Soil Infiltration

$$I = K_{sat}t + \frac{S^2}{\beta K_{sat}}\left\{1 - \left[1 + \beta\left(\frac{K_{sat}t^{1/2}}{S}\right)\right]^{-1}\right\}$$

Soil ability to take in water from rainfall or irrigation event at field capacity

By Clarence Chavez

USDA NRCS

Infiltration Ring Demonstration

#1.

Place the ring in the soil 3" deep

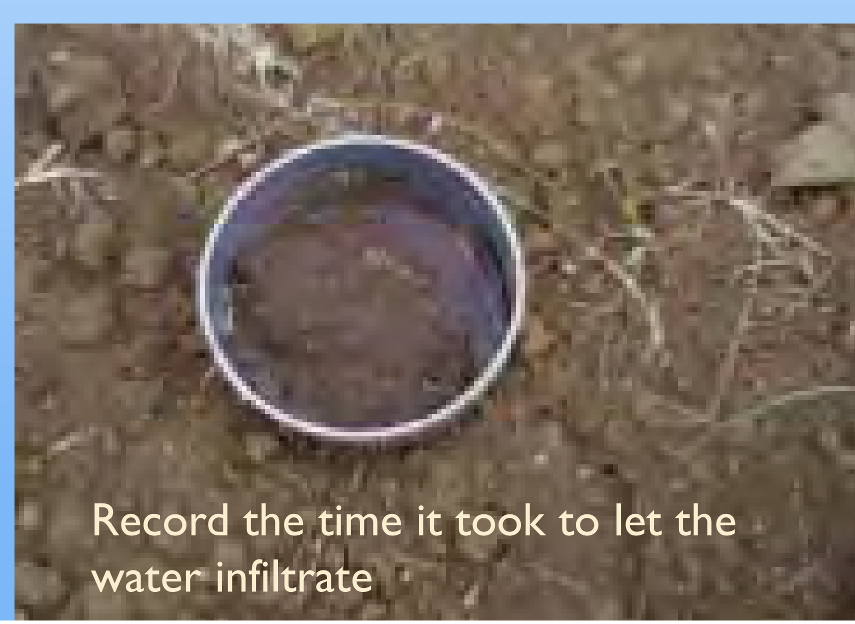
#2.

Place plastic wrap over ring and 444 mL of Water

#3.

Pull the plastic wrap and start timing

#4.



Record the time it took to let the water infiltrate

Repeating the Respiration or Infiltration Tests if needed !

1. Repeat test in the same ring a second time following steps 2, 3 & 4 with a second inch of water. On the soil data worksheet enter the number of minutes elapsed and depth of water for the second infiltration measurement. If the soil moisture is at or near field capacity, the second test is not necessary.

2. At this time if a second respiration measurement will be performed, set the lid loosely on the ring and leave it covered for approximately 16 to 24 hours. Then follow the instructions for the respiration measurement again

Saturated Hydraulic Conductivity and Permeability

- Saturated hydraulic conductivity: is a quantitative measure of a *saturated soil's* ability to transmit water when subjected to a hydraulic gradient. It can be thought of as the ease with which pores of a saturated soil permit water movement.

- Permeability: is defined qualitatively as the ease with which gases, liquids, or plant roots penetrate or pass though a soil mass or layer.

Saturated Hydraulic Conductivity and Permeability Conversions

- **Rate *um* s^{-1} = *Micrometers/sec.***
  - *um* s^{-1} = Ksat or Saturated Hydraulic Conductivity
  - in/hr = Permeability
- Conversion from ***um*** s^{-1} to in/hr.

  Multiply um s^{-1} by 0.1417

  Example: 100 *um* s^{-1} X 0.1417 = 14.17 in/hr.
- To convert back to in/hr to ***um*** s^{-1}

  Multiply in/hr by 7.0572

  Example: 14.17 in/hr x 7.0572 = 100.000 *um* s^{-1}

Texture Symbol and Texture Name

S = Sand,

LS = Loamy Sand

LFS= Loamy Fine Sand

SL=Sandy Loam

L = Loam

VFSL = Very Fine Sandy

CL = Clay Loam

SI= Silt

SC = Sandy Clay

Used on next slide

Gr = Gravelly

FS = Fine Sand

SL = Fine Sandy Loam

SCL= Sandy Clay Loam

SIL = Silt Loam

L = Loam

SICL = Silty Clay Loam

SIC = Silty Clay

C = Clay

NSSH Exhibit 618-9

Infiltration Rates: for general soil texture groups

Soil Properties	Permeability					Ksat		
Texture	Classes	Rate In/Hr				Rate *um* s^{-1}		
		Low	Rv	High		Low	Rv	High
S, Gr	Very rapid	**20.00**	**60.0000**	**100.00**		**>141.00141**	**>141.00**	
LS, FS	Rapid	**6.0000**	**13.0000**	**20.0000**		**42.0000**	**91.5000**	**141.0000**
LFS, FSL, SL	Moderately rapid	**2.0000**	**4.0000**	**6.0000**		**14.0000**	**28.0000**	**42.0000**
SCL, L, SIL, VFSL	Moderate	**0.6000**	**1.3000**	**2.0000**		**4.0000**	**9.0000**	**14.0000**
CL, SICL, SI, SIC, SC	Moderately slow	**0.2000**	**0.4000**	**0.6000**		**1.4000**	**2.7000**	**4.0000**
C, SIC	Slow	**0.0600**	**0.1300**	**0.2000**		**0.4200**	**0.9100**	**1.4000**
C W/ > 60% CLAY	Very slow	**0.0015**	**0.0308**	**0.0600**		**0.0100**	**0.2150**	**0.4200**
	Impermeable	**0.0000**	**0.0008**	**0.0015**		**0.0000**	**0.0005**	**0.0010**

Soil Infiltration: It is important because

- It is sensitive to near surface conditions and is subject to significant change with soil use, management and time.
- Indicates the rate and amount of water will enter the soil.
- Indicator of compaction or soil porosity (degradation or healthy soil).
- Which leads to decreased yields and increased erosion rates (soil structure/porosity).
- To refer to the intake family chart (irrigation water management).

