

Role of Soil Organic Carbon in Crop Production

Jason Warren

Oklahoma State University



What is Soil Organic Carbon

- Carbon is a primary constituent of soil organic matter.
- The organic matter content of a soil can be estimated from organic C:

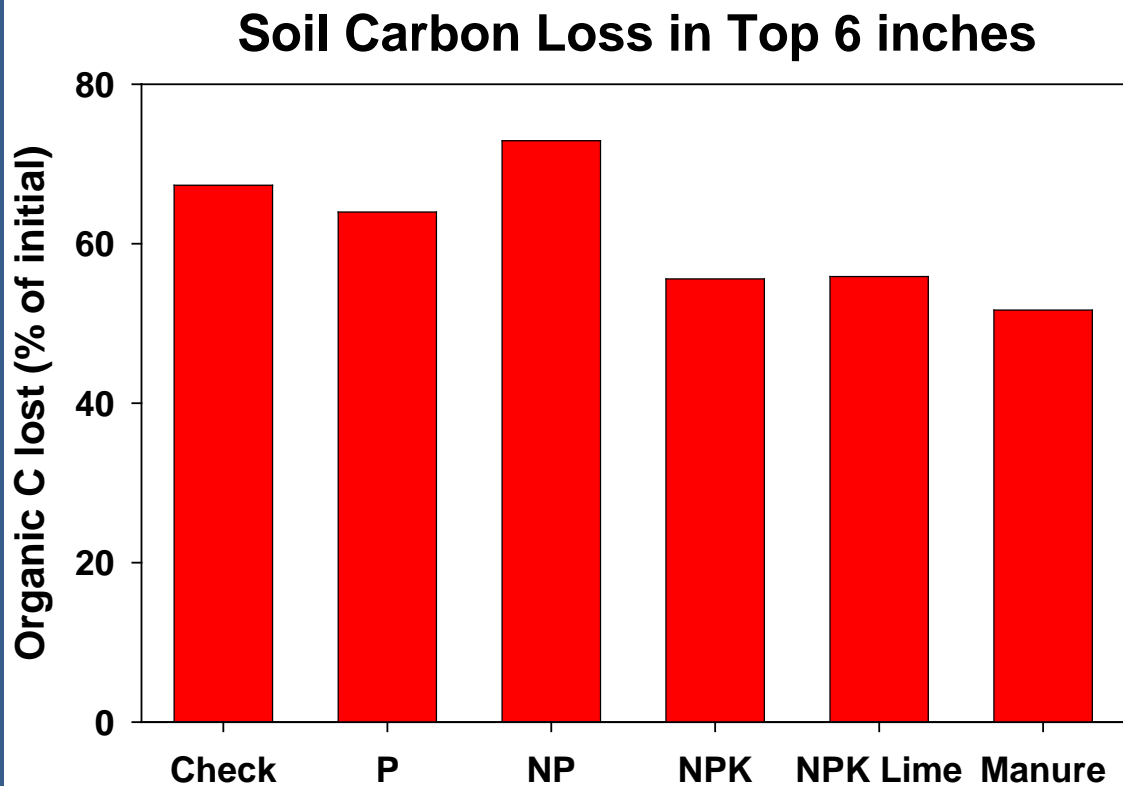
$$\text{Organic Matter} = 1.724 * \text{organic carbon}$$

Soil Organic Carbon Loss in Oklahoma

- Presettlement there were approximately 2.3 billion tons of carbon in Oklahoma Soils
- We have lost ~114 million tons of Carbon through cultivation:
 - (38% of C in top 6 in)

Magruder Plots, Stillwater: Soil Carbon lost after 110 years of Continuous Wheat

- Initial C was 1.8%
- Lost 46 to 70% of the initial C.



