

Carbon, Crops and Covers

A Conservation Planning Perspective

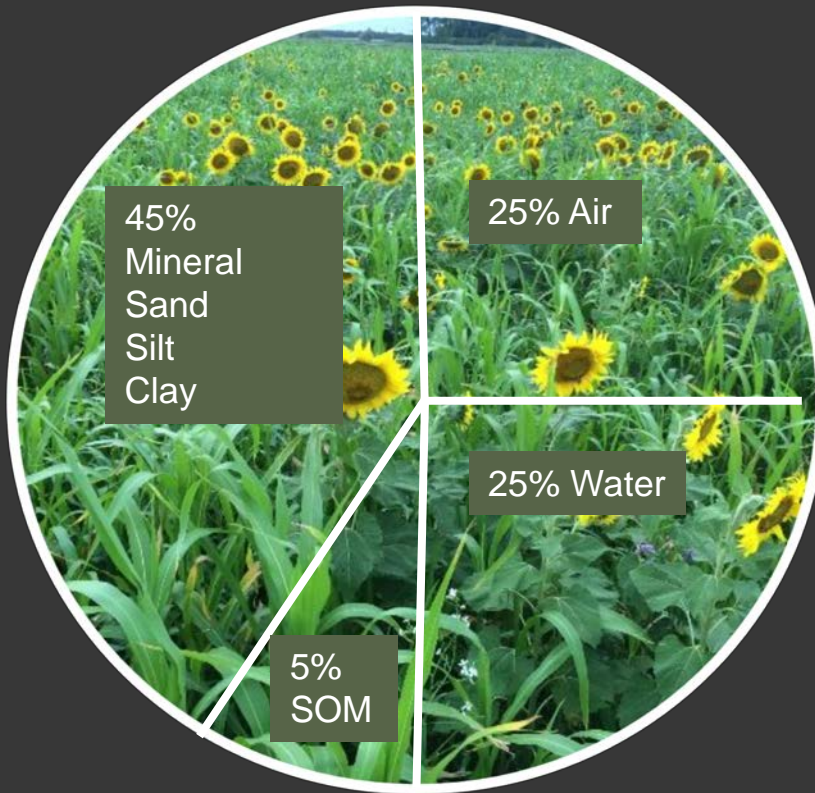


By: Jay Fuhrer | Soil Health Specialist | Bismarck, ND - USA
Natural Resources Conservation Service - USDA



Soil

Jay Fuhrer
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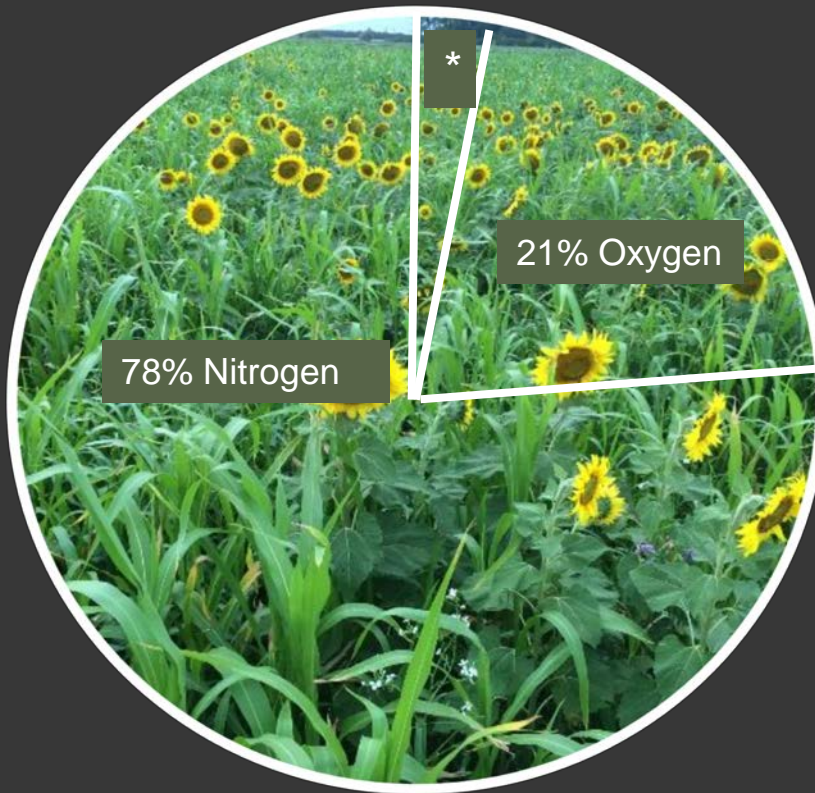
What Does A Soil Consist Of?

