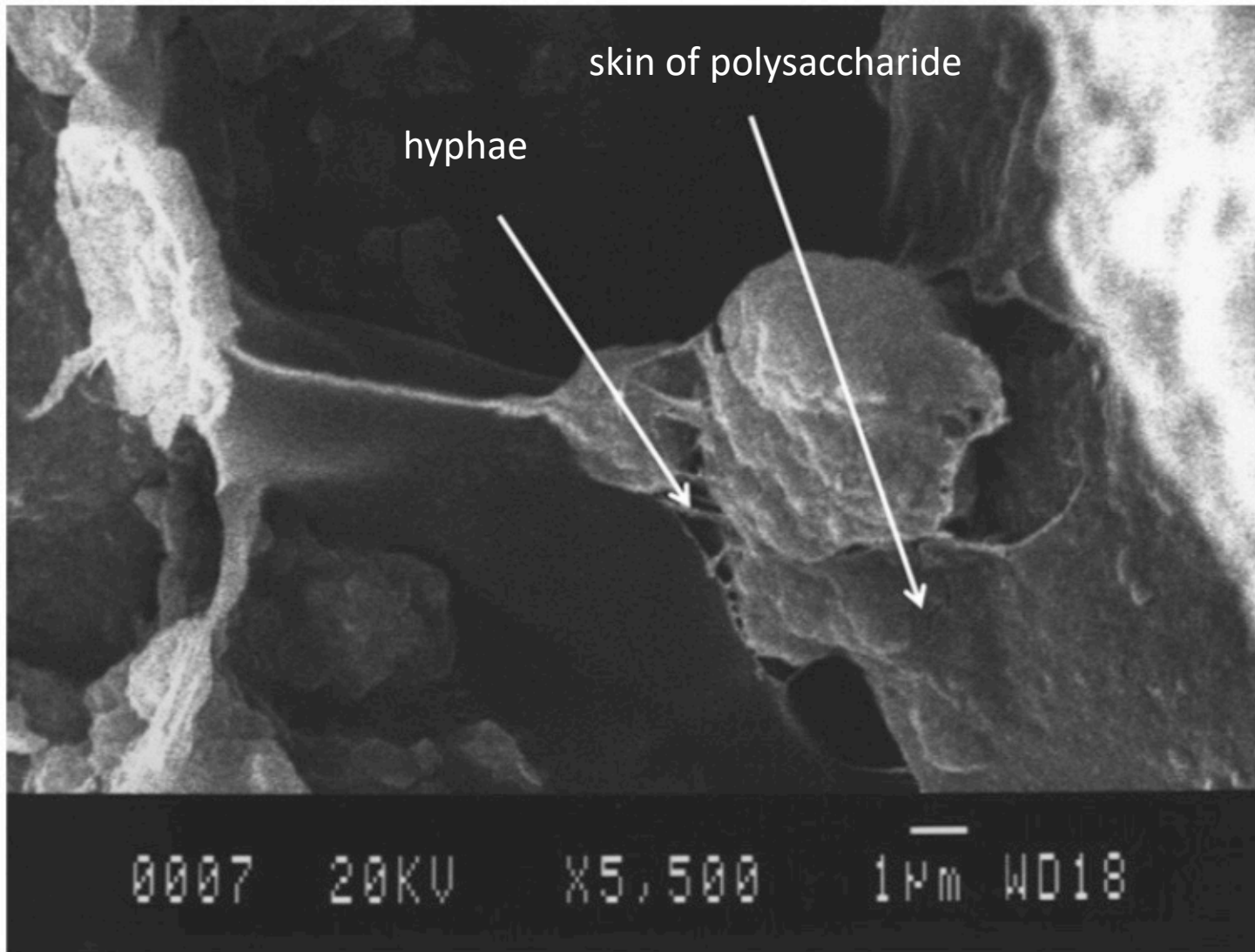
# *Aggregated Sandy Soil (newly transitioned)*