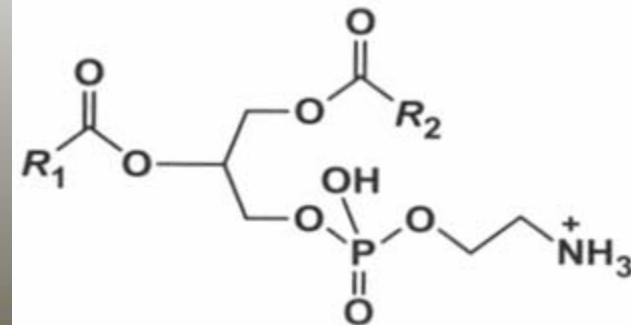
Functions of Soil Organic Carbon/Matter

- Store house for nutrients
- Increases cation exchange capacity
- Buffers the soil against rapid pH changes
- Increases water-holding capacity
- Improves soil structure
 - Reduces crusting and increases infiltration
 - Reduces the effects of compaction
- Provides energy for biological activity

Storehouse for Nutrients

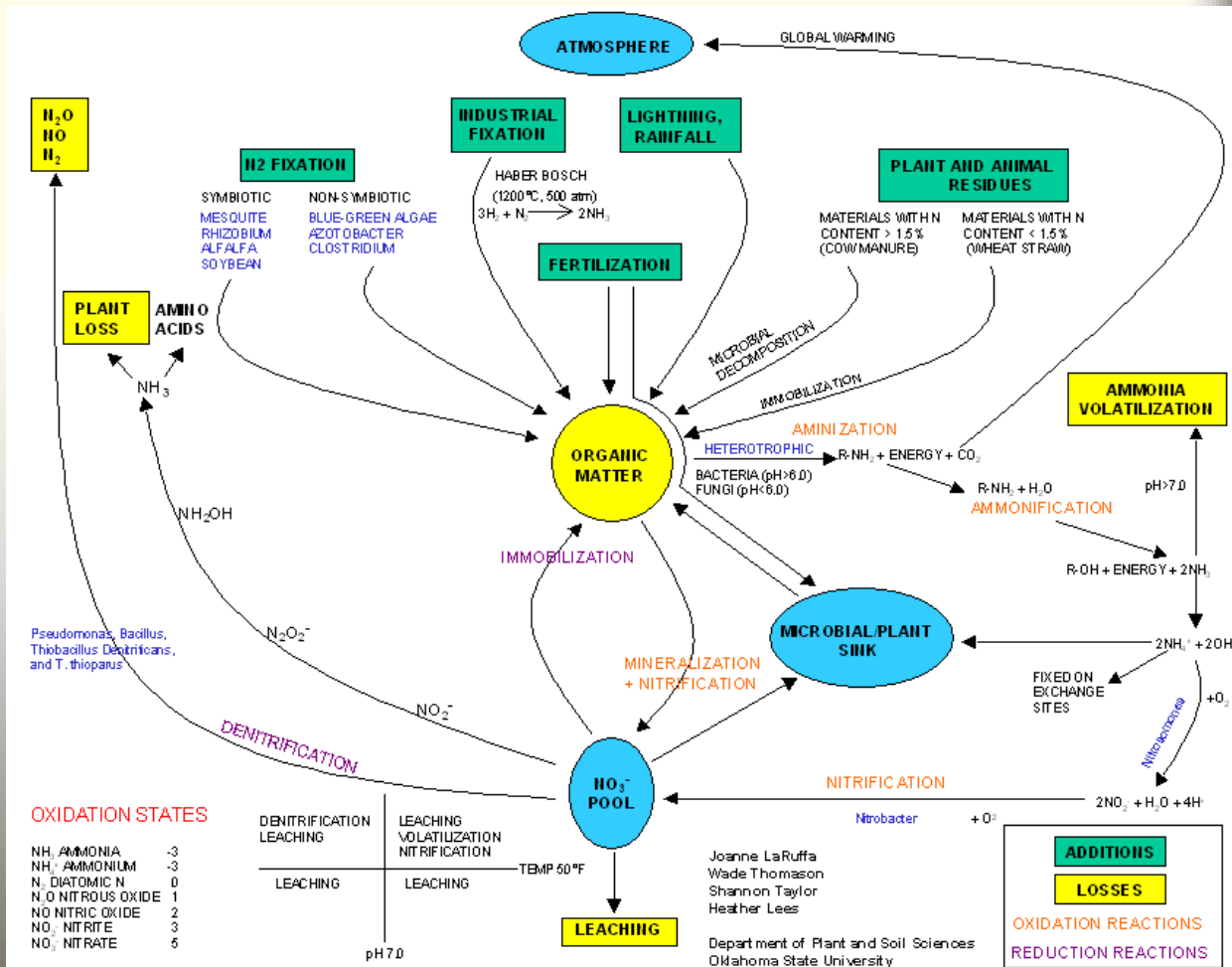
Nutrient	Concentration in Organic Matter	Fraction of Total in Surface Soil
	------%-----	
C	50	90-100
N	5	95
P	2	50
S	0.7	90

