PATHWAY TOWARD A HEALTHY AND RESILIENT SOIL TO ACHIEVE OPTIMUM PRODUCTIVITY AND ENVIRONMENTAL QUALITY

Cover Crops are Key

DEFINITIONS

Resilience- ability to recover from a stress

Optimum productivity- production that effectively utilizes the resources available from water, light, and nutrients

Environmental quality- state of water, soil, and air resources

FRAMEWORK

G x E x M

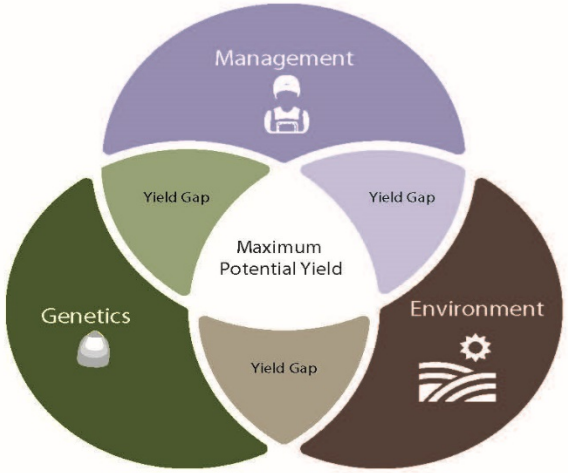
Water, Nutrient, and Light Use Efficiency

Soil Health

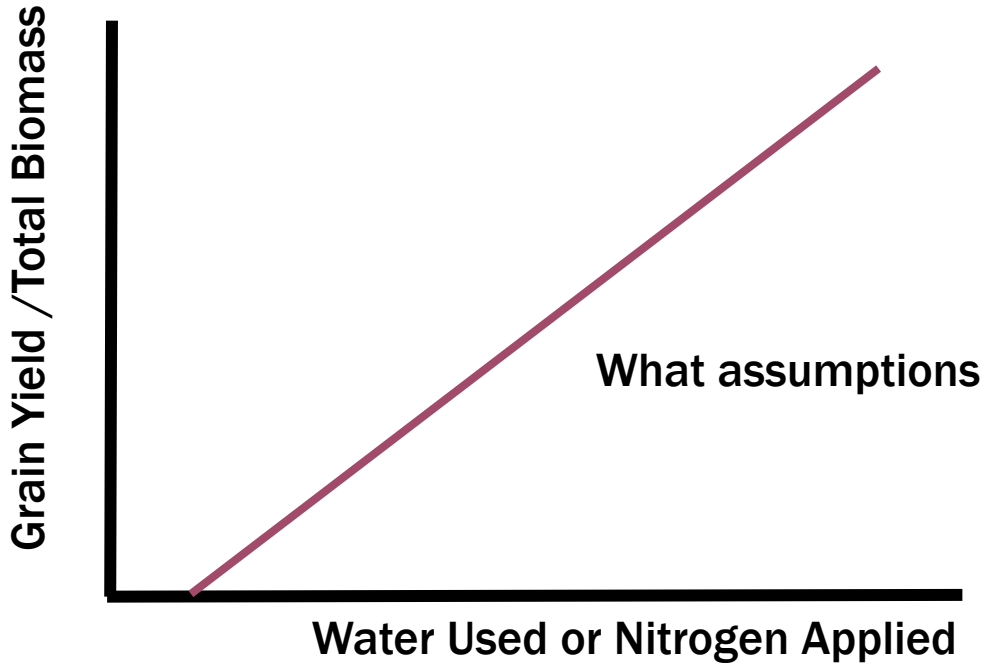
Overcoming Variability for Maximum Yield

G x E x M

Genetics (optimize) x Environment (overcome) x Management (oversee)



WATER OR NITROGEN USE EFFICIENCY

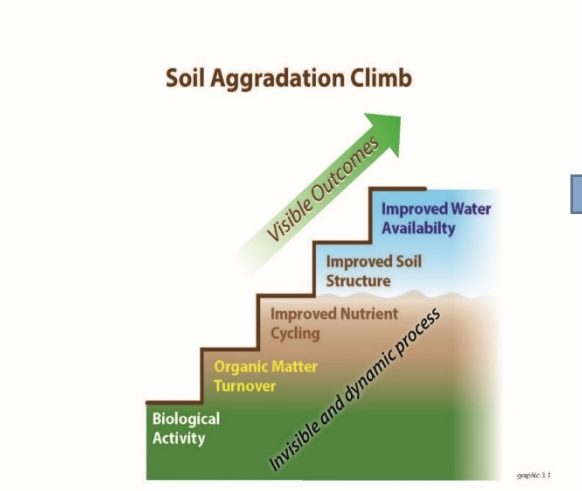


What assumptions do we make about efficiency?

SOIL HEALTH

Soil health is a cornerstone to production, environmental quality, and economic return.

The impact of soil health can be seen in the visible attributes of the soil



OUTLINE

Soil Degradation

Soil Health Processes

- Cover Crops
- Nutrient Management

Implications for Improved Crop Production Efficiency

SOIL DEGRADATION SPIRAL

Poor Land Management

Aggregation Degradation

Compaction & crusting

Water & Wind Erosion

Plant Growth

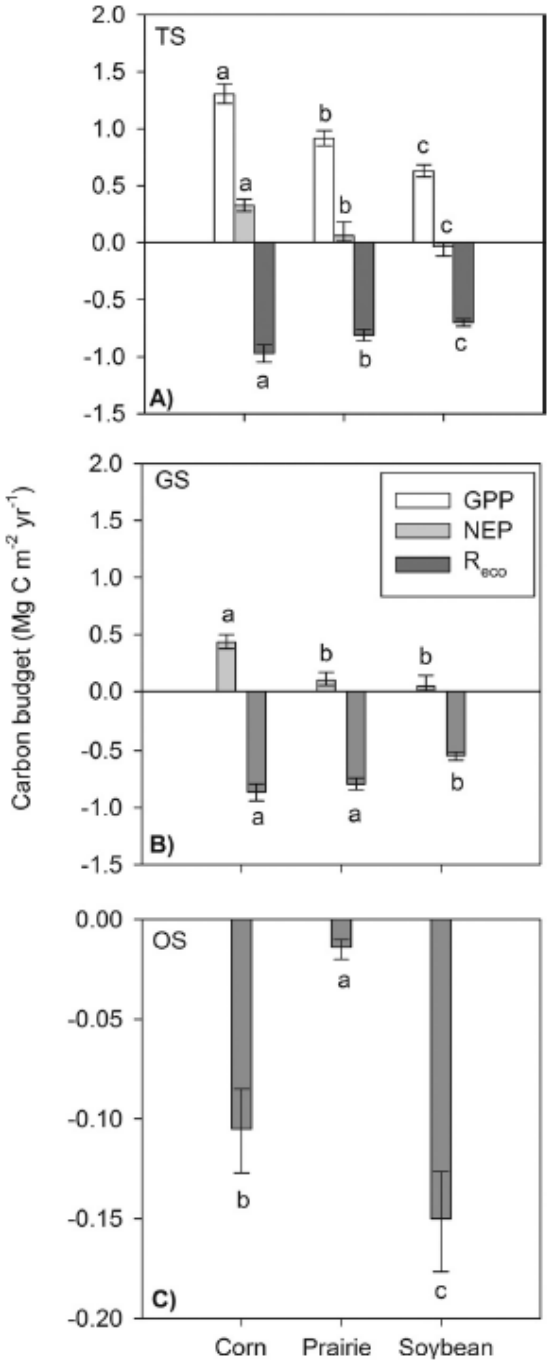
Soil Biology

Yield

Reduced Soil Productivity

Carbon Balance of Midwestern Cropping Systems

Typical corn-soybean production systems lose nearly 1000 lbs/acre of carbon each year



