Evaluating Soil Health Using Tea Bags

Iowa Watershed Academy
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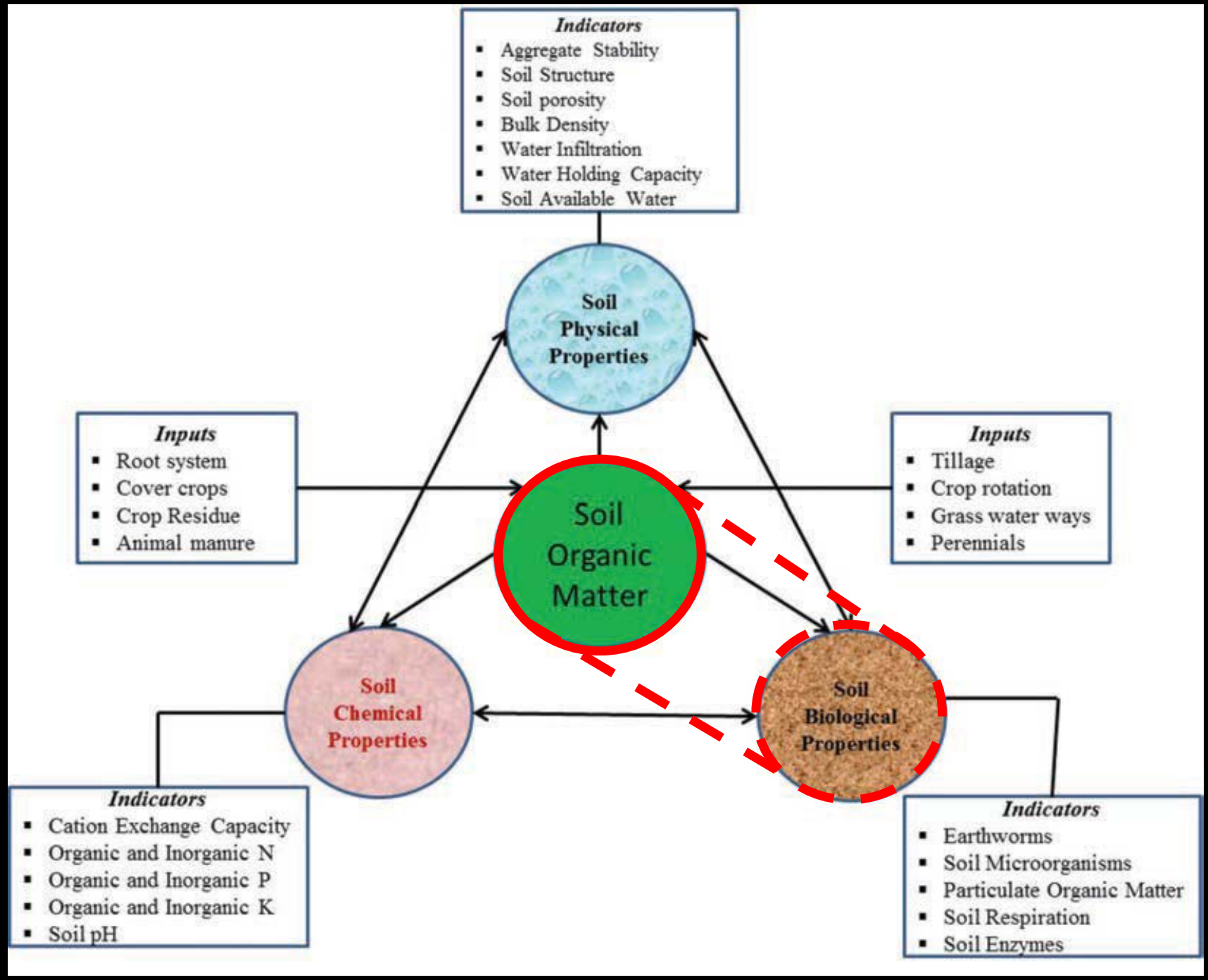
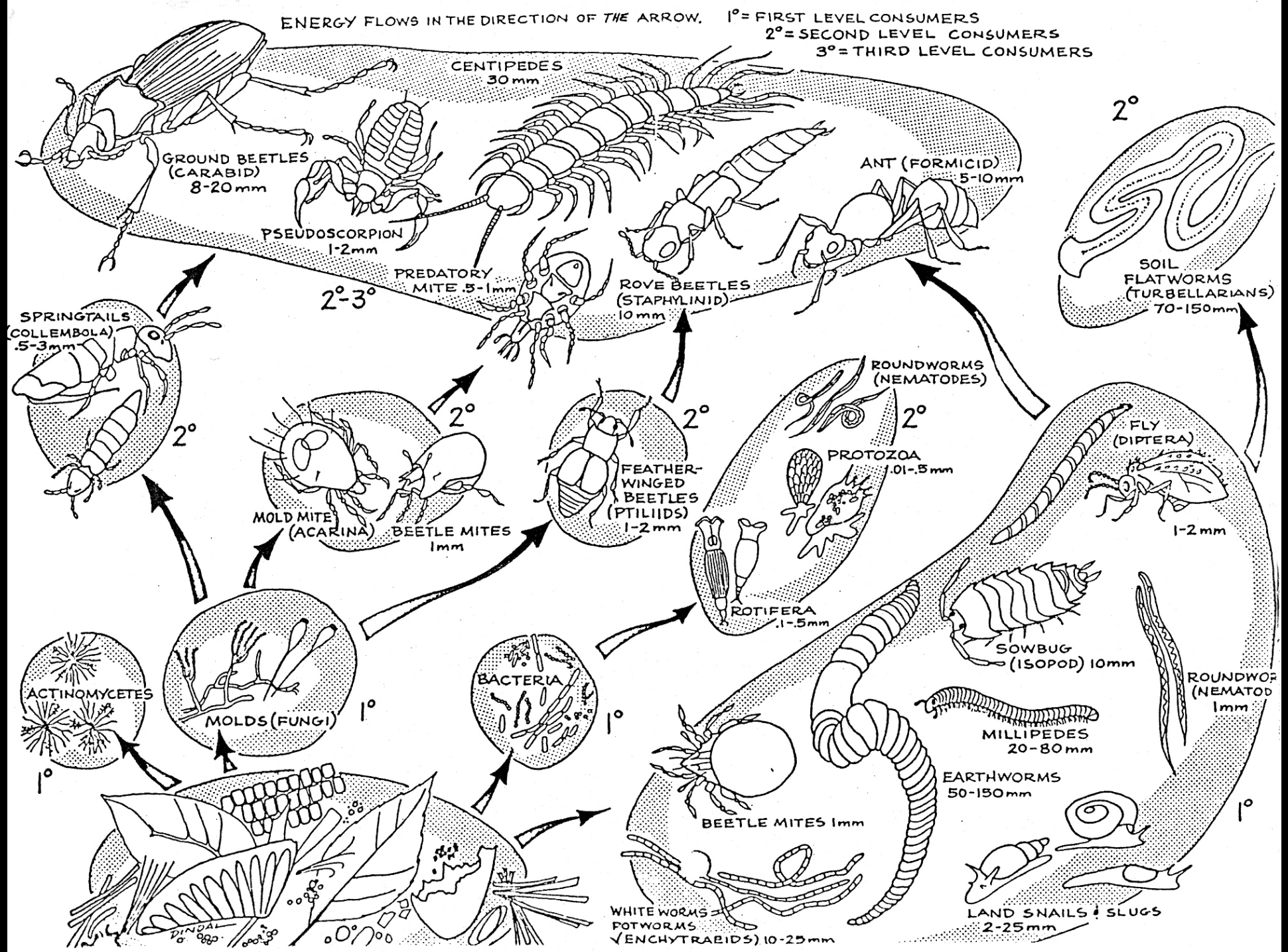
Soil Tilth → Soil Quality → Soil Health

SOM is central to soil health, but emphasis on soil biology is what separates it from tilth/quality



Source: Al-Kaisi and Kwah-Mensah (2016)

The "living SOM" and soil health



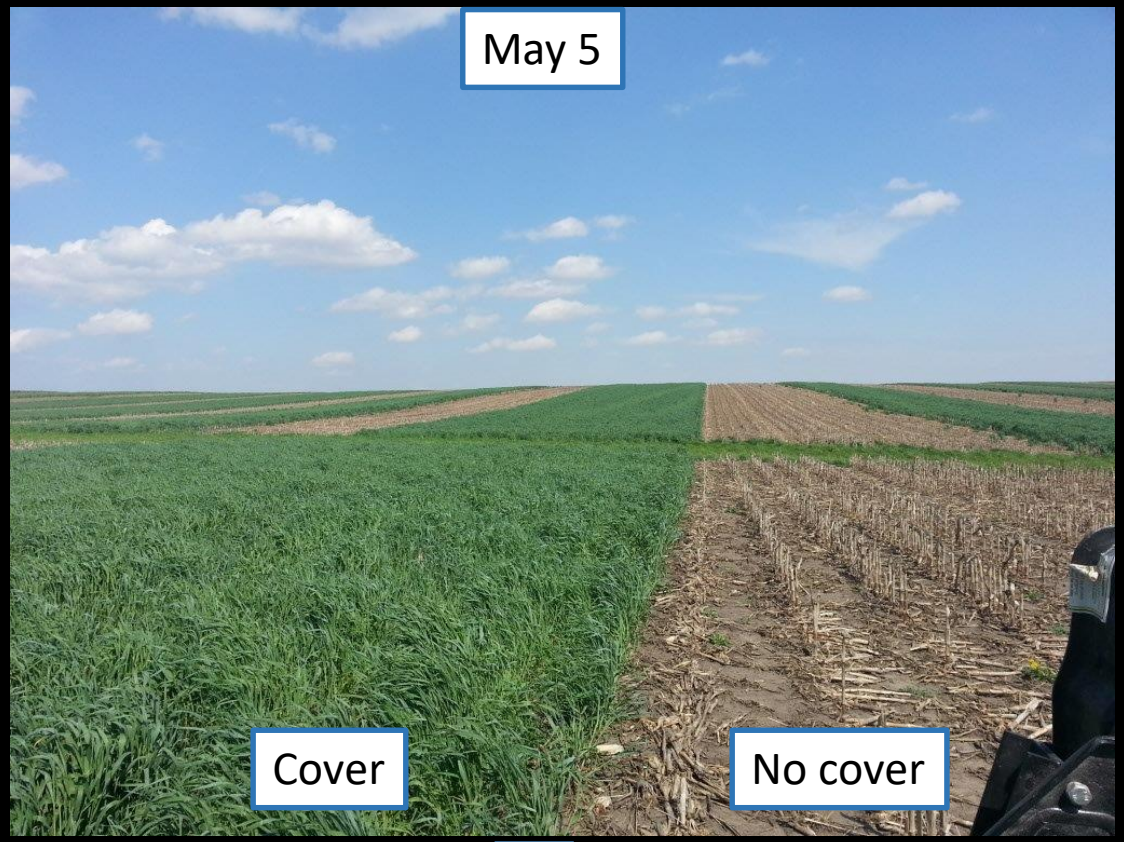
How can we increase soil health?