- Availability of N and S are influenced by organic matter



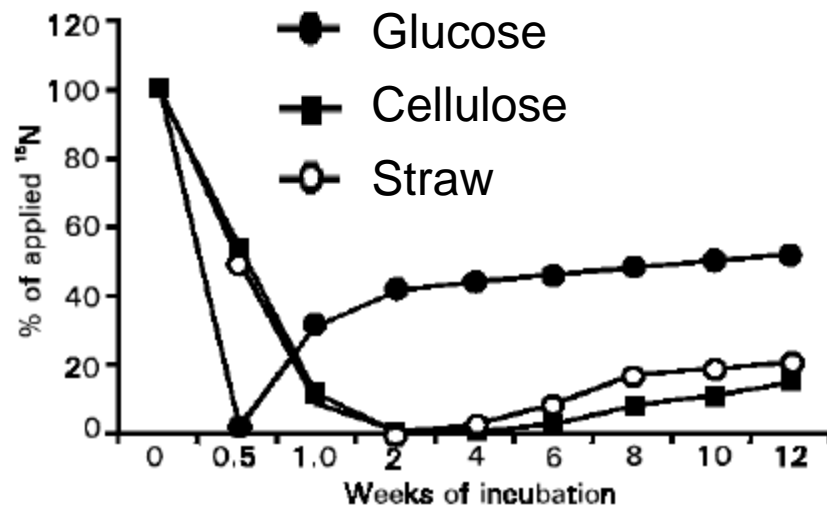
Storehouse for Nutrients

- Organic Matter plays a central role in the N and S cycles.



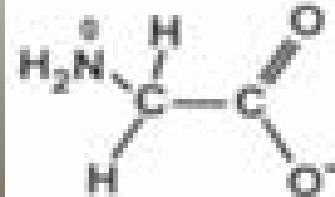
Storehouse for Nutrients

- During organic residue decomposition inorganic N can be
 - Immobilized if C/N ratio is above 10 (Straw)
 - Mineralized if C/N ratio is below 10 (Soybean)
- Must overcome microbial demand for N



Cation Exchange Capacity

- CEC is responsible for the soils ability to adsorb positively charged nutrients
 - Ca^{2+} , K^{+} , or Mg^{2+}
- CEC can adsorb protons (H^{+})
 - Therefore organic matter buffers against rapid pH changes (changes in proton concentrations)
 - This does not mean that organic matter will prevent acidic pH