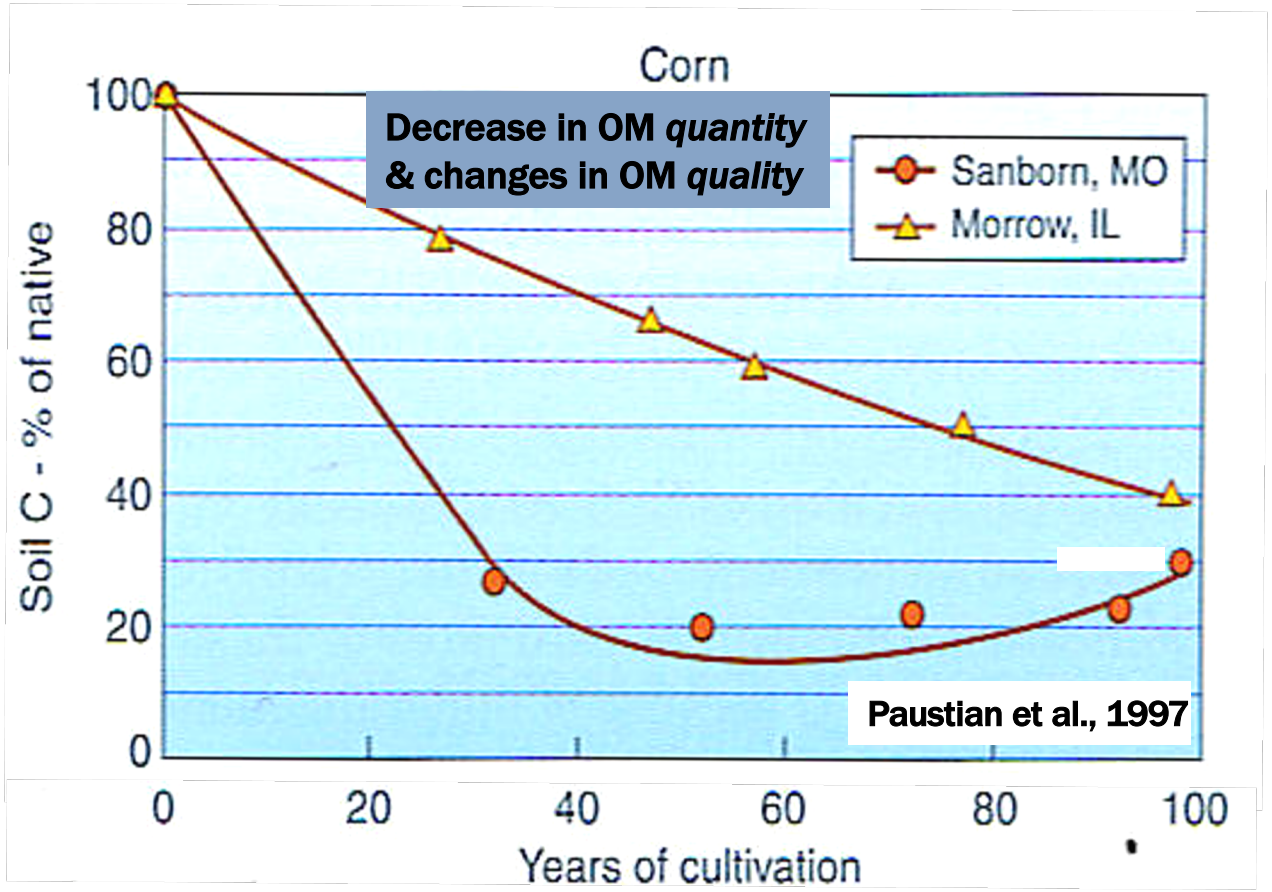
INTENSIVE TILLAGE

Reduces soil carbon in the upper surface

Leads to instability in the aggregates at the soil surface

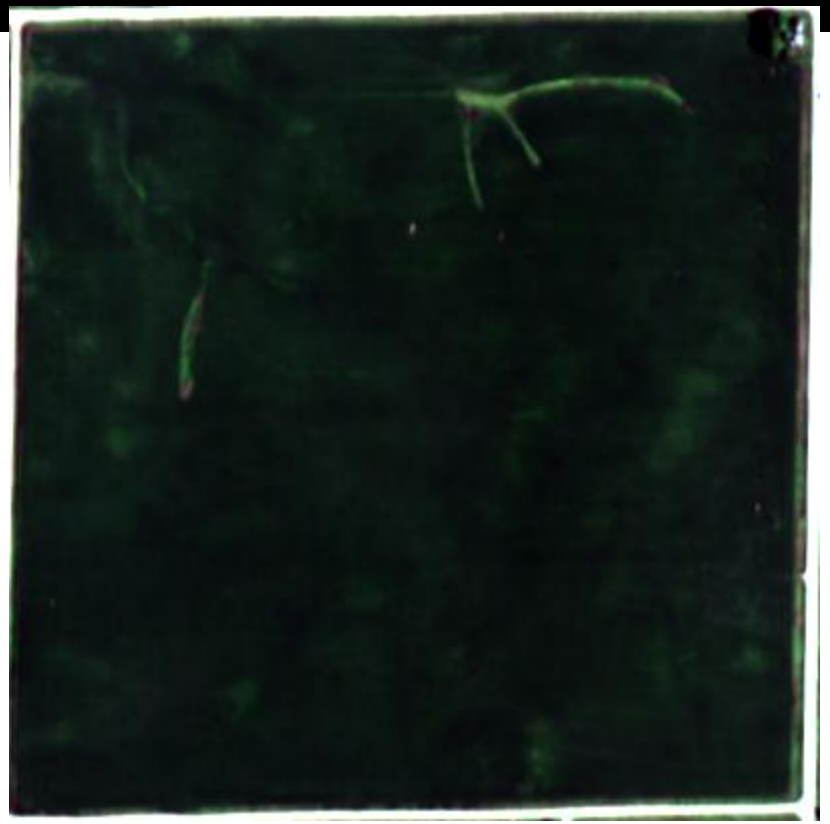
Limits the potential infiltration of precipitation because of the lack of stable aggregates and exposure to direct impact of raindrops onto the soil surface

Soil Organic Matter Changes over Time

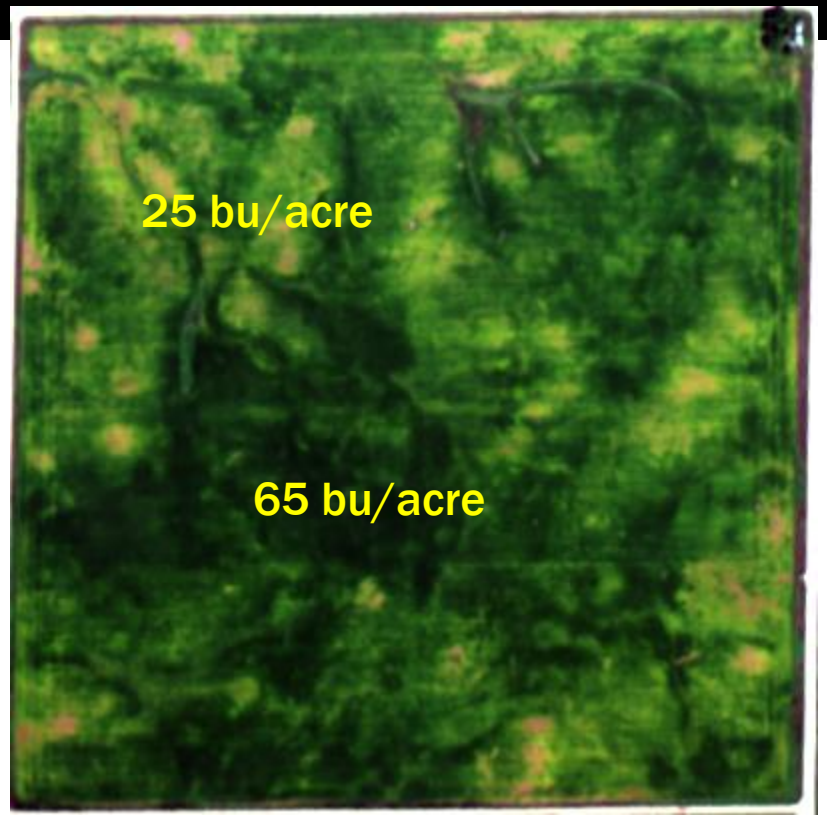


SOYBEAN PRODUCTION FIELD

Early August



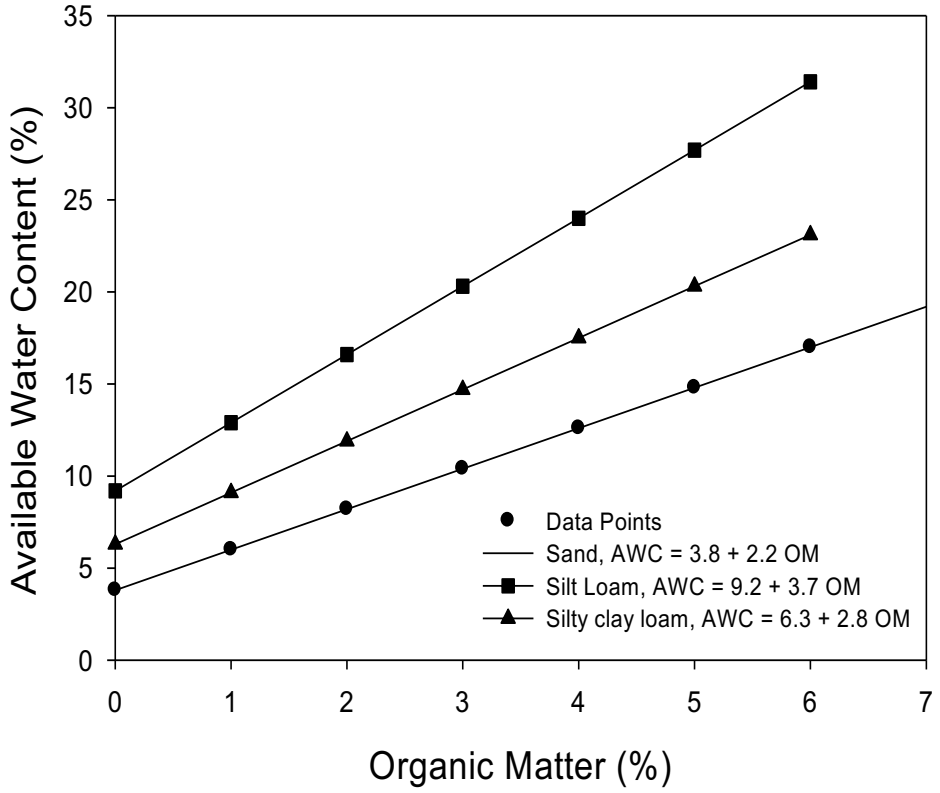
Late August



Yield variability in a field comes from soils inability to supply water during grain-filling

