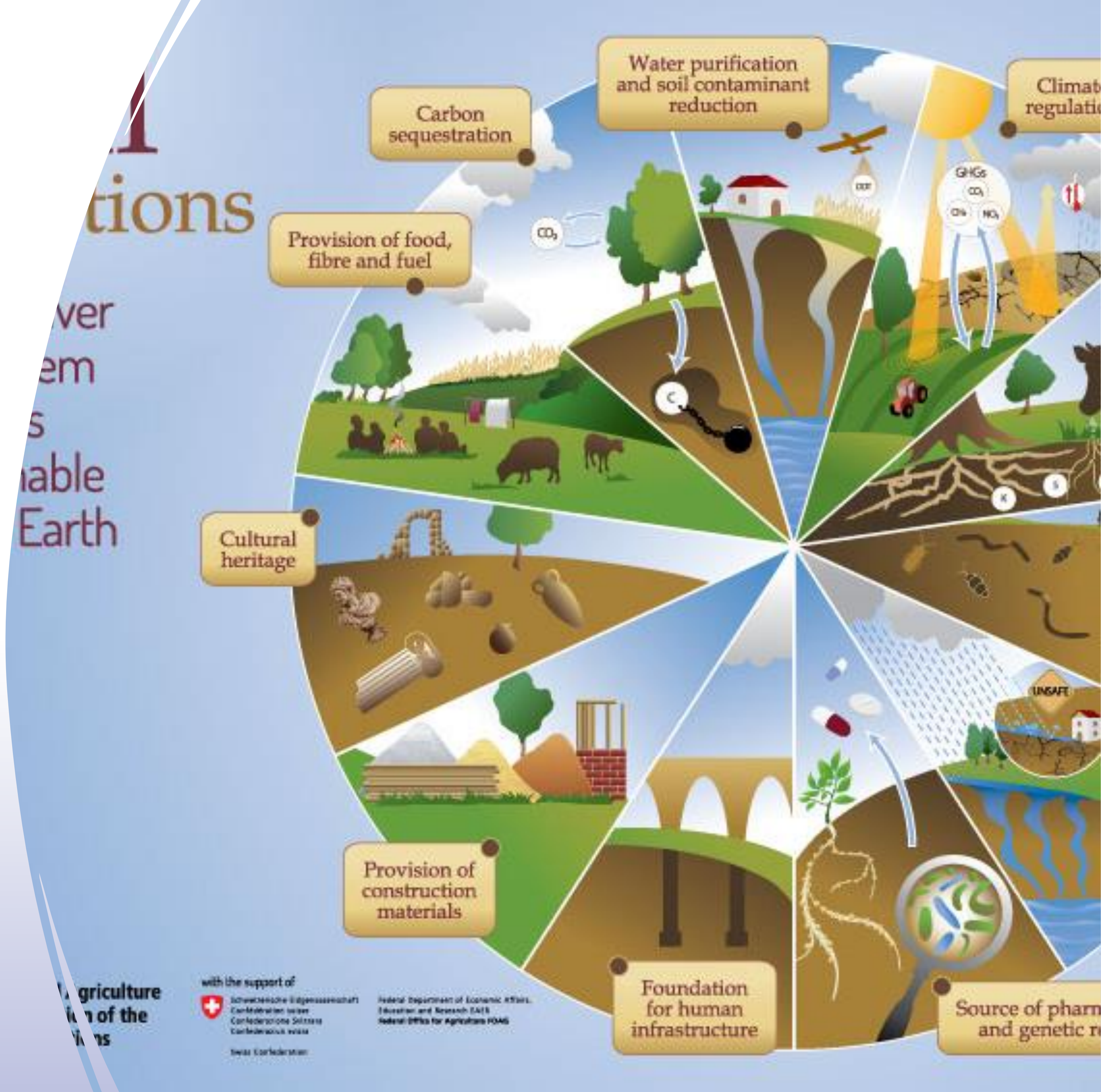
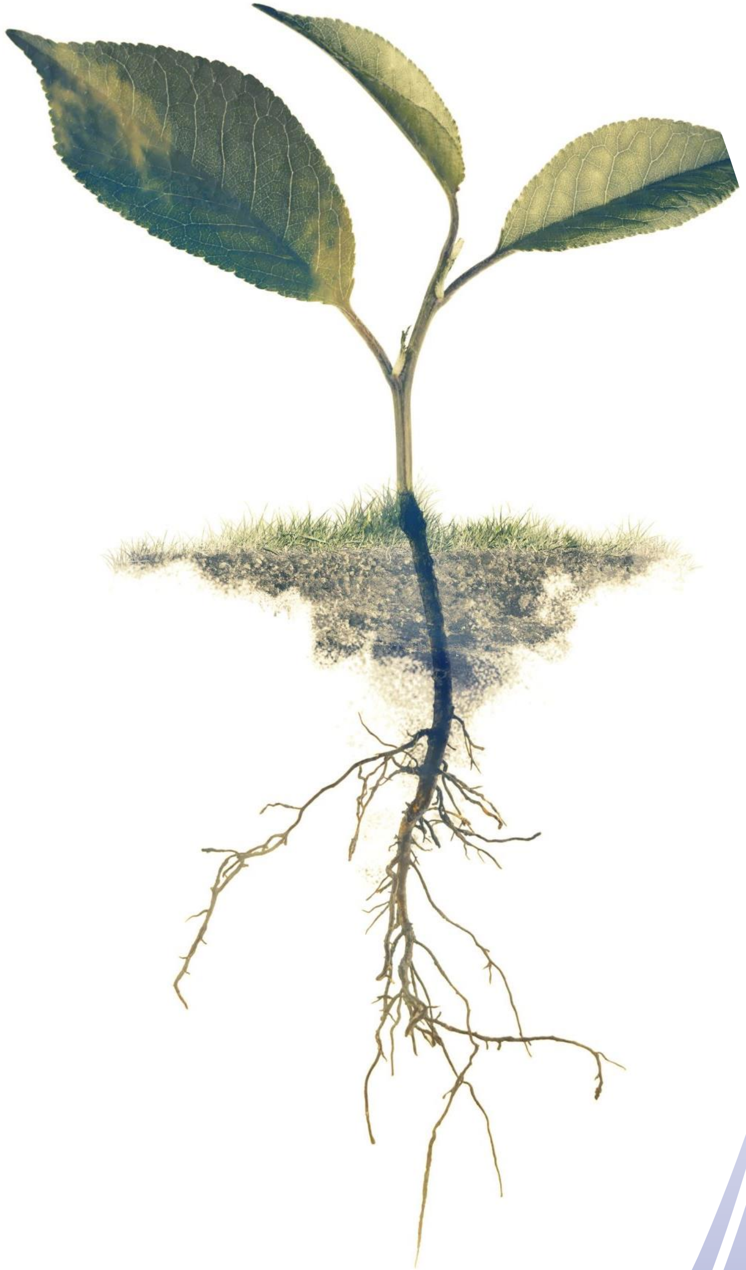
SOIL HEALTH

The key to optimal soil functionality!

FUNCTIONS OF SOIL-AGRICULTURE

- Provide support for plants
- Serve as a water reservoir
- Nutrient source for plants
- Carbon cycling
- Efficient gas exchange
- Decomposition of pesticides, antibiotics

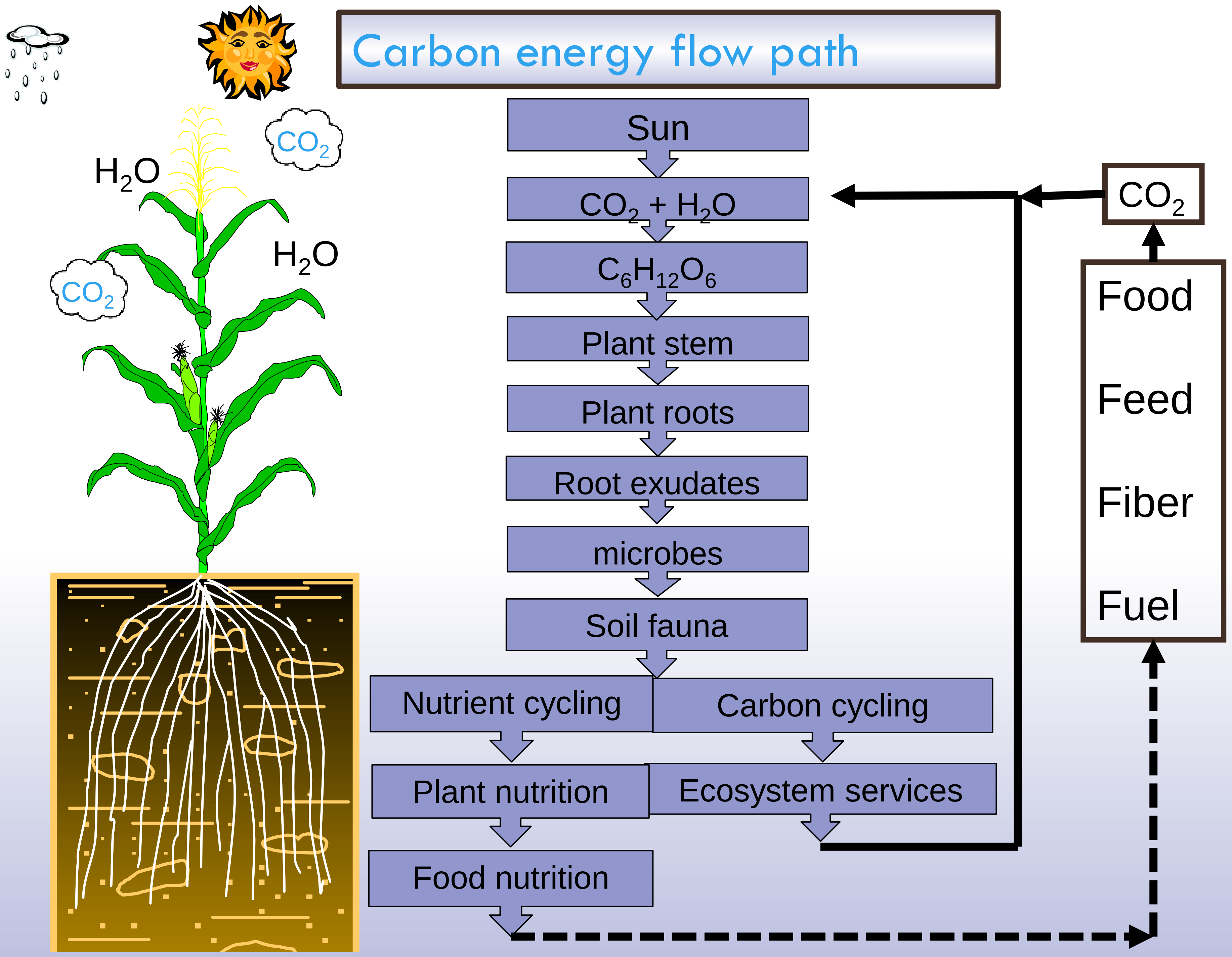




PRINCIPLES OF REGENERATIVE AGRICULTURE

- Maintaining Soil Armor (crop residue).
- Minimizing Soil Disturbance (less tillage).
- Maintaining Continual Living Plant Roots (continual input of energy to the soil microbial system).
- Adding Planting Diversity (diversity pays).
- Integrating Livestock (incorporation of carbon and nutrients).