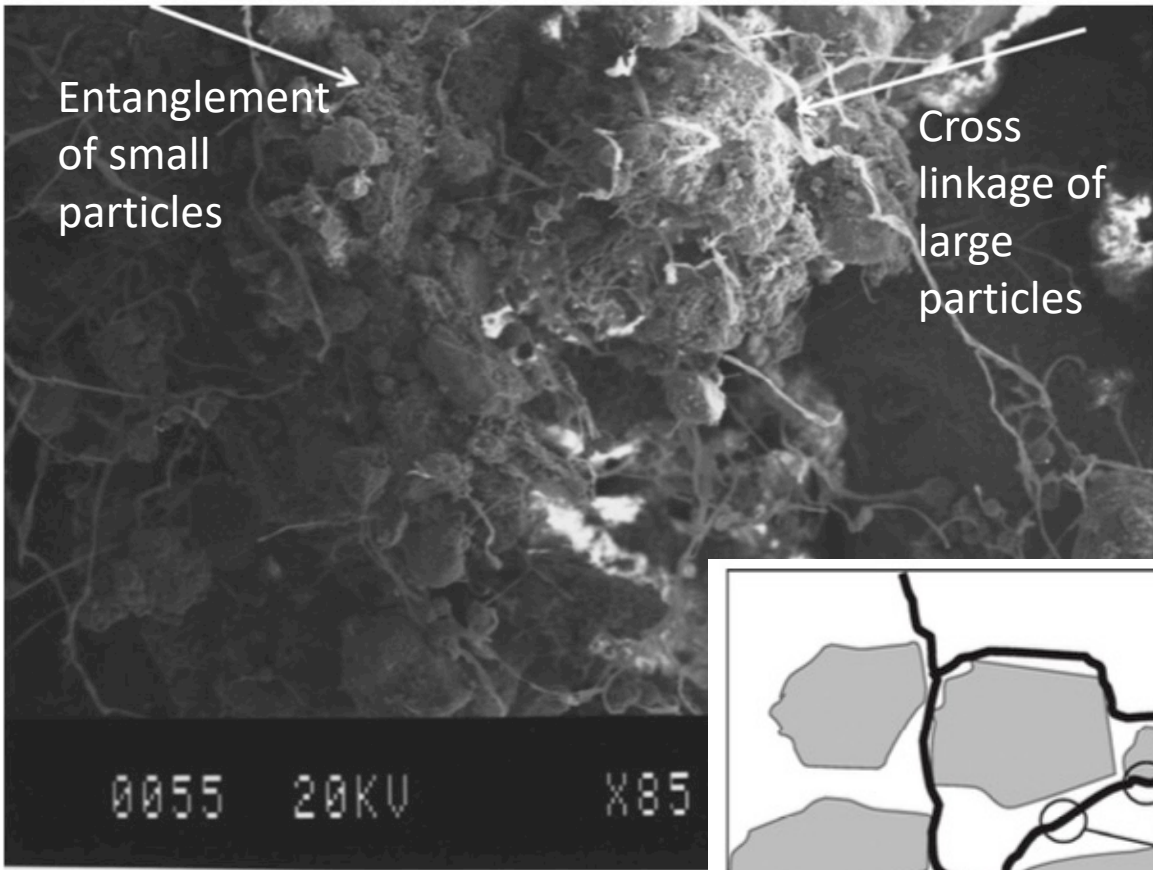


## Aggregate Stabilization - Sandy Soils





# Aggregate Stabilization - Sandy Soils



Tisdall, J., S. Nelson, K. Wilkinson, S. Smith, B. McKenzie. 2012. Stabilization of Soil Against Wind Erosion by Six Saprotrophic Fungi. *Soil Biology and Biochemistry* 50: 134-141.

Chenu, C., D. Cosentino. 2011. Microbial Regulation of Soil Structural Dynamics. In: *The Architecture and Biology of Soils*. Ritz, Young (Eds). CABI, p. 37-70.



## *Key Benefits of Aggregation*

### **Physical:**

Erosion Management

Pore Space Development  
Water/Air

Organic Matter Protection

### **Biological:**

Promote Activity  
Hot Spots

Evolutionary Incubators  
Microbial Diversity

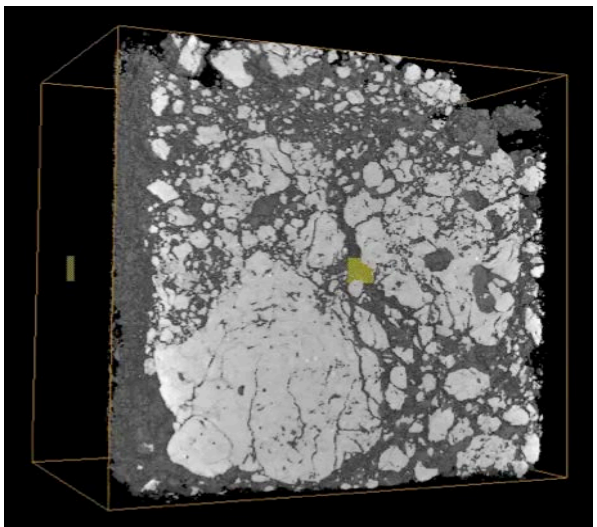


# *Physical Benefits: Erosion Management*



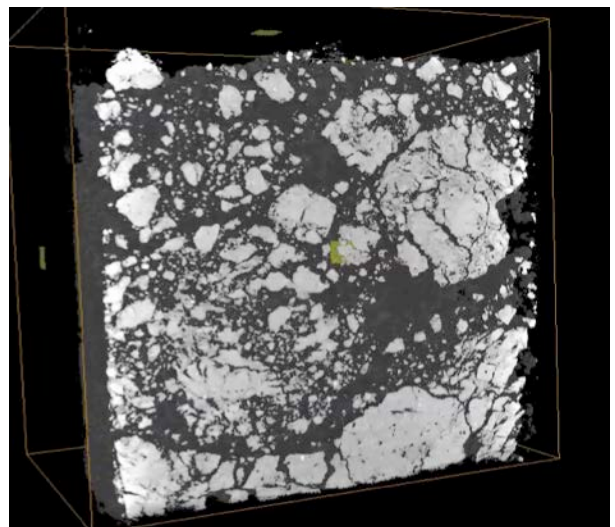


# Physical Benefits: Variable Sizes and Connected Pores



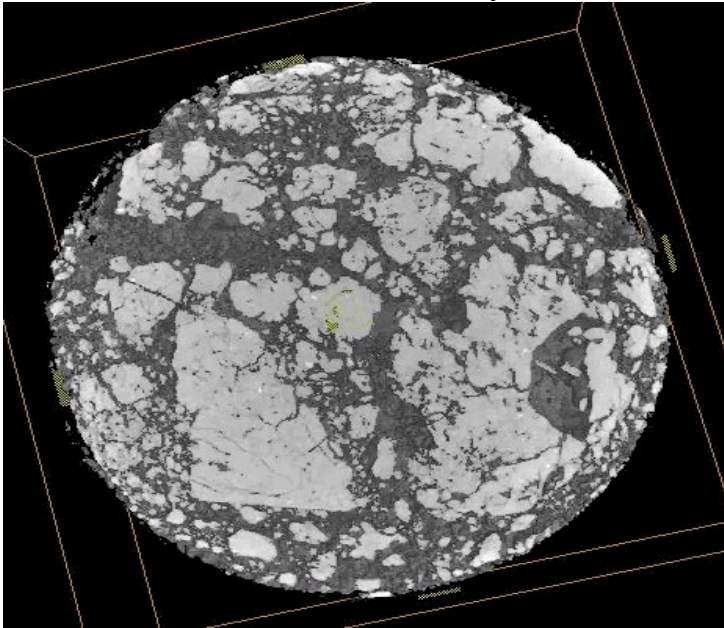
No Till - Cereal Rye

Surface

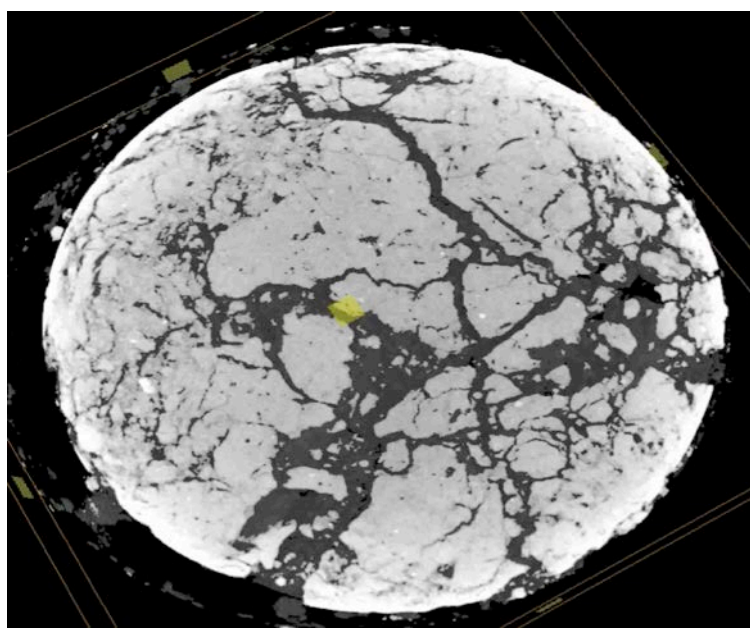


Conventional Till - Wheat

6"