ORGANIC MATTER AND SOIL WATER HOLDING CAPACITY

Hudson 1994 showed a direct relationship between organic matter and available water content



ORGANIC MATTER AND SOIL WATER

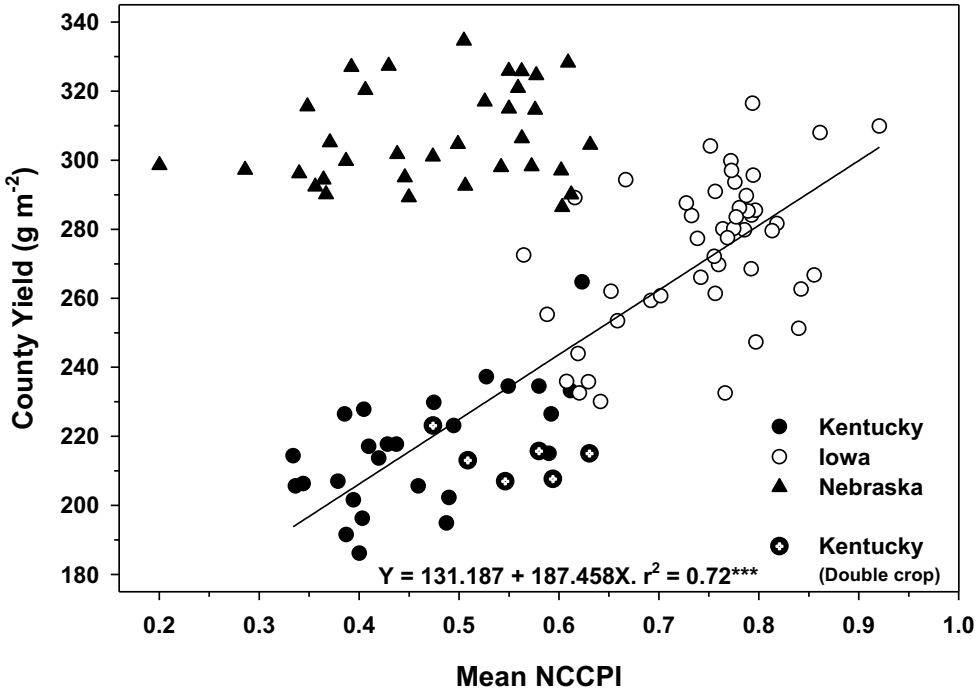
One question is how much organic matter enhance water availability

To address that question, consider that the upper 6 inches of soil has a mass of 1,808, 322 lbs/acre and if organic matter can hold 10 times its weight in water then a change in 1% organic matter would increase the water by 22,644 gal/acre

A corn crop during grain-filling could use 4000 gal/day, an extra 1% organic matter would provide 5 more days of water for optimum productivity