1. Control traffic on soil
2. Minimum tillage
3. Manure use
4. Cover crops
5. Increase residue cover
6. Crop rotations – increase crop variety (i.e. diversity)

How can we measure soil health (specifically the biology)?

1. Many available to scientists
2. Haney Test
3. Solvita
4. Other tests???

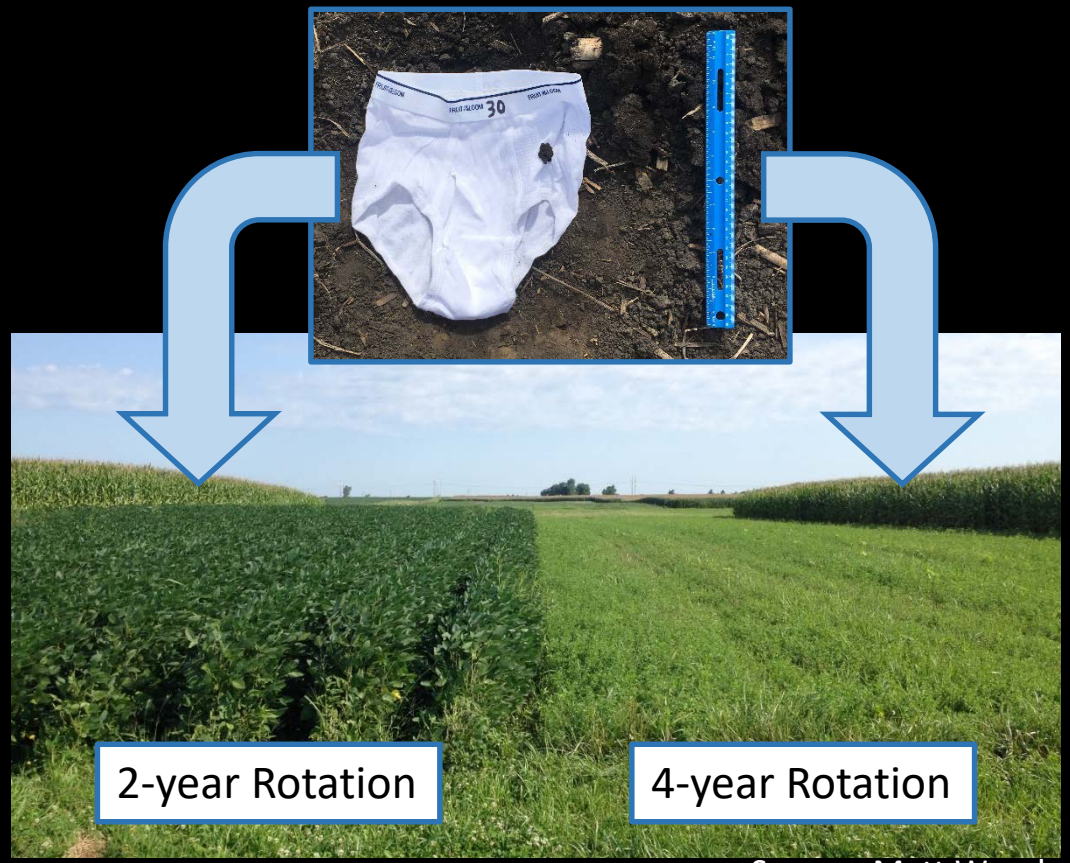
Cover crops increase soil biological activity (Solvita) in corn-soybean rotations



Cover	No Cover
Solvita CO_2-C (ppm C)	
89.1	60.6

24 samples x $50/sample = EXPENSIVE!

Crop rotations increase soil biological activity in extended rotations



Source: Matt Woods

Percent decomposed:

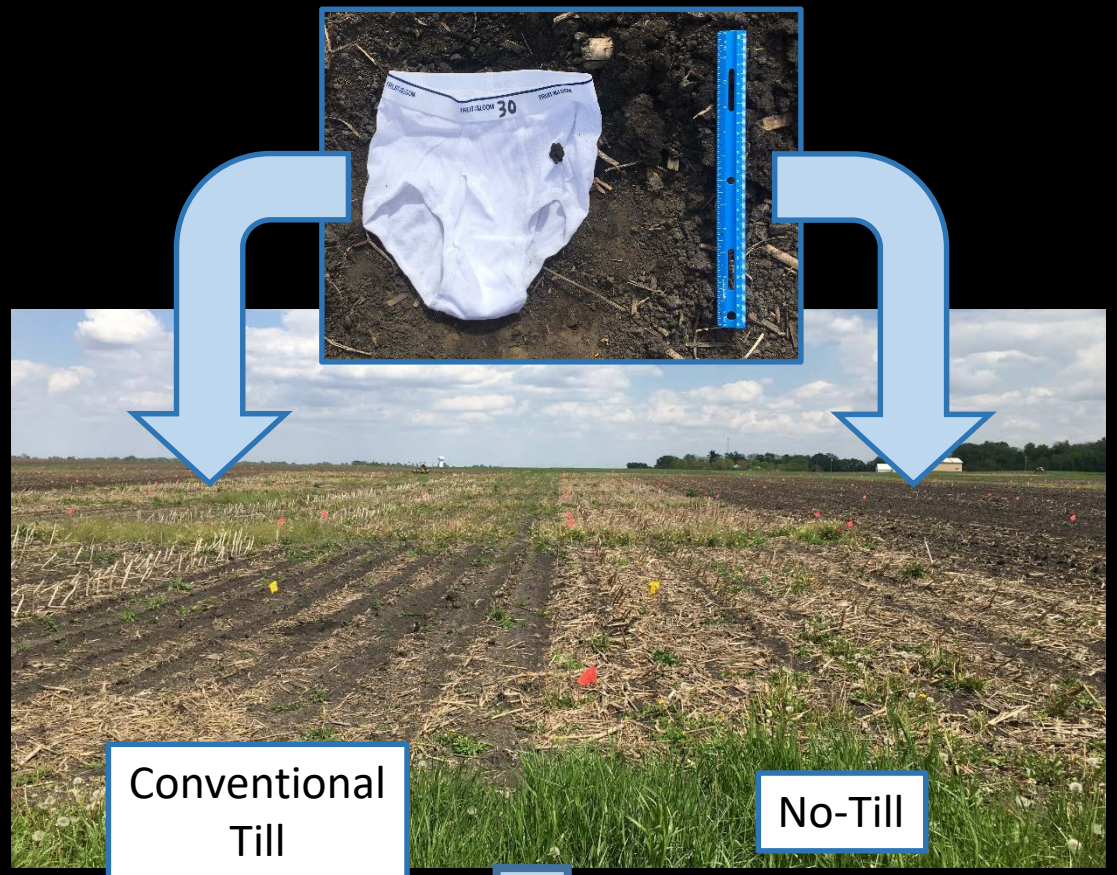
7 %

20 %

#SoilYourUndies

7 weeks later

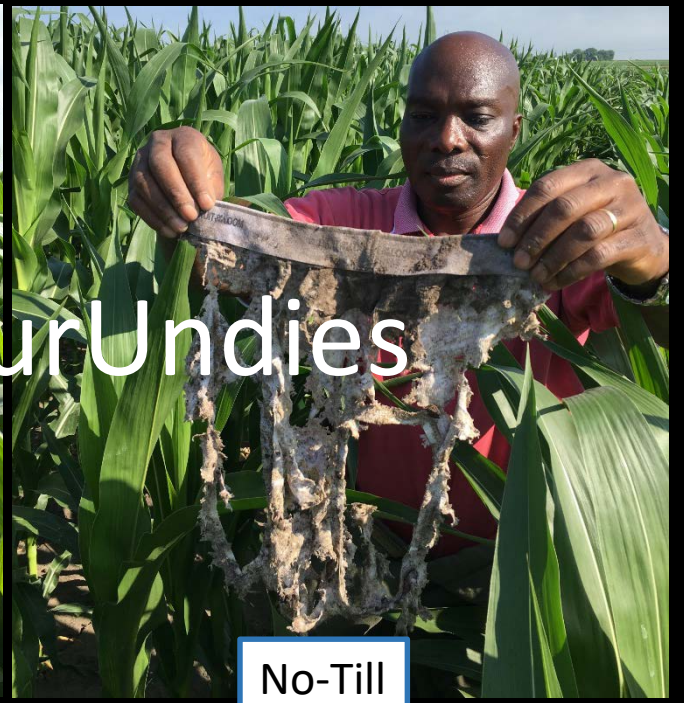
Crop rotations increase soil biological activity in reduced tillage



Percent decomposed:

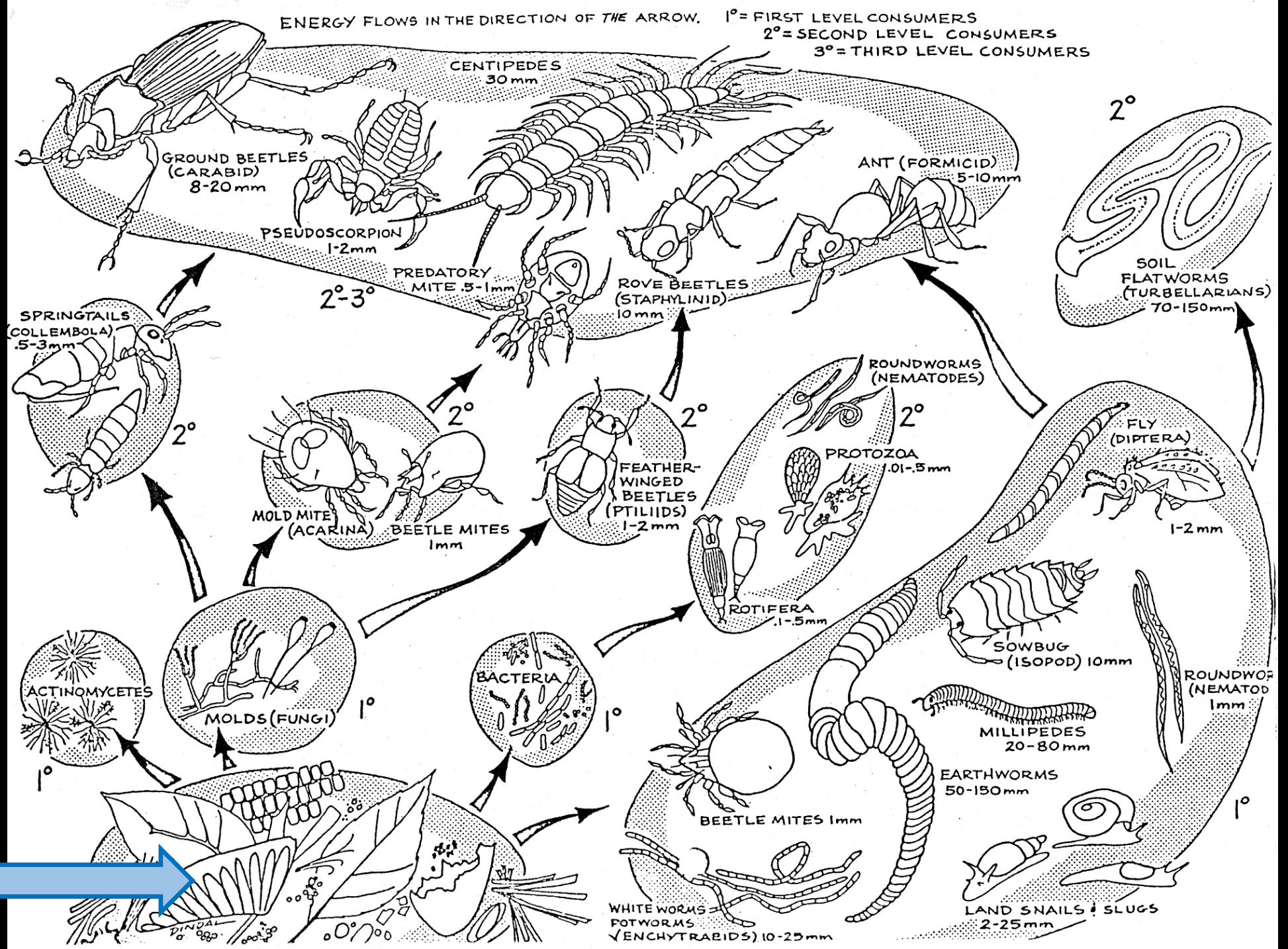
19 %

48 %



7 weeks later

The Soil Food Web



Soil Your Undies

- Works great as a demonstration tool but not as a robust, scientific indicator of biological activity, but…
  - It's messy and inconvenient
    - ✓add lots of variability
    - ✓Difficult to compare among soils/treatments

Can we develop a scientifically-robust soil health (biology) indictor that is relatively independent of soil temperature and moisture?

How does the health of soil determine decomposition of HIGH and LOW quality residues?

Continuous corn

Unhealthy

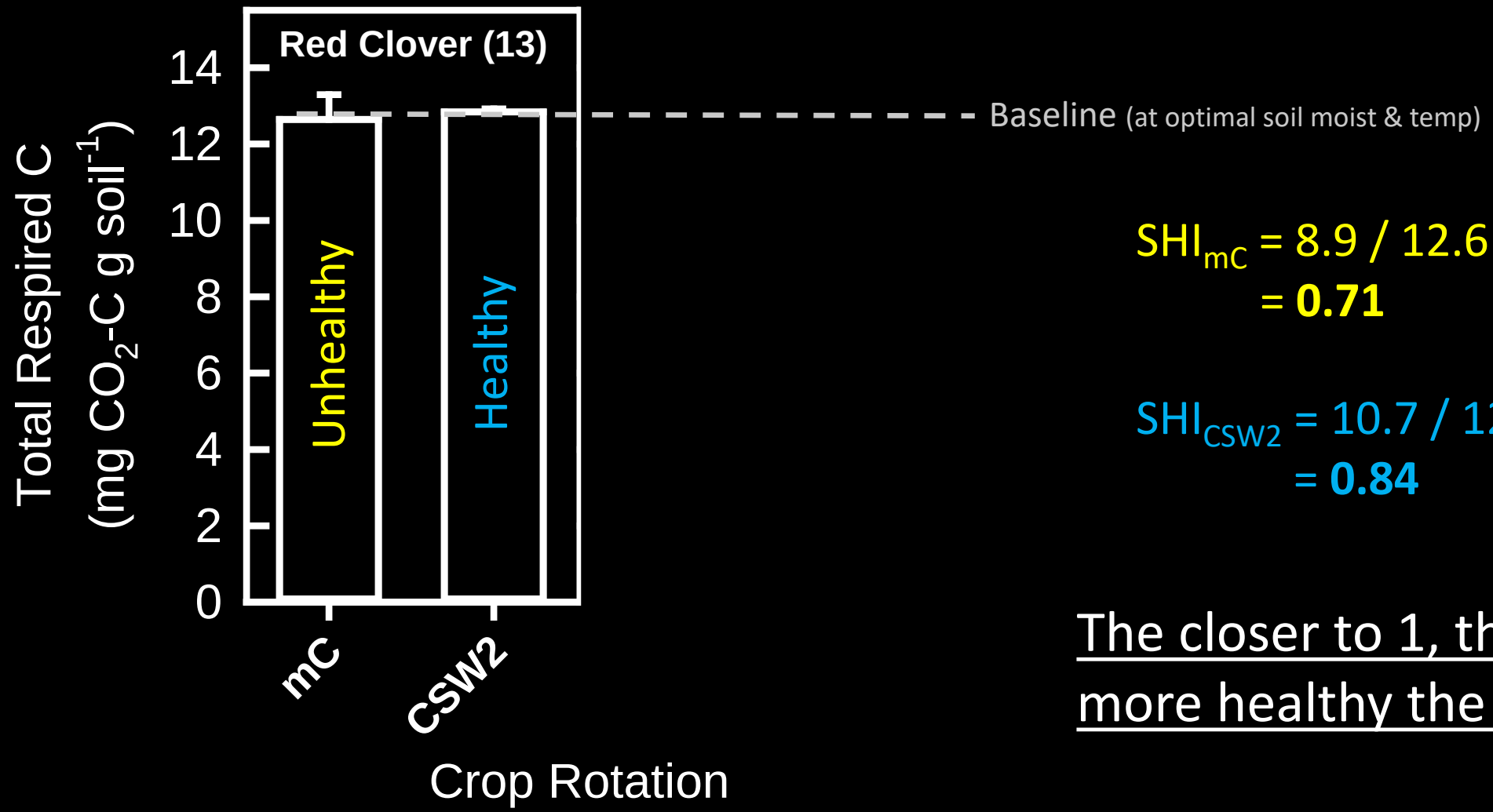
Corn-soy-wheat

Healthy

Could such a comparison be used to calculate a Soil Health Index?

McDaniel et al., 2014

How does the health of soil determine decomposition of HIGH and LOW quality residues?