Top View @ 6" depth





## *Physical Benefits: Water Movement*





# *Physical Benefits: Water Movement*





## *Physical Benefits: Field Example, Wahpeton, ND*





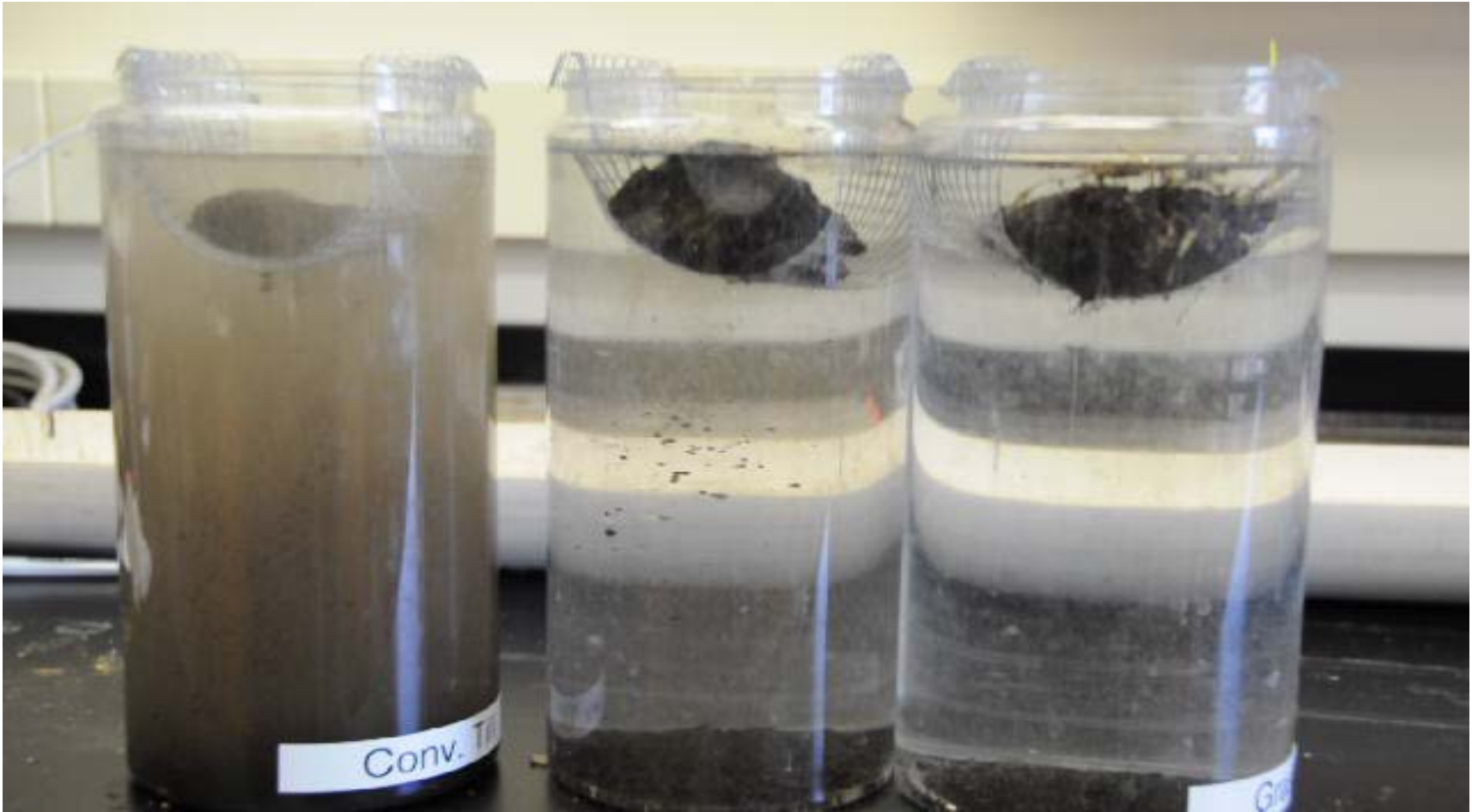


# *Physical Benefits: Field Example, Wahpeton, ND*

Moldboard Plow

Chisel Plow

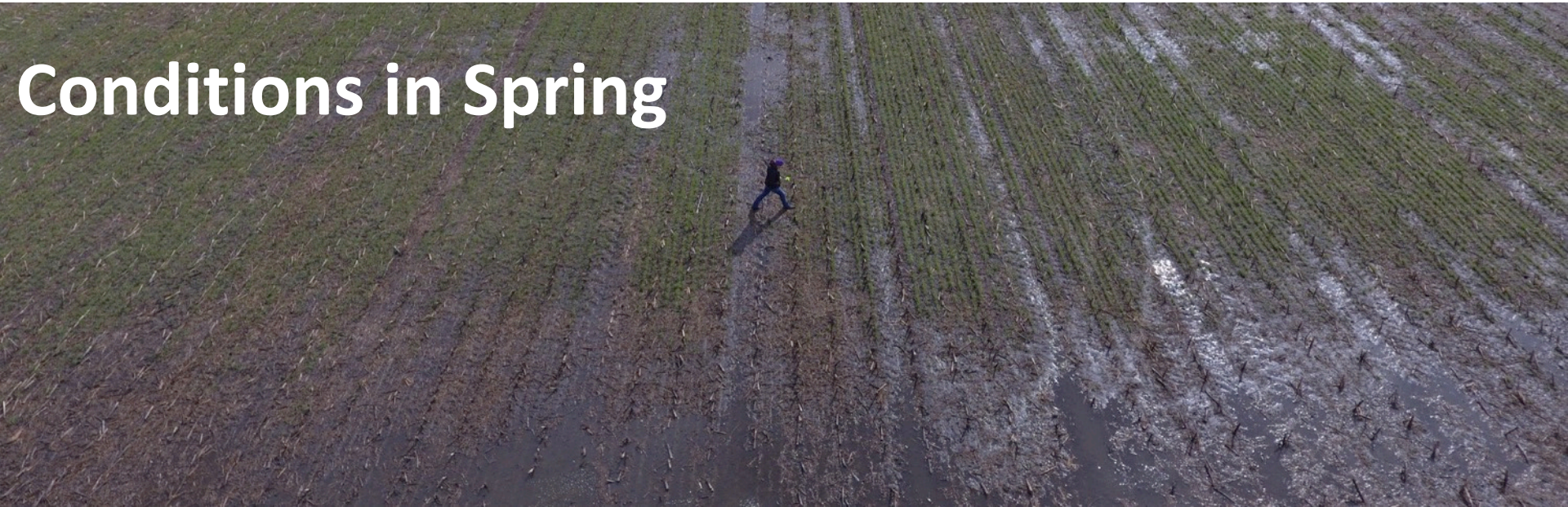
1<sup>st</sup> Year No-Till





# *Physical Benefits: Field Example, Wahpeton, ND*

## Conditions in Spring





# *Physical Benefits: Field Example, Wahpeton, ND*



**Conditions in Fall**



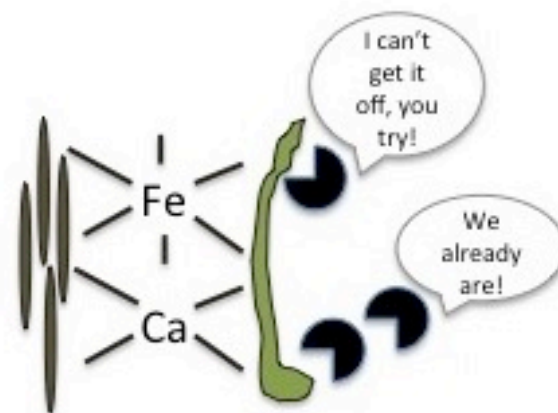
# Physical Benefits: SOM Stabilization

Jastrow, J., R. Miller. 1998. *Soil Aggregate Stabilization and Carbon Sequestration: Feedbacks through Organomineral Associations*. In: *Soil Processes and the Carbon Cycle*. Lal, Kimble, Follett, Stewart (Eds), p. 207-224.