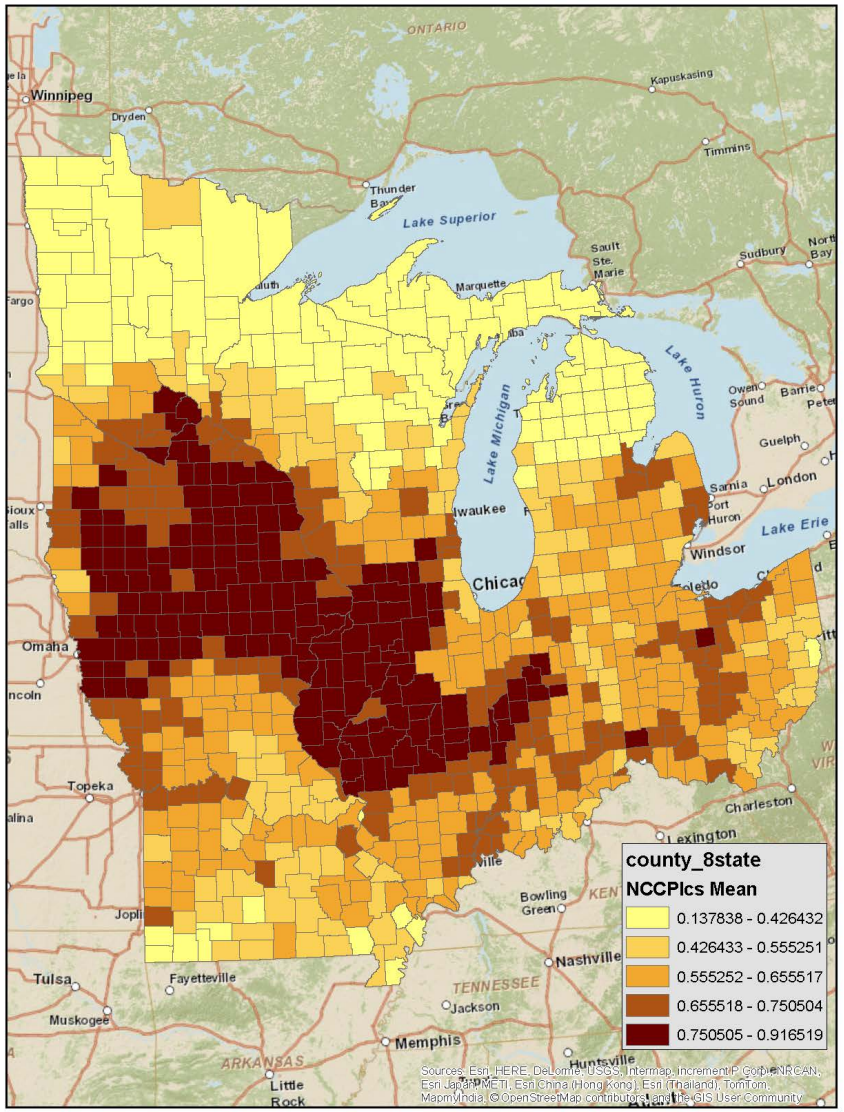
GOOD SOILS = GOOD YIELDS

Soybean yields across Iowa, Kentucky, and Nebraska

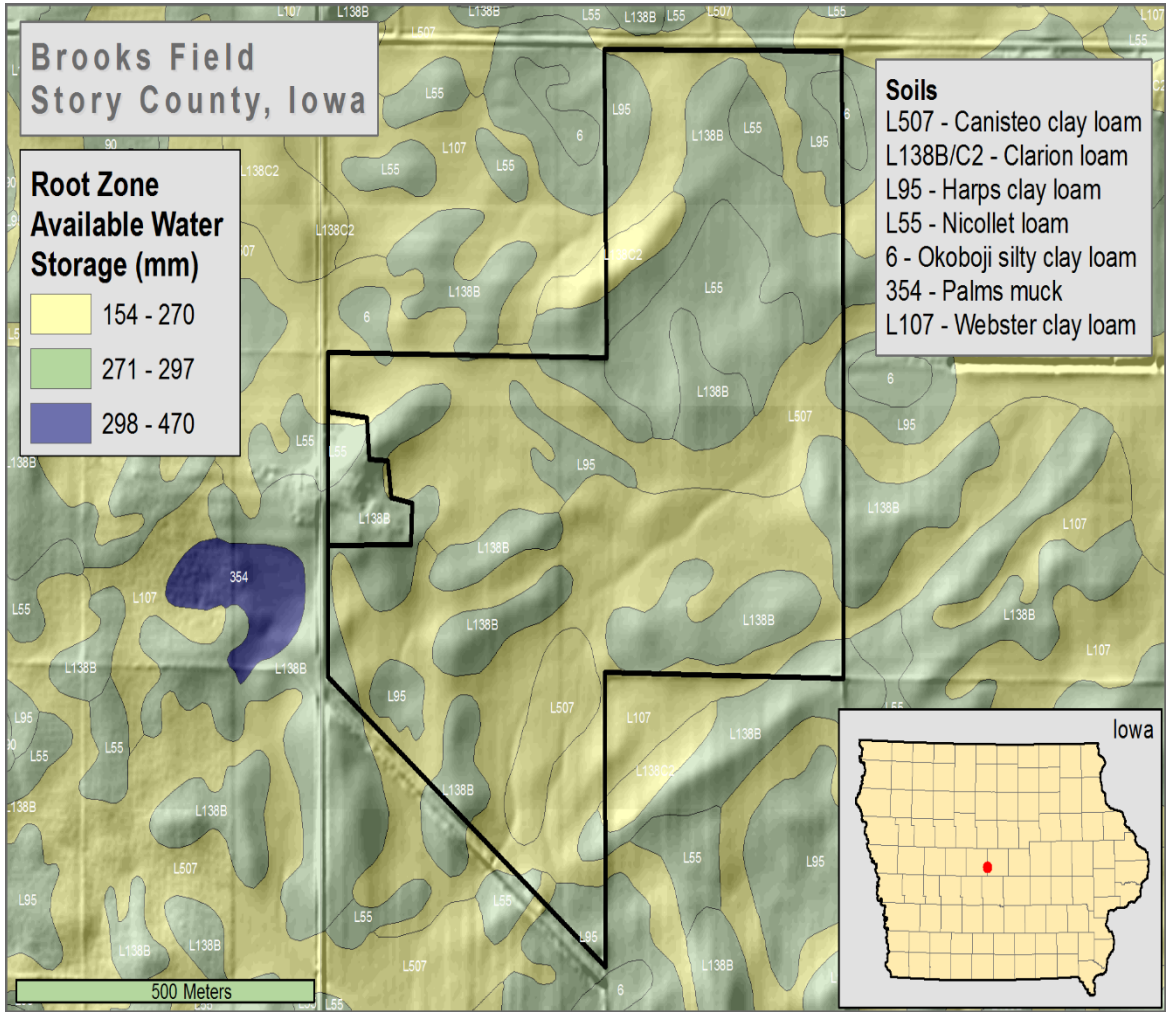


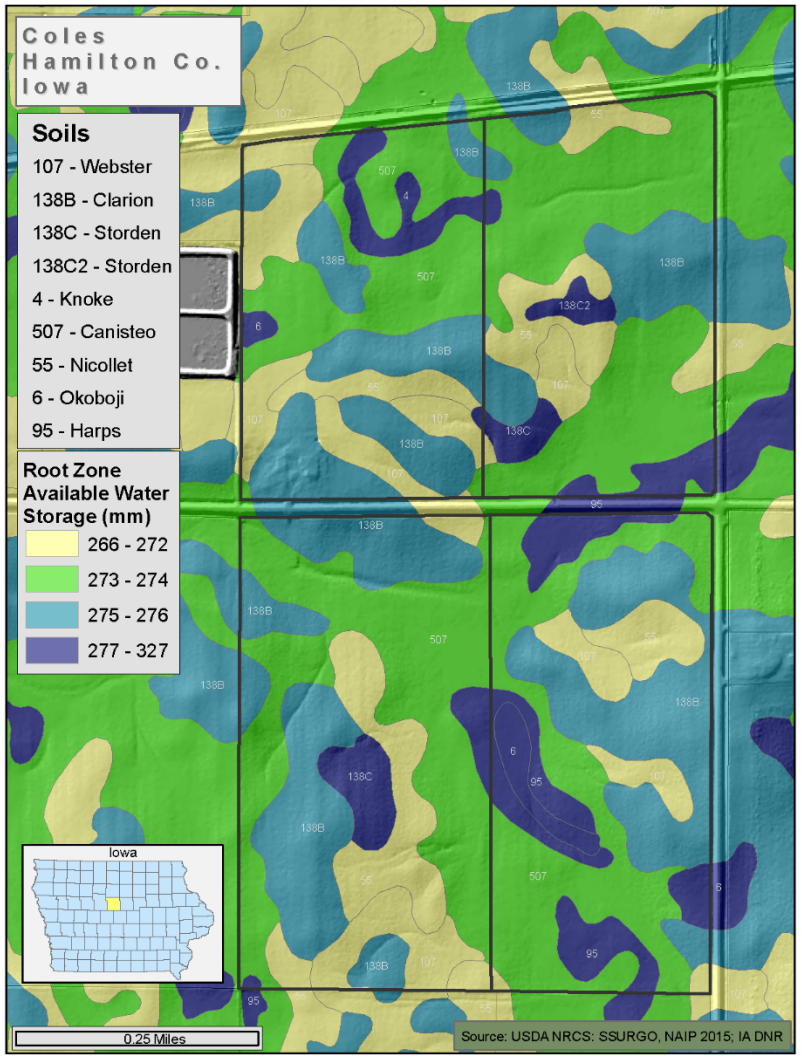
Climate resilience is derived from good soils in rainfed agricultural systems

VARIATION IN NCCPI ACROSS THE MIDWEST



Variation of Water Holding Capacity within production fields





SOIL HEALTH PATHWAY

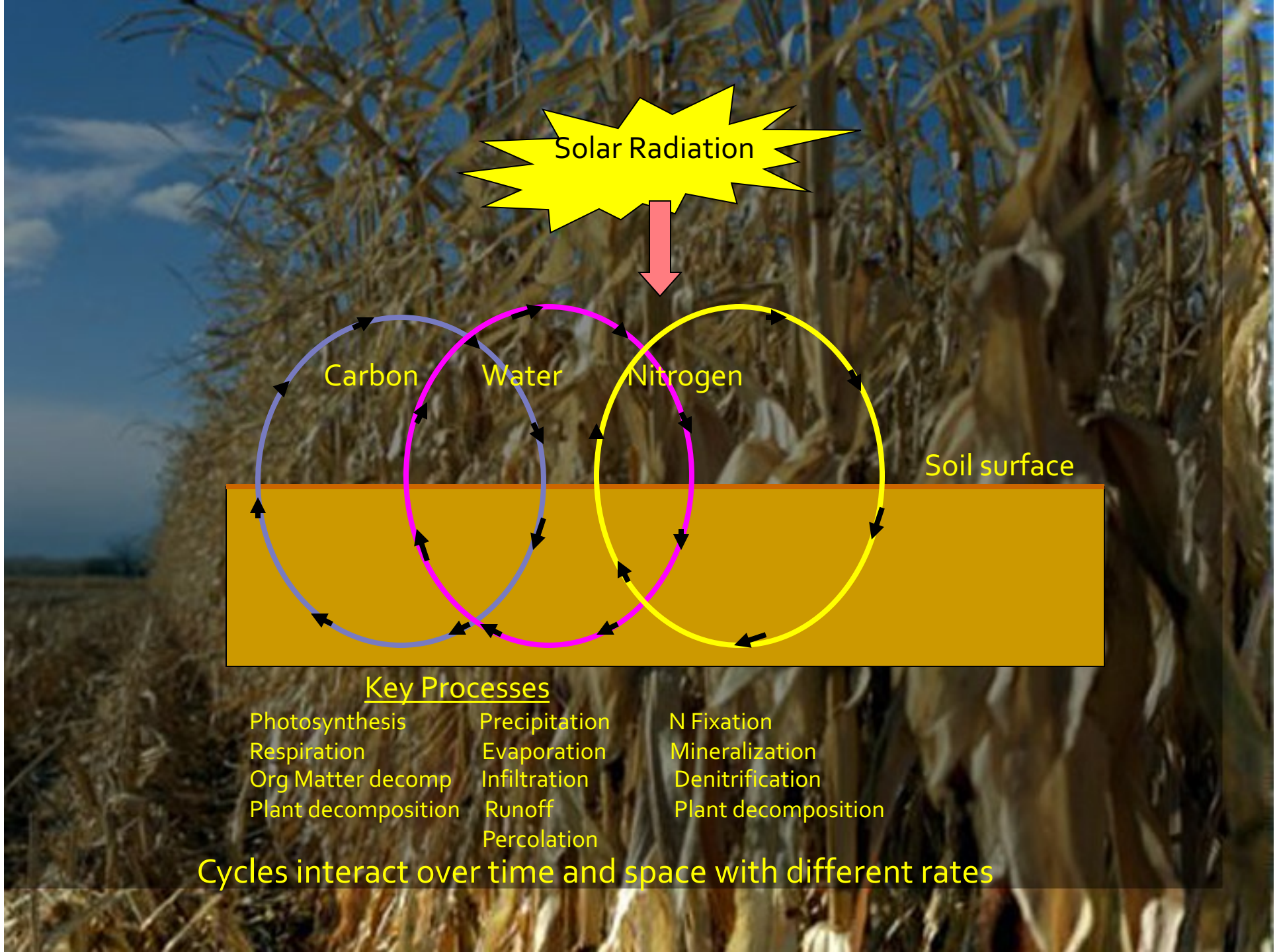
TO CHANGE SOIL HEALTH

FOOD

WATER

AIR

SHELTER



Key Processes

Photosynthesis	Precipitation	N Fixation
Respiration	Evaporation	Mineralization
Org Matter decomp	Infiltration	Denitrification
Plant decomposition	Runoff	Plant decomposition
	Percolation	

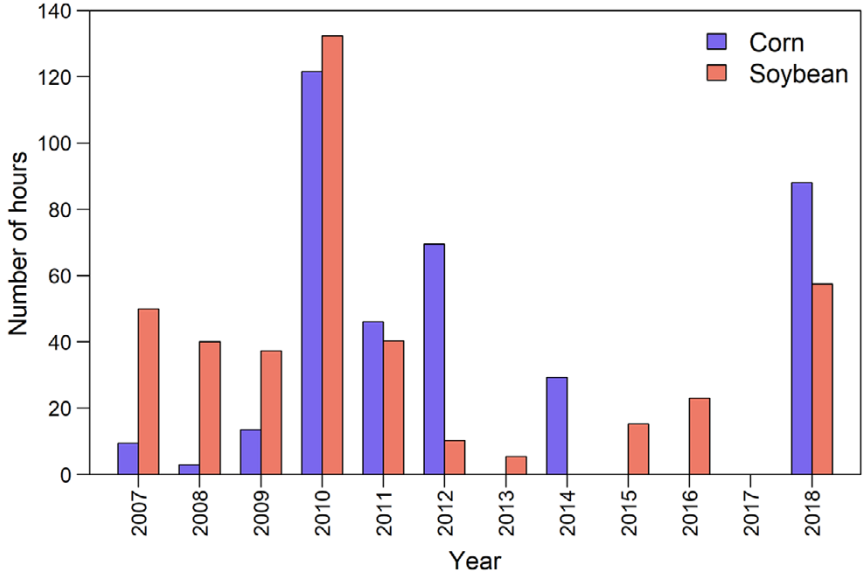
Cycles interact over time and space with different rates