PRINCIPLES OF REGENERATIVE AGRICULTURE FOCUS ON THE CAPTURE OF ENERGY AND TRANSFER TO THE SOIL


Carbon energy flow path
Sun
$CO_2 + H_2O$
$C_6H_{12}O_6$
Plant stem
Plant roots
Root exudates
microbes
Soil fauna
Nutrient cycling
Carbon cycling
Plant nutrition
Ecosystem services
Food nutrition
CO_2
Food
Feed
Fiber
Fuel
H_2O
H_2O
CO_2
CO_2

SEASONAL INPUT OF ENERGY

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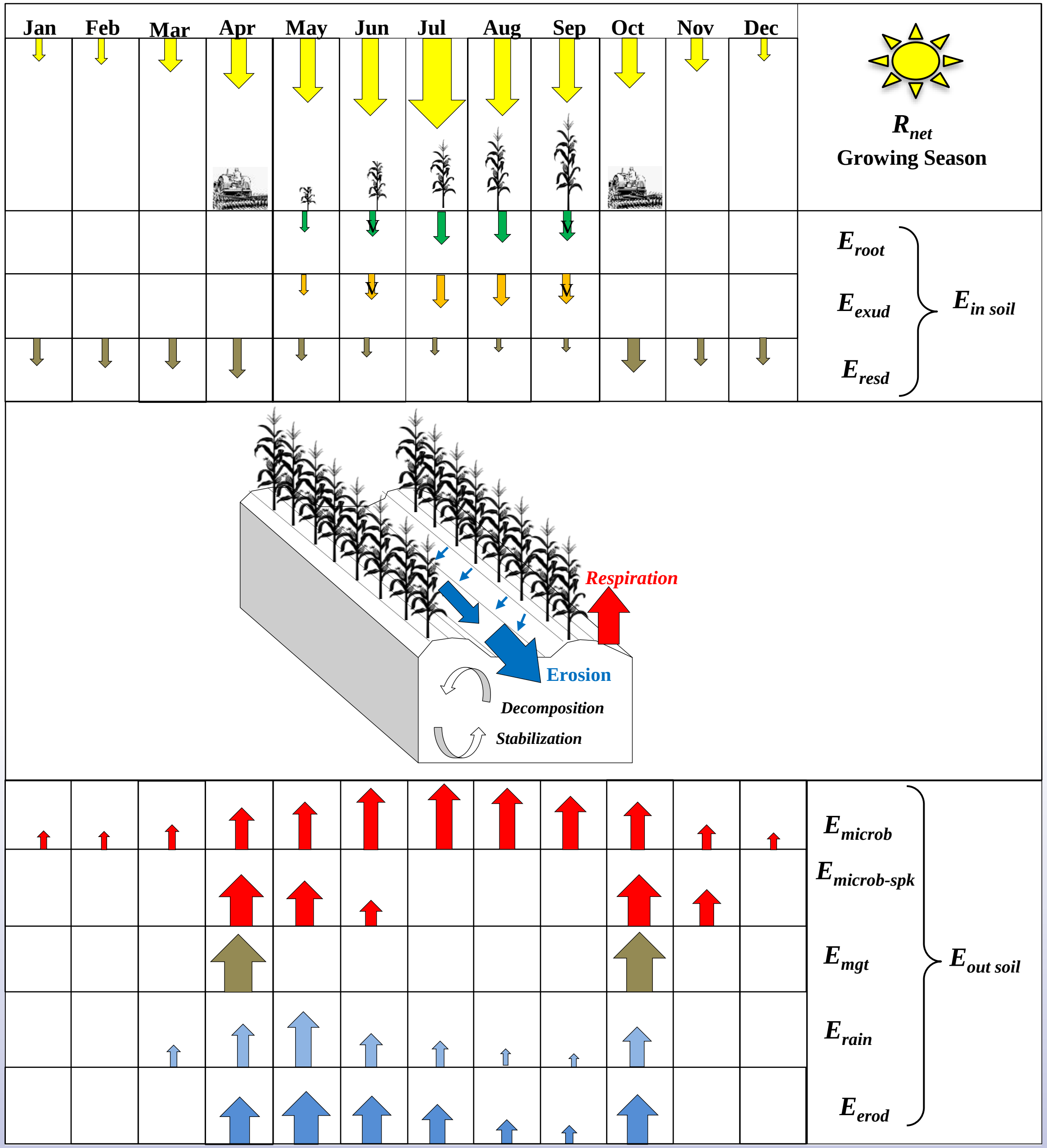
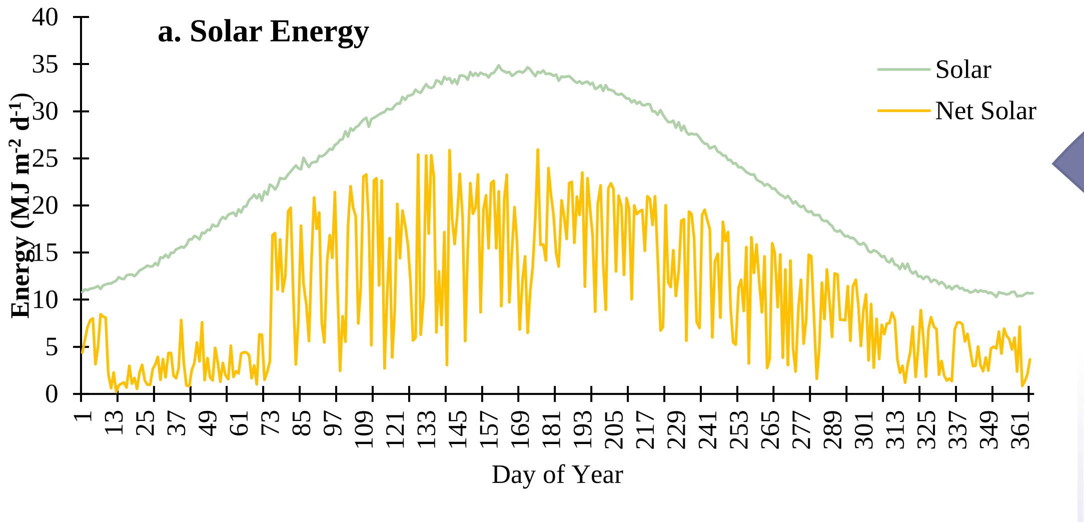
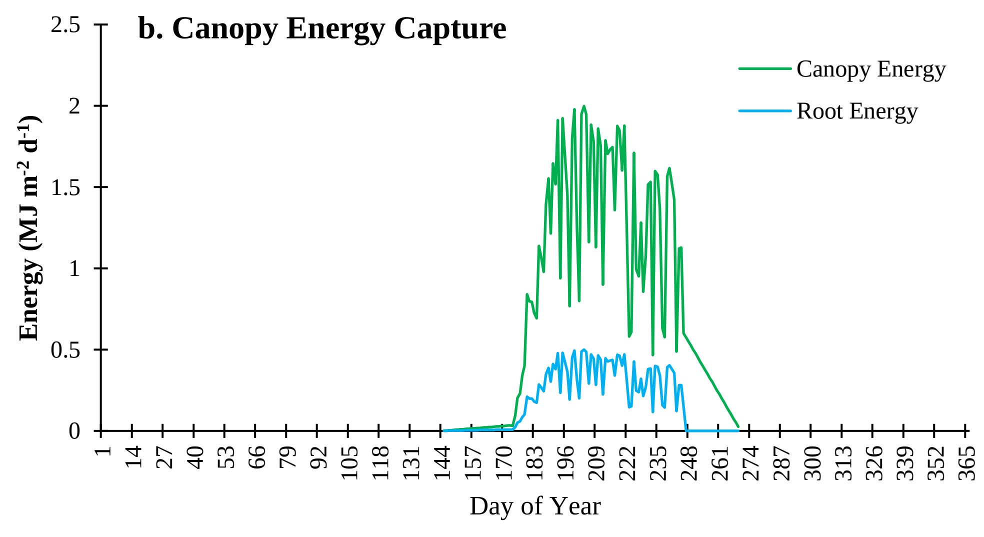