## Biochemical Recalcitrance



## Chemical Stabilization



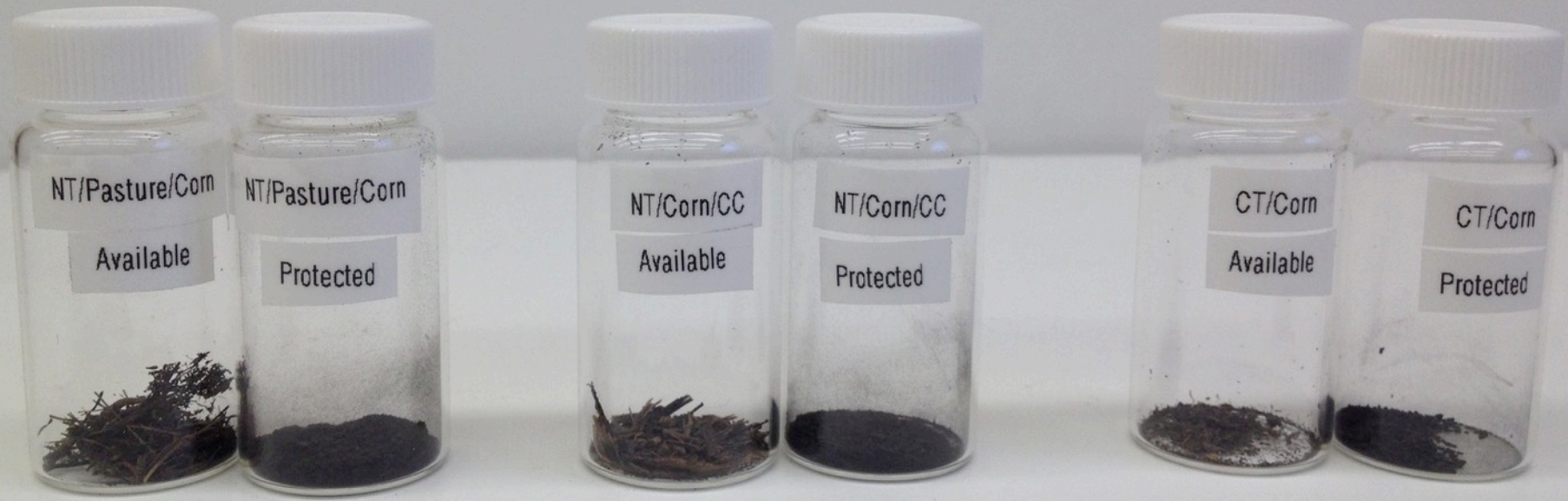
## Physical Protection





# Organic Matter Pools

*(visual)*





# Aggregate-Associated Organic Matter



Between-aggregate  
material

35-40% C; 1.5-2% N

25:1

Aggregate-protected  
material

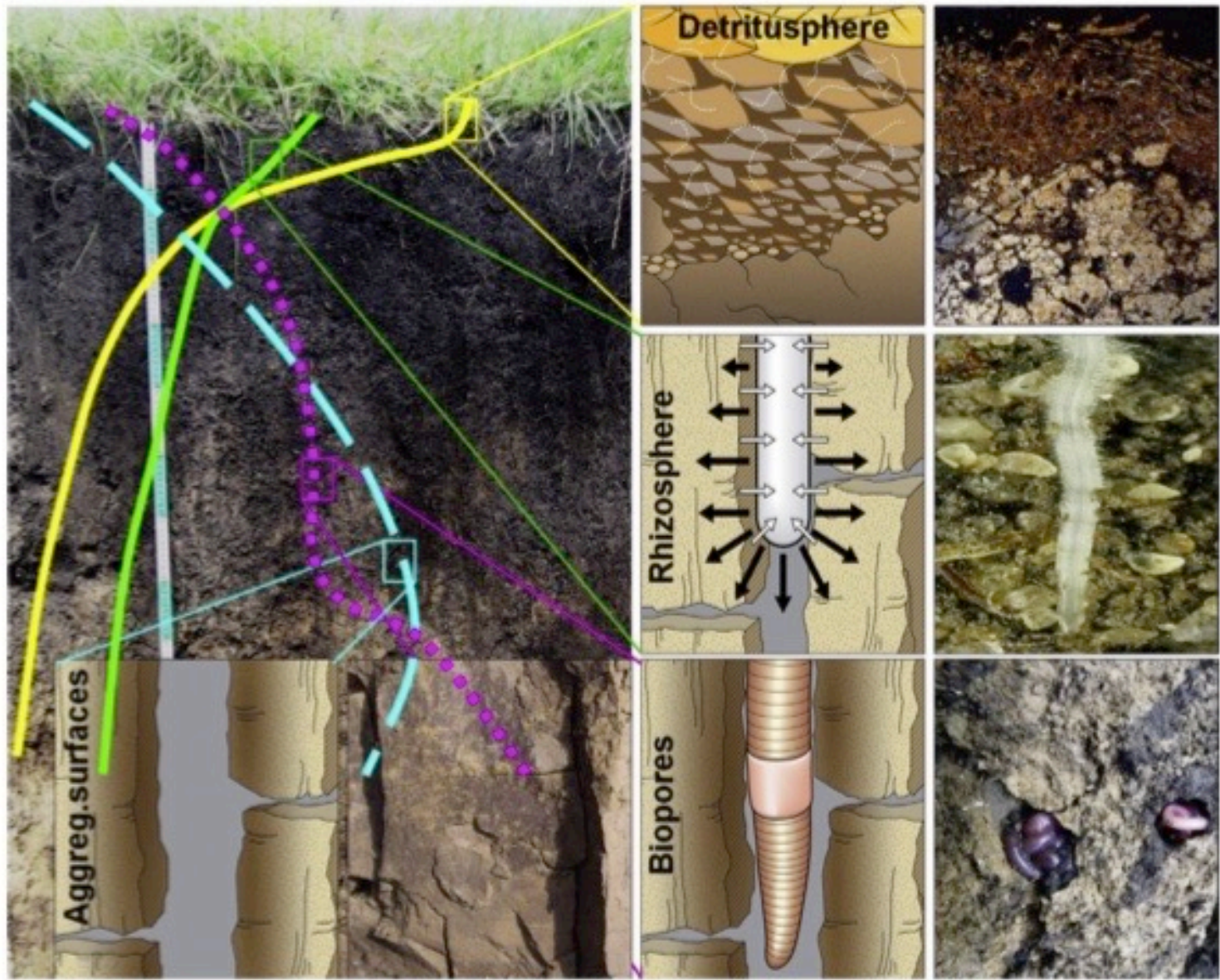
20-25% C; 1-1.5% N

15:1