Soil Intake Rate: Irrigation

- The *infiltration rate* (sometimes called intake rate) of a soil.

- It is commonly expressed in inches per hour.

- It is dependent on the permeability of the surface soil, moisture content of the soil and surface conditions such as roughness (tillage and plant residue), slope, and plant cover.

Soil Intake Guide

Section 2 of 22 (2f - Soils Intake Guide)									
Acre-Inches applied	Soils Intake Family								
	0.1	0.3	0.5	0.75	1.0	1.25	1.5	1.75	2.0
	Approximate time for the applied depth to infiltrate *(Hours)*								
1	2.8	1.0	0.63	0.48	0.33	0.28	0.23	0.2	0.18
2	10.5	3.5	2.0	1.5	1.0	0.8	0.7	0.6	0.52
3	22.3	6.8	3.8	2.8	1.8	1.5	1.2	1.1	0.9
4	34.0	10.0	5.5	4.1	2.6	2.2	1.8	1.6	1.33
5	49.0	14.0	7.6	5.6	3.6	3.0	2.4	2.2	1.78

Acre-Inches applied: By knowing the:

- Irrigation flow rate (Q = cfs) (cubic feet per second)
- Irrigation time set (T = hours)
- And area irrigated (A = acres)

You can calculate the acre-inches applied (D = QT/A). Where D is equal to the depth of application in inches.

Soils Intake Family: The intake family number of a soil relates the time required to infiltrate a given quantity of water in a specific soil type. Since the intake rate of the soil decreases as more water is applied, the family designation (e.g., 0.1, 05, 1.0, 1.5,…) reflect the final intake rate of the soil.

Time (Hours): This is the total hours required (i.e., Opportunity Time) for the given Irrigation application amount to infiltrate into the soil for a specific Intake Family. The times shown in the table do not reflect the total time of the irrigation set.

NOTE: The intake rate of the soil under irrigation is affected by many factors such as: Soil Texture, Soil Structure, Compaction, Organic Matter, Stratified Soils, Salts in the soil, Water Quality, Sediments in the irrigation water, etc. Therefore, the above times can very for a given application depth and intake family number. rudy.garcia.2009

Agronomy Tech Note 76 (http://www.nm.nrcs.usda.gov/technical/handbooks/iwm/nmiwm.html)

How long will it take to put 2 inches of water on a Clay or Sandy soil

Total Water Holding Capacity in a Soil

Section 2 of 22 (2c - Soils Data Interpretation Table for IWM Planning)

Soil Texture	% Sand	% Silt	% Clay	CEC Range (meq/100g)	Bulk Density (g/cm^3)	Soil weight (Million lbs. per ac-ft)	Soil Solids		Unavail-able Water		Available Water		Soil Porosity at FC	
							% Vol.	in/ft	% Vol.	in/ft	% Vol.	in/ft	% Vol.	in/ft
Sands	86 - 98	2 - 14	2 - 8	2 – 6	1.65	4.48	62.3	7.47	2.5	0.3	4.17	0.5	31.1	3.73
Loamy Sands	72 - 88	2 - 28	2 - 14		1.6	4.35	60.4	7.25	7.0	0.84	8.33	1.0	24.3	2.91
Fine Sands	86 - 98	2 - 14	2 - 8		1.65	4.48	61.5	7.38	10.2	1.22	10.4	1.25	17.9	2.15
V. F. Sands	86 - 98	2 - 14	2 - 8		1.65	4.48								
Loamy F. Sands	72 - 88	2 - 28	2 - 14		1.6	4.35								
Loamy V. F. Sands	72 - 88	2 - 28	2 - 14		1.6	4.35								
Sandy Loam	46 - 84	2 - 48	2- 18	3 – 8	1.56	4.24	58.8	7.06	12.3	1.48	12.5	1.5	16.3	1.96
Fine Sandy Loam	46 - 84	2 - 48	2 - 18		1.56	4.24								
V. F. Sandy Loam	46 - 84	2 - 48	2 - 18		1.53	4.16	55.4	6.65	16.2	1.94	16.7	2.0	11.8	1.41
Loam	26 - 50	30 - 48	10 - 26	7 – 15	1.42	3.86								
Silt Loam	2 - 48	52 - 78	2 - 26	10 –19	1.46	3.97								
Silt	2 - 18	82 - 98	2 - 10		1.47	3.99								
Sandy Clay Loam	46 - 78	2 - 26	22 - 36		1.4	3.8	50.2	6.02	20.0	2.4	18.3	2.2	11.5	1.38
Silty Clay Loam	2 - 18	42 - 70	28 - 38		1.27	3.45								
Clay Loam	22- 44	18 - 50	28 - 38		1.32	3.59								
Sandy Clay	46 - 62	2 - 16	38 - 54		1.33	3.61	47.9	5.75	21.5	2.58	16.7	2.0	13.9	[illegible]
Silty Clay	2 - 18	42 - 58	42 - 58		1.23	3.34								
Clay	2 - 44	2 - 38	42 - 98	15 - 30	1.25	3.4								