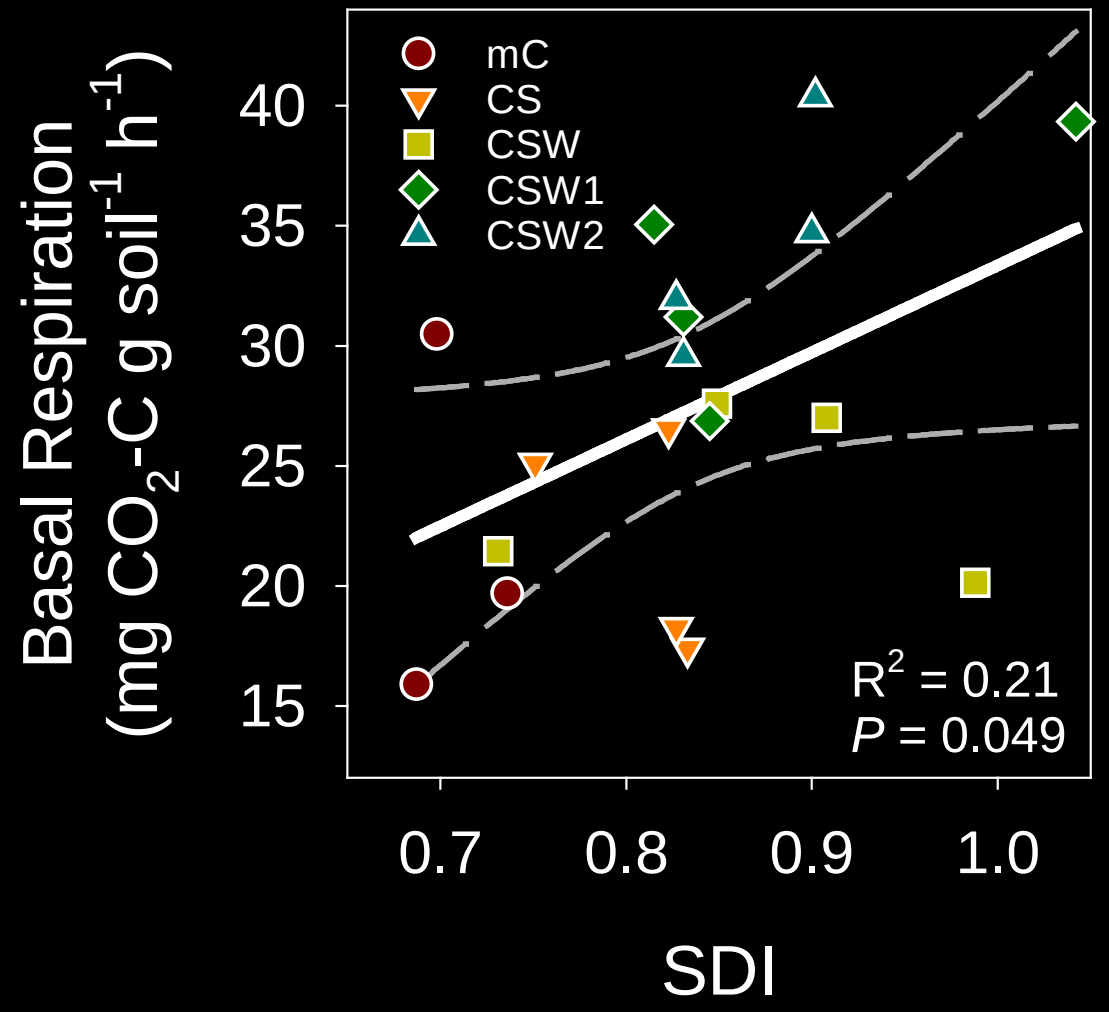
SHI_{mC} = 8.9 / 12.6
= **0.71**

SHI_{CSW2} = 10.7 / 12.8
= **0.84**

The closer to 1, the more healthy the soil is

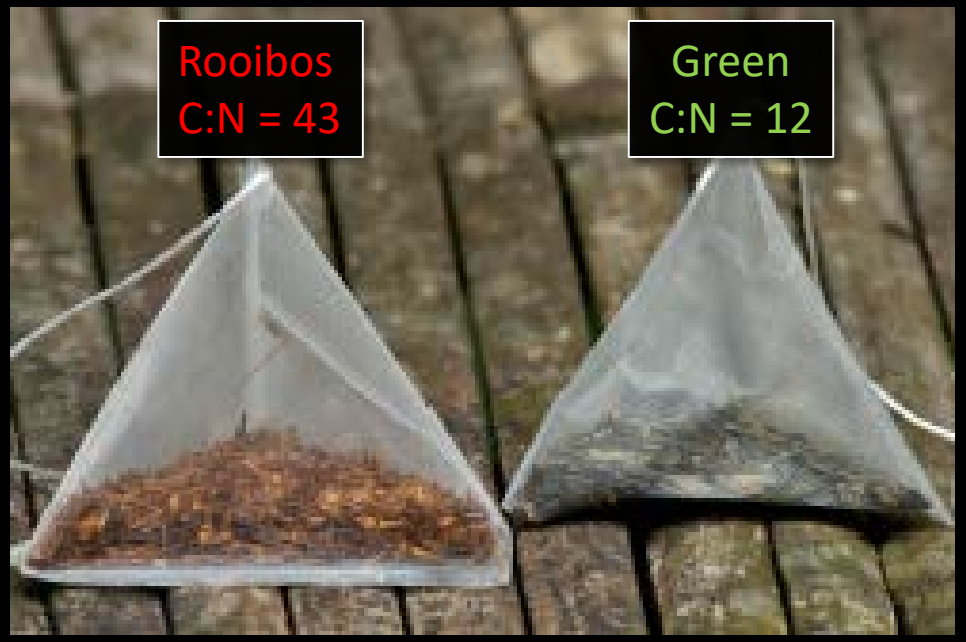
McDaniel et al., 2014

SDI increased with crop system complexity

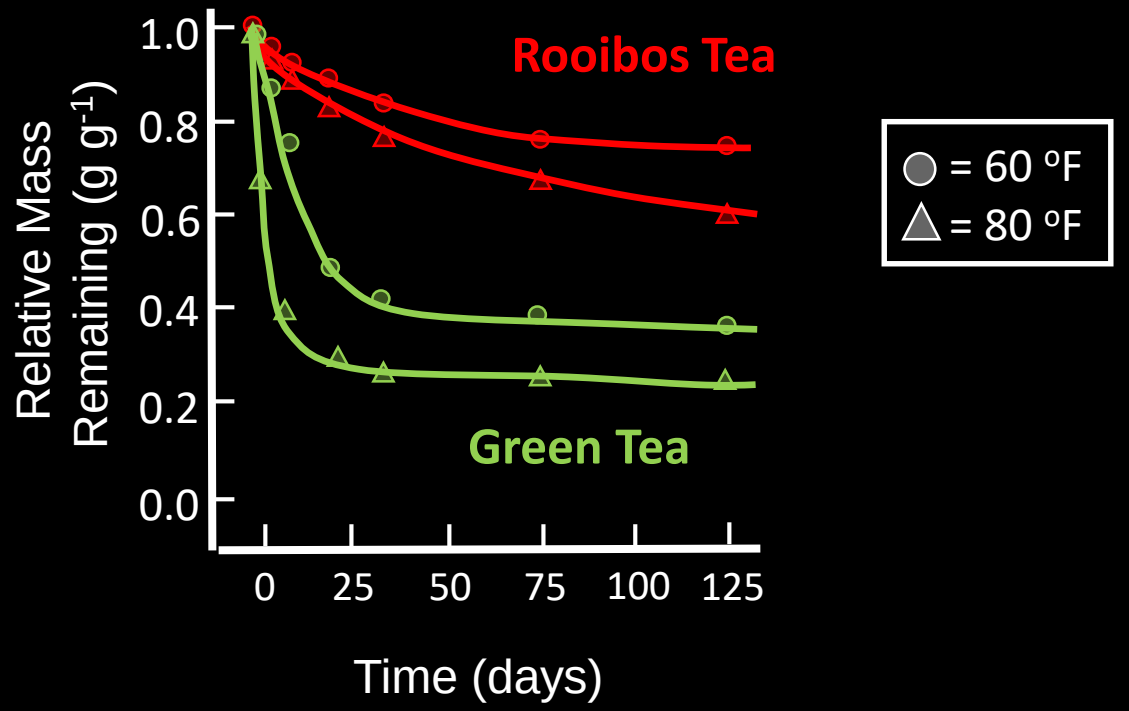


It’s not easy, or cheap, for just anyone to do this type of experiment!

Use two types of tea bags as easy indicators



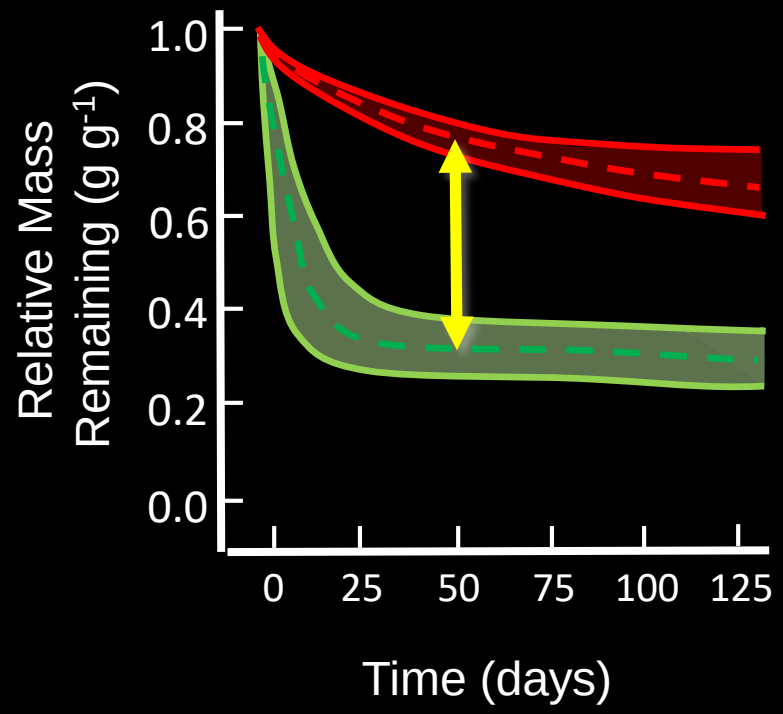
~$20 for 60 pyramids



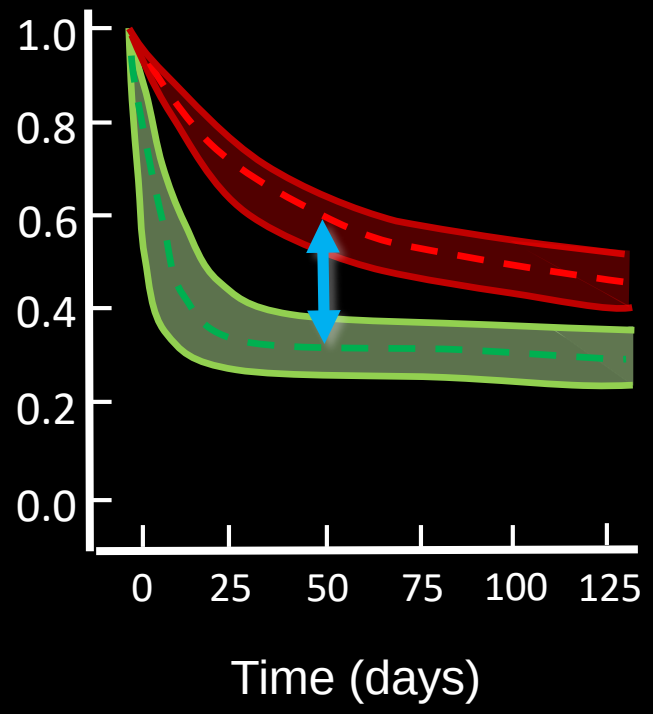
adapted from Keuskamp et al. (2013)

