Soil Health

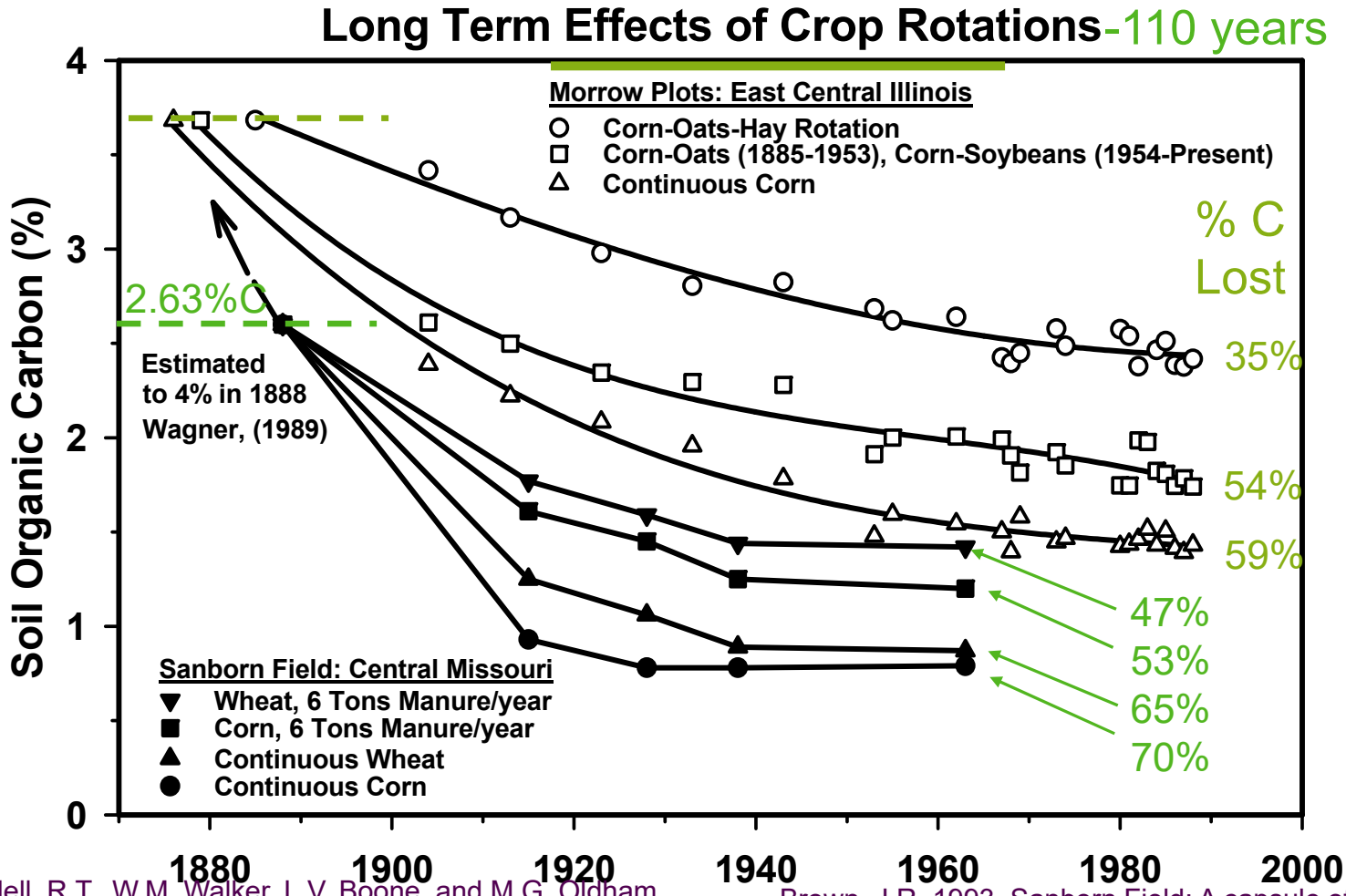
KEY TO INCREASING
PRODUCTIVITY AND PROFITABILITY