# Biological Benefits: Hot Spots

Kuzyakov, Y., E. Blagodatskaya. 2015. *Microbial Hotspots and Hot Moments in Soil: Concept and Review. Soil Biology and Biochemistry* 83: 184-199.

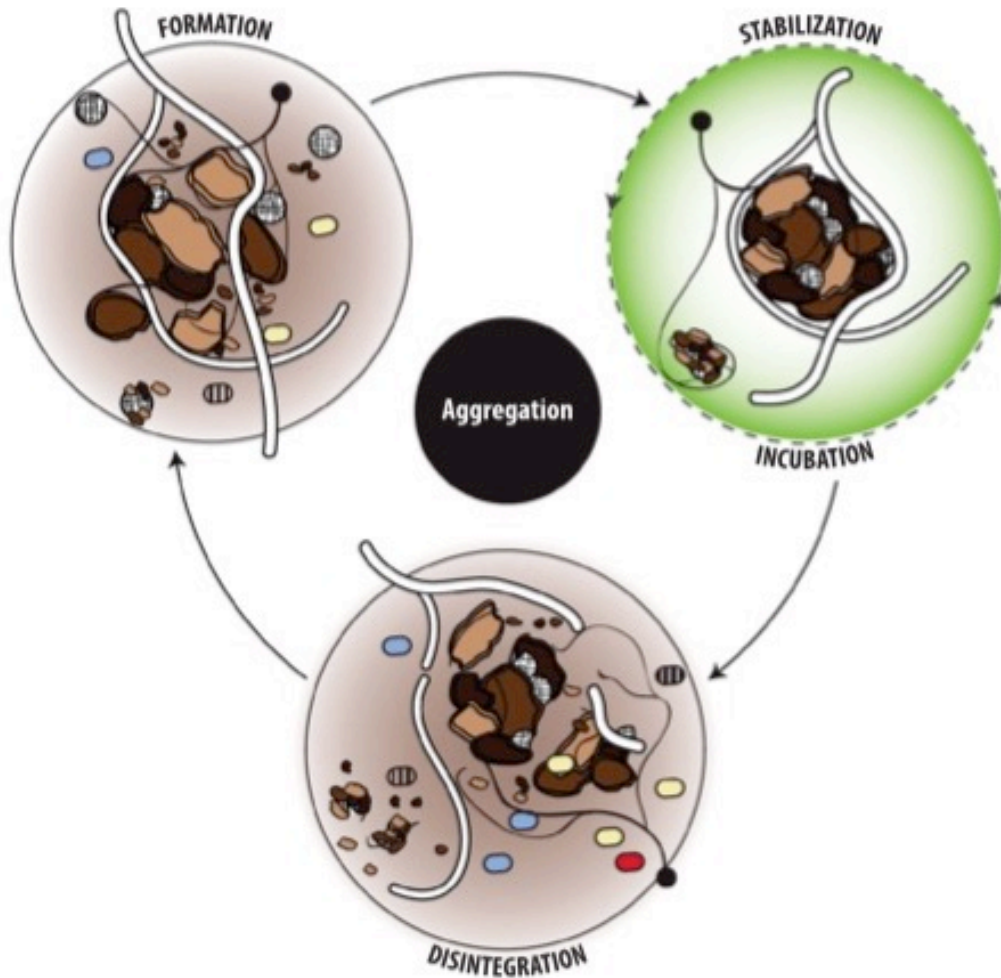











# Aggregates as Microbial Community Incubators

Rillig, M., L. Muller, A. Lehmann. 2017. Soil Aggregates as Massively Concurrent Evolutionary Incubators. *ISME Journal* 11: 1943-1948.