The Tea Bag Index (or TBI) of Soil Health

Unhealthy Soil



Healthy Soil



= Rooibos Tea

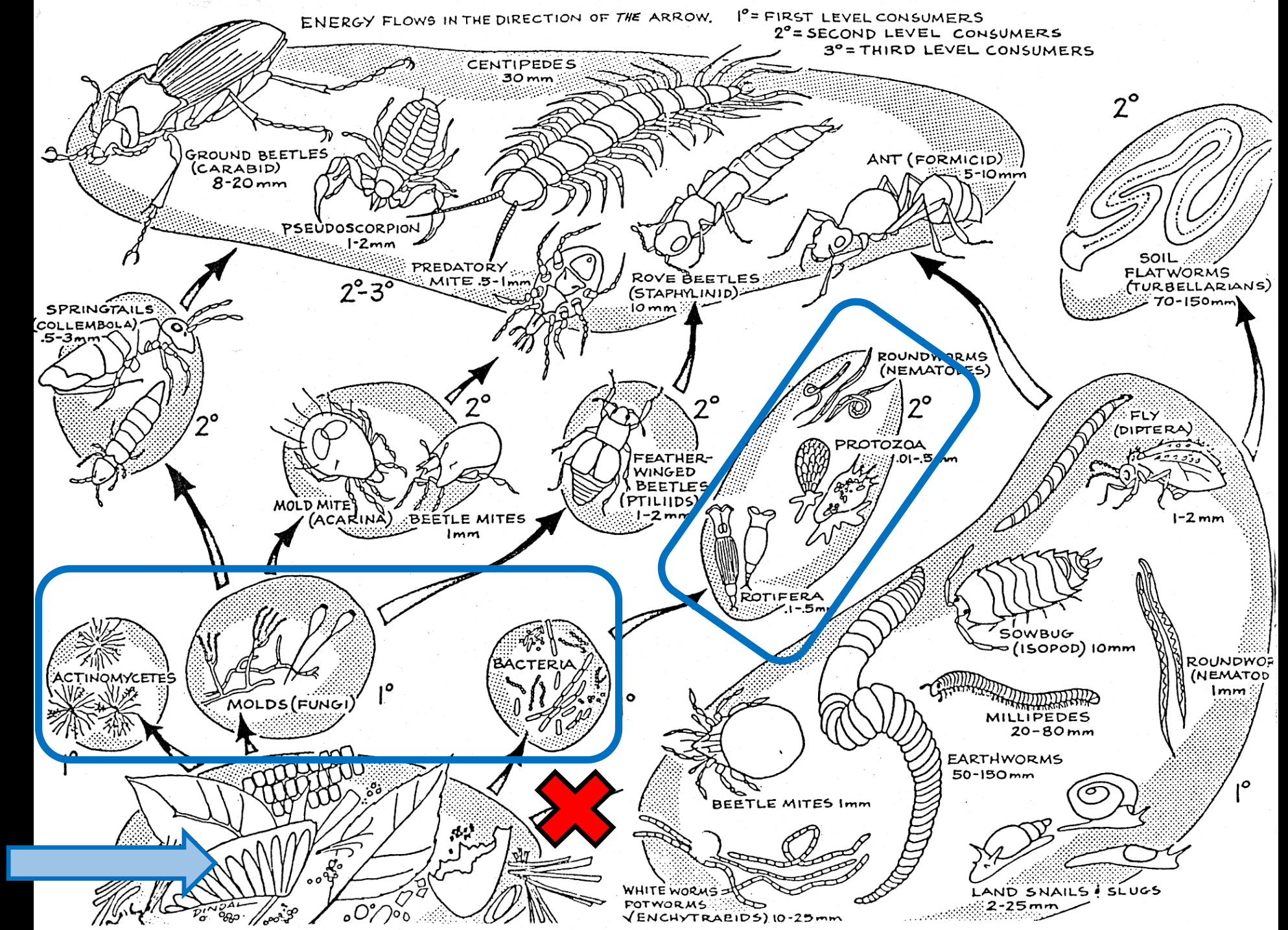
= Green Tea

$$TBI_{US} = \frac{(1.0 - 0.8)}{(1.0 - 0.35)} = 0.31$$

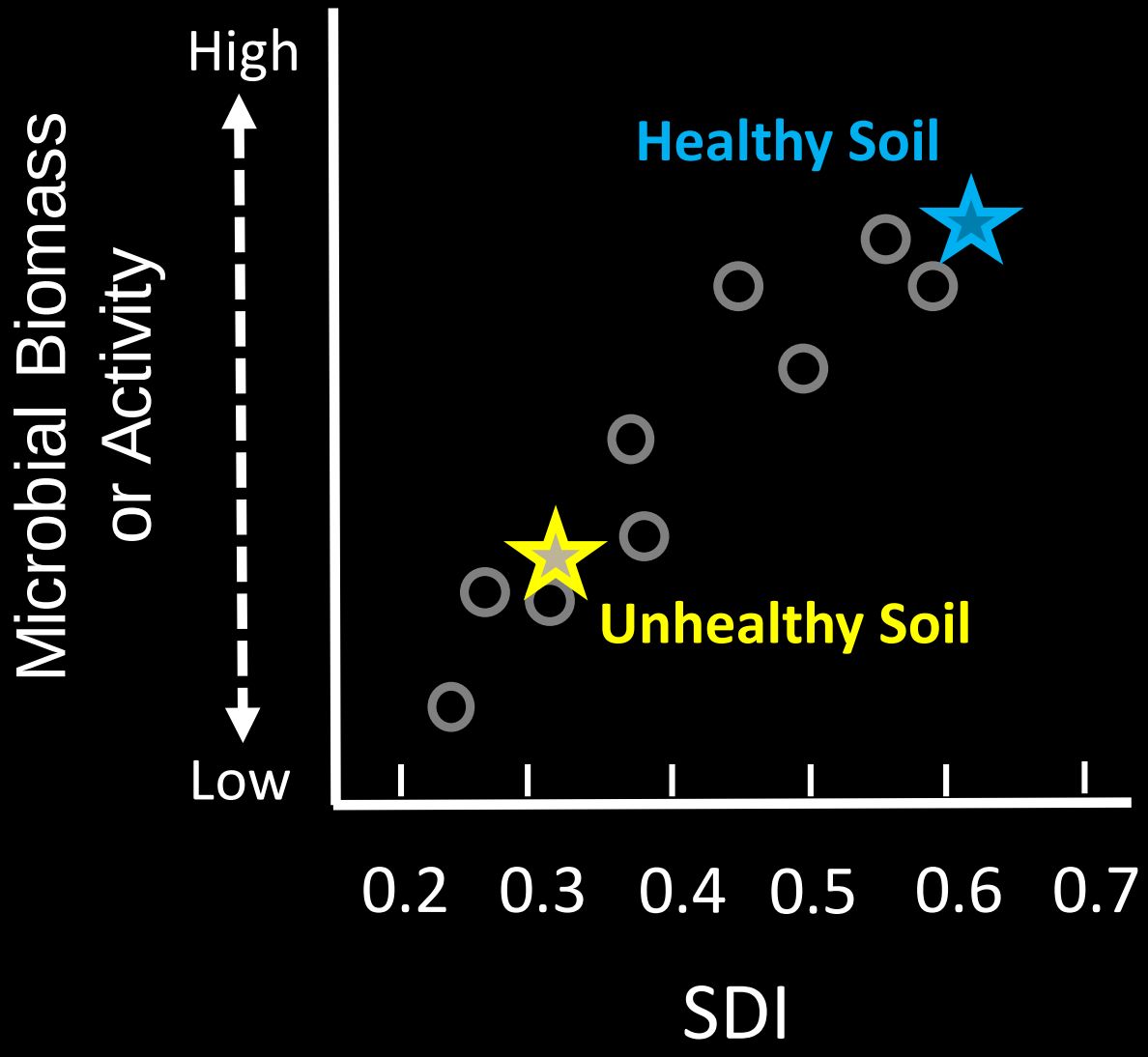
$$TBI_{HS} = \frac{(1.0 - 0.6)}{(1.0 - 0.35)} = 0.62$$

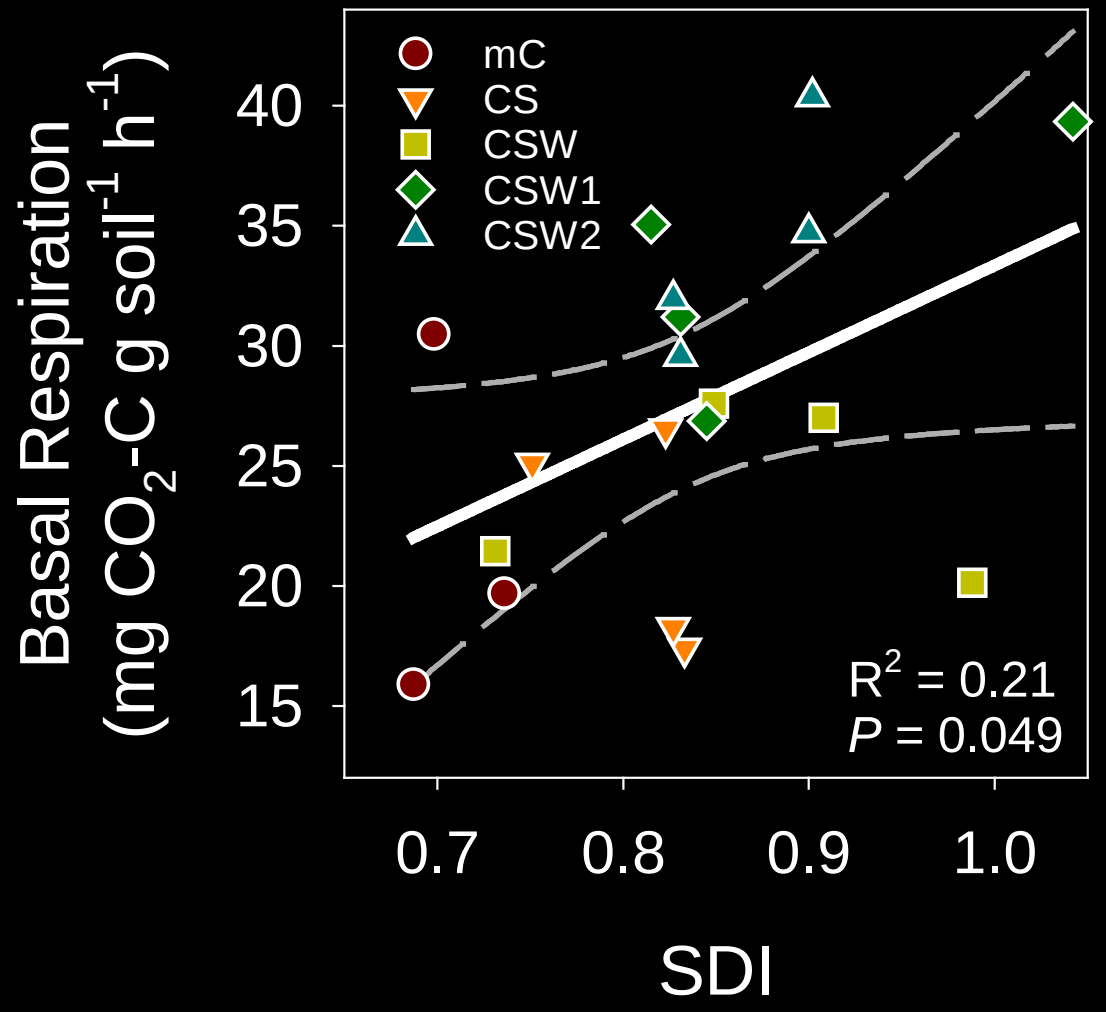
The closer to 1, the more healthy the soil is

The Soil Food Web



Calibration and Validation of the TBI

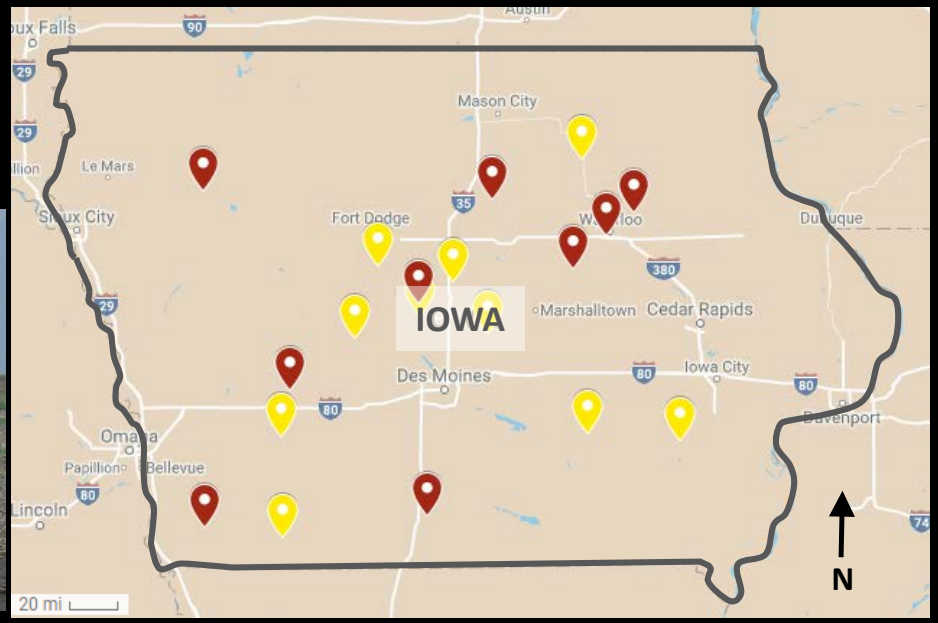




The Approach, 2017

- Cover Crop = Healthy Soil, No Cover = Less-Healthy Soil
- Last summer we buried tea bags (8 cm deep) in…
  1. Replicated strip trials (n = 3-5) of cover crops of 10 farms located around Iowa
     wide variety of soil types, fertilizer management, and tillage
  2. Nine volunteer farmers buried their own tea bags (not replicated)
  3. Retrieved tea bags at 4, 7, 14, 30, 68 and 130 days