EXAMPLE OF ENERGY INPUTS

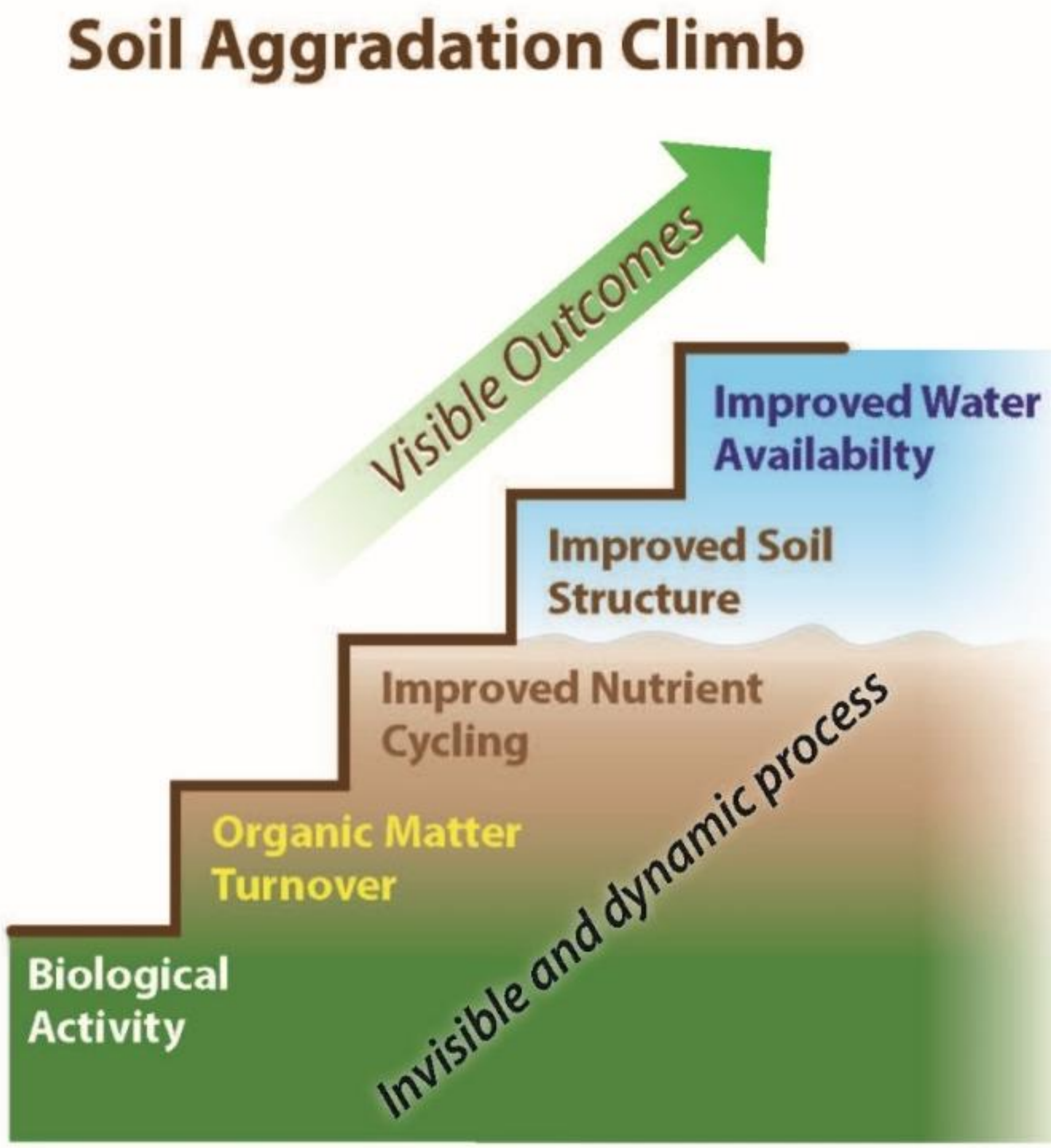
1 MJ = 239000 calories



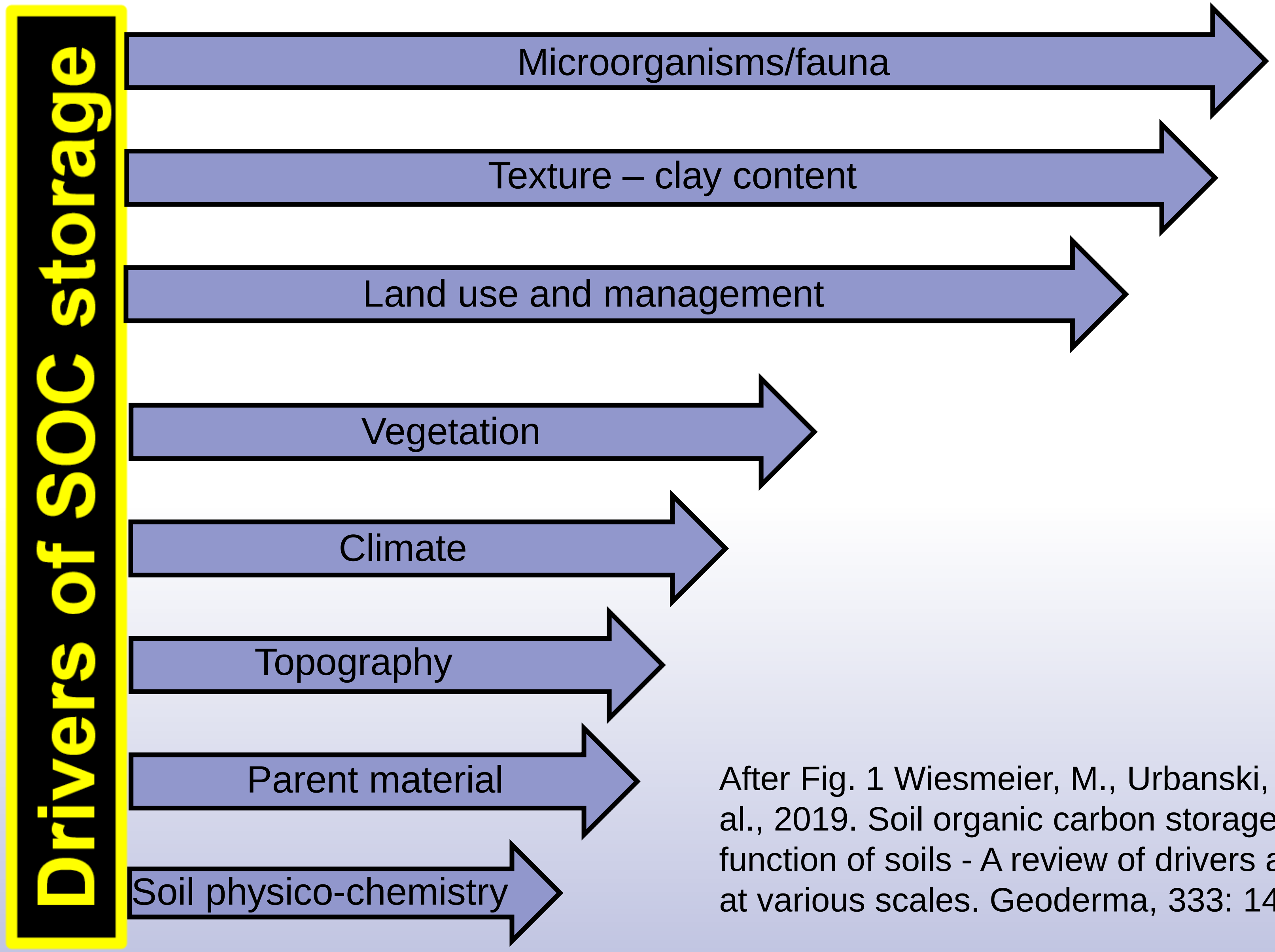


SOIL HEALTH PATHWAY

- TO CHANGE SOIL CARBON BIOLOGY NEEDS
- FOOD
- WATER
- AIR
- SHELTER



Relative ranking of SOC storage drivers

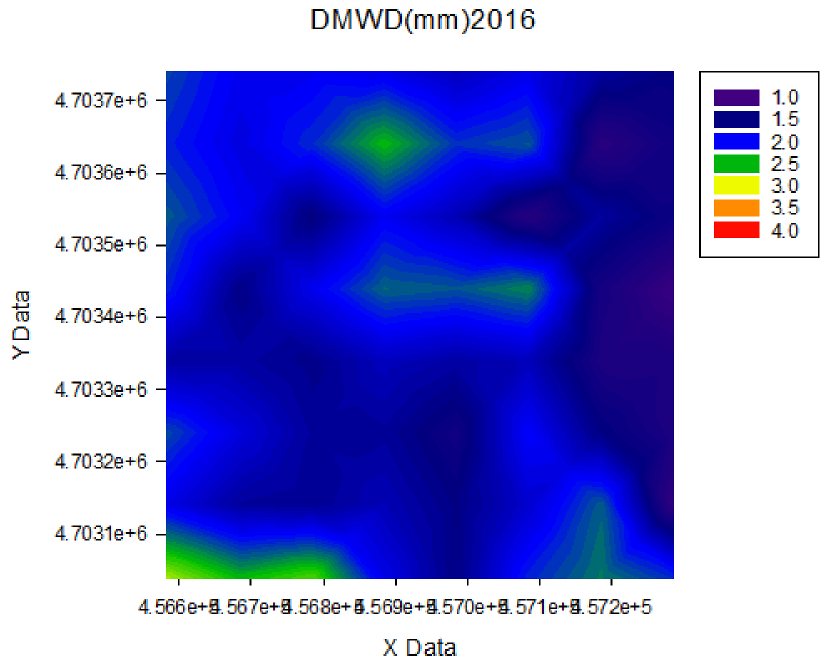


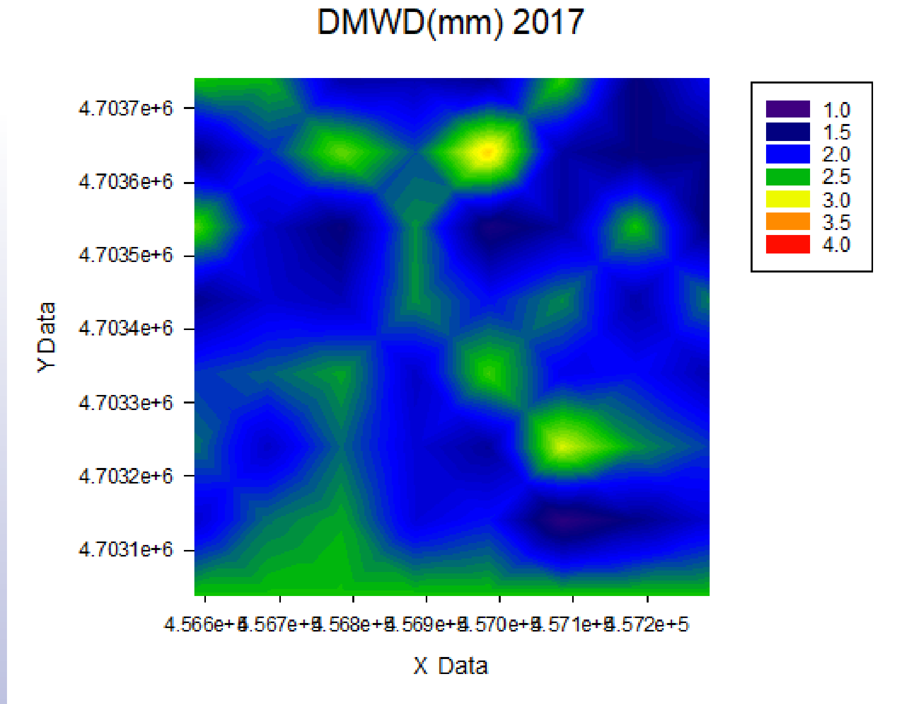
After Fig. 1 Wiesmeier, M., Urbanski, L., Hobley, et al., 2019. Soil organic carbon storage as a key function of soils - A review of drivers and indicators at various scales. Geoderma, 333: 149–162.