Soil Health
Soil Functionality

Functions of Soil-Agriculture

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

Current State of Soils

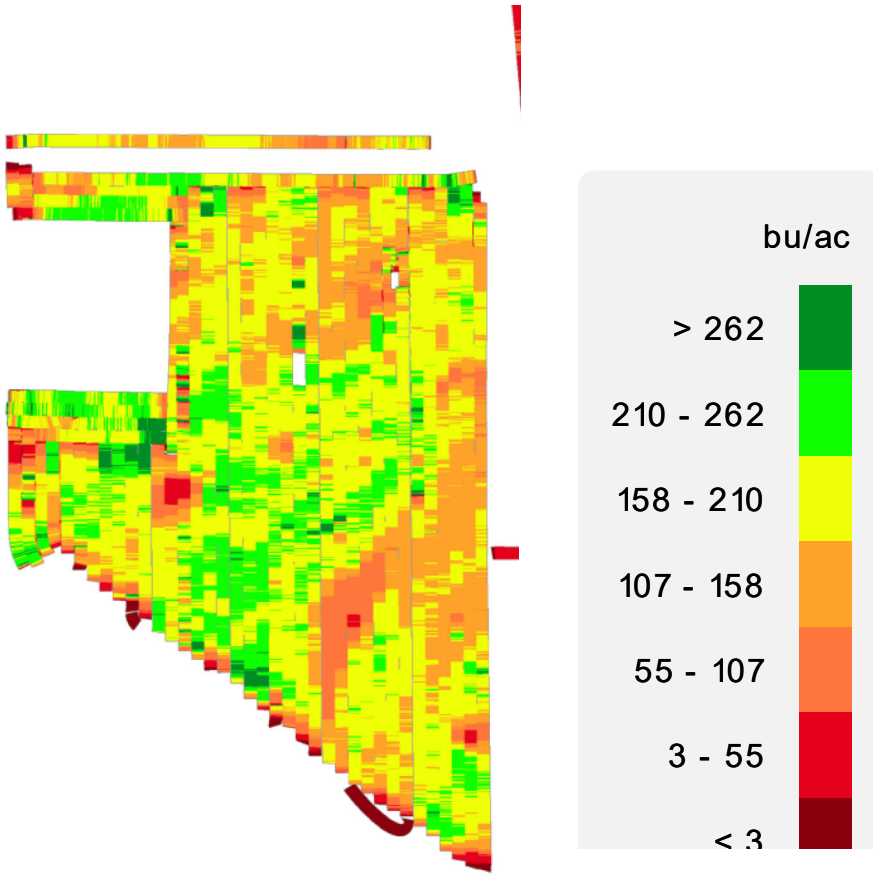


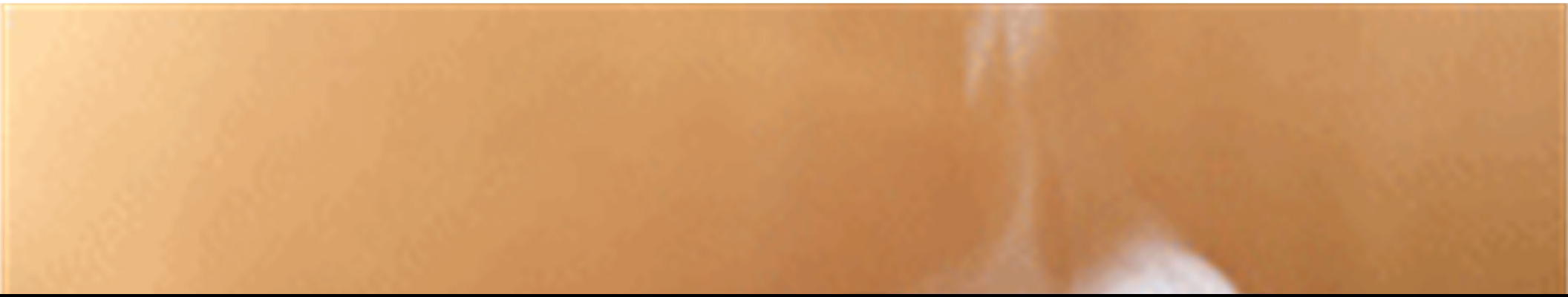
Odell, R.T., W.M. Walker, L.V. Boone, and M.G. Oldham. 1982. The Morrow Plots: A century of learning. Agricultural Experiment Station, College of Agriculture, Univ. of Illinois Bull. 775, Urbana-Champaign, IL.

Brown, J.R. 1993. Sanborn Field: A capsule of scientific agricultural history in central Missouri. Missouri Agric. Experiment Station, Columbia, MO.

Major Limitation to Crop Production is Water

- Water availability is the factor limiting yields and the cause of yield variation within fields