- V = Very & F = Fine
- Particle diameter (mm) for Sand, Silt & Clay: Very Coarse Sand (2.0 - 1.0), Coarse Sand (1.0 - 0.5), Med. Sand (0.5 - 0.25), Fine Sand (0.25 - 0.1), Very Fine Sand (0.1 - 0.05), Silt (0.05 - 0.002) and Clay (< 0.002)
- Cation Exchange Capacity (CEC) taken from the Western Fertilizer Handbook, 2nd ED., 1995
- Bulk Density (Ref. bulk density calculator @ Pedosphere.com)
- Unavailable Water (Ref. Figure 1-9 of the National Engineering Handbook; Section 15 – Irrigation)
- Available Water (Ref. NRCS Salinity Management for Soil & Water; Table 5.1, page 5.10)
- FC = Field Capacity.

NOTE: Soil structure is evaluated for its effect on downward movement of water: Single grain (rapid), Granular (rapid), Blocky (moderate), Prismatic (moderate), Platy (slow) and Massive (slow). The Soil Intake Family (typically 0.1 thru 2.0) is used in IWM field evaluations and irrigation system design. Irrigation Water Quality (i.e., Electrical Conductivity of irrigation water (ECiw) in dS/m & Sodium Adsorption Ratio (SAR)) is evaluated for its potential detrimental effects on plant moisture availability and water infiltration. rudy.garcia.2008

Agronomy Tech Note 76 (http://www.nm.nrcs.usda.gov/technical/handbooks/iwm/nmiwm.html)

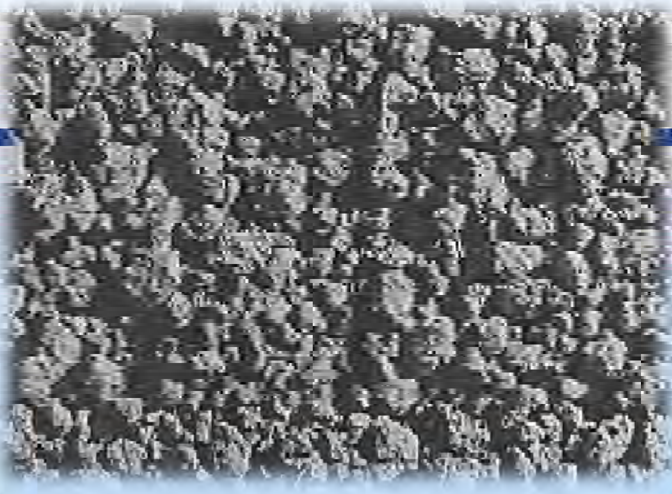
Unavailable Water
1.94 "/ac ft.