Cation Exchange Capacity

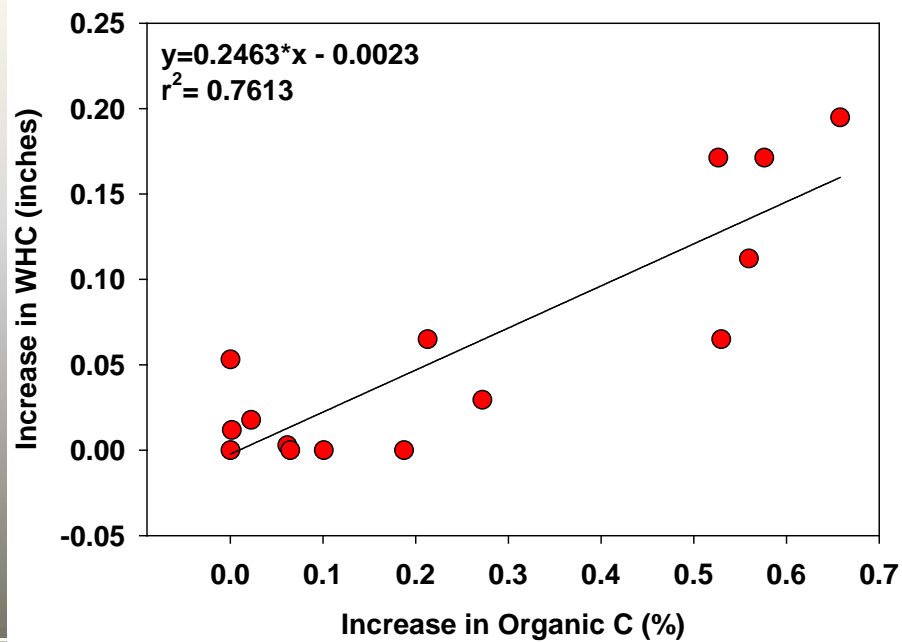
- Soils capacity to adsorb cationic nutrients.

Soil Constituent	CEC
	Charge /100gram
Kaolinite	1-10
Mica	20-40
Vermiculite	120-150
Montmorillonite	80-120
Soil Organic Matter	100-300

- Changing organic matter content most viable way to increase CEC

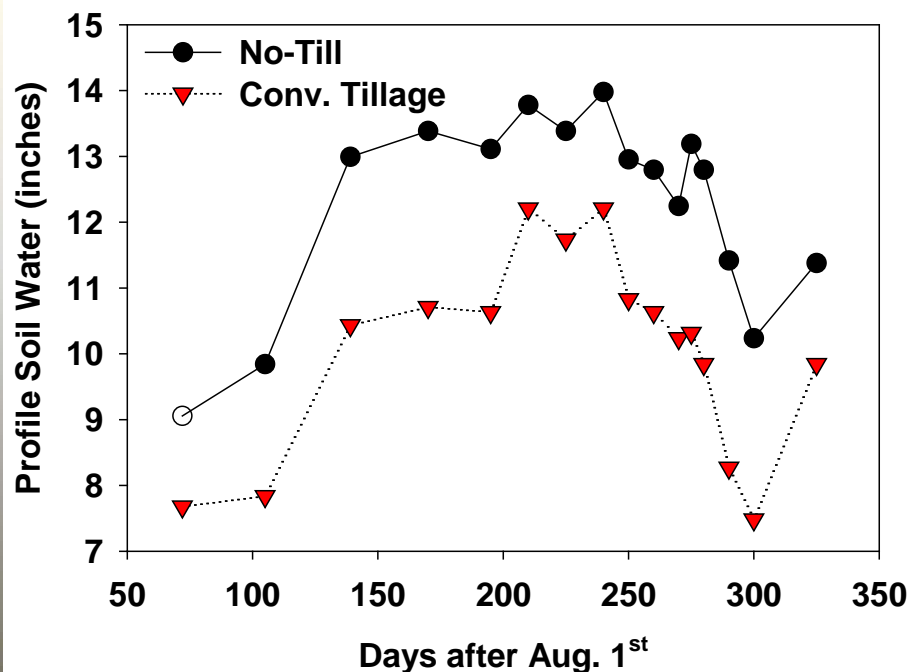
Influences on Soil Water

- Organic matter can adsorb up to 90 % of its weight in water
- Increasing organic C content by 1% increases water holding capacity of top 6 in. by 0.25 in.