IF WE WANT SOILS TO CHANGE, WE HAVE TO SUPPLY ENERGY TO SUPPORT BIOLOGICAL ACTIVITY

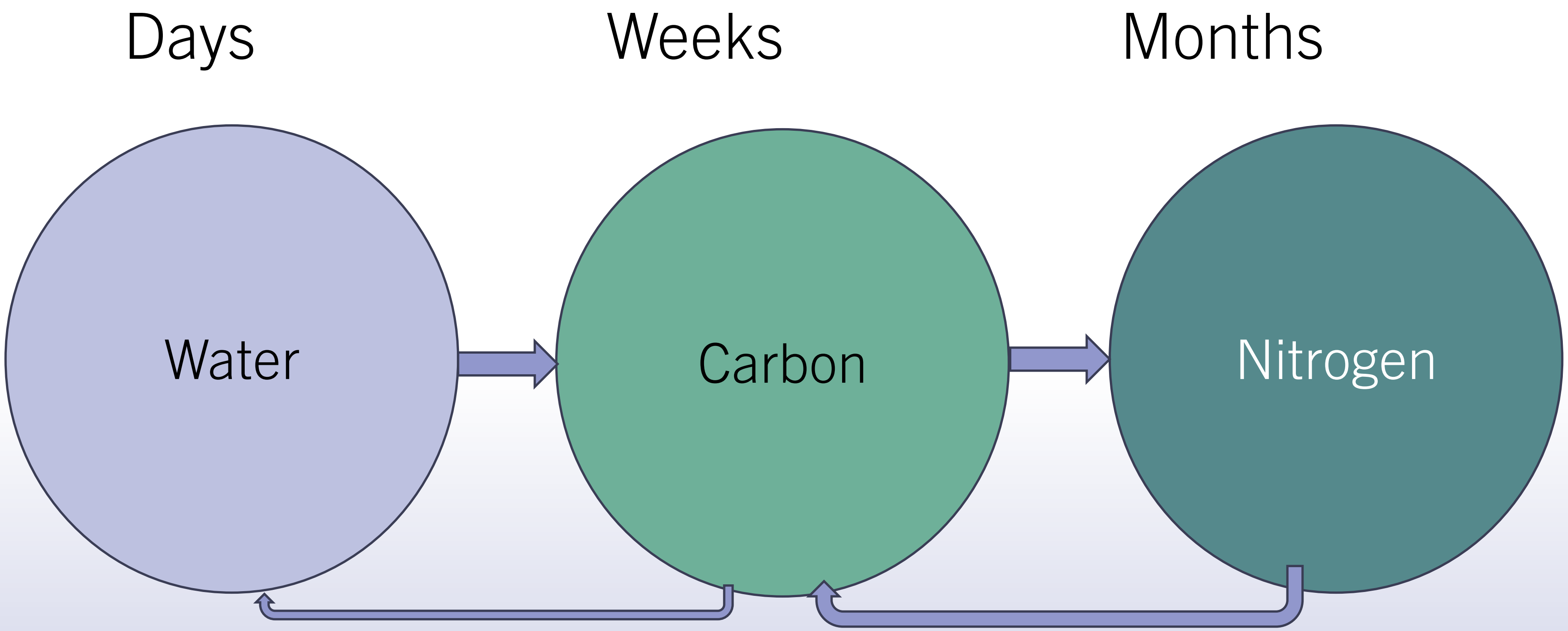
SOILS CHANGE RAPIDLY

- Transition of a field from conventional tillage to no-till with a cover crop showed a rapid change in aggregates and microbial biomass
- The conversion occurred in the fall of 2016 and within one year, there was a doubling of the microbial biomass in the upper soil surface(0-6 in)



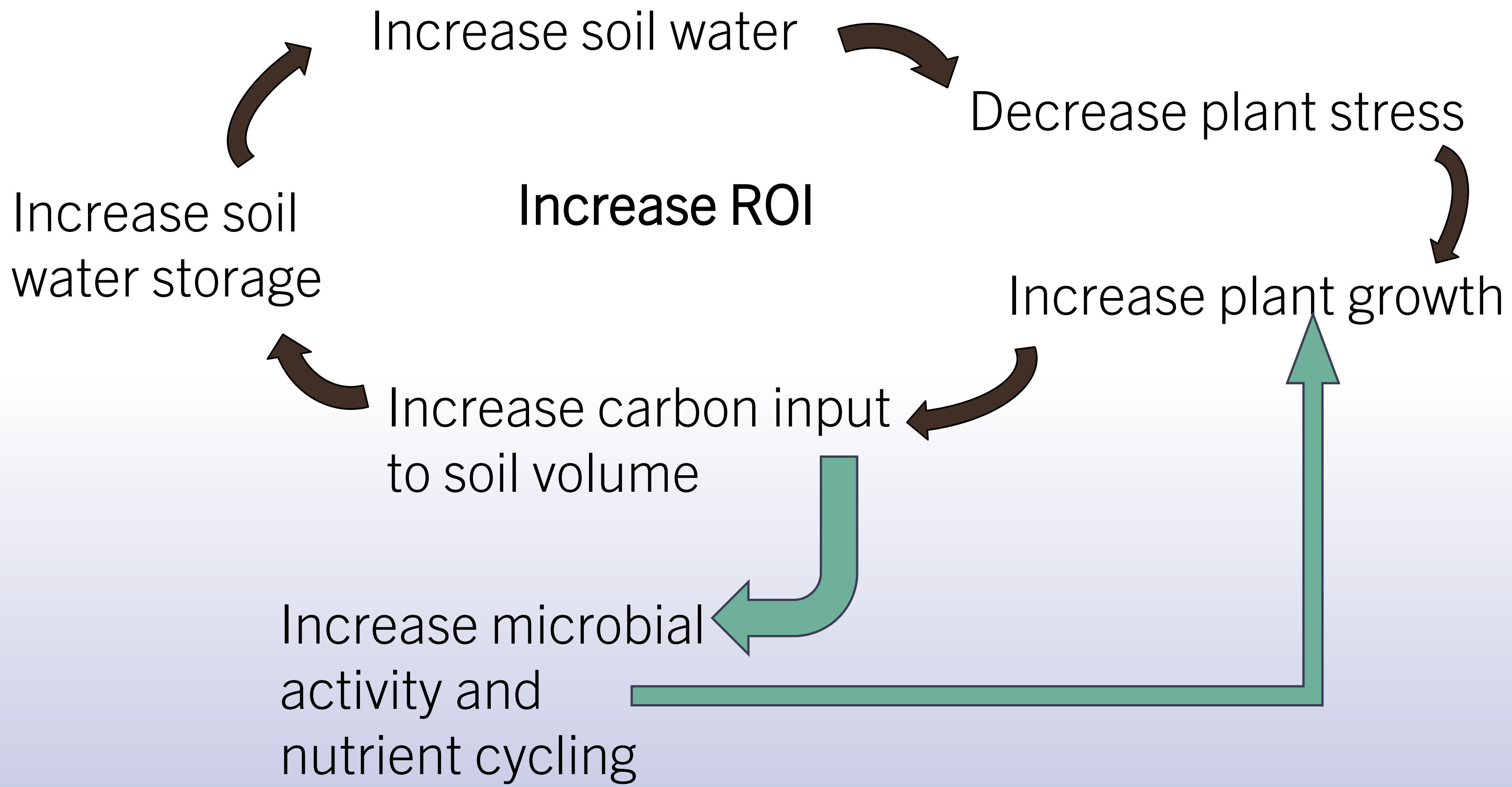


PROCESS OF CHANGE



Regenerative practices affect water availability, then carbon, then nitrogen

SOIL WATER AND SOIL CARBON



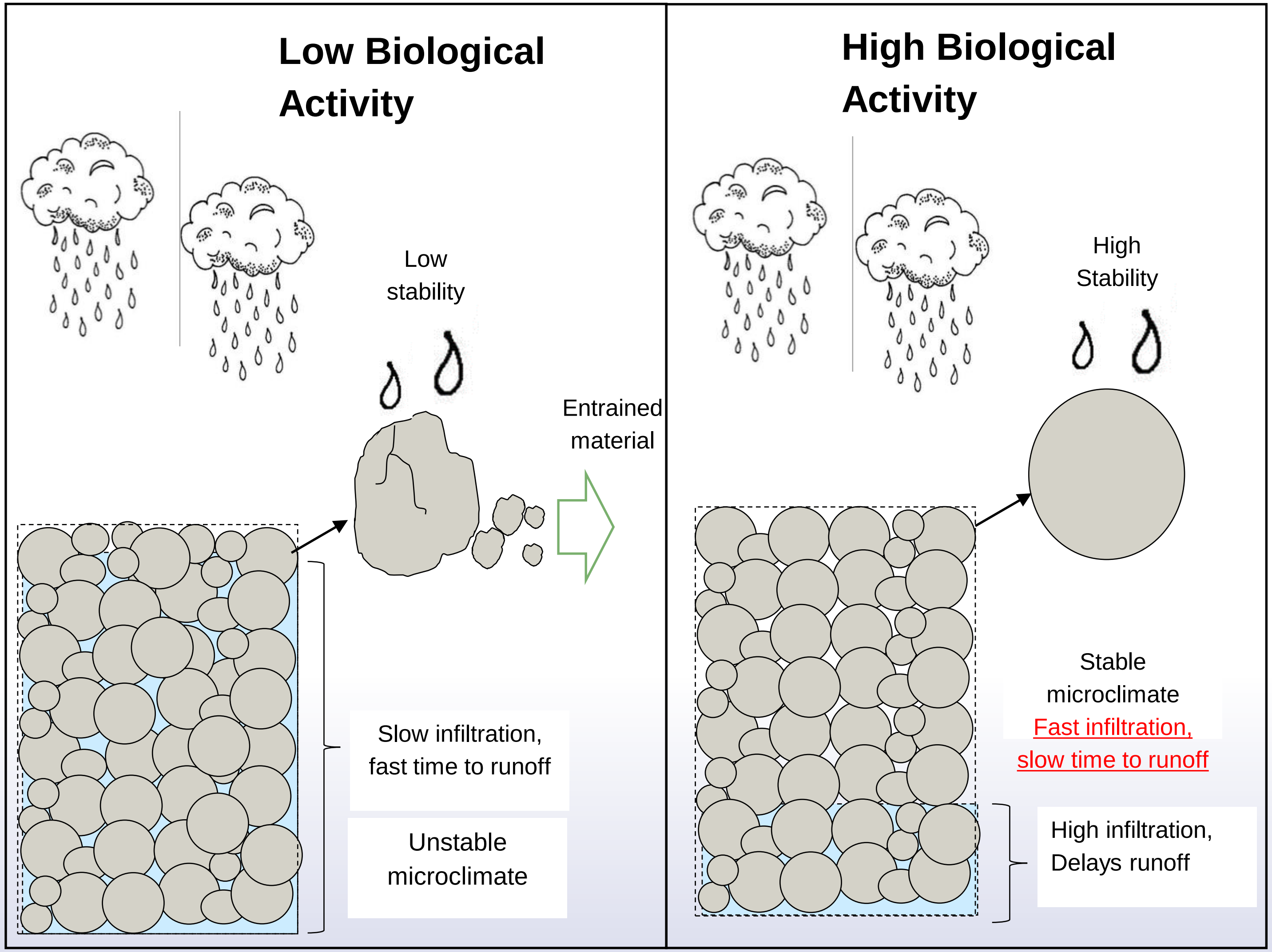
MAINTAINING SOIL ARMOR

Attributes of regenerative agriculture that impact water significantly are the focus on continual cover of the soil

Continual cover provides three advantages for soil water

- First, protection against raindrop energy so soil aggregates are protected and infiltration rates are maintained
- Second, soil water evaporation is reduced so water is used by the plant for transpiration
- Third, plant roots are near the surface so take advantage of small rainfall events

Assessing the Dynamics of the Upper Soil Layer Relative to Soil Management Practices