Available Water
2.0"/ac ft

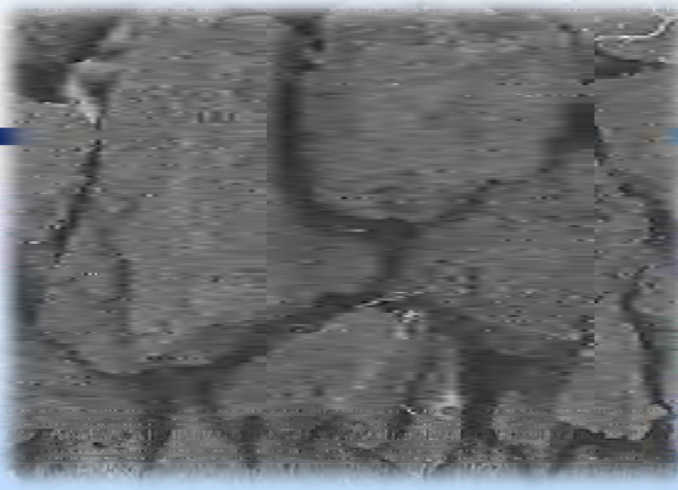
Total Water Holding Capacity

3.94 "/ac ft

Soil Structure

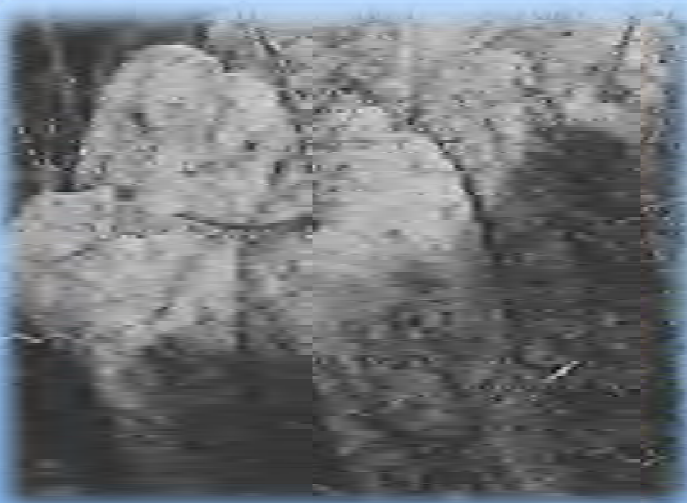


Granular



Blocky

Prismatic



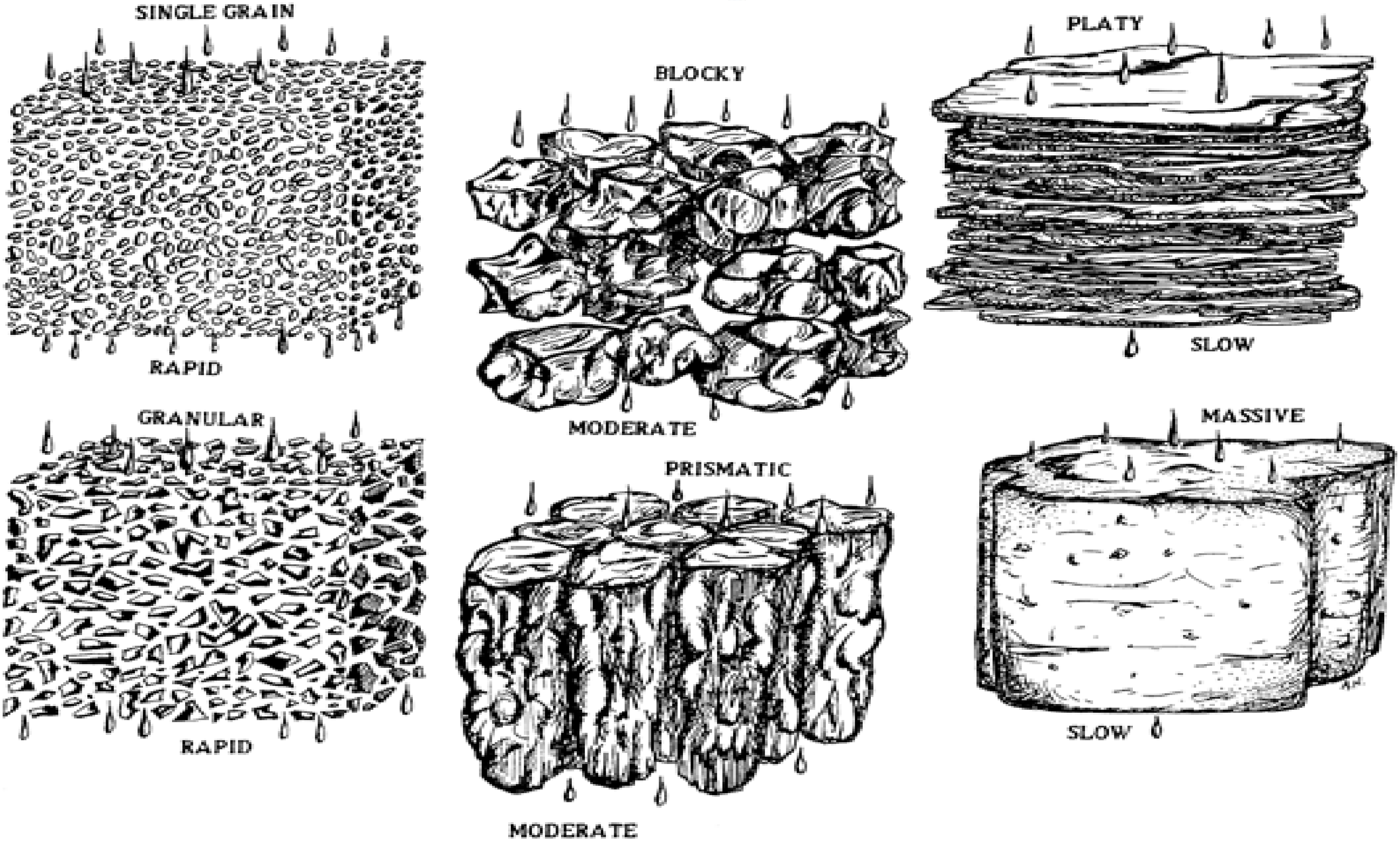
Columnar

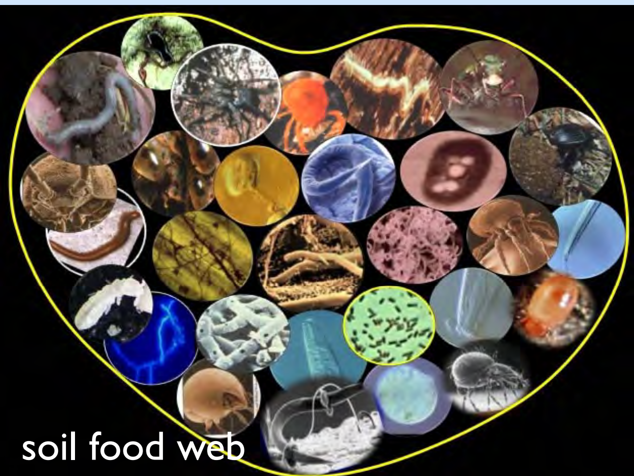
Platy

Single grained