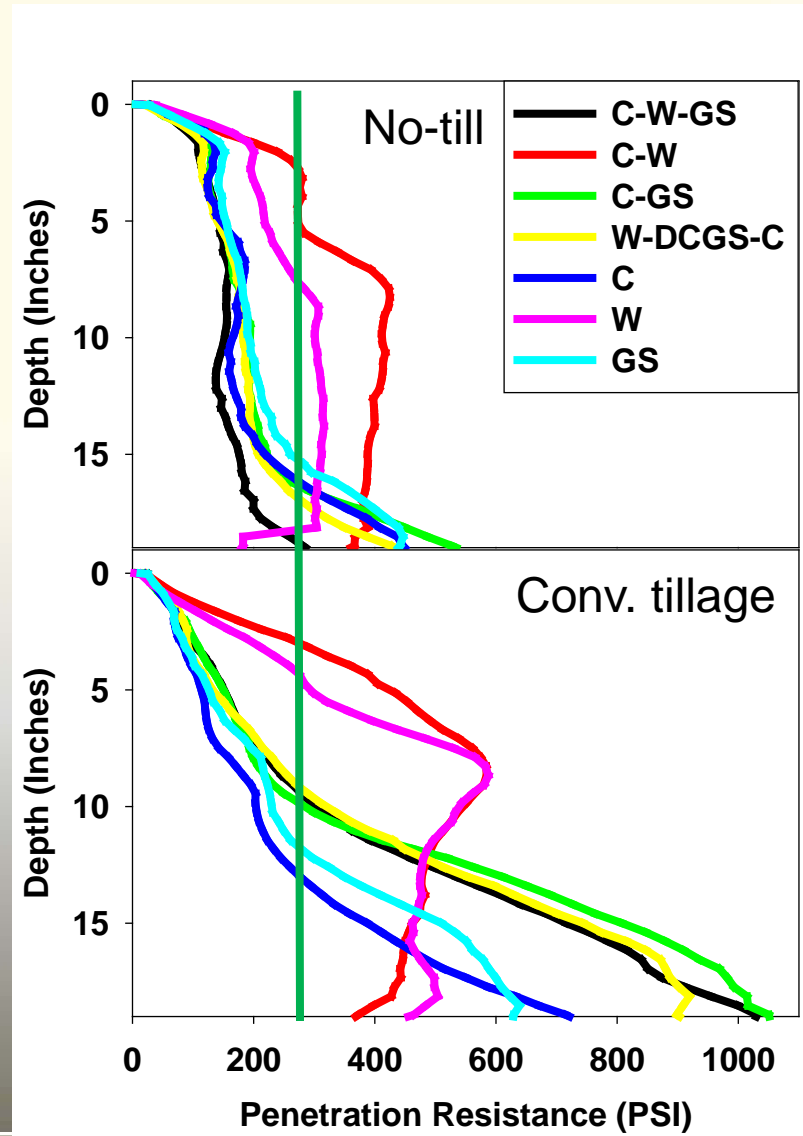
Influences on Soil Water

- Soil organic C improves structure
 - Biological macropores
 - Influences adhesive forces in soil
- Surface residue is also needed to prevent crusting
 - Increases infiltration
- Residue reduces evaporative water losses.