Source: http://practicalfarmers.org/blog/2014/04/16/cover-crop-affect-corn-soybean-yields/



Step 1: Finding a good row to bury the tea bags

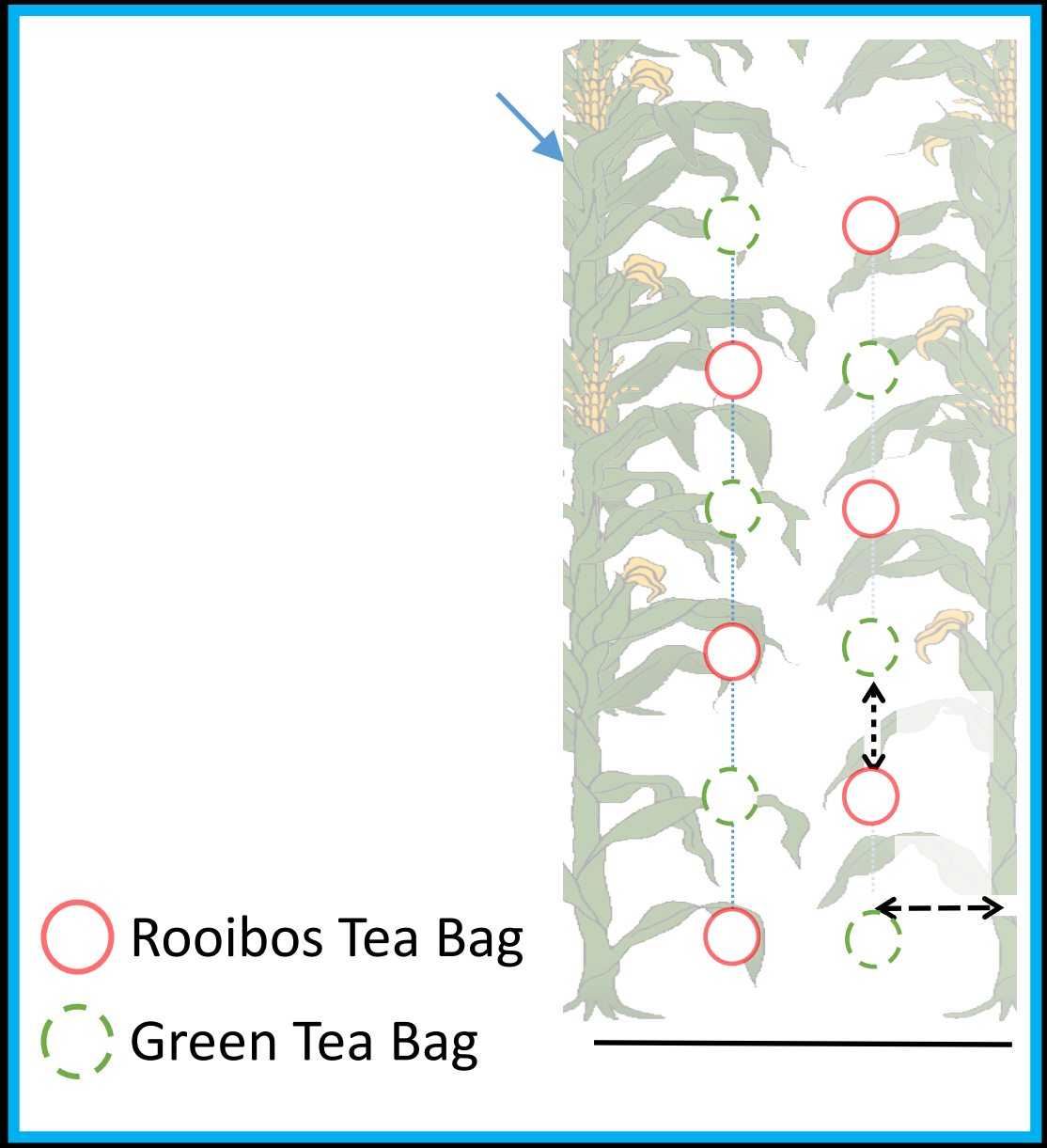
Source: http://practicalfarmers.org/blog/2014/04/16/cover-crop-affect-corn-soybean-yields/

a) Row should be between strips, free of wheel traffic and other weird stuff
b) Should start a few feet down the row from the field margin
c) If you have a GPS, it would be good to mark them or draw a map of where you buried them.

Bury them shortly after planting

Step 2: Mark out your holes for the tea bags

a) Row of tea bags should parallel crop rows (1/3) distance between rows

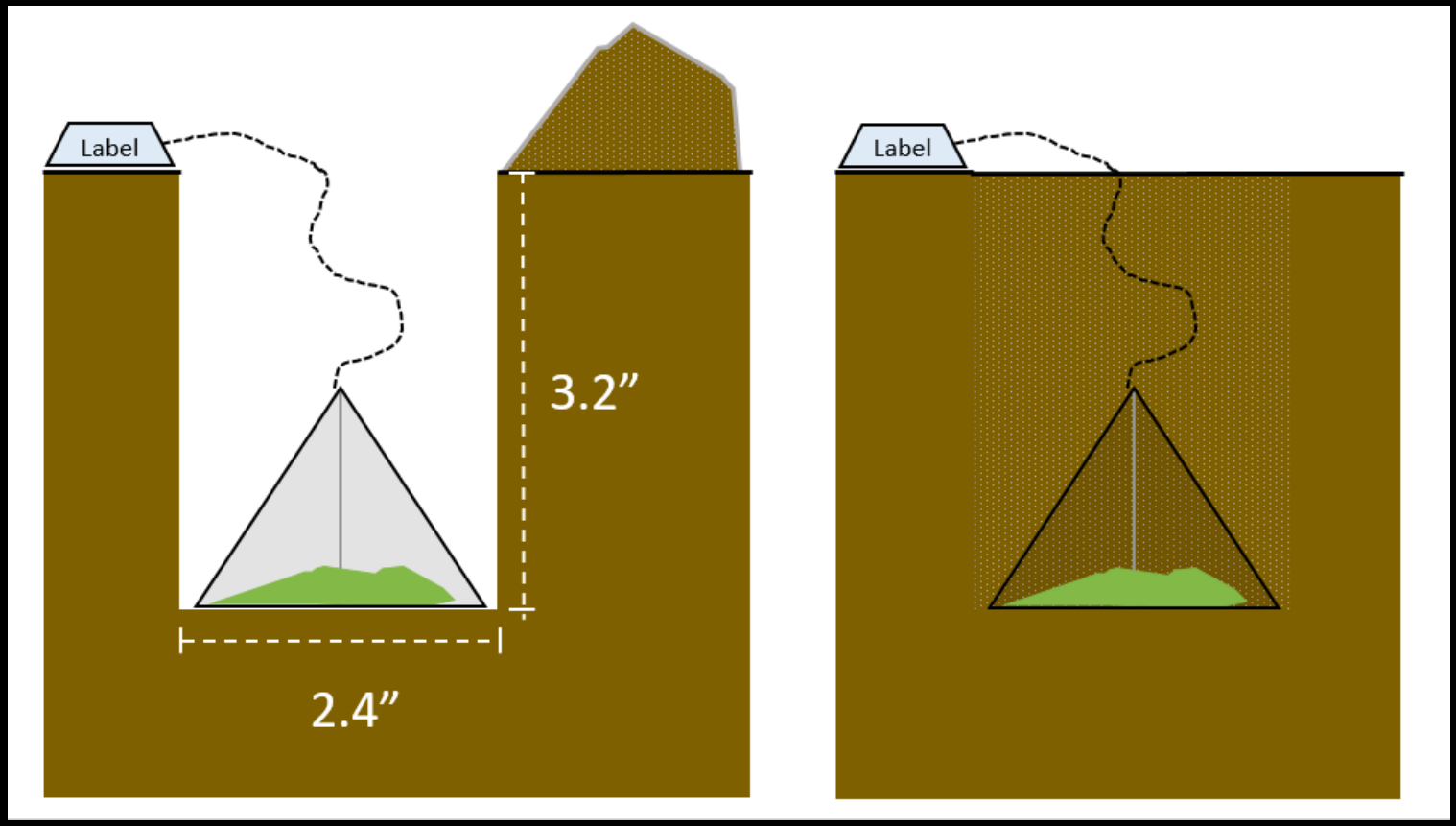


Step 3: Dig small holes for each tea bag

a) With a hand towel dig a small hole for each tea bag (~2.4” wide, 3.2” deep)

b) Place the teabag inside, and cover with soil

c) Gently pat down with tag remaining on surface



STEP 3a

STEP 3b and 3c

Step 4: Retrieving buried tea bags

a) Collect on the date suggested, or within the acceptable range

b) Record the date, weather, any other information on the conditions (mail and email information to ISU)

c) Gently pull (or excavate) two tea bags (green and rooibos) out of the soil from each plot

d) Carefully brush off any soil adhering to the tea bags

Order	Tea Bag Letters	Time After Burial (acceptable range of days)	Date Retrieved
1	a	4 (3-5)	
2	b	7 (6-8)	
3	c	14 (13-15)	
4	d	30 (28-32)	
5	e	68 (64-72)	
6	f	130 (125-135)	

Step 5: Handling the tea bags after retrieval

a) The tea bags should be dried at about 140 ^{o}F, but most ovens do not go this low and are not consistent at this low temperature