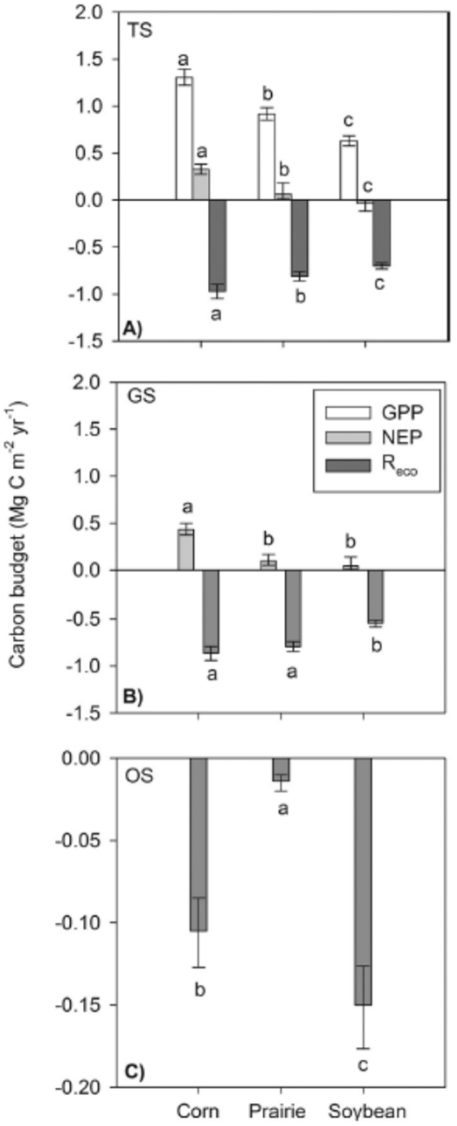




What Causes C loss from soils

Carbon Balance of Midwestern Cropping Systems

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



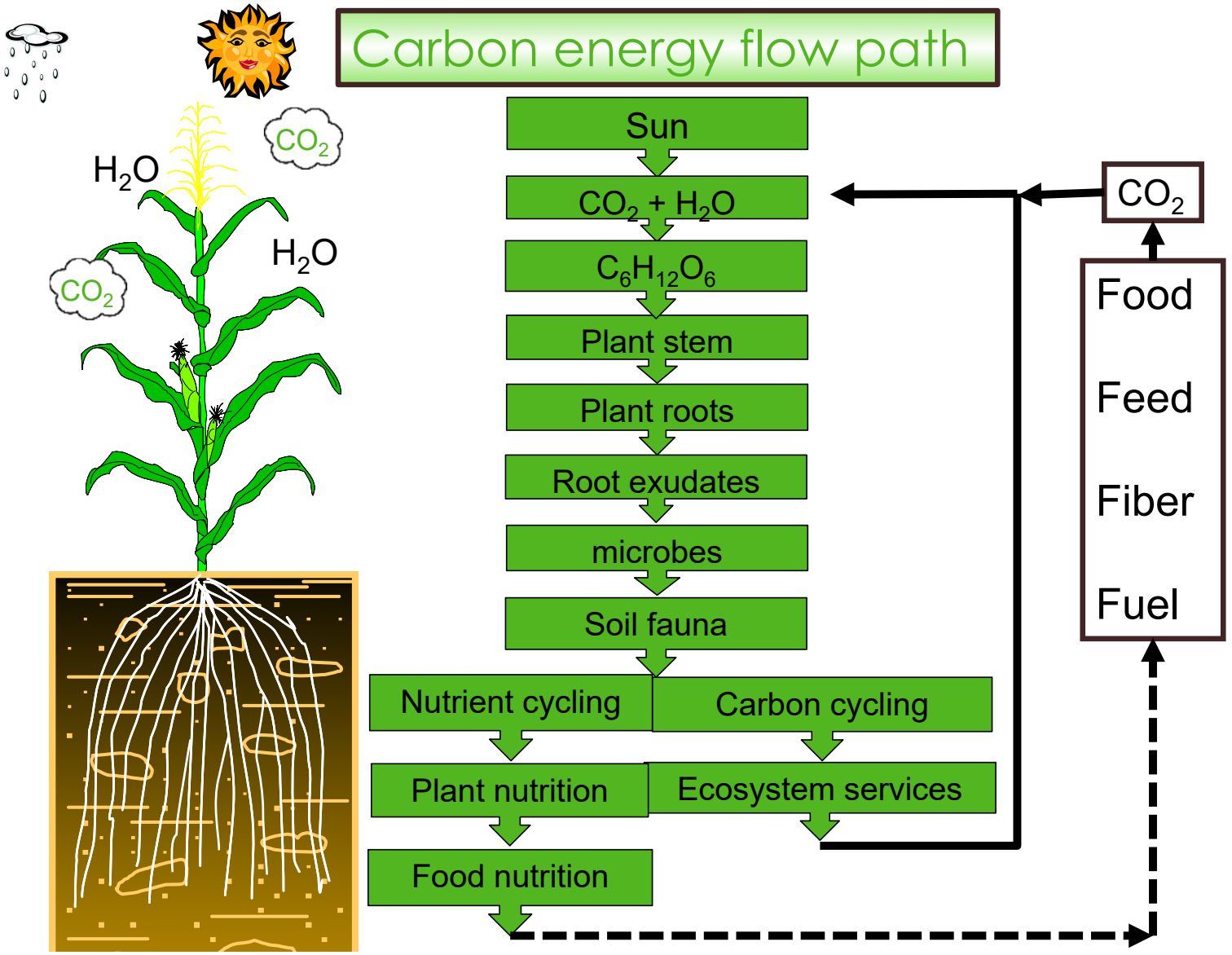
Management of Agricultural Systems have Changed Our Soils