Massive does not have structure

Soil Structure Type
Permeability Classes

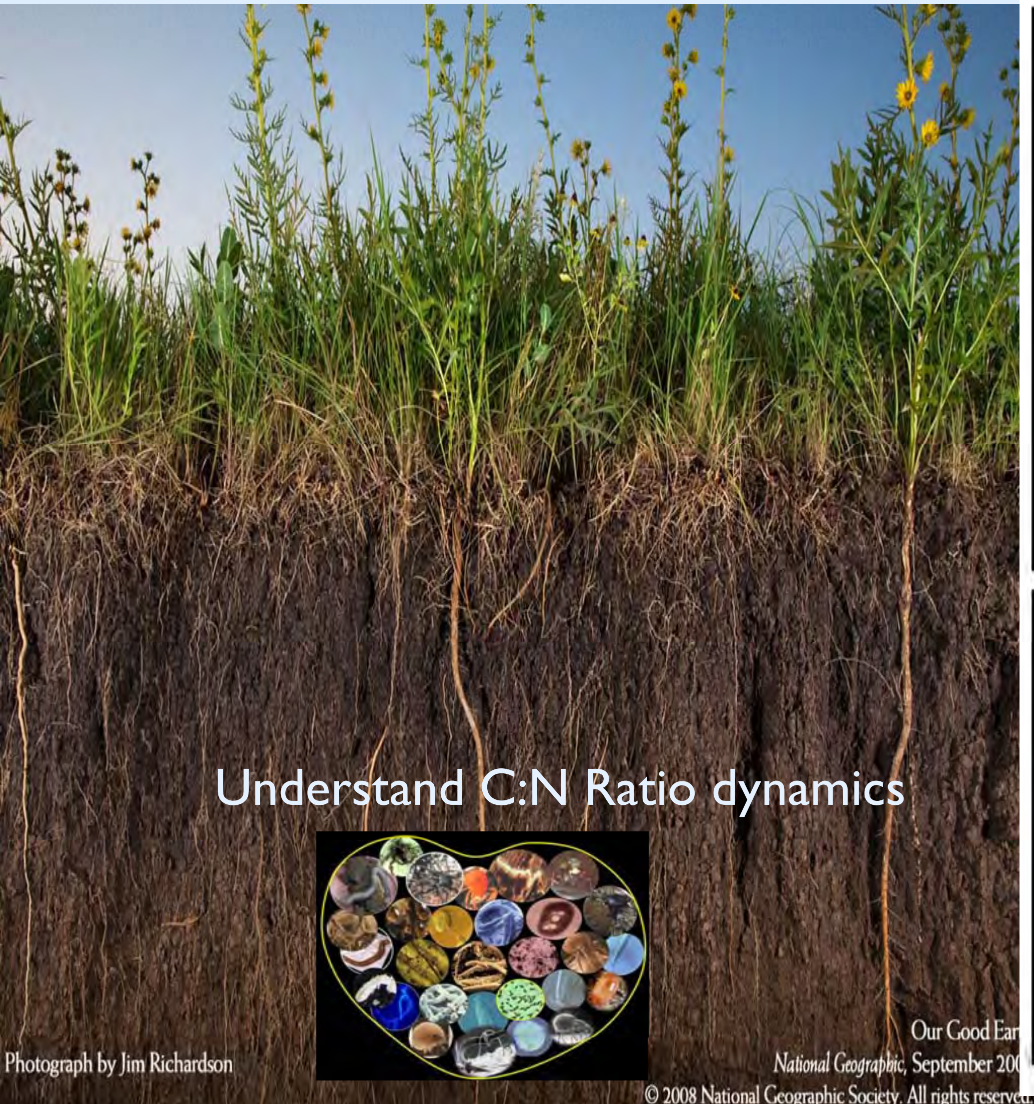


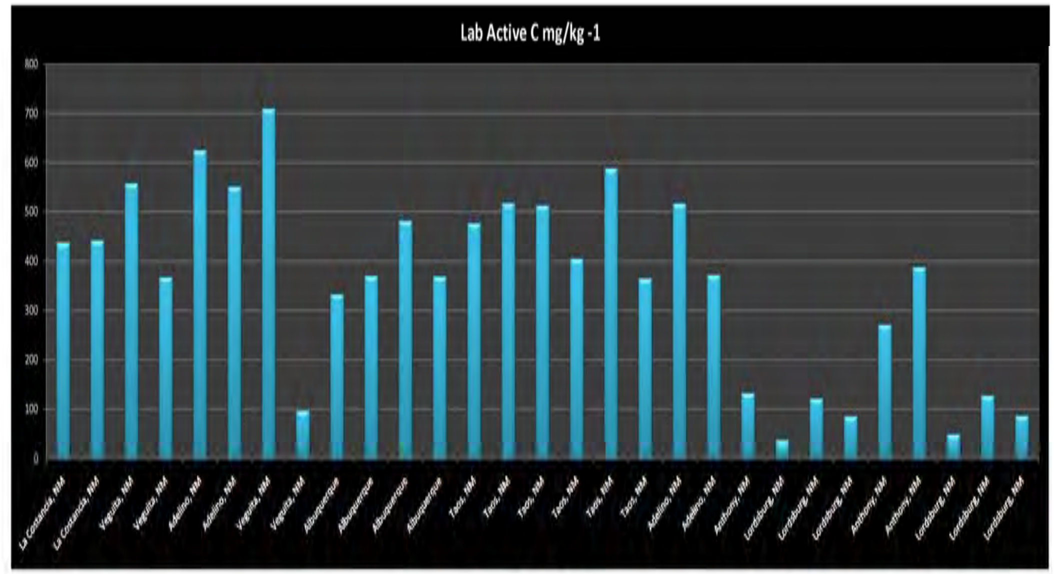


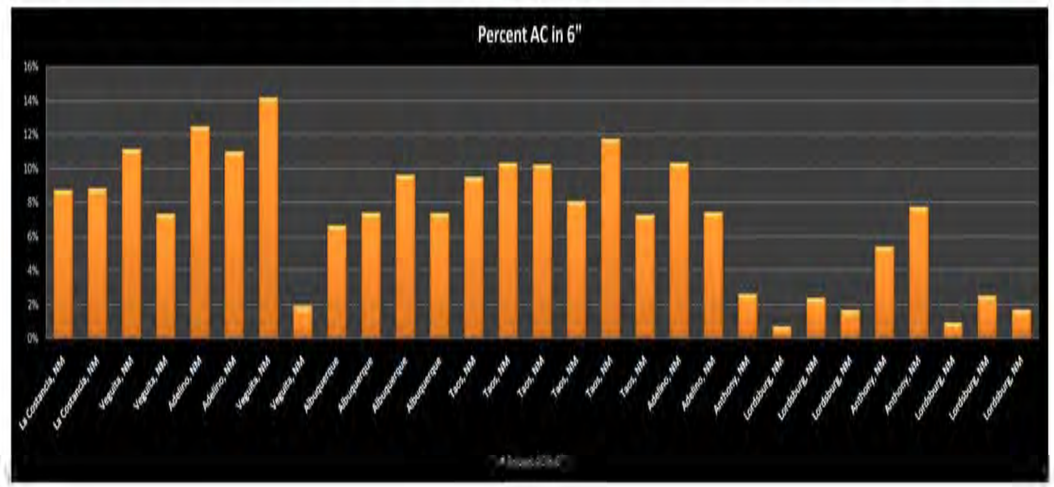
Soil Health - will have the highest influence on soil aggregation and soil development.

Infiltration: Reactive Carbon:

Must understand the sources of carbon: (root exudates, glomalin, roots, predator pray, crop residue, etc…) they provide the glues and carbon for developing soil structure.



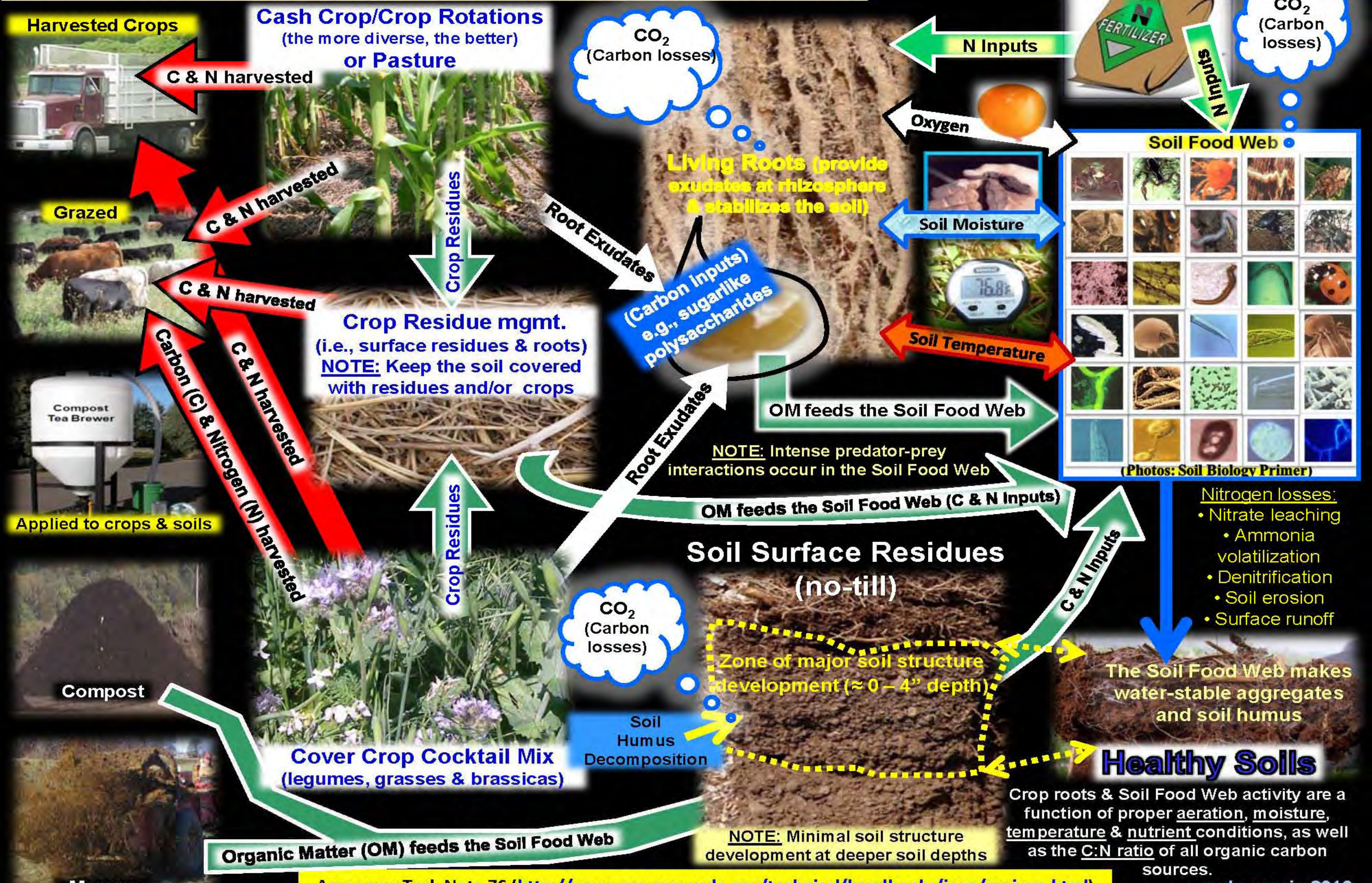




Reactive Carbon in Soils helps in the development of Soil Structure and Microorganisms