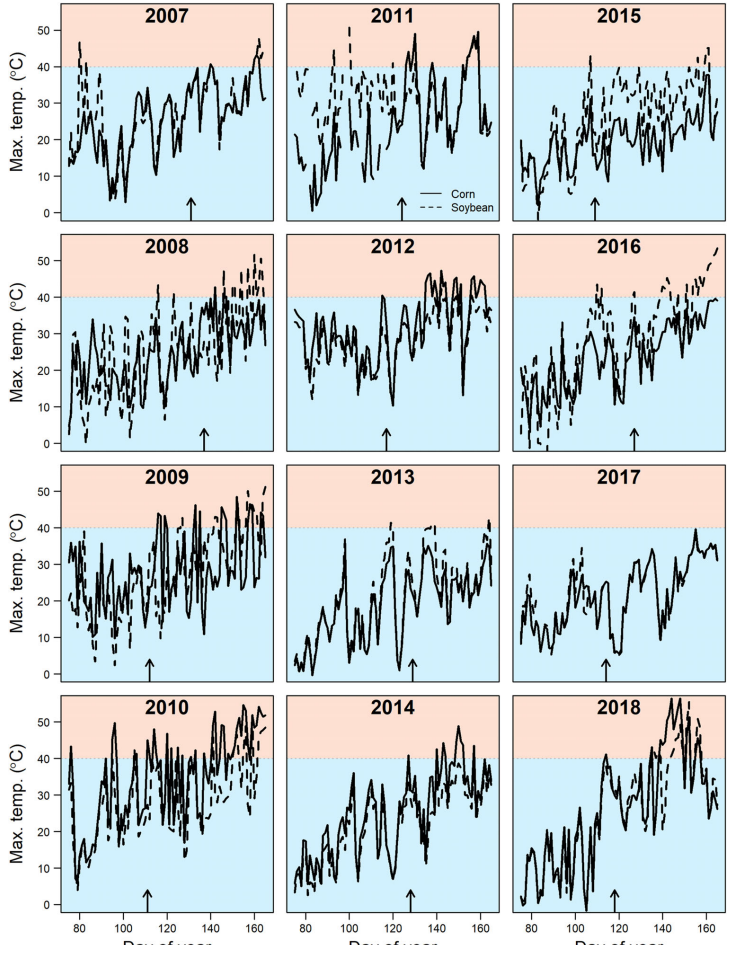
COVER CROPS

“Passive protective blanket”

“Active protective blanket”

SURFACE TEMPERATURES





Typical conventional systems are exposed to temperatures above lethal limits for biological activity

STABLE MICROCLIMATE

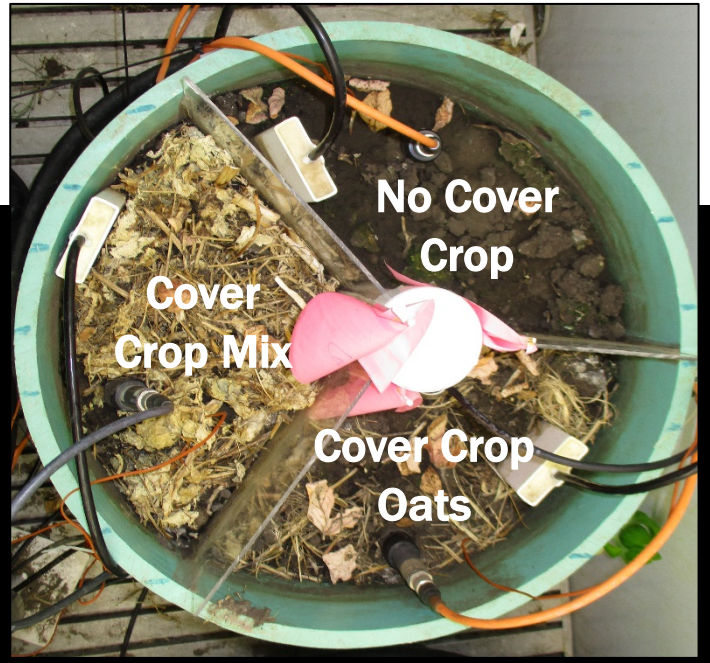
Temperature profiles in the soil

Extremes in temperature limit the biological activity in the soil, induced by a dry soil

GROWTH CHAMBER EXPERIMENTS

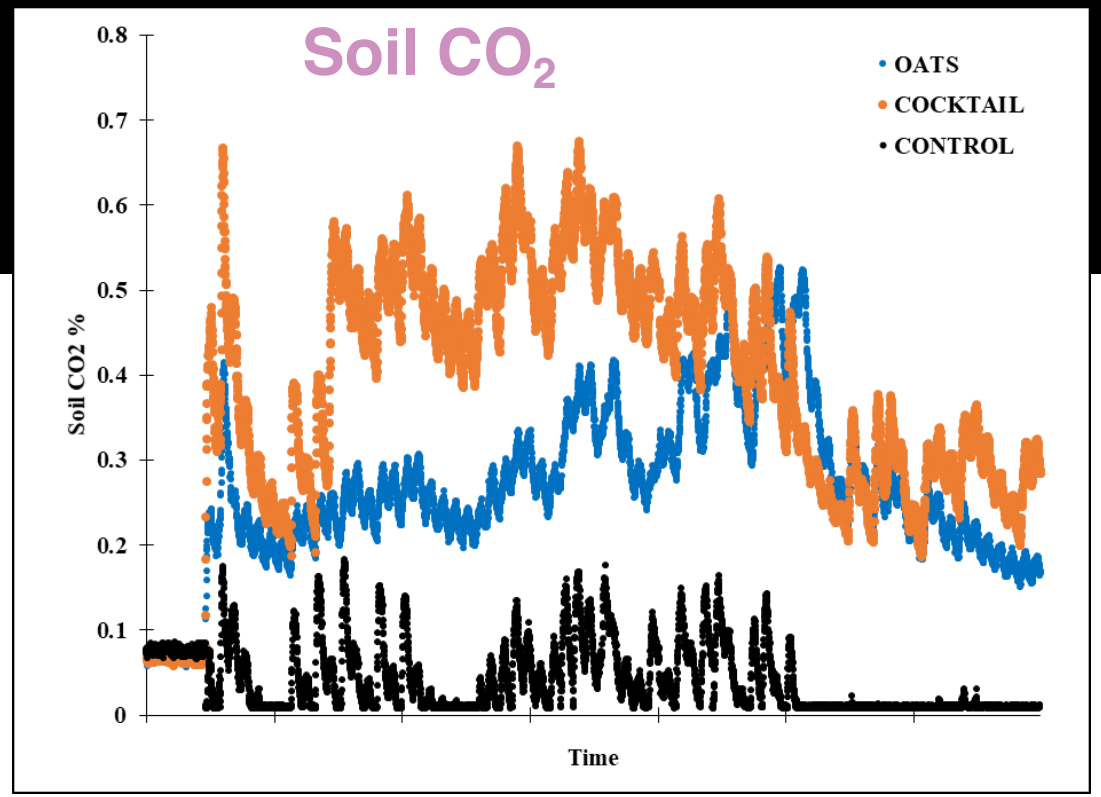
Continuous data being monitored: soil moisture, temperature, CO_2, Soil O_2

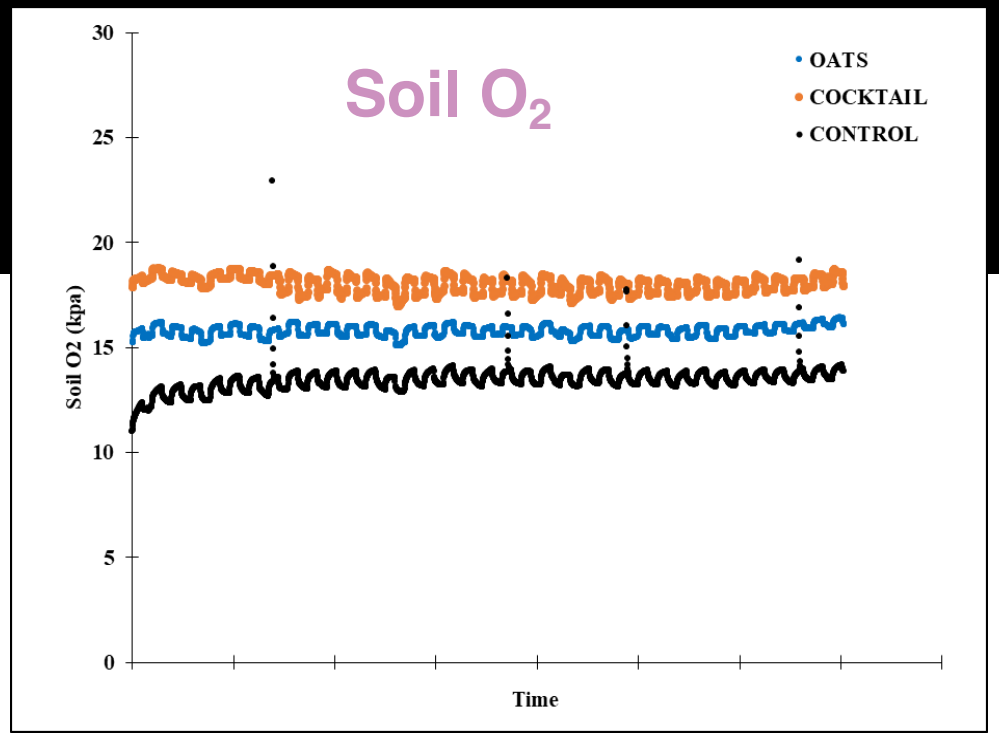
GROWTH CHAMBER EXPERIMENT



Cover crops not only provide surface cover but can enhance soil biology, structure and production