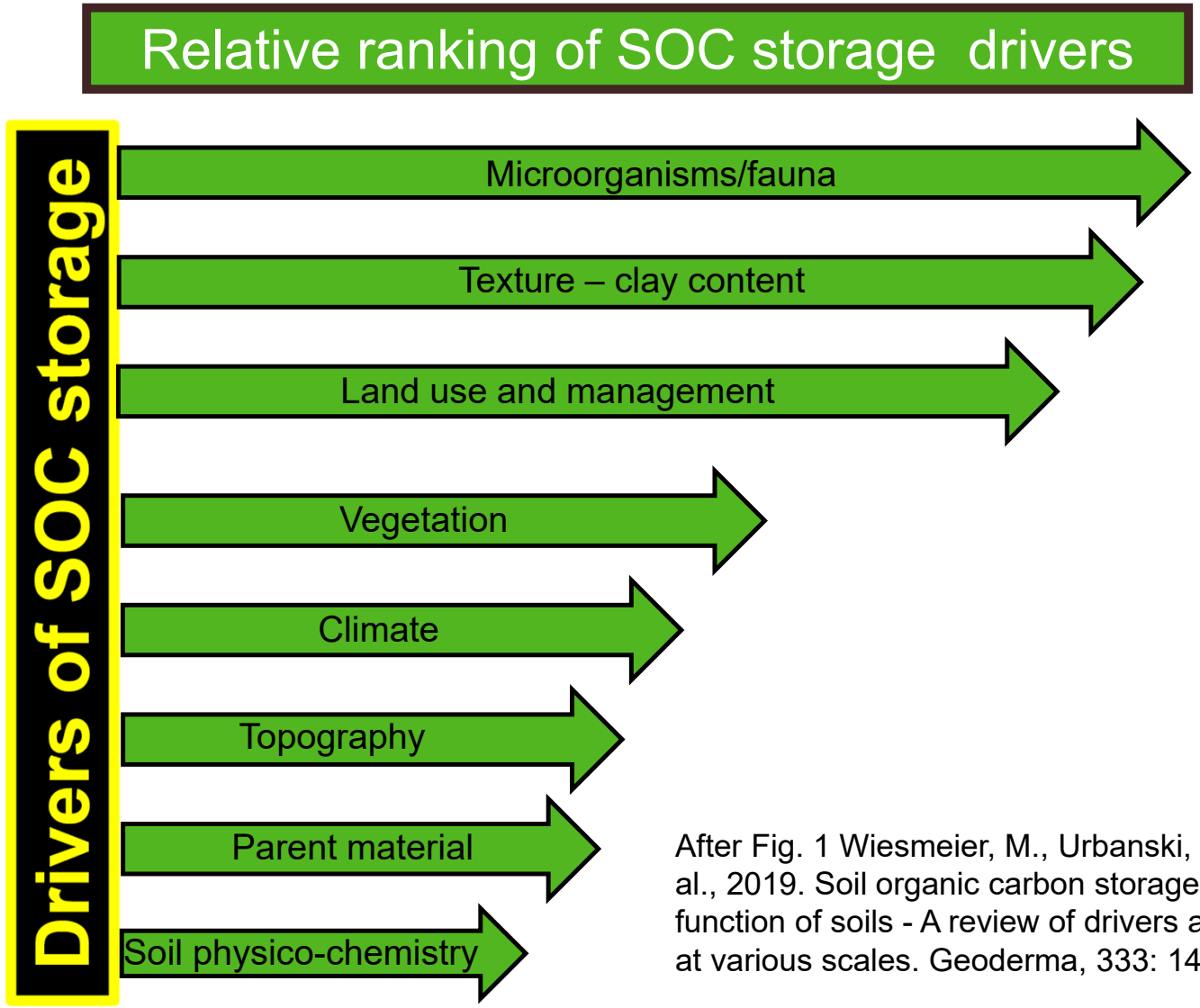
- Removed organic matter through tillage
- Cropping practices that limit return of carbon to the soil
- Reduced the functionality of soils and increased reliance on external inputs
- Increased erosion rates and increased soil degradation

Primary factor affecting agricultural systems is water

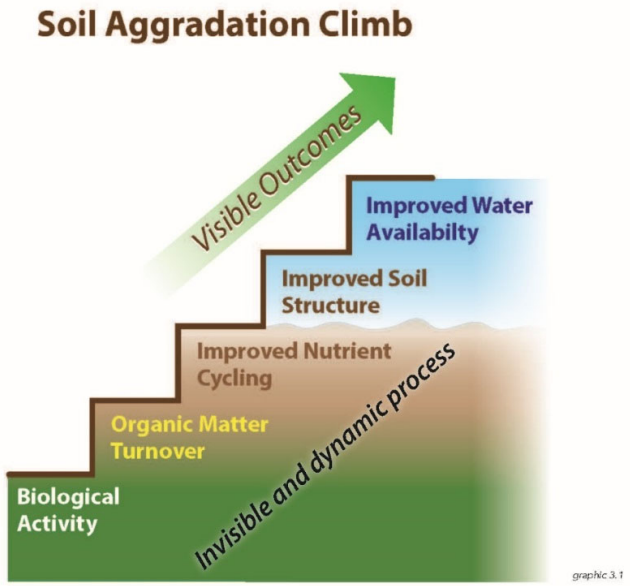
Soil Health is Affected by

- Reduced tillage
- Continuous cover
- Cover crops
- Crop diversity
- Livestock
- Bio-based fertilizers


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
CO_2
H_2O



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.