## Soil Aggregate Life Cycle



## Legend

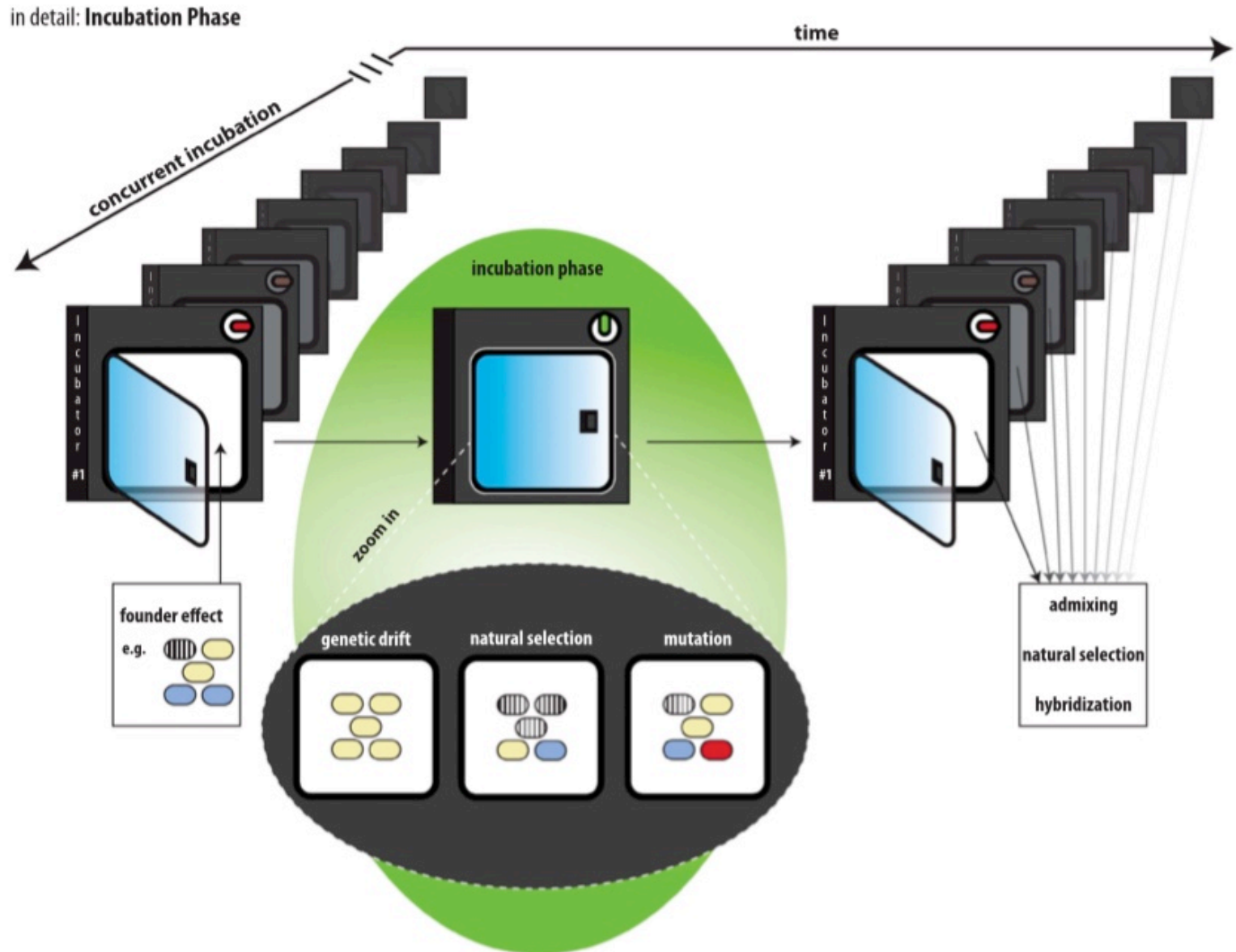
-  primary particles
-  (old) micro-aggregate
-  (new) micro-aggregate
-  macro-aggregate
-  particulate organic matter
-  biotic binding agents (e.g. fungi, roots)
-  microbial community