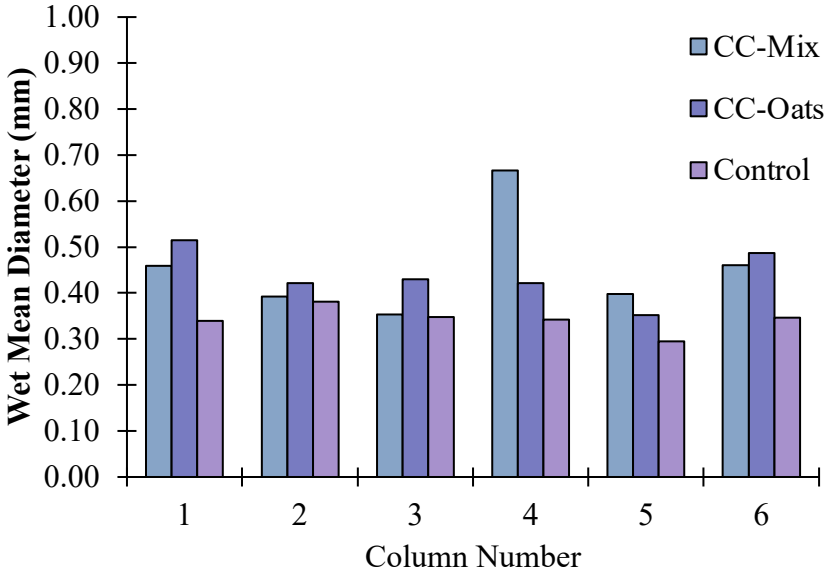
GROWTH CHAMBER EXPERIMENTS

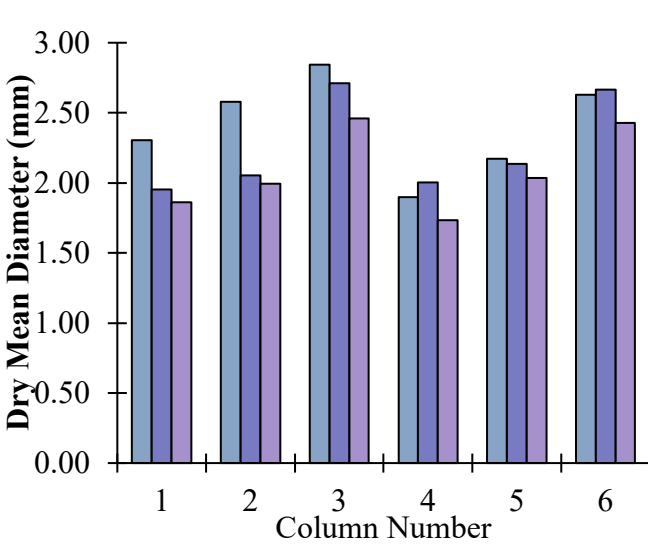


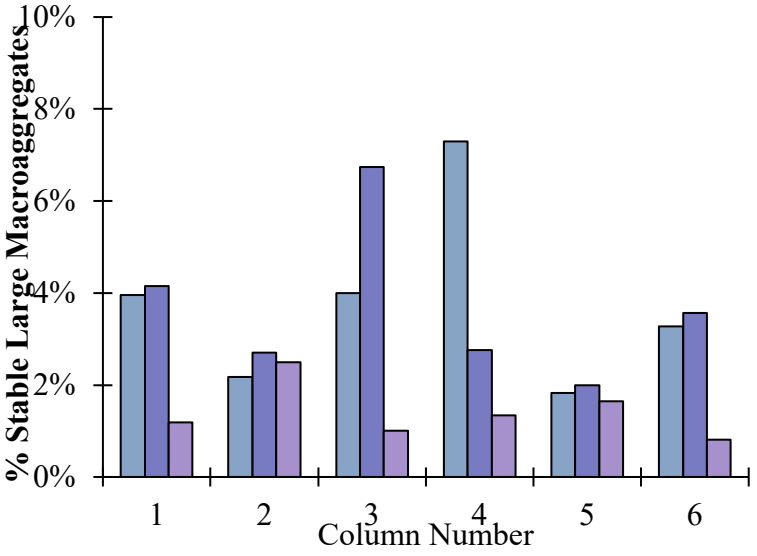


- *Highest activity (soil CO2) observed in the cover crop cocktail*
- *Higher soil O2 concentrations observed in cover crop systems with the cocktail being highest*