Process of increasing soil health

- Enhancing the soil begins with creating a stable microclimate for the soil biological system in the soil profile that supplies:
  - Food, carbon supply
  - Water, need water
  - Air, need oxygen
  - Shelter, don't like disturbance

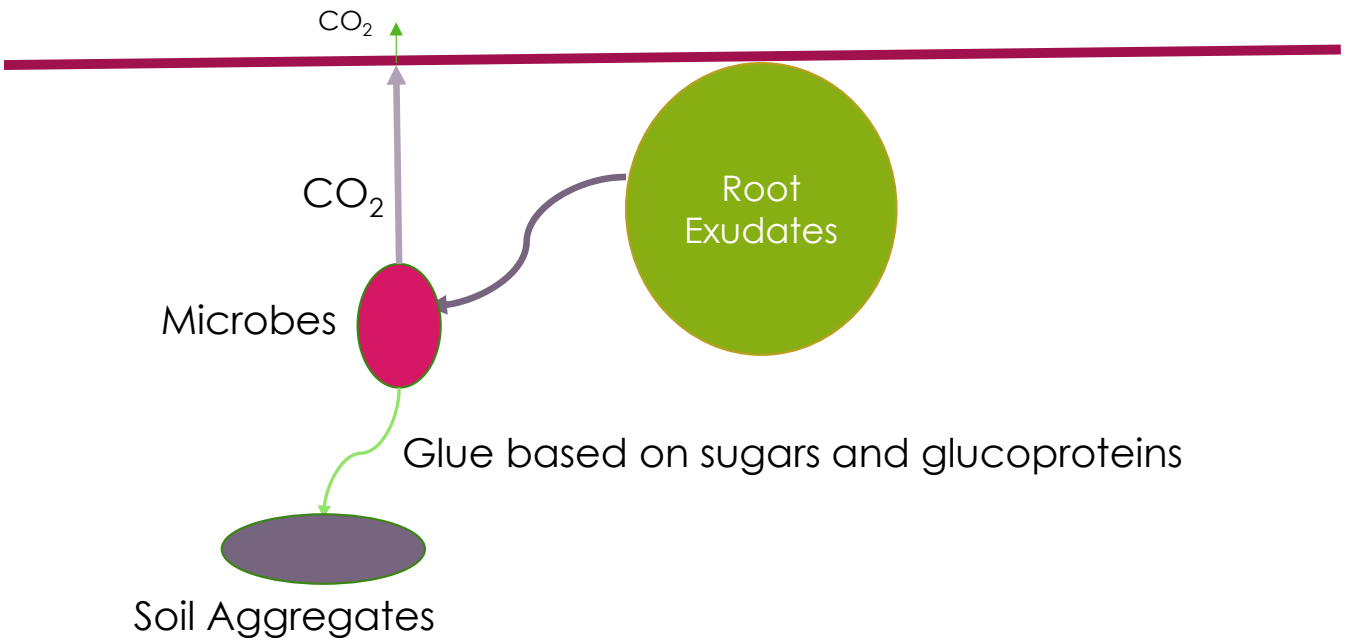
Root Exudates

- 15-40% of photosynthetically fixed C is exuded from the roots
- Glucose is the most abundant of root exudates (40-50%) followed by fructose (23%), saccharose (23%) and ribose (8%)
- Estimated that 64-86% of C from roots goes to CO_2, and 2-5% is in SOM

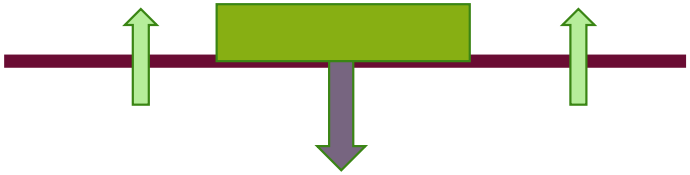
Fate of Sugars in the Soil

- Aggregate formation (natural glue)
  - Monomers- short-term
  - Polysaccharides – long-term (clay particles)
  - Glucoproteins – bind mineral and organic particles to soil aggregates
- C sequestration
- Maintenance of microbial activity and function

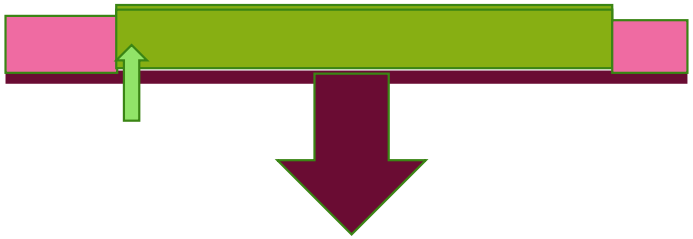
Dynamics of C within the soil



Role of different cropping systems



Limited time for input and losses due to tillage, losses equal the gains or exceed



Increased time for inputs into the soil volume with minimal loss due to soil disturbance