# Aggregates as Microbial Community Incubators

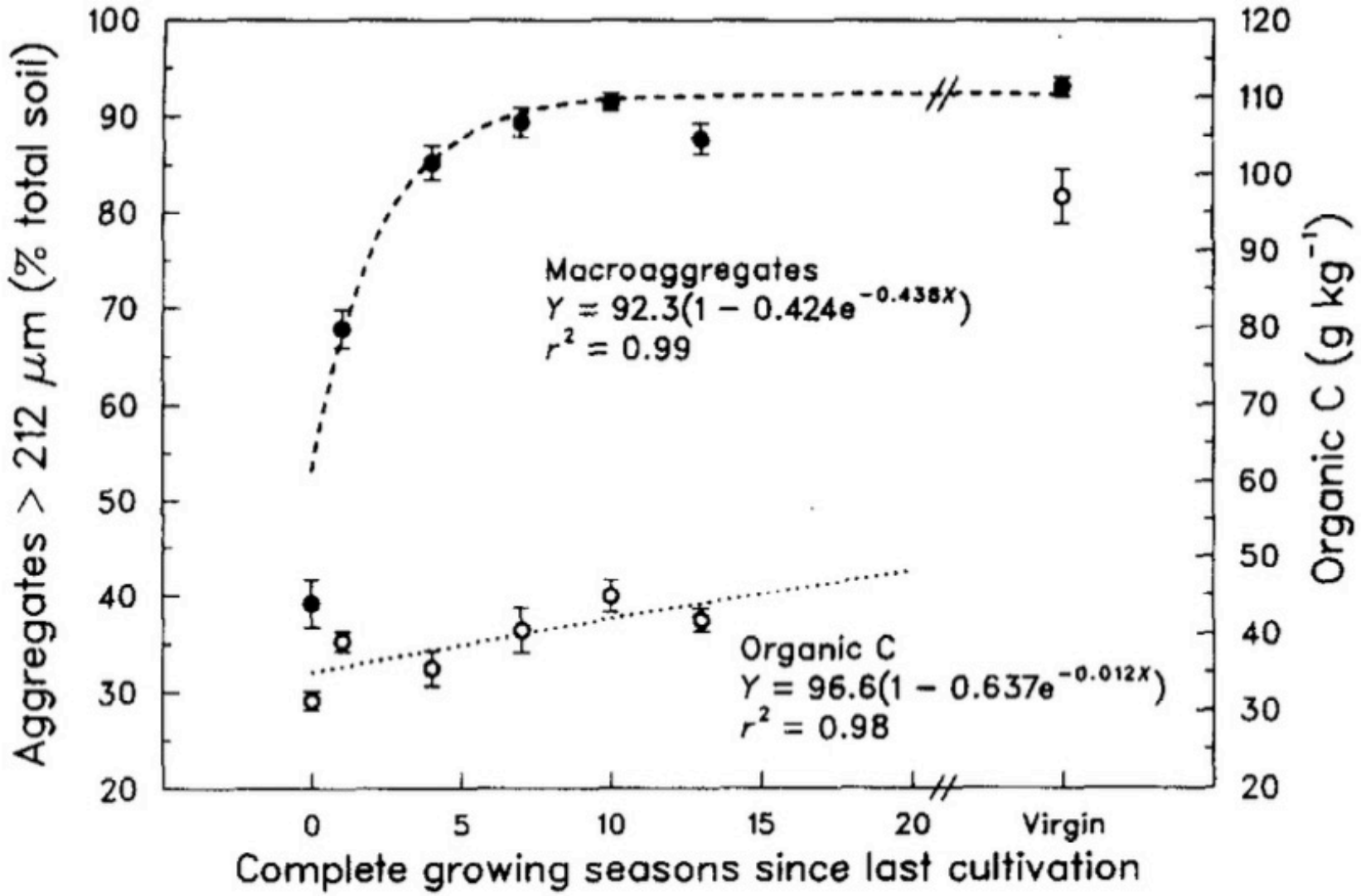
Rillig, M., L. Muller, A. Lehmann. 2017. Soil Aggregates as Massively Concurrent Evolutionary Incubators. *ISME Journal* 11: 1943-1948.





# Management – Reducing Tillage

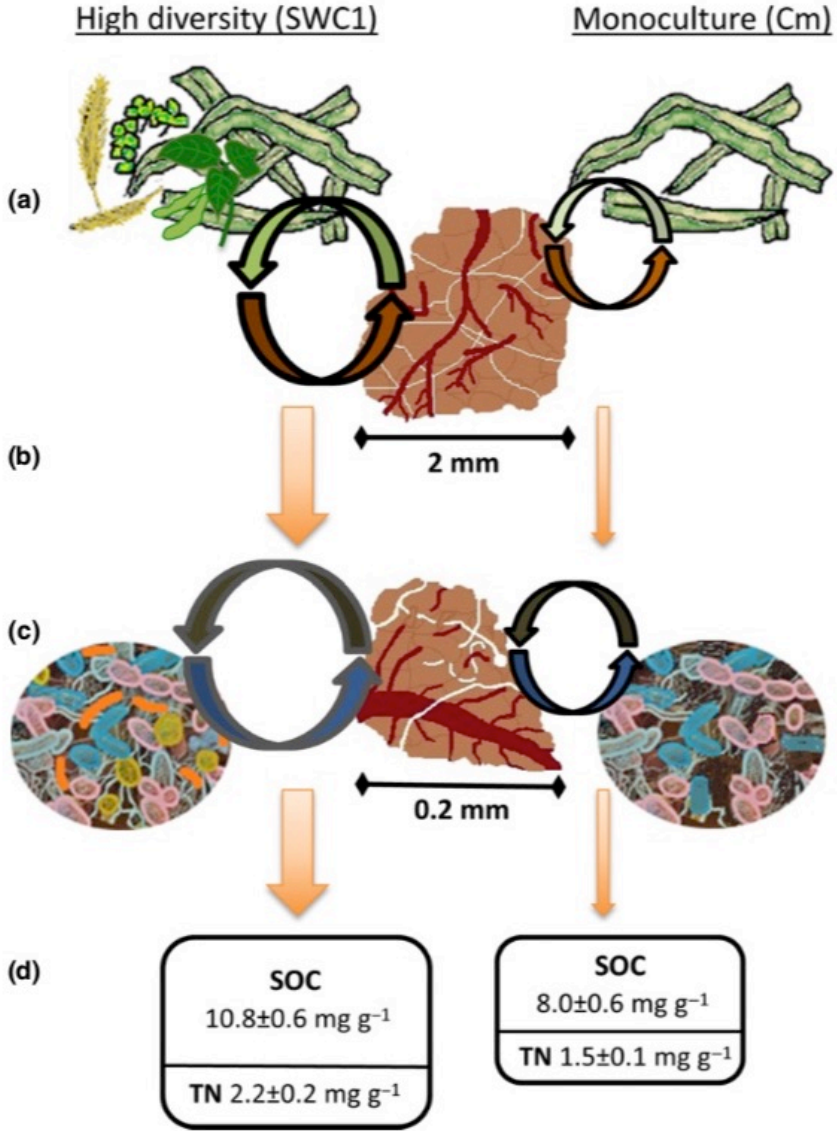
Jastrow, J. 1996. Soil Aggregate Formation and the Accrual of Particulate and Mineral-Associated Organic Matter. *Soil Biology and Biochemistry* 28: 665-676.





# Management – Diverse Inputs

Tiemann, L., A. S. Grandy, E. Atkinson, E. Marin-Spiotta, M. McDaniel. 2015. Crop Rotational Diversity Enhances Belowground Communities and Functions in an Agroecosystem. *Ecology Letters* 28: 761-771.