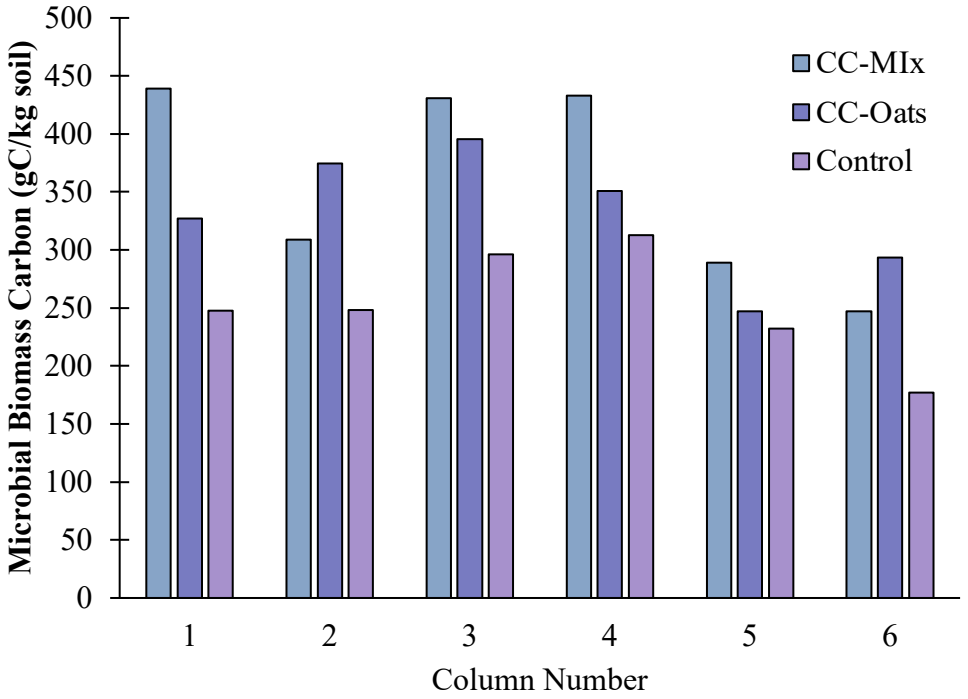
IMPACT OF COVER CROPS

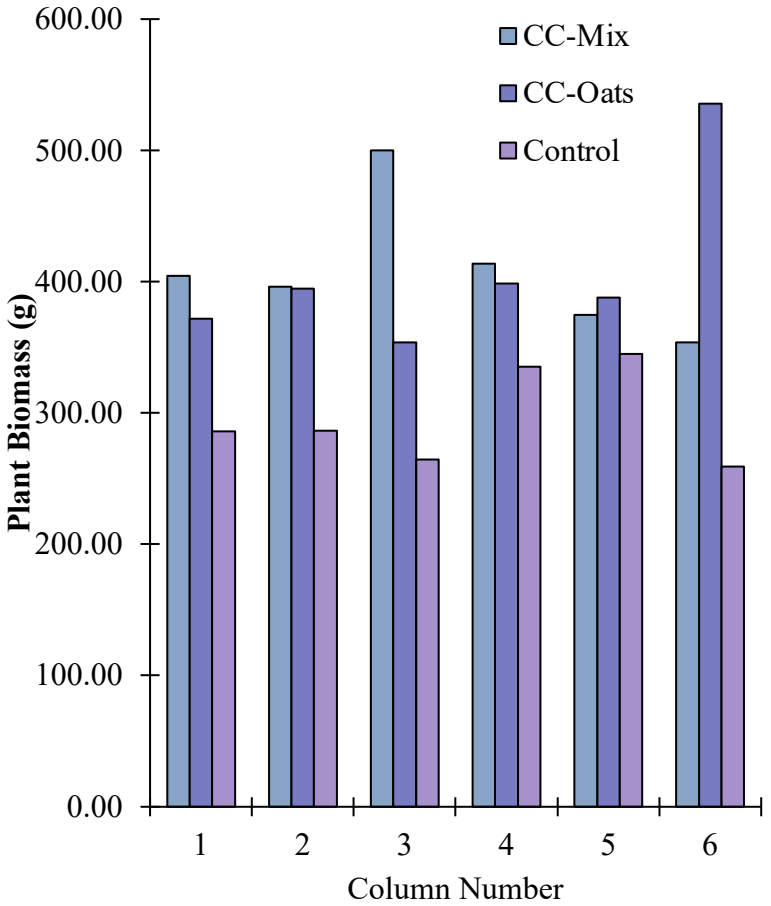






IMPACT OF COVER CROPS





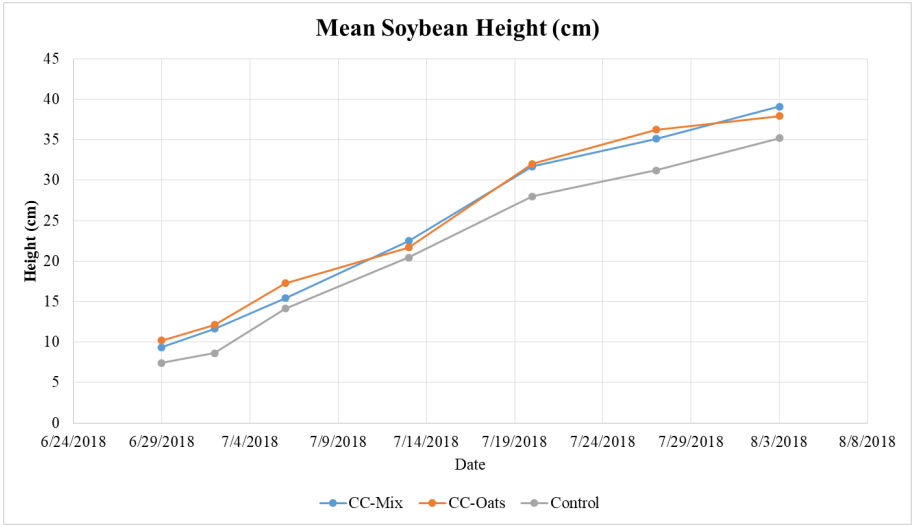
IMPACT ON PRODUCTIVITY

6-21-2018

7-27-2018

10-19-2018

Growth Chamber 1: Mean Values from soybean harvest				
Treatment	**Pod Dry Weight (g)**	**# Seeds**	**Seed Dry Weight (g)**	**Yield (bu/ac)**
CC-Mix	23.5	91.0	17.5	37.0
CC-Oats	25.8	97.3	19.0	40.0
Control	17.6	70.2	12.8	27.0



LINKING THE FOUR R'S

Nitrogen

- Right Rate
- Right Time
- Right Place
- Right Form

Water

- Revitalize-organic matter
- Retain-infiltrate
- Reduce-evaporation
- Retrieve- transpiration

SOIL HEALTH AND WATER

Attributes of soil health 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

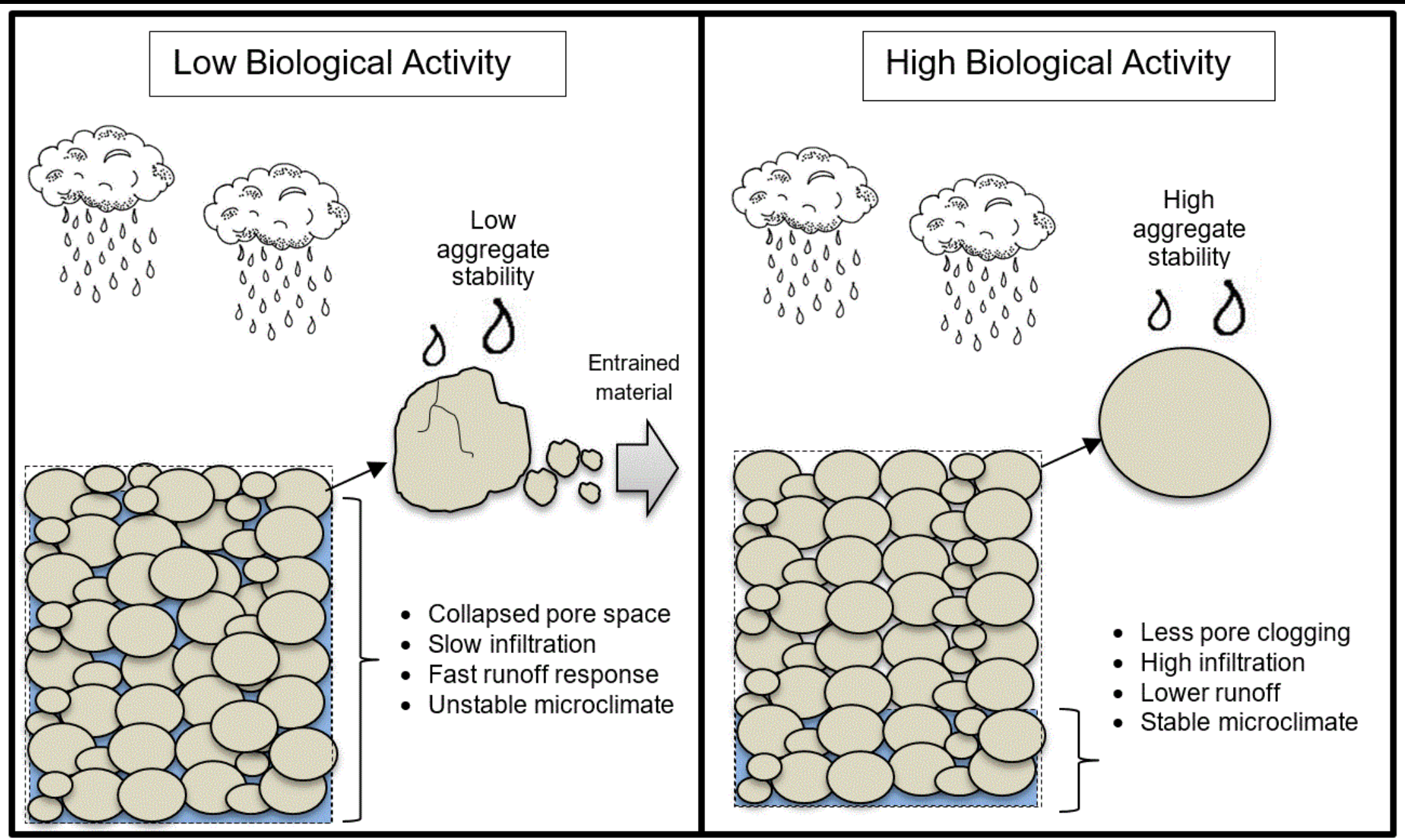
Third, plant roots are near the surface so take advantage of small rainfall events

SOIL HEALTH AND WATER

Attributes of soil health that impact water significantly are the focus on crop diversity and carbon supply into the soil

Cover crops and crop diversity provide the following advantages

- First, continual supply of food for microbial populations
- Second, supply of organic matter to create stable aggregates
- Third, continual recycling of nutrients in the root volume that promotes better plant growth


Low Biological Activity
Low aggregate stability
Entrained material
Collapsed pore space
Slow infiltration
Fast runoff response
Unstable microclimate
High Biological Activity
High aggregate stability
Less pore clogging
High infiltration
Lower runoff
Stable microclimate