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

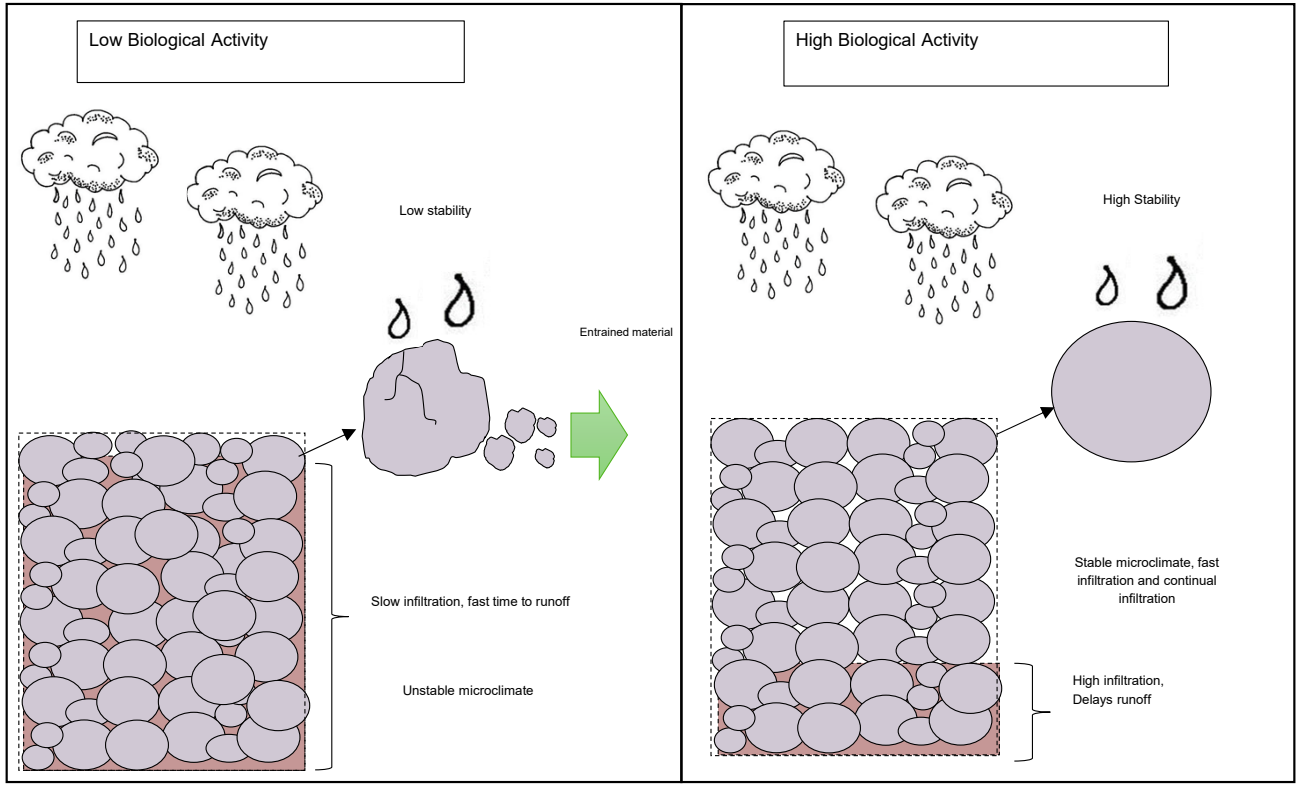
First, protection against raindrop energy so soil aggregates are protected and infiltration rates are maintained

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

Stable Soil Systems: Key to Effective Precipitation Infiltration

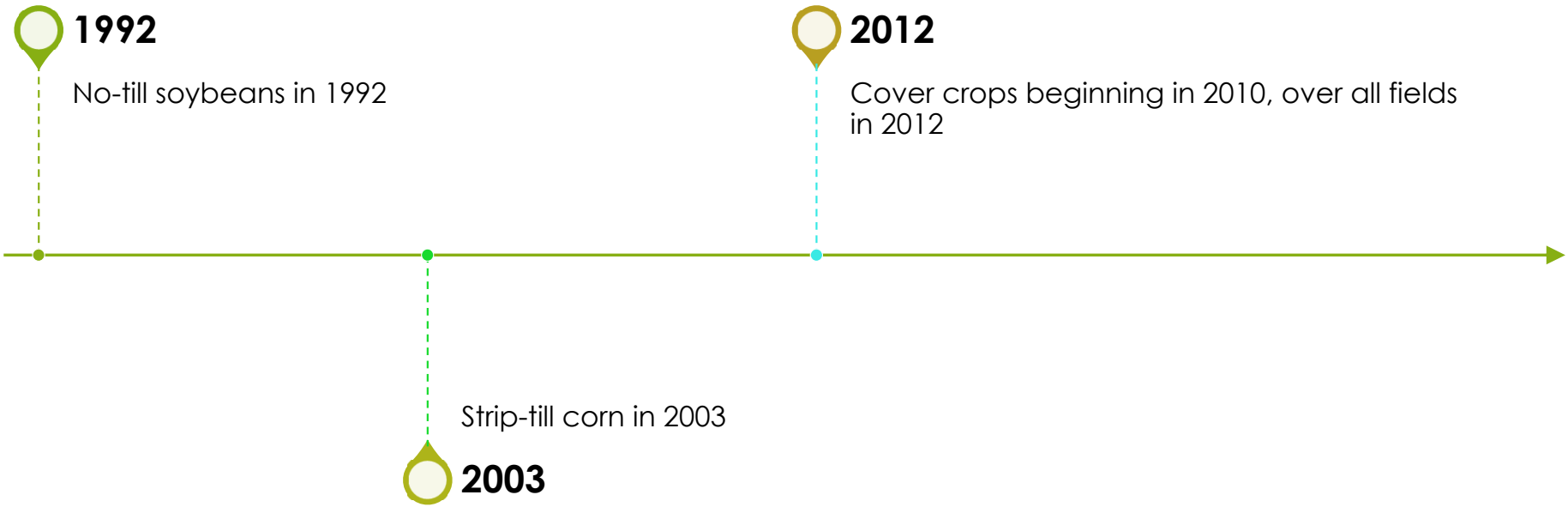
- Stable soil aggregates withstand the forces of water and maintain their integrity allowing water to continue to infiltrate