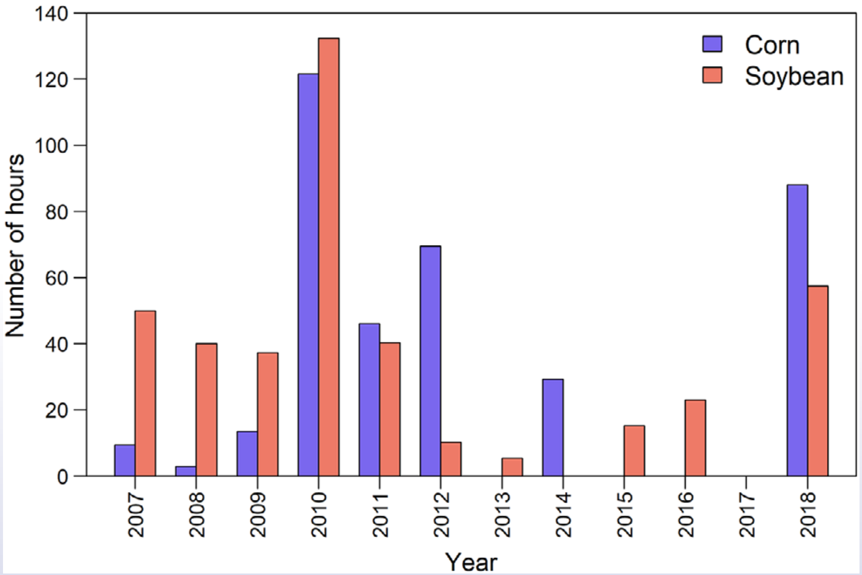
MAINTAINING SOIL ARMOR

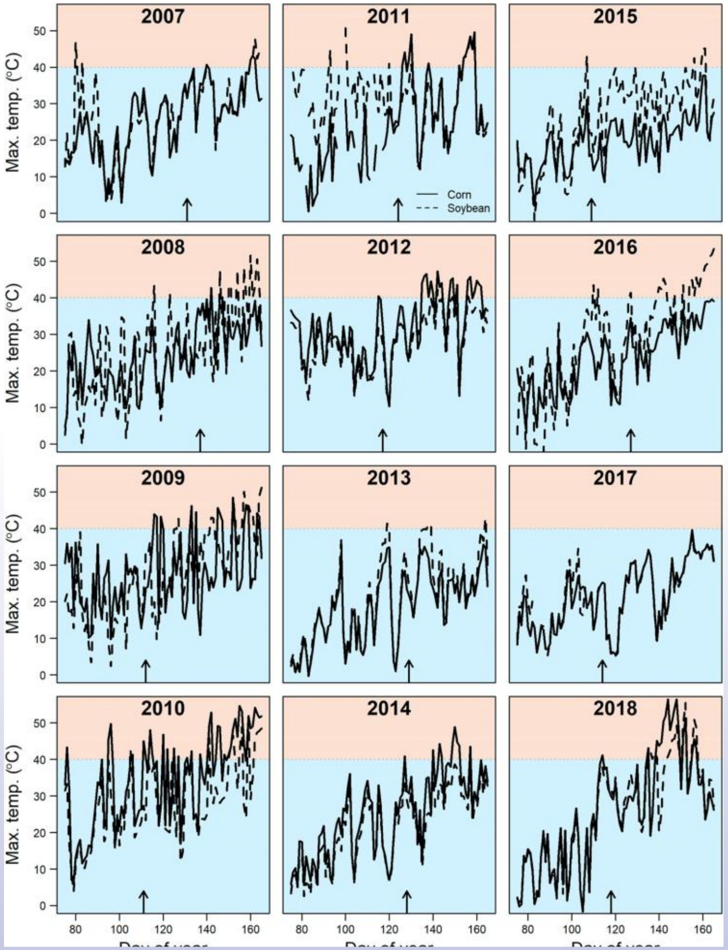
- Attributes of regenerative agriculture that impact soil microclimate significantly are the focus on continual cover of the soil
- Continual soil cover

  Reduces temperature extremes

  Maintains the temperature in an optimal range for microbial activity

SURFACE TEMPERATURES UNDER CONVENTIONAL TILLAGE SYSTEMS

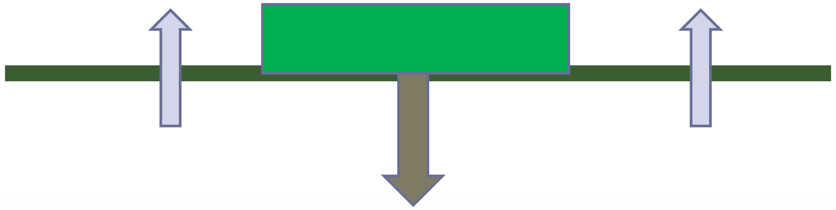




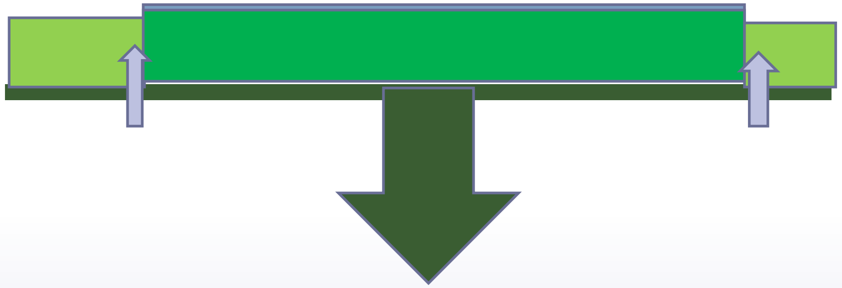
Typical conventional systems are exposed to temperatures above lethal limits (40 C or 104 F) for biological activity

ROLE OF COVER CROPS IN CROPPING SYSTEMS

Cropping system without cover crops - Limited time for input and losses due to tillage, losses equal the gains or exceed



Cropping system with cover crops - Increased time for inputs into the soil volume with minimal loss due to soil disturbance



Estimate 25% of the available solar radiation in Ames, Iowa is in these shoulder periods

AGRICULTURE AND SOIL FUNCTIONALITY

Revolves around the flow of energy across the soil-plant-atmosphere system

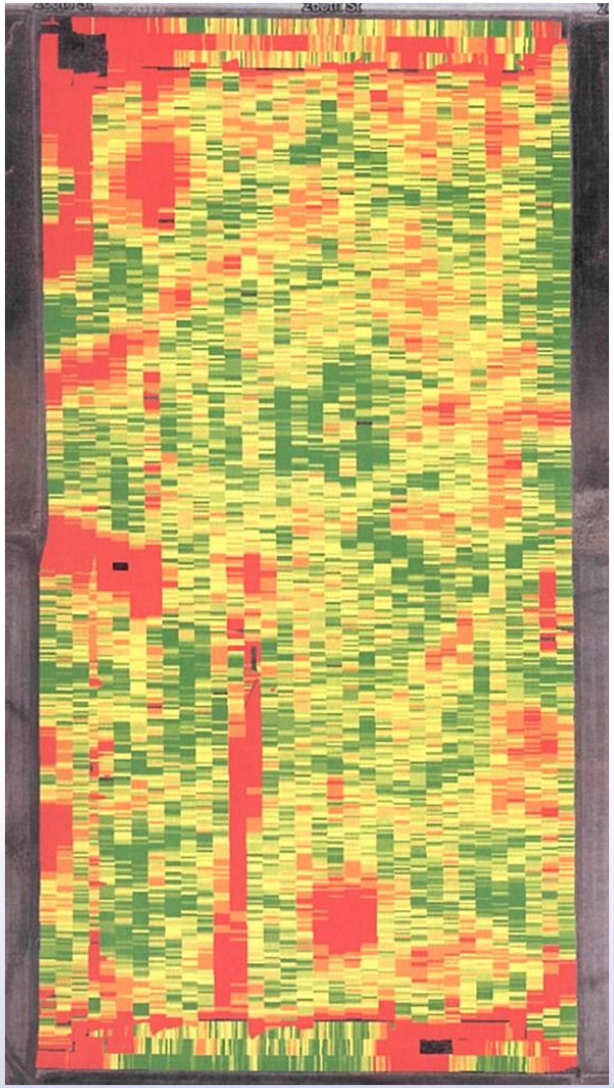
Proper functioning of the ecosystem begins with the soil

Regenerative agricultural practices have their foundation on how we enhance soil functionality

CURRENT CROPPING SYSTEMS IN THE MIDWEST

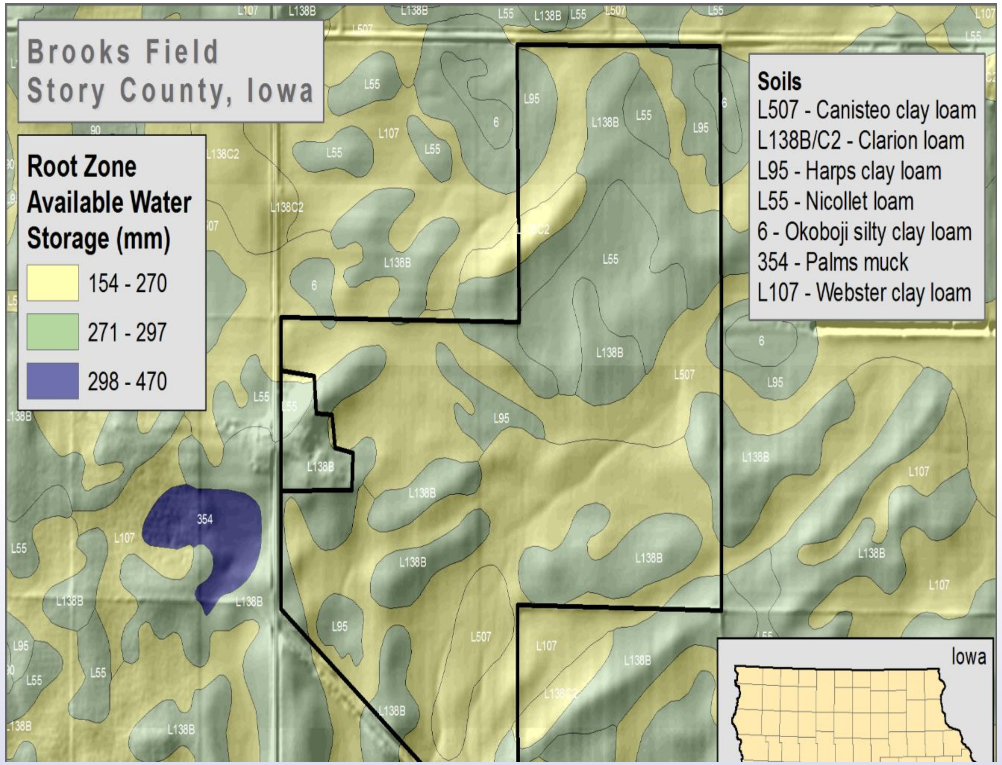
- Losing carbon at the rate of 1000 lbs C/acre/year (8000 lbs water/acre/year)
- If you farm 40 years, lost 20 tons of C
- What we consider as proper management is slowly degrading our soils
- We have lost our ability to infiltrate, store, and make water available
- Created yield variation across fields because of limited soil water holding capacity