**Monoculture:** Corn-Corn  
**High Diversity:** Corn-Soy-Wheat w/ Red Clover

Formation of Mega-aggregates (> 2mm)

Enhanced microbial activity,  
increase microbial by-products,  
increase micro-aggregate formation

Increased SOC and N stocks in soil



# *Soil Aggregation is a Primary Component of Soil Health*

*Keys: Reduce Tillage, Diversify Rotation*



# Series 2

Starting March 1

// We believe that building **healthier soils** is not just a prescription, but rather a pursuit.

This **journey** requires collaboration, curiosity, and communication among farmers, agricultural researchers, agronomists, consultants, and extension.

You're going to hear their stories and discover how and why they're working together to **make sense out of what's happening in the soil.** //

- **Tim Hammerich**

Future of Agriculture · Podcast Host

SOIL SENSE  
NDSoilSense.com





## SOIL HEALTH CAFÉ TALKS 2020

**JANUARY 23** 11:30AM – 1:30PM

WISHEK, ND

**Big Screen Bar and Grill (5th St N)**

- Greg Endres (agronomy)
- Dave Franzen (soil fertility)
- Crystal Schaunaman (Extension agent)

**JANUARY 28** 11:30AM – 1:30PM

MICHIGAN, ND

**Wagon Wheel Bar and Grill (110 Broadway)**

- Naeem Kalwar (soil health)
- Kevin Sedivec (grazing)
- Katelyn Hain (Extension agent)

**JANUARY 28** 11:30AM – 1:30PM

OAKES, ND

**Angry Beaver Lodge (404 Main Ave)**

- Abbey Wick (soil health)
- Greg Endres (agronomy)
- Breana Kiser (Extension agent)

**JANUARY 29** 11:30AM – 1:30PM

CASSELTON, ND

**Governors Inn (2050 Governor's Dr)**

- Luke Ressler (soil health)
- Aaron Daigh (soil water and temperature)
- Kyle Aasand (Extension agent)

**JANUARY 30** 11:30AM – 1:30PM

WALHALLA, ND

**Waters Family Restaurant (108 Central Ave.)**

- Naeem Kalwar (soil health)
- Lesley Lubenow (agronomy)
- Kevin Sedivec (grazing)
- Kari Helgoe (Extension agent)

**FEBRUARY 3** 11:30AM – 1:30PM

JAMESTOWN, ND

**Pizza Ranch (805 20th St SW)**

- Abbey Wick (soil health)
- Greg Endres (agronomy)
- Alicia Harstad (Extension agent)

**FEBRUARY 6** 11:30AM – 1:30PM

PARK RIVER, ND

**Alexander House (903 Park Street West)**

- Naeem Kalwar (soil health)
- Abbey Wick (soil fertility)
- Brad Brummond (Extension agent)

**FEBRUARY 11** 11:30AM – 1:30PM

DRAYTON, ND

**Hastings Landing Restaurant (104 ND-66)**

- Naeem Kalwar (soil health)
- Tom Peters (weed science, sugar beets)
- Kari Helgoe (Extension agent)

**FEBRUARY 12** 11:30AM – 1:30PM

LANGDON, ND

**NDSU Langdon Research Extension Center (107th Ave NE)**

- Naeem Kalwar (soil health)
- Joe Ikley (weed science)
- Lesley Lubenow (cropping specialist)
- Brian Jenks and Venkata Chapara (plant pathology)
- Anitha Chirumamilla (Extension agent)

**FEBRUARY 13** 11:30AM – 1:30PM

COOPERSTOWN, ND

**Coachman (504 9th St SE)**

- Luke Ressler (soil health)
- Gerald Stokka (livestock stewardship)

**FEBRUARY 18** 11:30AM – 1:30PM

NEW ROCKFORD, ND

**New Rockford Golf Course (6791 20th St NE)**

- Greg Endres (agronomy)
- Dave Franzen (soil fertility)
- Abbey Wick (soil health)

**MARCH 4** 11:30AM – 1:30PM

WISHEK, ND

**Big Screen Bar and Grill (5th St N)**

- Mary Keena (compost/manure)
- Mike Ostlie (agronomy)
- Kevin Sedivec (grazing)
- Marisol Berti (cover crops)
- Crystal Schaunaman (Extension agent)





## SOIL HEALTH CAFÉ TALKS 2020

**MARCH 5** 11:30AM – 1:30PM

**NEW ROCKFORD, ND** New Rockford Golf Course (6791 20th St NE)

- Mary Keena (compost/manure)
- Mike Ostlie (agronomy)
- Kevin Sedivec (grazing)

**MARCH 18** 11:30AM – 1:30PM

**VELVA, ND**

Star City Golf Course (4525 ND-41)

- Mary Keena (compost/manure)
- Mike Ostlie (agronomy)
- Kevin Sedivec (grazing)
- Rachel Wald (Extension agent)

**MARCH 19** 11:30AM – 1:30PM

**MADDOCK, ND**

Harriman's Restaurant (114 Central Ave)

- Naeem Kalwar (soil health)
- Greg Endres (agronomy)
- Scott Knoke (Extension agent)

**MARCH 24** 11:30AM – 1:30PM

**VELVA, ND**

Star City Golf Course (4525 ND-41)

- Greg Endres (agronomy)
- Chris Augustin (soil health)
- Rachel Wald (Extension agent)



# Save the Date!

DECEMBER 7-9, 2020

Delta by Marriott • Fargo



DAKOTA  
INNOVATION  
RESEARCH AND  
TECHNOLOGY  
WORKSHOP

NDSU | EXTENSION

#DIRTworkshopND





# Dr. Abbey Wick

Soil Health Specialist

Associate Professor



NDSU SNRS

PO Box 6050, Dept 7680

Fargo, ND 58108



@NDSUsoilhealth



701-850-6458 (cell)



[abbey.wick@ndsu.edu](mailto:abbey.wick@ndsu.edu)

[ndsu.edu/soilhealth](http://ndsu.edu/soilhealth)



NDsoilsense.com

S O I L



HEALTH

NDSU

EXTENSION

DAKOTA INNOVATION, RESEARCH AND TECHNOLOGY WORKSHOP



[DIRTworkshopND.com](http://DIRTworkshopND.com)