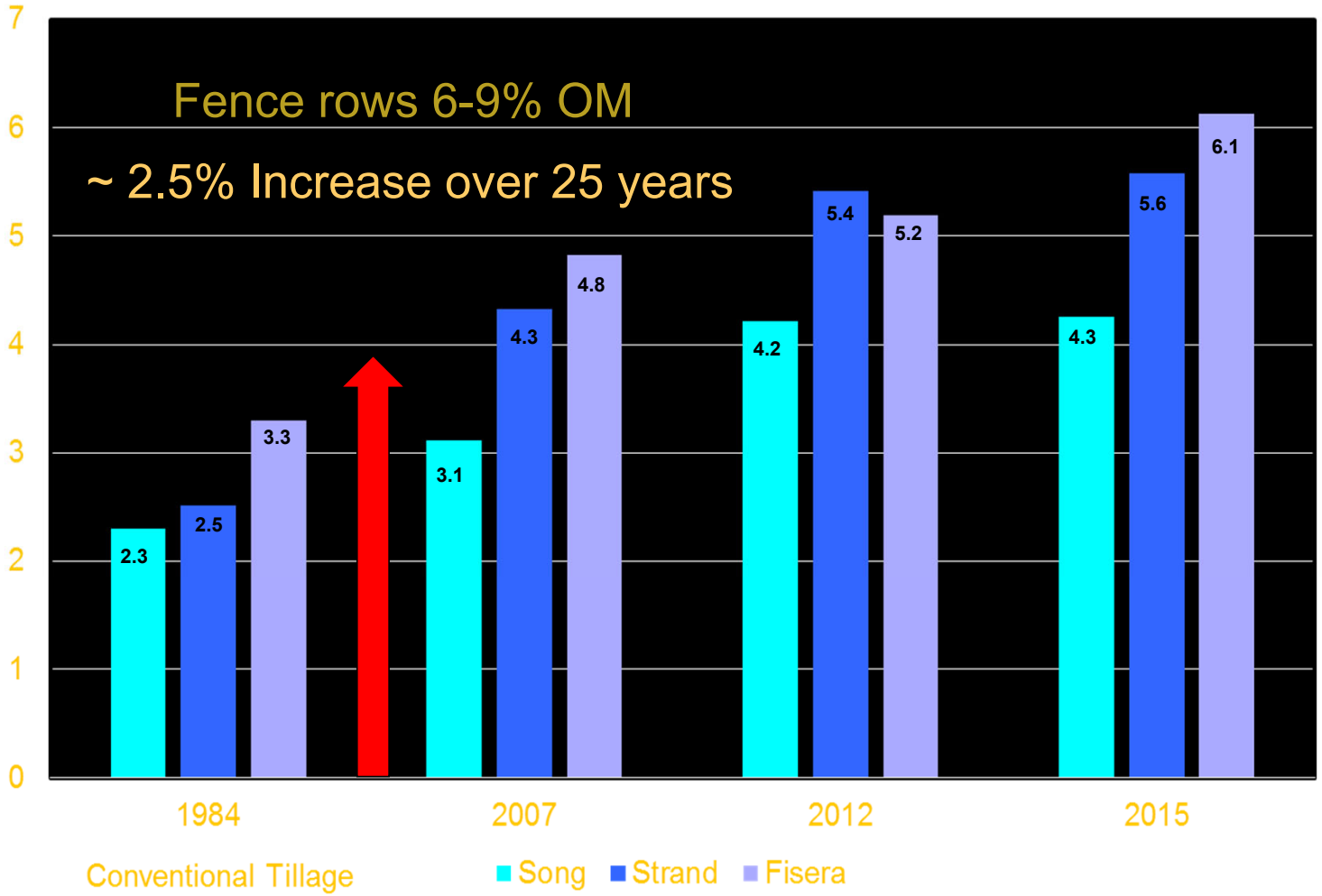
Carbon Balance in Soils

- To increase the carbon content (sequester) inputs have to exceed the outputs
- Since it is a biological system, inputs must be in excess of maintenance levels for growth to occur