MAIZE FIELD VARIATION



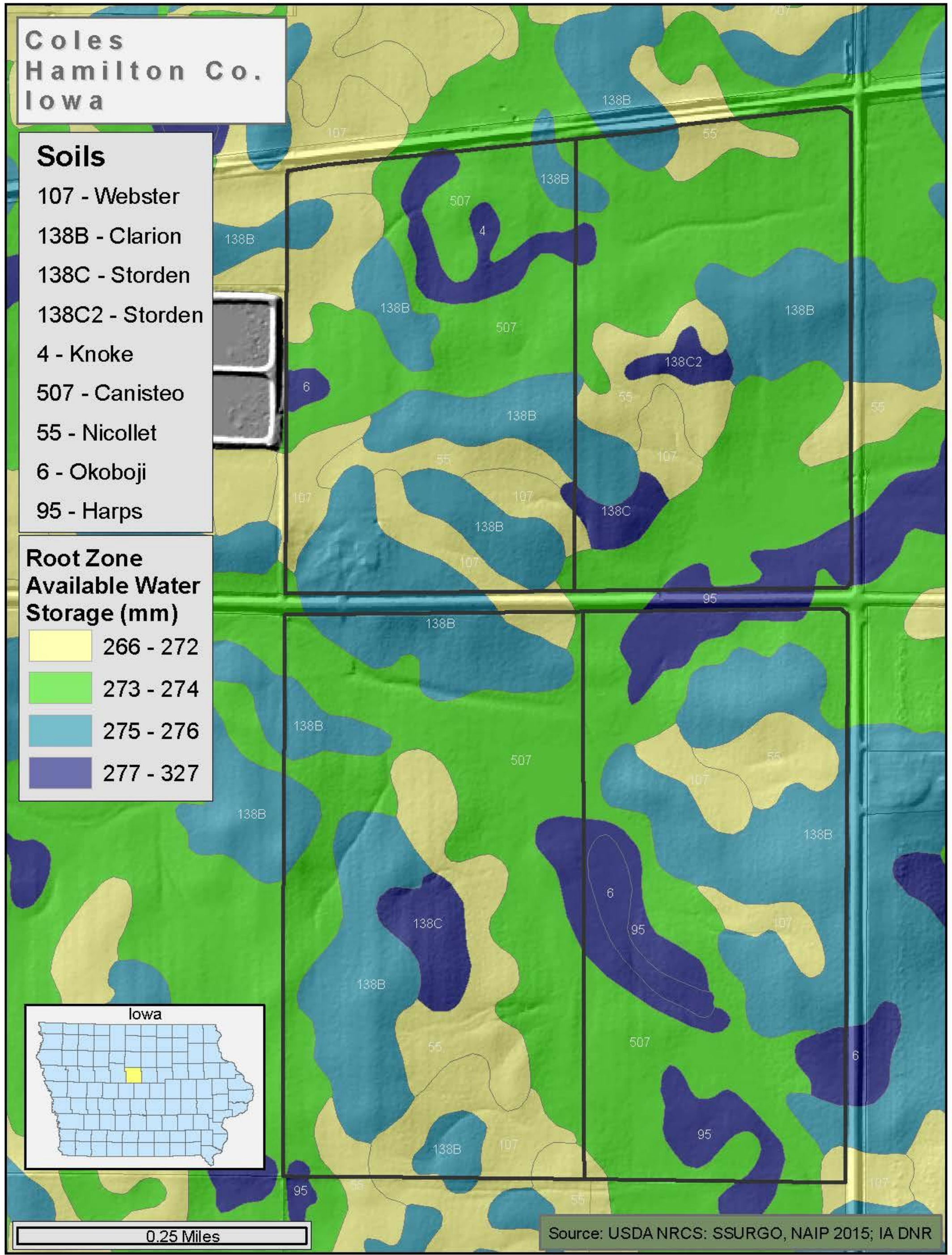
ROLE OF SOIL WATER

- Soils vary in their water holding capacity
- Organic matter affects soil water availability within a soil type



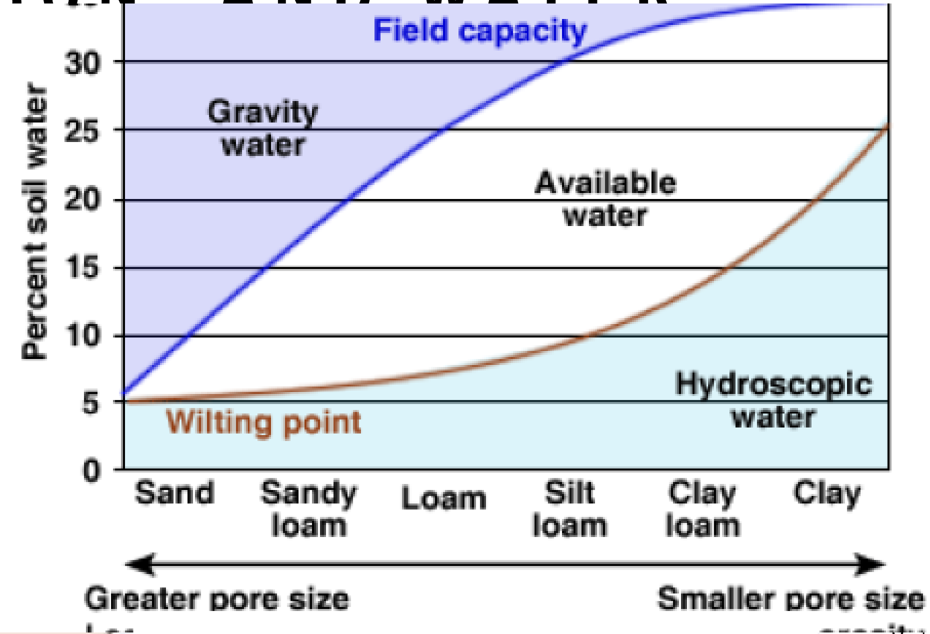
VARIATION IN WATER HOLDING CAPACITY

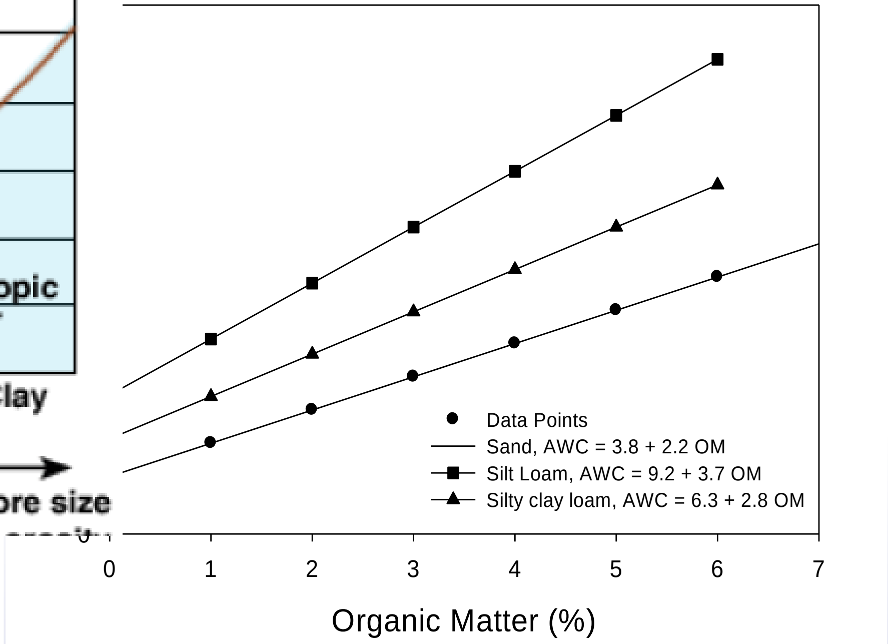
VARIATION IN AVAILABLE SOIL WATER DRIVES YIELD VARIATION IN A FIELD



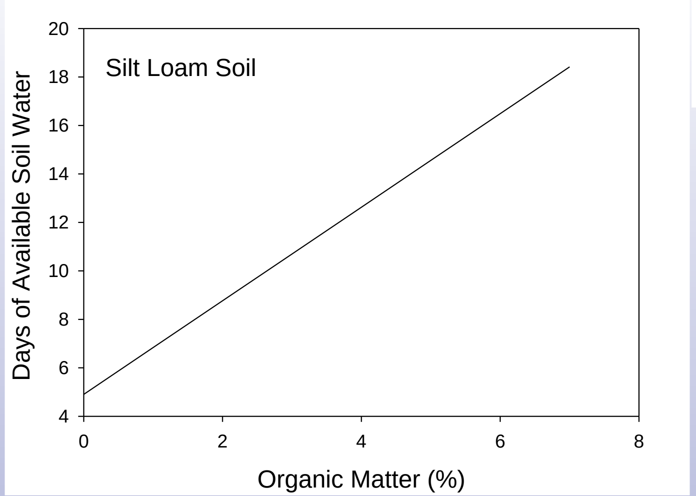
SOILS, CARBON, AND WATER

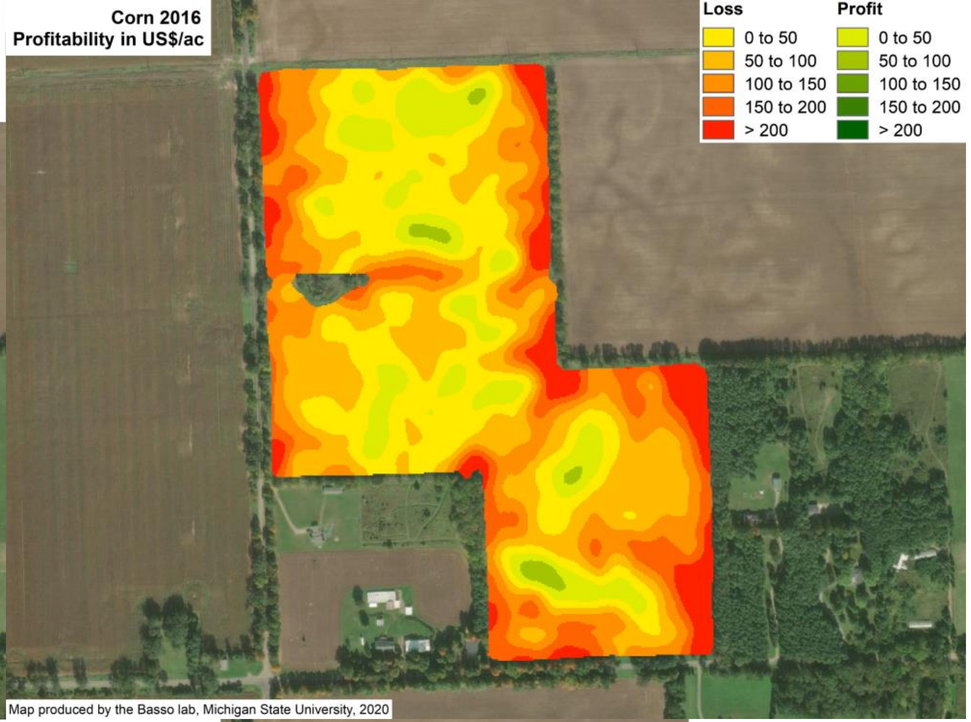
Available water capacity by soil text	
Textural class	Available water capa (inches/foot of dep
Coarse sand	0.25–0.75
Fine sand	0.75–1.00
Loamy sand	1.10–1.20
Sandy loam	1.25–1.40
Fine sandy loam	1.50–2.00
Silt loam	2.00–2.50
Silty clay loam	1.80–2.00
Silty clay	1.50–1.70
Clay	1.20–1.50