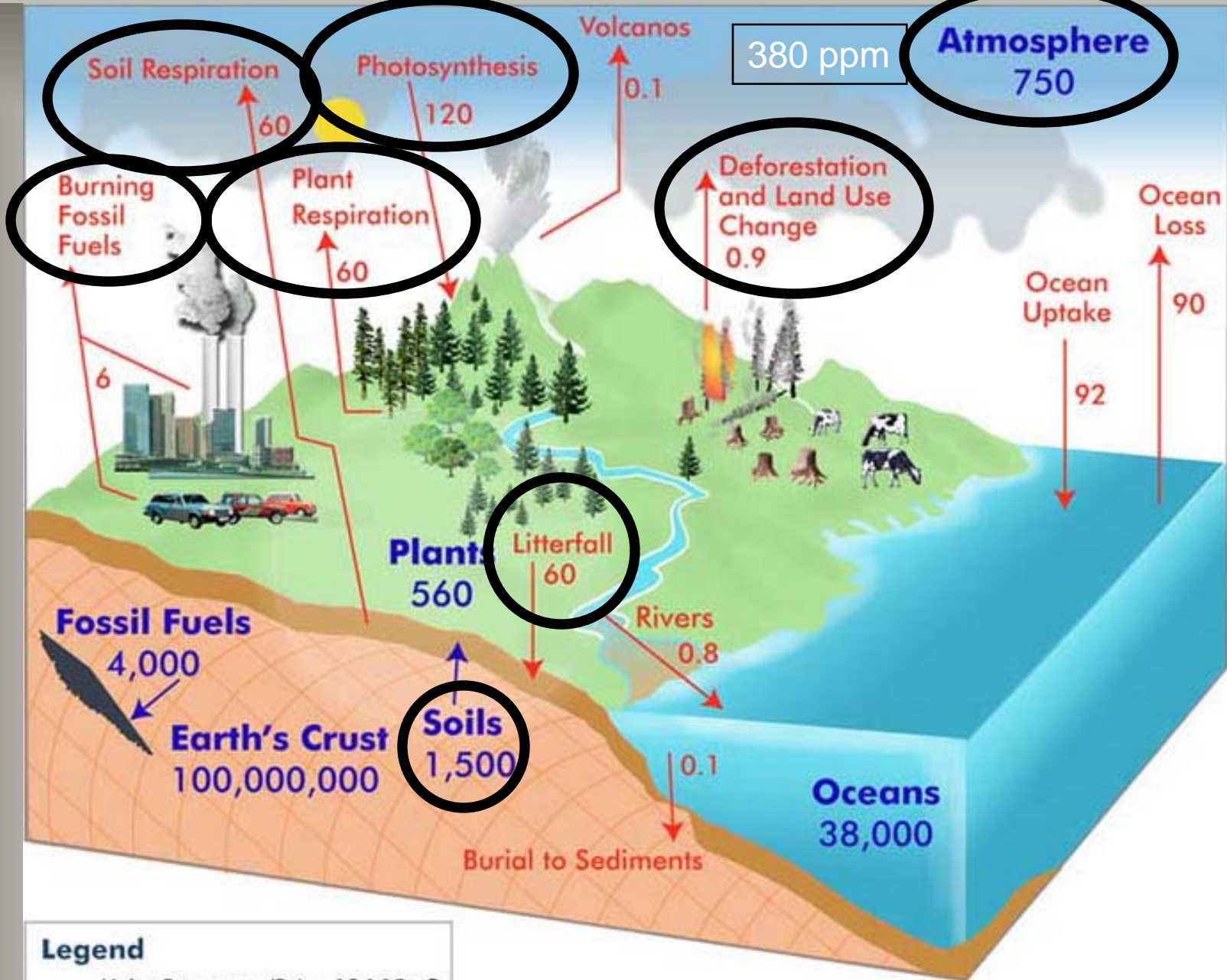
Soil Structure

- Improved soil structure in no-till systems reduces penetration resistance



Soil Carbon Sequestration

- Transfer of atmospheric CO₂ to the soil through land management practices.
- The sequestration of CO₂ results in the formation of a Carbon Credit or Offset.
- Goal:
 - Offset anthropogenic CO₂ emissions to atmosphere



Legend
Units: Petagrams (Pg) = 10^{15} gC
● Pools: Pg
● Fluxes: Pg/year



What's the Potential for Soil Sequestration of CO₂

- The USDA estimates that U.S. Farms and Rangeland could sequester 12-14% of current U.S. CO₂ emission
- Much of this CO₂ will be sequestered through the reversal of soil carbon losses from:
 - Cultivation
 - Overgrazing