Organic Matter and Organic Carbon

Introduction to Section 1 (1b – Managing Organic Matter & Nitrogen Inputs to Improve the Soil Resource)



Agronomy Tech Note 76 (http://www.nm.nrcs.usda.gov/technical/handbooks/iwm/nmiwm.html)

rudy.garcia.2010

Soil Biota / Microorganisms

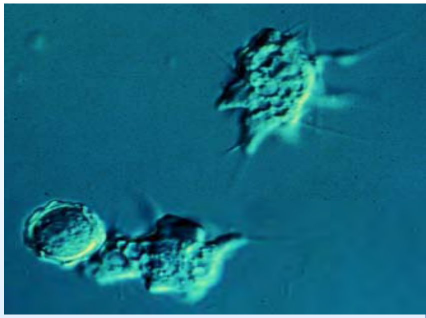
Biological Activity is directly proportional to the quantity of organic matter in the soil.

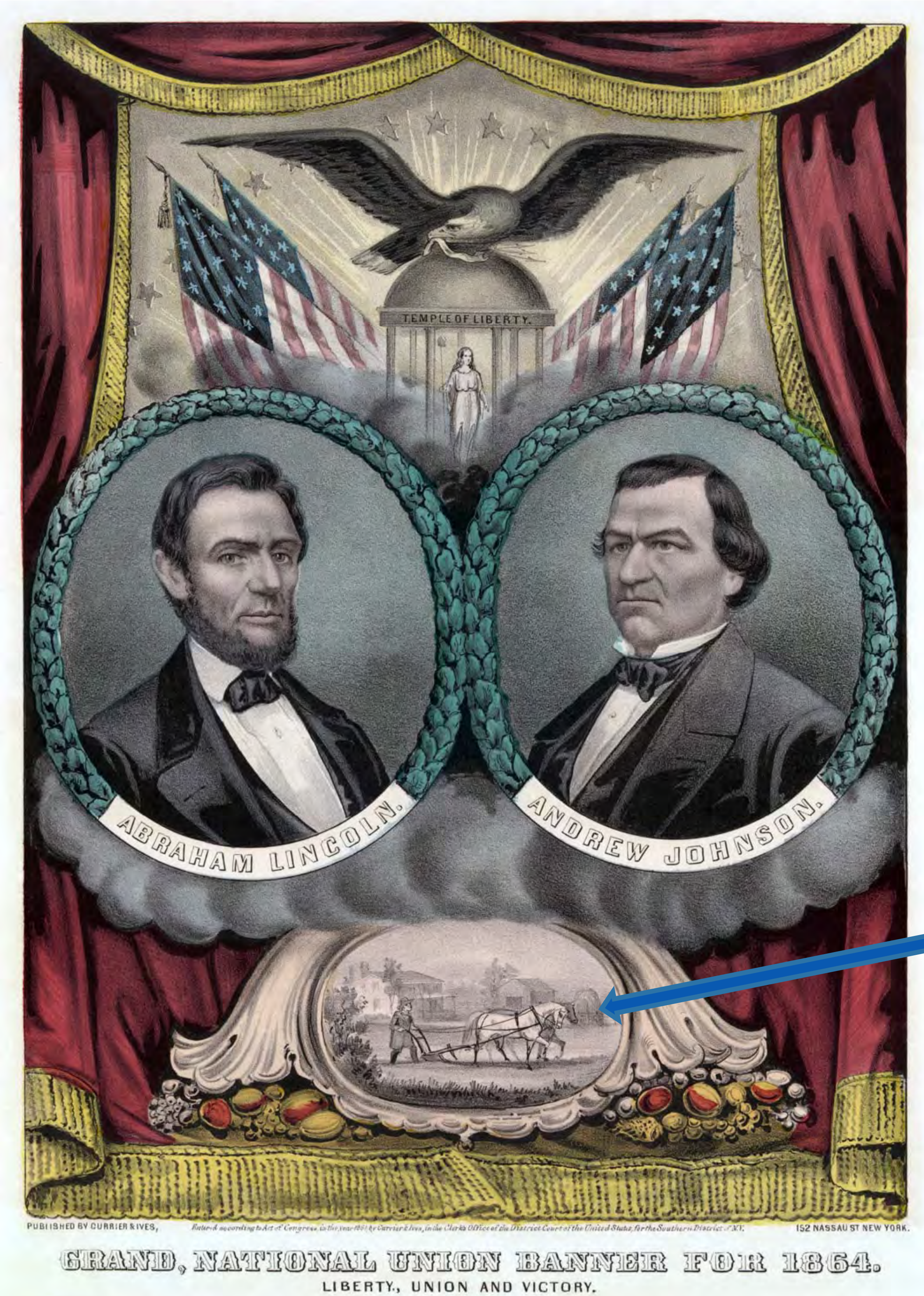
Soil Processes effected by reduced biological activity:

1. Carbon Cycle
2. Macronutrient and micronutrients cycling

Remember to feed the soil microorganisms!