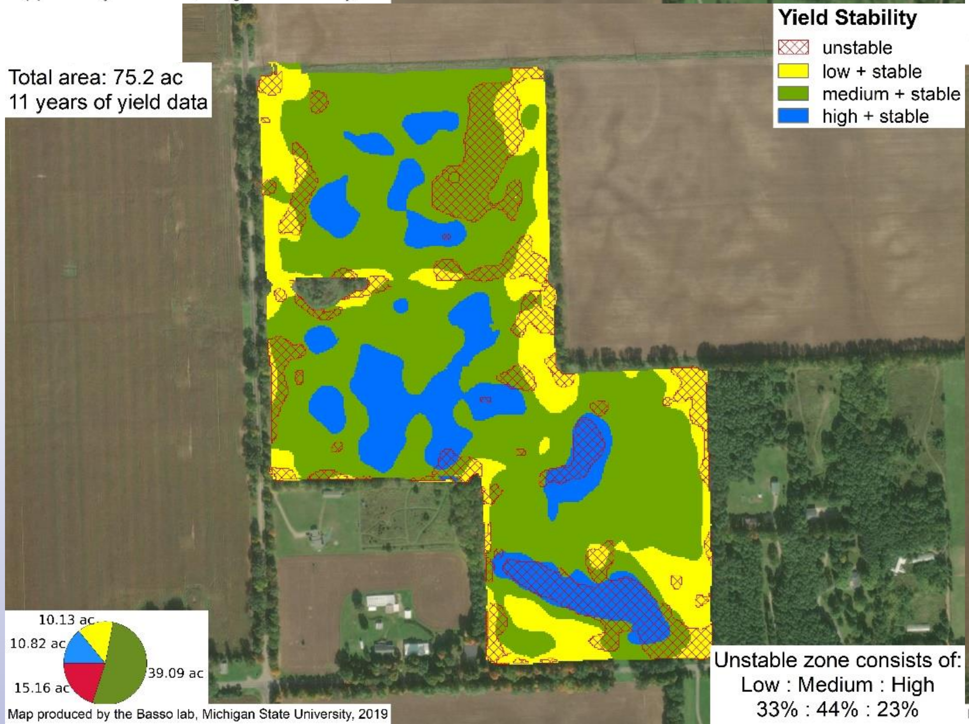


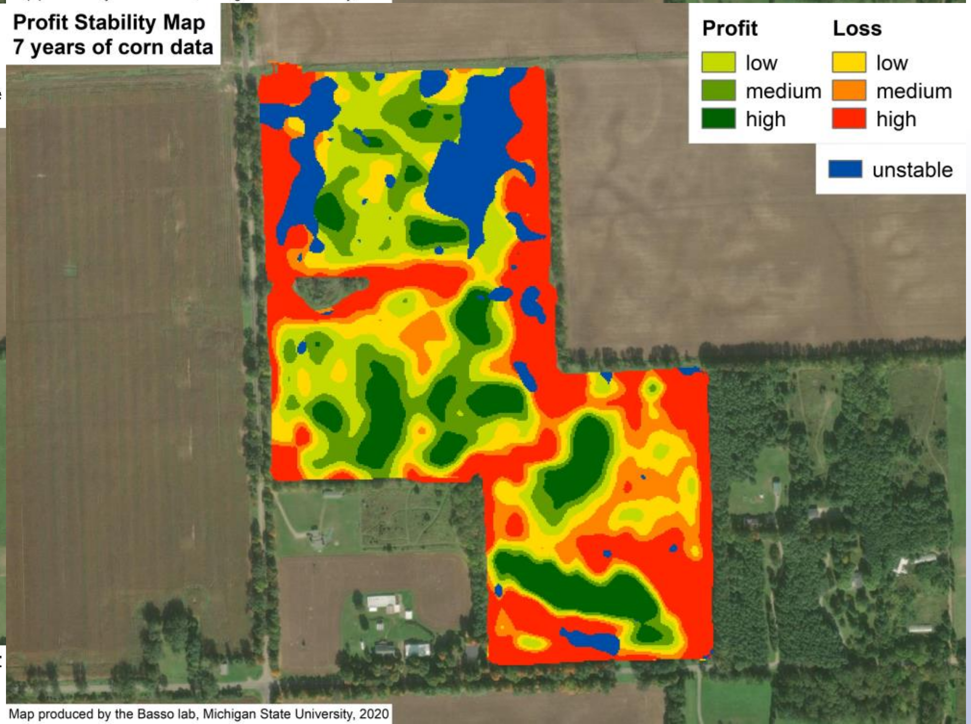


Hudson, 1994









Low $50
Med. $100
High $200

INCREASE WUE AND NUE

- Practices that enhance the efficiency of plant growth will benefit plant productivity more than water use
- Practices that increase water availability will benefit plant productivity because of increased photosynthetic efficiency
- Practices that enhance ability of the soil to alleviate stress in the early season (enhanced aggregates) and late season (increased SOM content and reduced evaporation) will increase WUE
- Practices that enhance plant productivity will increase NUE

SOIL WATER DYNAMICS

- Water is one of the most limiting factors to crop productivity

  80% of the yield loss is due to short-term water stress because of insufficient soil water in the profile

  Yield and profit robber is due to the inability of the soil to infiltrate and store water

Which field is profitable?

LINKING THE FOUR R'S

- <u>Nitrogen</u>
  - Right Rate
  - Right Time
  - Right Place
  - Right Form
- <u>Water</u>
  - Revitalize-organic matter
  - Retain-infiltrate
  - Reduce-evaporation
  - Retrieve- transpiration

Untapped potential in the application of precision agriculture to link water and nitrogen management to benefit agricultural producers

CHANGES AT WAYNE FREDERICKS

1992

No-till soybeans in 1992

2003

Strip-till corn in 2003

2012

Cover crops beginning in 2010, over all fields in 2012



DATA

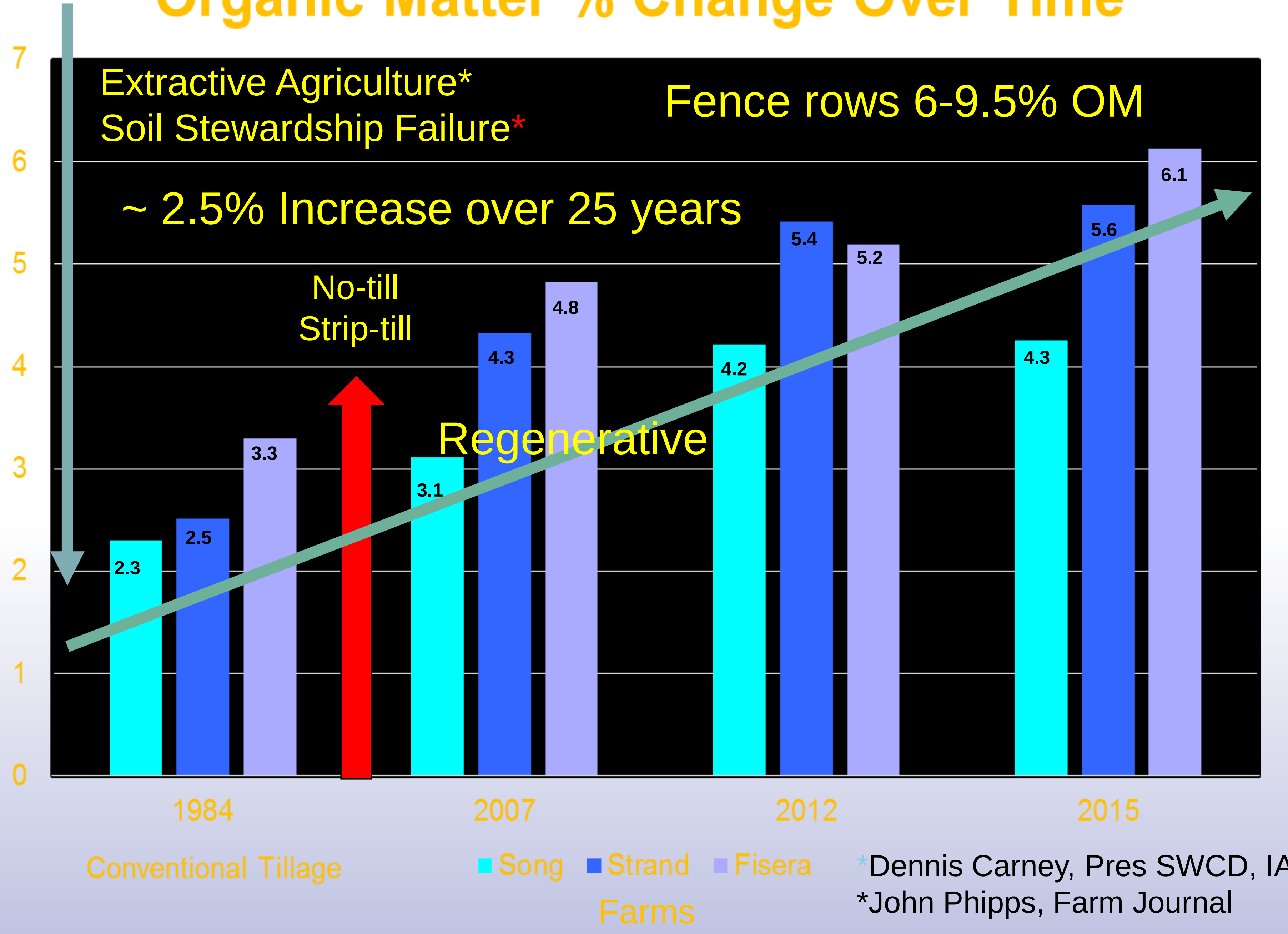
Availability

- Soil organic matter samples in fields
- Yield monitor data
- Weather data
- Mitchell county yield data

Analysis

- Soil organic matter changes
- Field vs county level yields
- Field uniformity of yield
- Weather resilience