CHANGES IN FIELDS

CHANGES AT WAYNE FREDERICKS

DATA

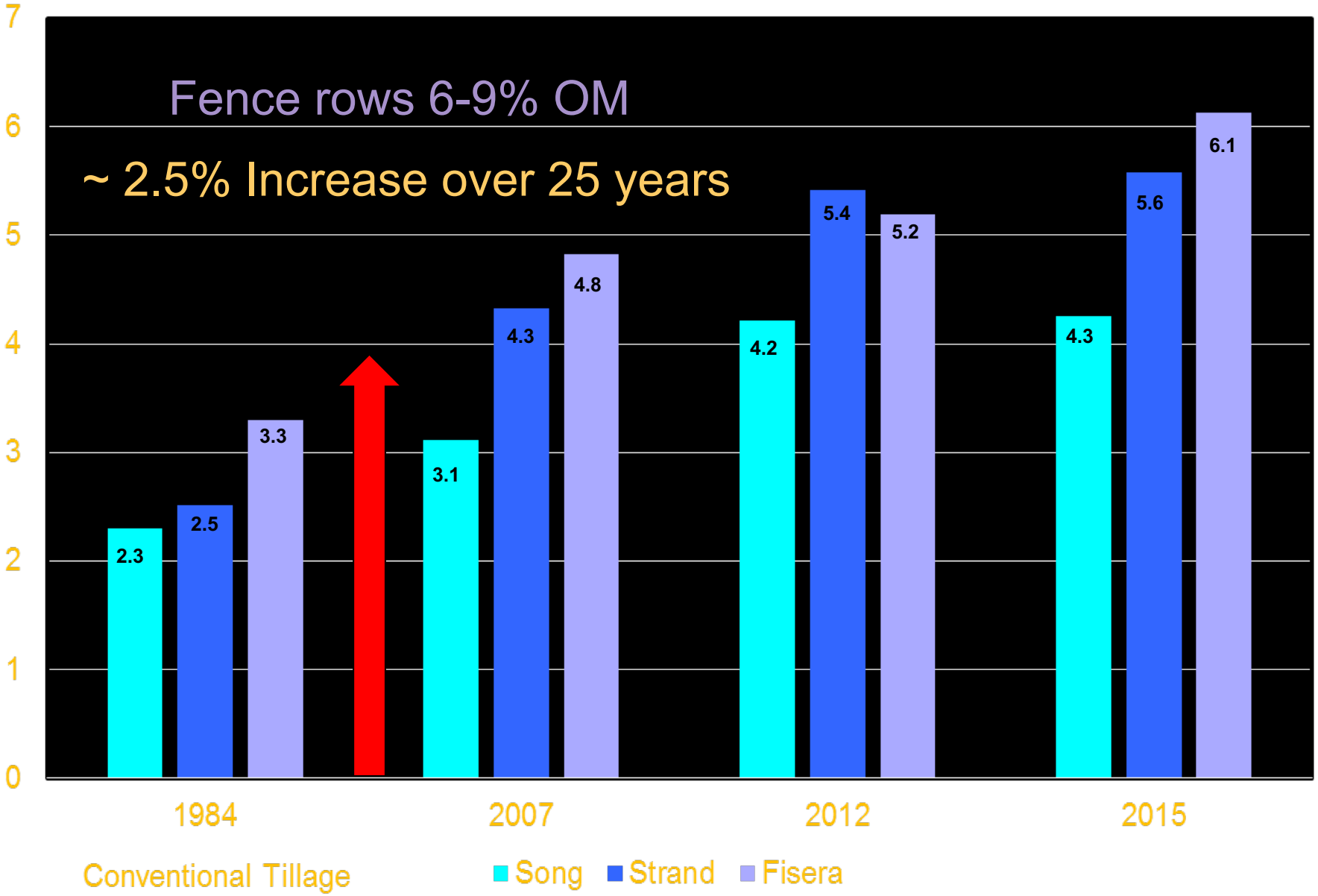
Availability

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

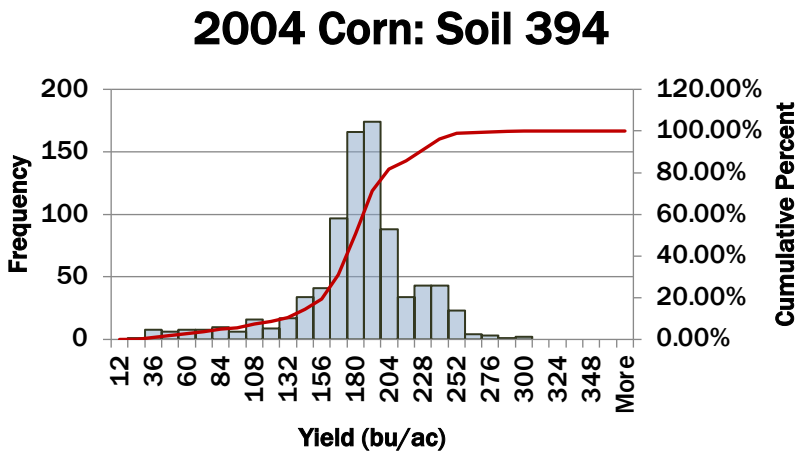
Analysis

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

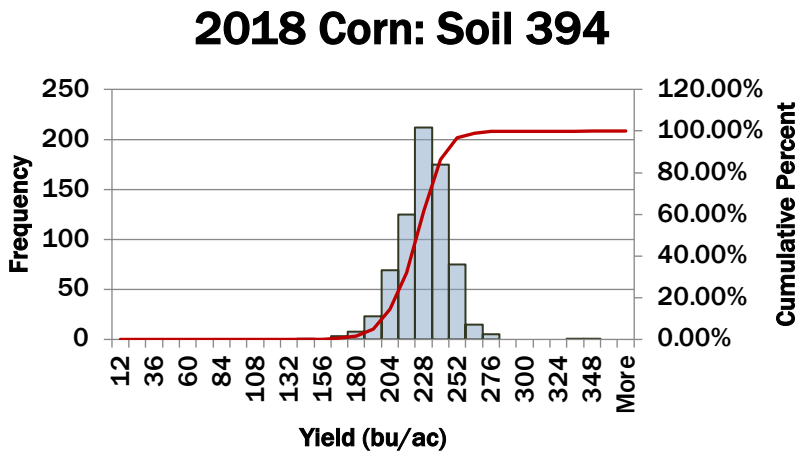
Organic Matter % Change Over Time



INCREASING UNIFORMITY



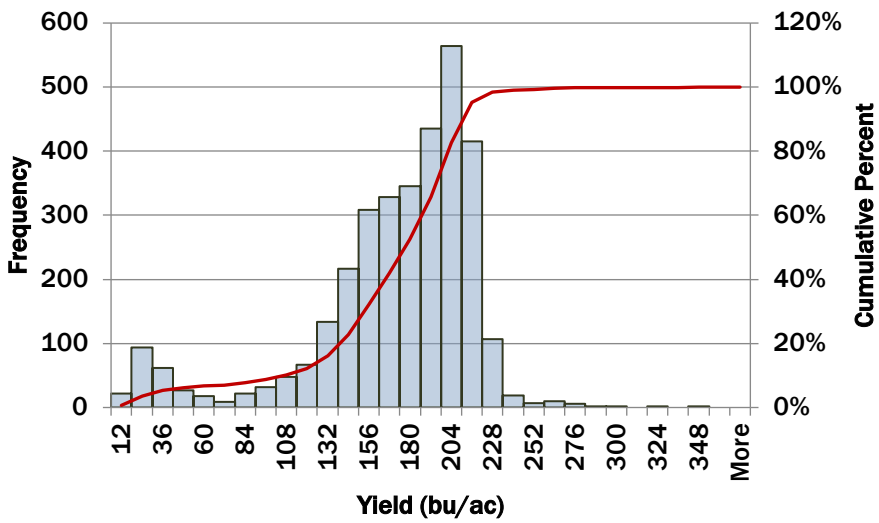
Skewness -1.01
Kurtosis 2.30

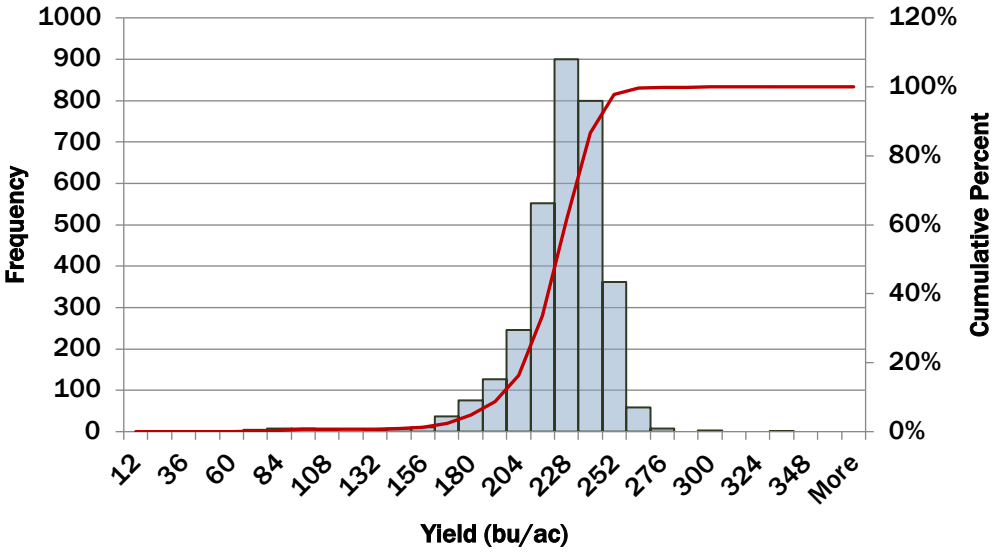


Skewness 0.19
Kurtosis 4.48

Soil 394 Ostrander loam

INCREASING UNIFORMITY





Skewness -1.99
Kurtosis 2.21

Skewness -0.86
Kurtosis 7.91

Soil 761 Franklin silt loam

IMPLICATIONS

The shifts from negative to positive skewness and increasing kurtosis tightens the distribution about the mean

The more we shift to the right the greater the income in the field because we have less low yielding areas in the field, i.e., a greater portion of the field becomes a profit center

IMPLICATIONS OF THE CHANGES IN SOIL

Yield is negatively correlated with April and May rainfall at the county level

Yield is positively correlated with July-September rainfall at the county level

Water use efficiency (corn) Fredericks fields

- 2004 3.9 bu/inch 2018 5.5 bu/inch 41% increase
- 2005 5.3 bu/inch 2017 7.9 bu/inch 49% increase

Water use efficiency (soybean)

- 2005 1.9 bu/inch 2017 2.4 bu/inch 26% increase

Profitability of the field will increase because the yields have become more uniform.

CHANGES IN WATER USE EFFICIENCY

Soil is capable of storing more water

Greater infiltration of rainfall events

More resilient in the years with uneven distribution of rainfall

Reduction in the correlations with excessive spring and deficit summer rainfall

Increased ability to convert the soil water into grain

NUTRIENT MANAGEMENT

Enhancing soil health recycles nutrients (macro and micro)

Evidence for this is the leaf chlorophyll maintenance during the grain-filling period and duration of green leaf area (photosynthetic efficiency)

Effective use of nutrients is linked with water availability to the plant

The more we increase soil health, can decrease the inputs of nutrients

ENHANCING THE SOIL

To change the soil requires energy

For growth, requires excess energy above maintenance

Cover crops provide excess energy into the soil because we convert solar energy into carbohydrates

QUESTIONS

How much is carbon worth in the soil?

What is more valuable, water or nutrients?

What is the upper limit on soil carbon?

How do we have to change farming systems to become more efficient in the use of water, nutrients, and light?

CONTACT INFORMATION

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