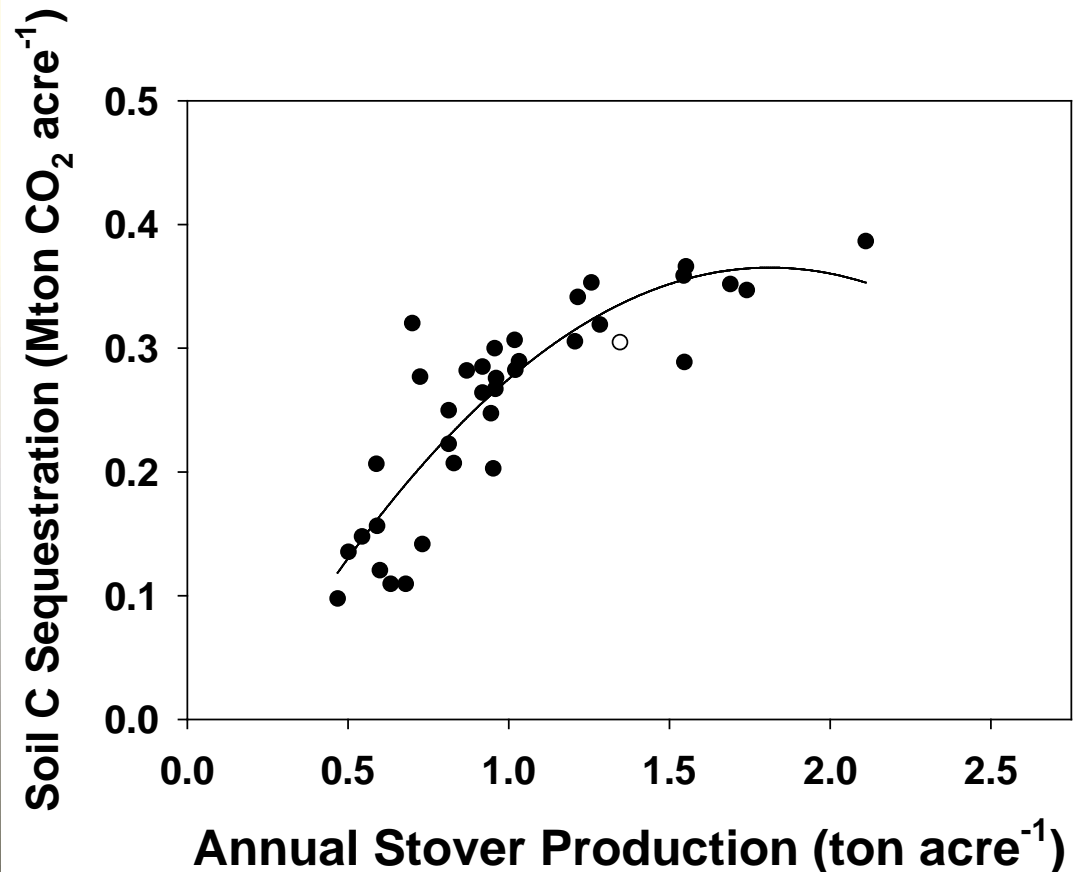
No-till Reduces Soil Respiration

- Residue decomposes more slowly on the soil surface.
- Increased water status potentially increases residue deposition.
- No-till minimizes soil aeration
 - Minimizes soil respiration.



Improved Soil Quality may Increase Litterfall if Productivity Increases

Dryland crop rotations
12-years, No-till
Eastern Colorado
0-8 inches
Sherrod et al. (2003)



Some No-till Guidelines:

- Implements acceptable for use include:
 - No-till planter/drill
 - Subsurface disturbance implements:
 - Anhydrous applicator
 - Manure knife applicator
 - Subsoiler/ripper
 - General rule:
 - 2/3 of soil can not be disturbed
- Residues can not be burned

Final Thoughts

- Organic C increases
 - Nutrient holding capacity
 - Water storage and infiltration
 - Limits compaction
- Accumulation of soil organic C has external value as a carbon credit.