Organic Matter % Change Over Time

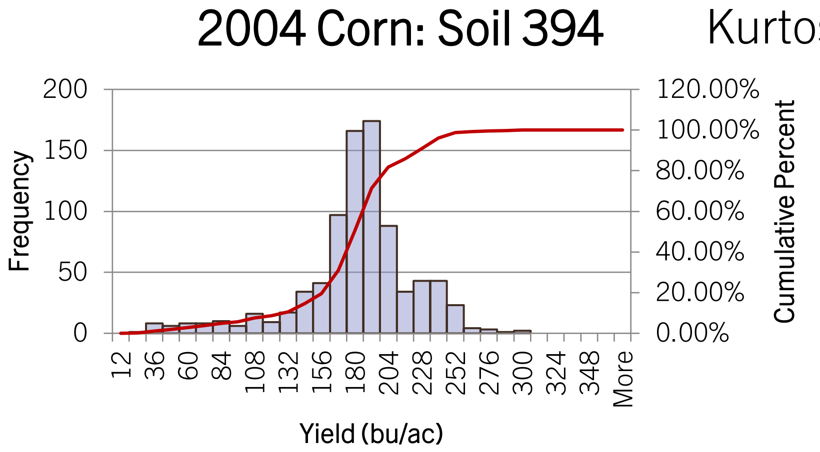


*Dennis Carney, Pres SWCD, IA
*John Phipps, Farm Journal

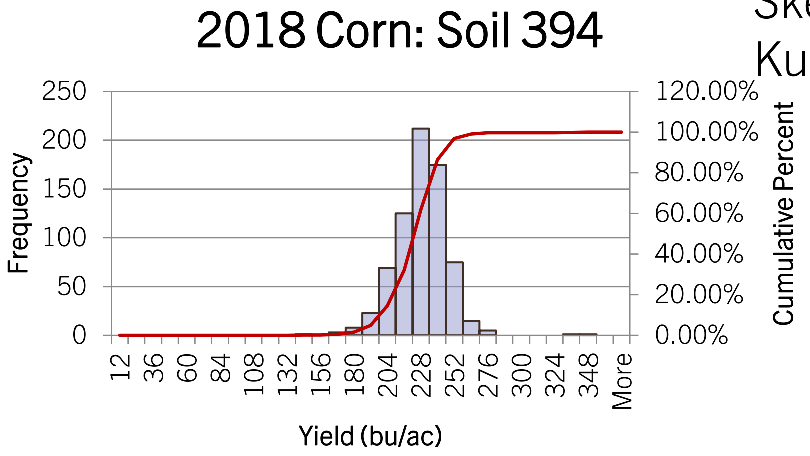
INCREASING UNIFORMITY IN FIELDS

Soil 394 Ostrander loam

Skewness -1.01
Kurtosis 2.30

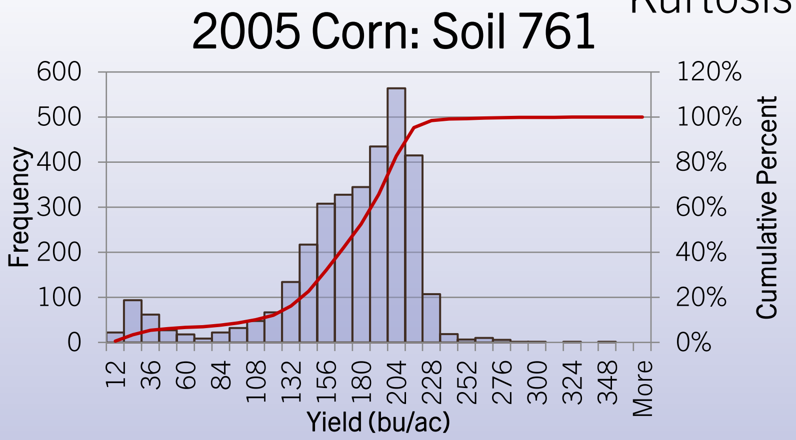


Skewness 0.19
Kurtosis 4.48

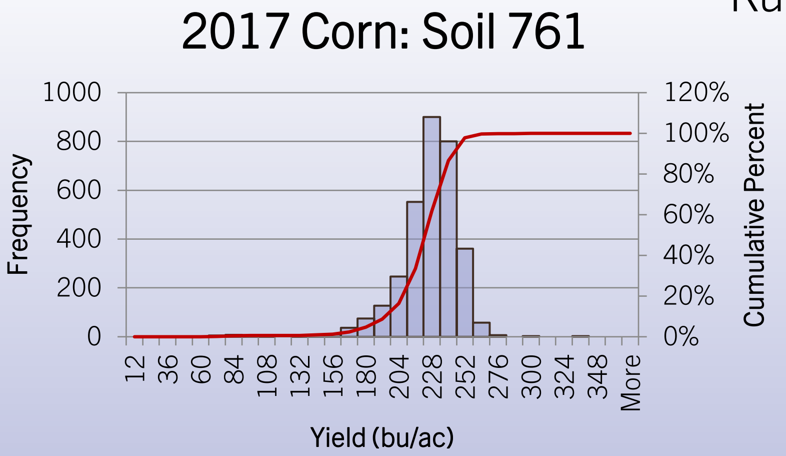


Soil 761 Franklin silt loam

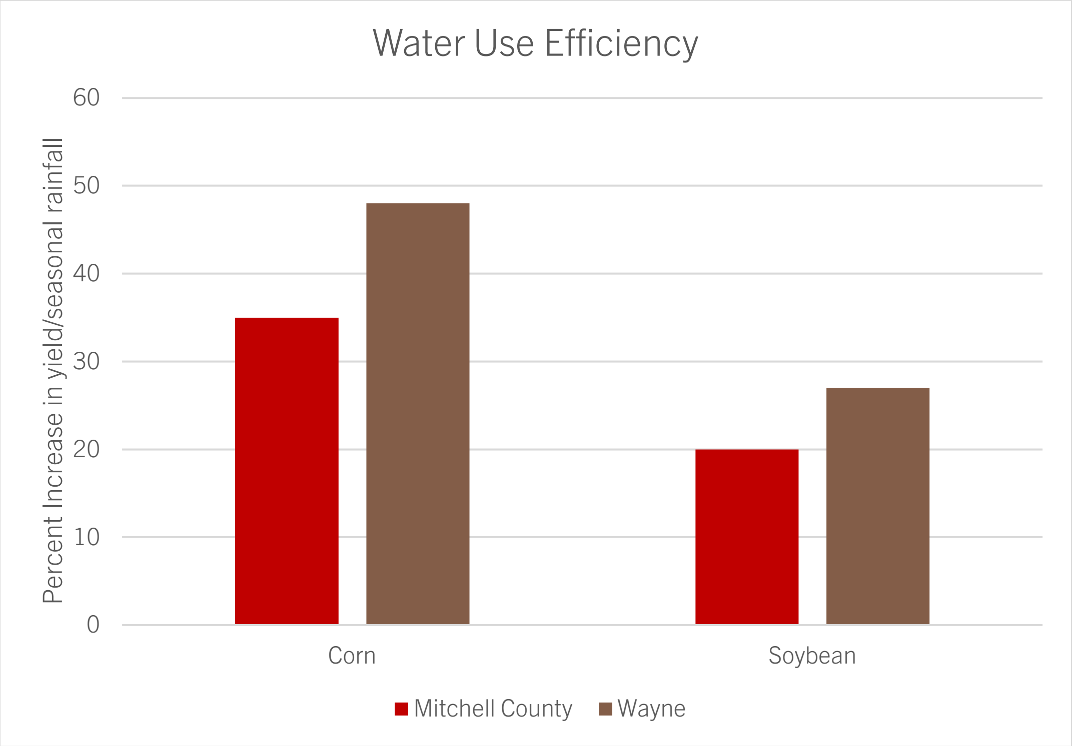
Skewness -1.99
Kurtosis 2.21



Skewness -0.86
Kurtosis 7.91

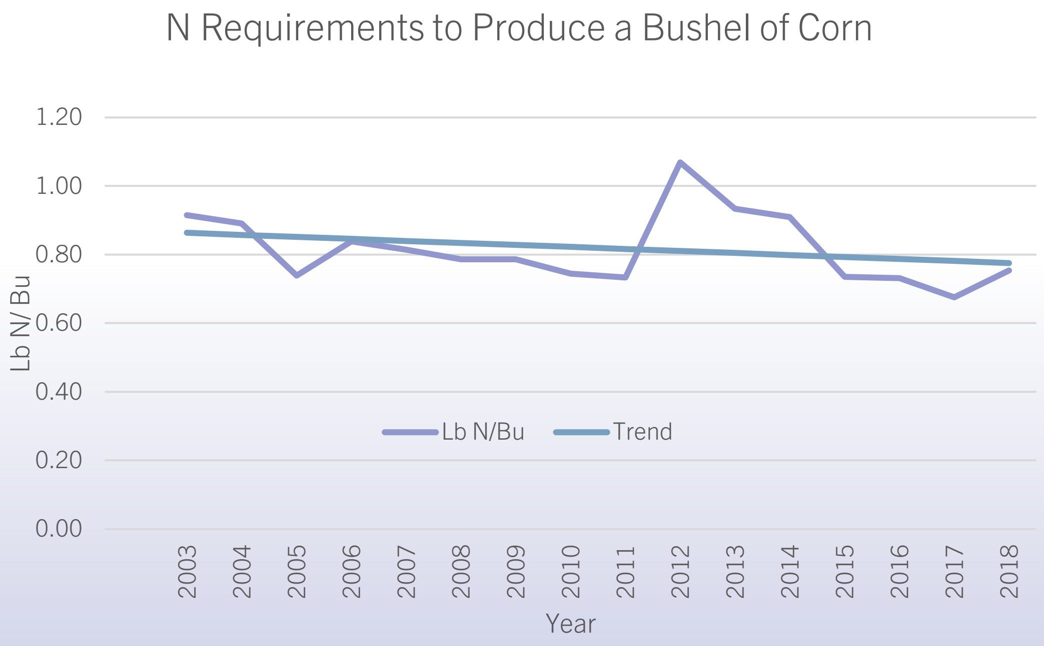


WATER USE EFFICIENCY



- Yield stability among years, less variation among years, standard deviation in yields half of conventional tillage
- Increased water use efficiency in terms of grain produced per unit of seasonal rainfall, increases in corn of nearly 50%
- Broke the correlation between April-May rainfall and low yields, and July-August rainfall and high yields

CHANGES IN N RESPONSE



With enhanced soil organic carbon and more water available the N requirements have decreased

CHALLENGES

- Build a system with a foundation of G x E x M (genetics x environment x management)
- Evaluate current cropping systems to determine where practice changes could be made that would enhance soil functionality
- Observe the changes within a soil within a field
- Form a support community to explore potential ideas and unexpected results
- Realize that seasonal weather changes often dominate the impact of any changes
- Try, evaluate, adjust, evaluate, tweak, repeat

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