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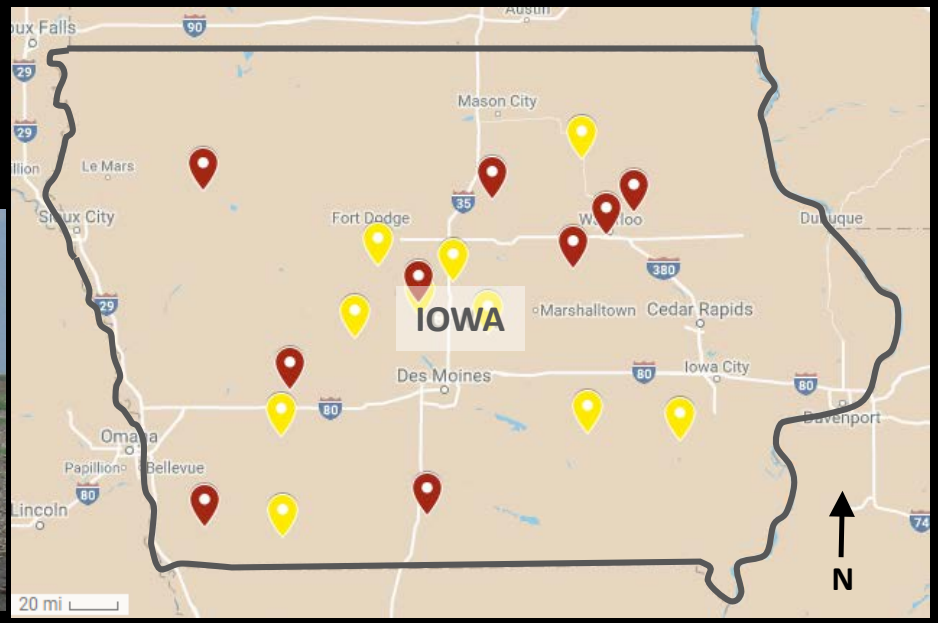

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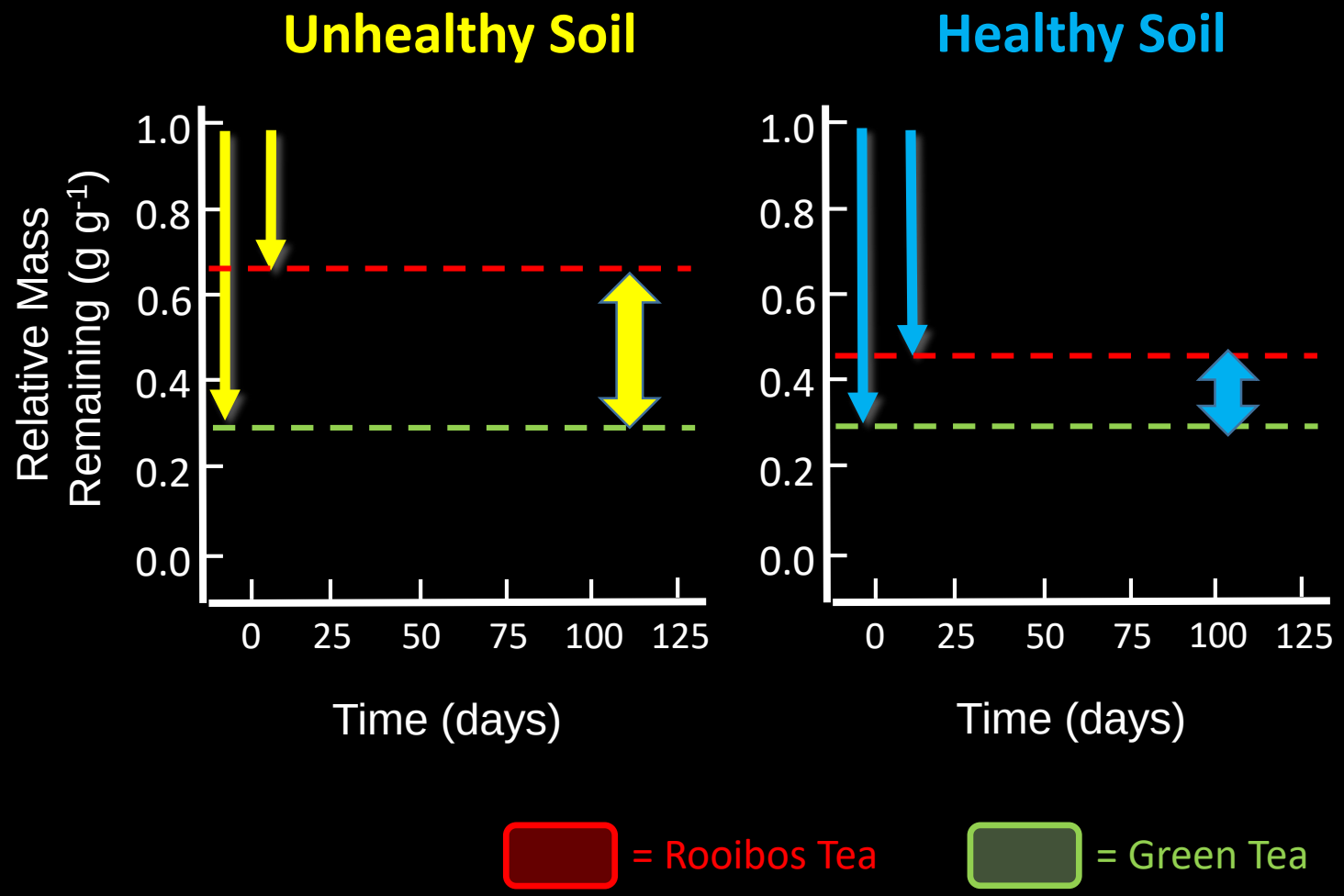
Hypothesis: SDI with tea bags to measure Soil Health