Infiltration – influenced by Soil Biota. Soil Biota is a major factor for forming soil aggregates





Soil Health

Farm Management: Tillage operations have been a common place in the USA for over 200 years

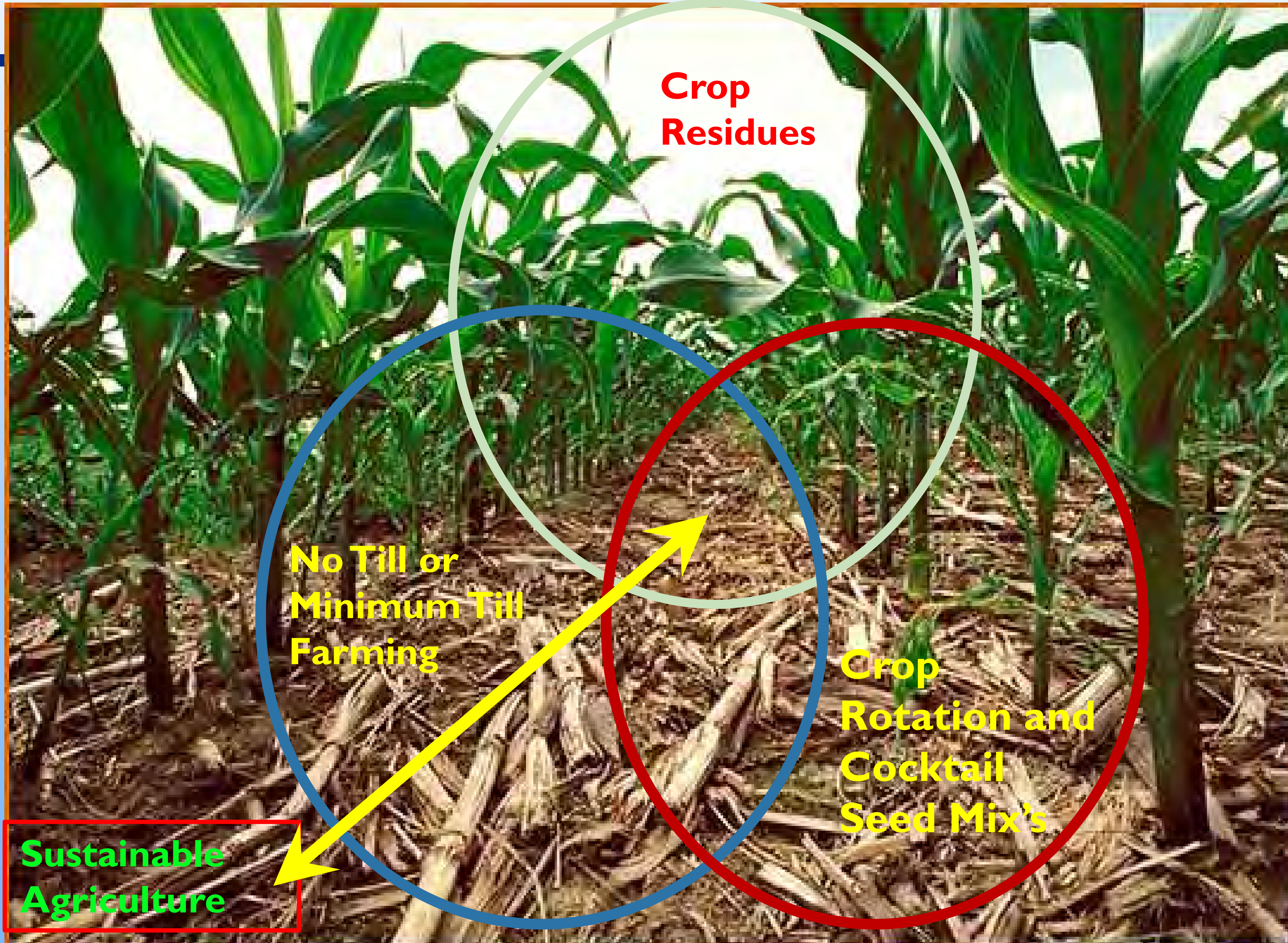
It is time to start healing the soil!

Tillage Operations: Impact negatively on the soil and also will impacts how the agroecosystem functions.

Wind and water erosion

Healthy Soils Through Management

Soil Organic Matter is replenished for Soil Biota



Soil Biota / Microorganisms Increase Nutrient Cycling

Soil Infiltration: Cover crops & No Till

- Increased soil biota and biological activity.
- Increased soil organic matter
- Increased infiltration
- Improved soil structure
- Increased carbon sequestration
- Decreased soil denitrification N_2O / NO_x / N_2

Soil Infiltration: Why

- Increased soil aggregation
- Improved soil health
- Increased pore space (roots and soil biota)
- Reduce salts effects
- Irrigation system efficiency & design
- Water Quality
- Improved IWM (irrigation water management)

For additional information please contact your local office of the

Natural Resources Conservation Service

or

Soil and Water Conservation District

USDA NRCS

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