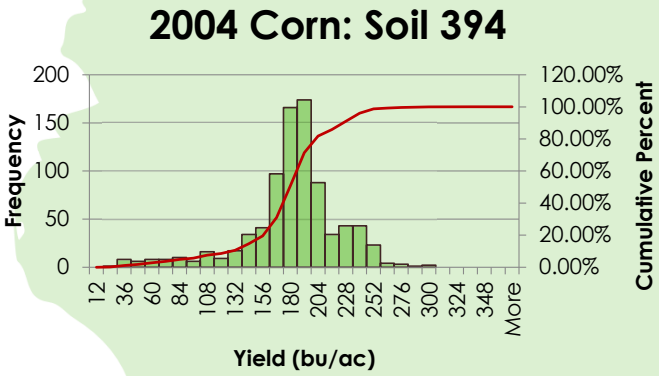
Changes in Wayne Frederick's Farm



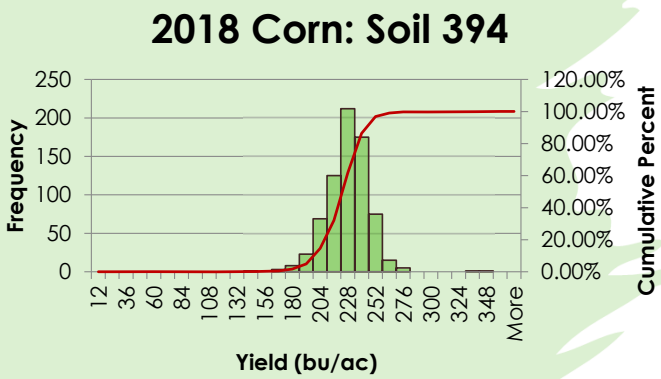
Organic Matter % Change Over Time



Increasing Uniformity



Skewness -1.01
Kurtosis 2.30

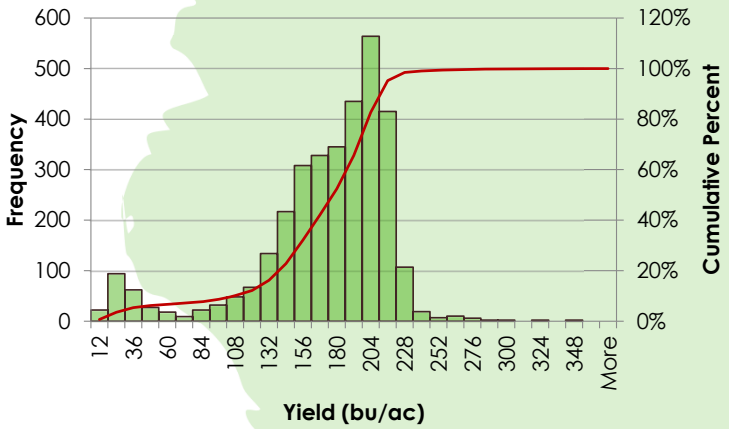


Skewness 0.19
Kurtosis 4.48

Soil 394 Ostrander loam

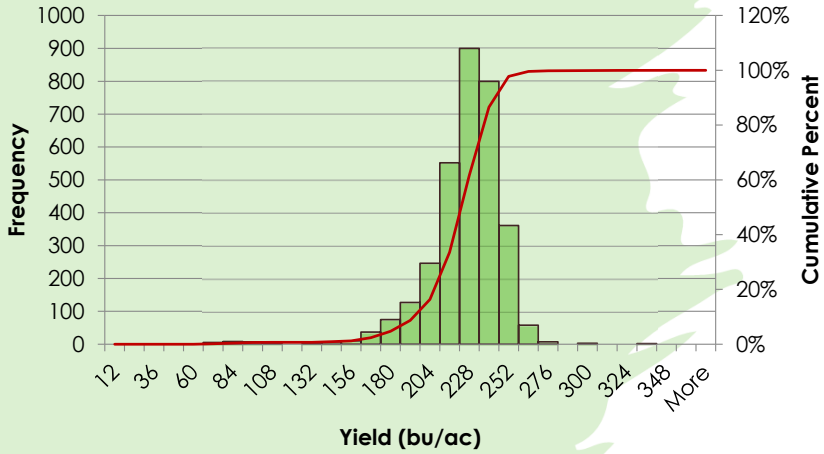
Increasing Uniformity

2005 Corn: Soil 761



Skewness -1.99
Kurtosis 2.21

2017 Corn: Soil 761



Skewness -0.86
Kurtosis 7.91

Soil 761 Franklin silt loam

Implications of the changes in soil

- Yield is negatively correlated with April and May rainfall at the county level, correlation is not evident since 2015
- Yield is positively correlated with July-September rainfall at the county level, correlation is not evident since 2015
- 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.

Positive Changes in Management

- No increase in N input over time and fertilizer use efficiency has increased
- Decrease in P and K inputs
- More timely operations in the spring because of better trafficability
- Yields have become more stable and resilient against seasonal variation
- Less risk in the system, allowing for changes in crop insurance programs
- Profitability has increased

Implications

- Soil health changes improves the ability to utilize precipitation as transpiration
- Increases in soil aggregate stability allow for better infiltration of water and gas exchange
- Increase in field uniformity by reducing the low yielding areas of the field and decreasing yield variation
- Eliminate the low yielding areas of the field, increase profitability of the field

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