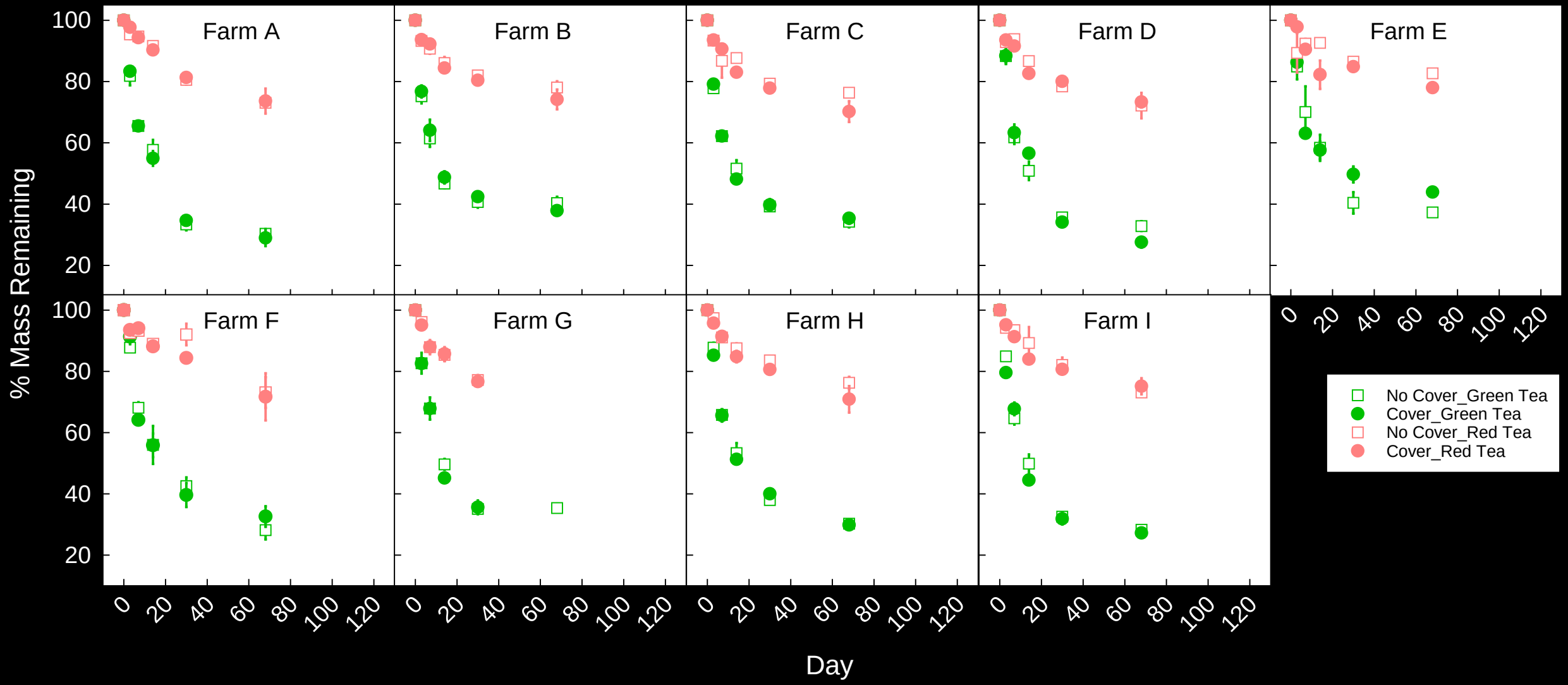


$$SDI_{US} = \frac{(1.0 - 0.65)}{(1.0 - 0.30)} = 0.31$$

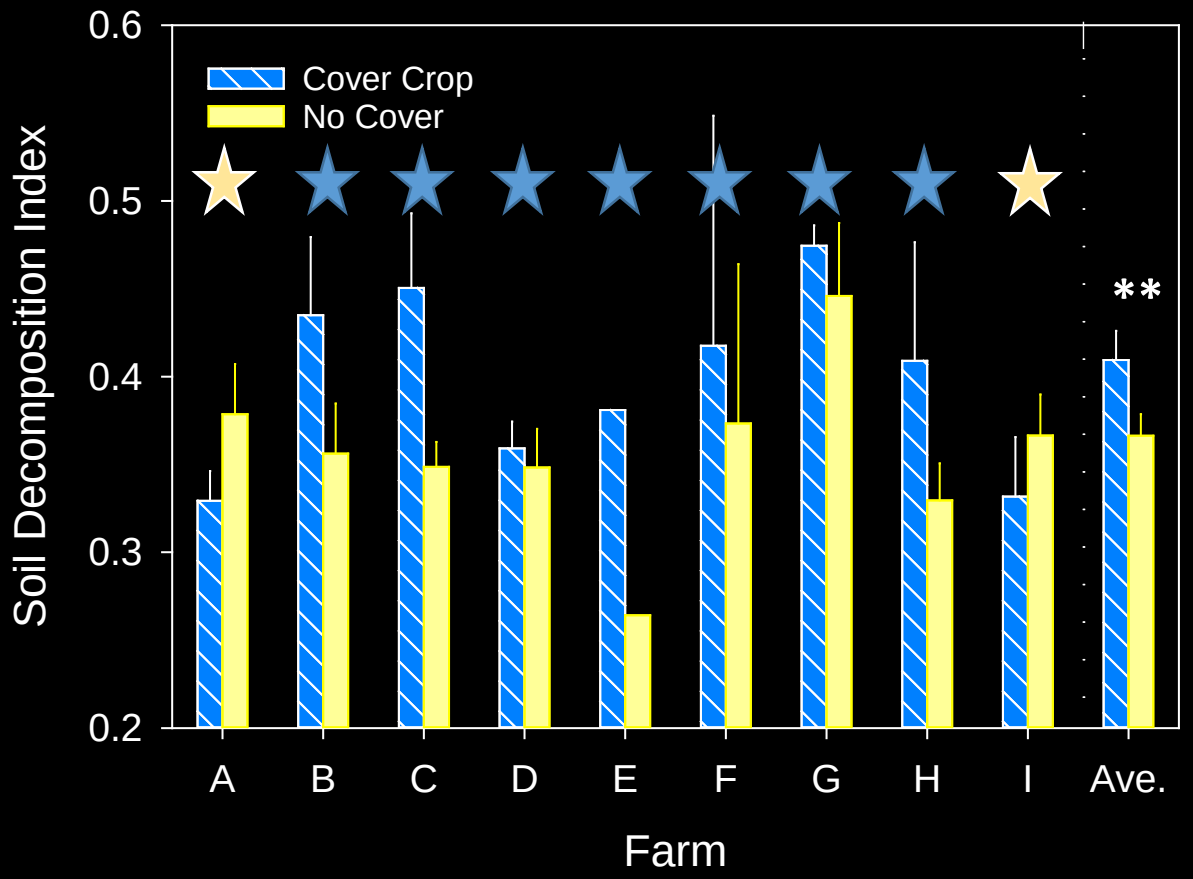
$$SDI_{HS} = \frac{(1.0 - 0.45)}{(1.0 - 0.30)} = 0.62$$

The closer to 1, the more healthy the soil is

Not much difference between COVER and NO COVER crop, yet



7/9 farms have higher SDI with cover crops, but a lot of variability



* = $P < 0.1$

** = $P < 0.05$

The SDI with Tea Bags Shows Some Promise, Next Steps…

- What soil and management factors explain the variation in SDI?
- Look at other aspects of decomposition as an index (i.e. rate)
- Validate any TB index with known measures of soil biological health
- Look at microbial community composition in 7 d and 130 d tea bags
- Sociological survey on participants (citizen scientists) and IA farming community
- Expand to other long-term experiments in Iowa and beyond!?!?

Materials Needed

- Provided by PFI and ISU, or in the “Tea Bag Kit”
  - ✓ 48 green and rooibos tea bags
  - ✓ 48 Ziploc “snack” plastic bags
  - ✓ 6 Pre-addressed envelope mailers
  - ✓ 8 flags for marking plots

- You will need to provide…
  - ✓ Hand trowel (depending on soil)
  - ✓ Bucket or Rubbermaid tote to carry Ziploc bags and collect teas
  - ✓ Notebook, pen, and sharpie to record any unusual findings/observations

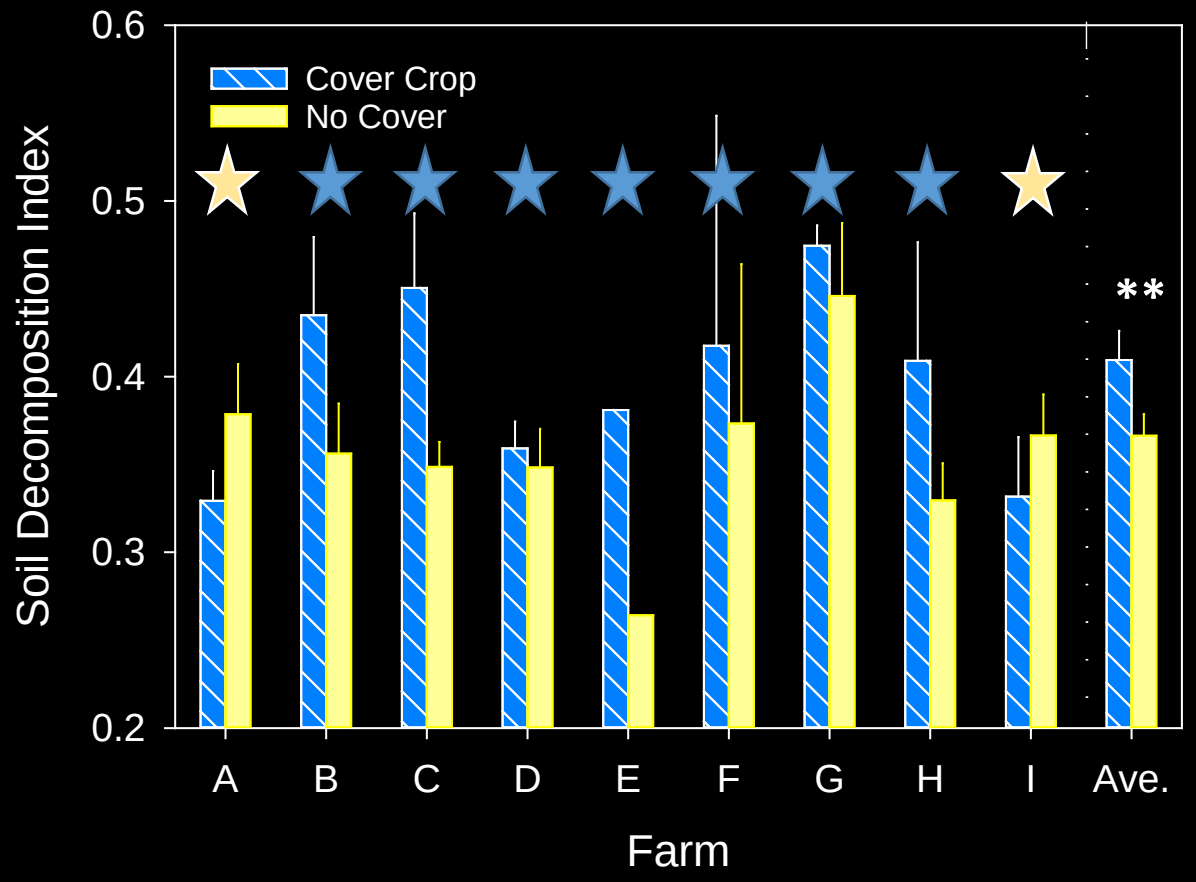
Procedure Overview

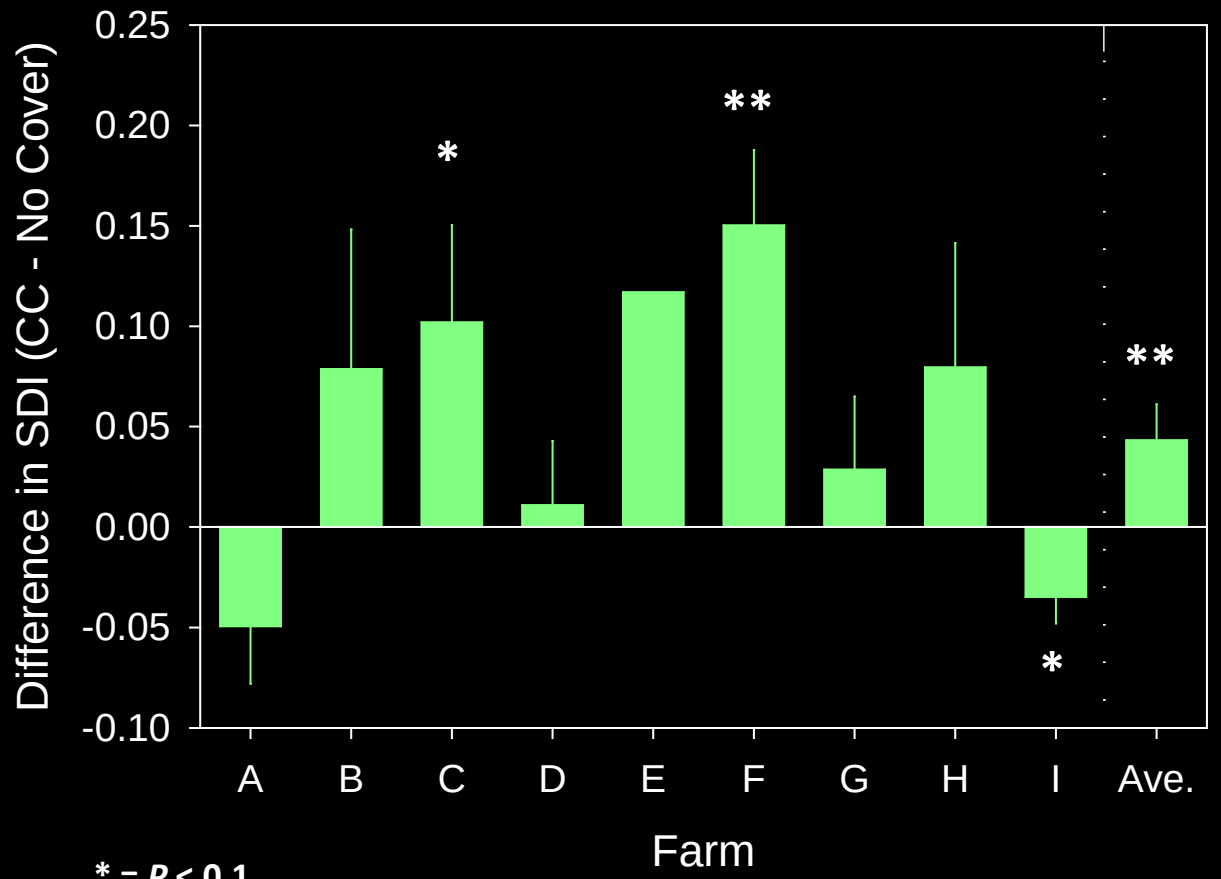
1. Finding a good row to place the tea bags
2. Mark out your holes for the tea bags
3. Dig small holes for each tea bag
4. Retrieving buried tea bags
5. Handling the tea bags after retrieval
6. Sending the tea bags to ISU

Step 6: Sending the tea bags to ISU

a) No more than a day or two after you collected and dried the tea bags
b) Close the Ziploc bags
c) Place all of the Ziploc bags (each with 2 tea bags) into a pre-addressed mailer provided by PFI
d) Drop it off at the post office
e) <u>You are ready for the next collection date</u>!

Incorporating landscape position helps to eliminate some noise





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