- 25% Air
- 25% Water
- 45% Mineral
- 5% SOM

Air



What Does Dry Air Consist Of?



- 78% Nitrogen N_2
- 21% Oxygen O_2
- 1% *
 - Argon Ar
 - Carbon Dioxide CO_2
 - Neon Ne
 - Helium He
 - Methane CH_4
 - Krypton Kr
 - Nitrogen Oxide N_2O
 - Hydrogen H_2
 - Xenon Xe
 - Ozone O_3

Source: Scifun.Chem.Wisc.edu



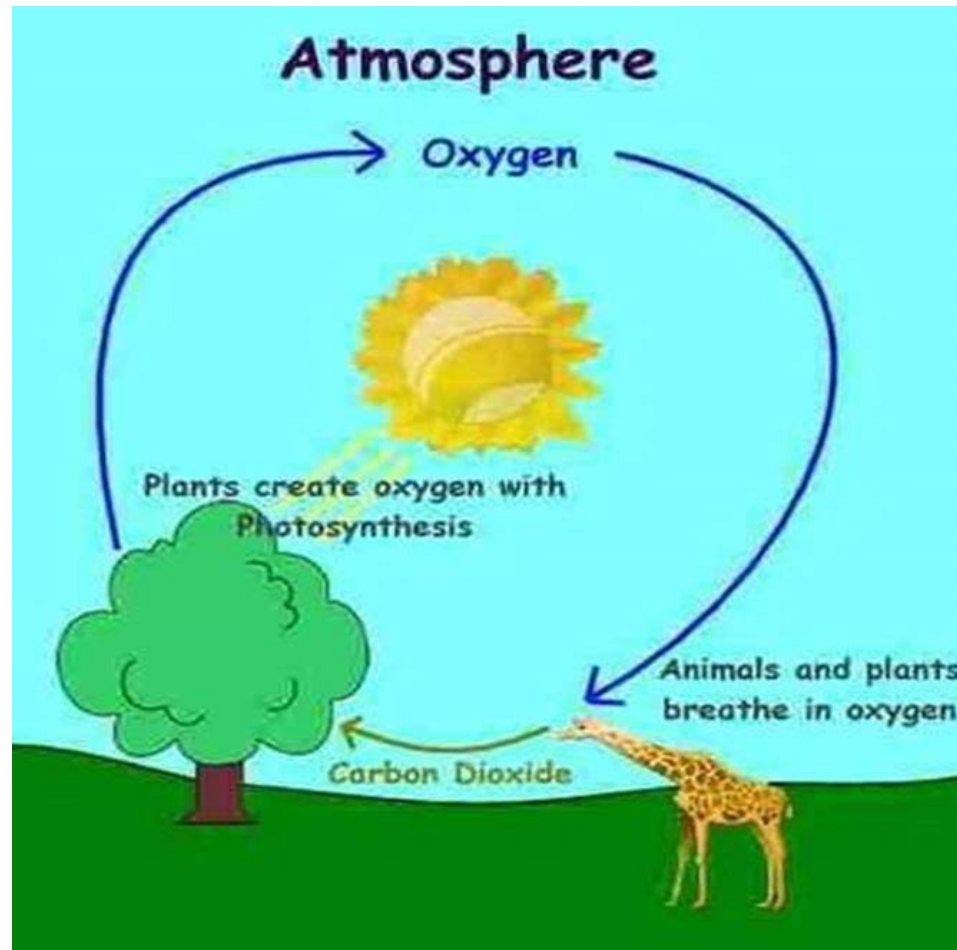
March 11, 2019
Menoken Farm

Carbon Cycle



It Takes A Green Plant

Atmosphere



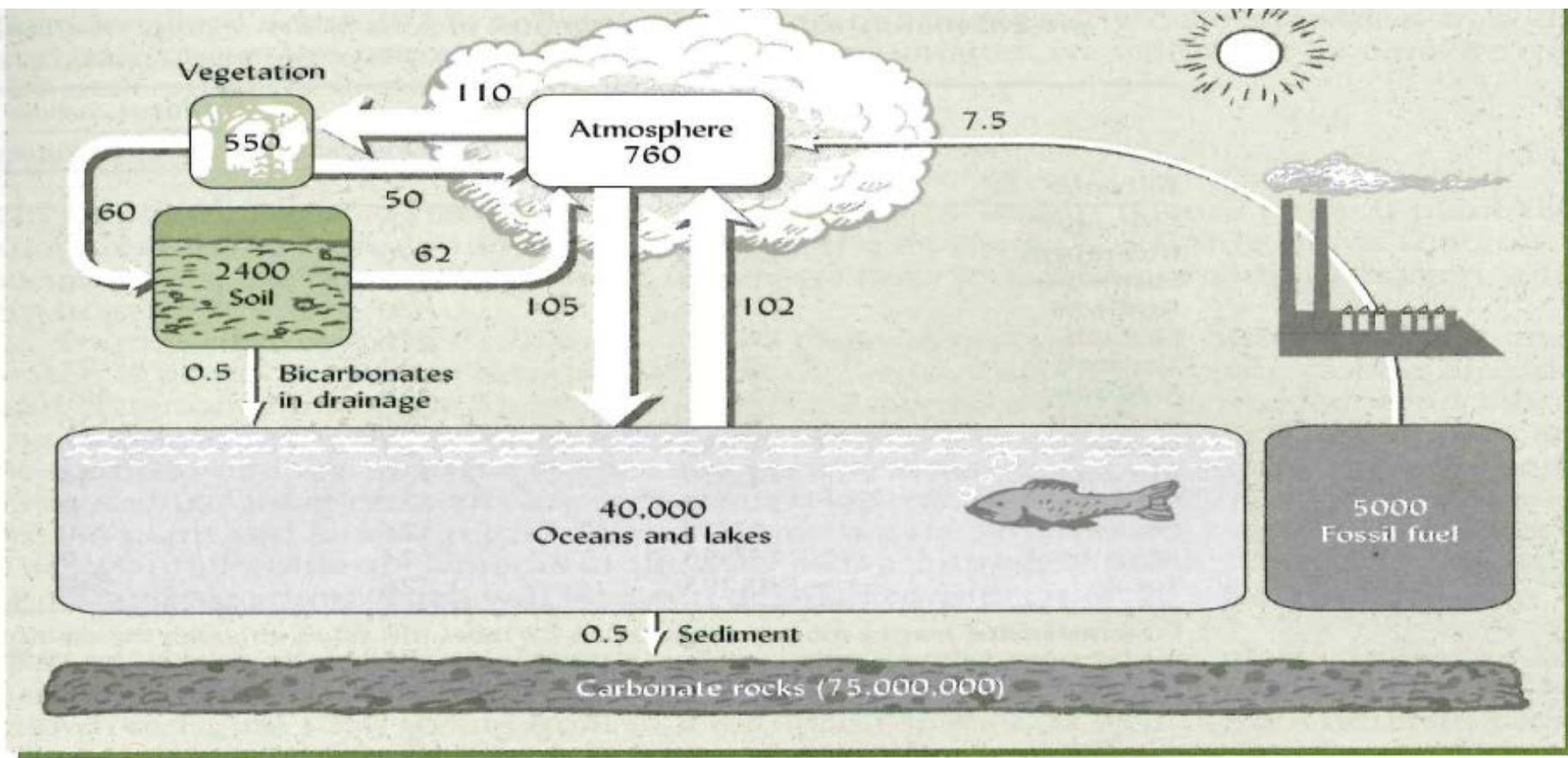


FIGURE 12.3 A simplified representation of the global carbon cycle emphasizing those pools of carbon which interact with the atmosphere. The numbers in the boxes indicate the petagrams (Pg = 10^{15} g) of carbon stored in the major pools. The numbers by the arrows show the amount of carbon annually flowing (Pg/yr) by various processes between the pools. Note that the soil contains almost twice as much carbon as the vegetation and the atmosphere combined. Imbalances caused by human activities can be seen in the flow of carbon to the atmosphere from fossil fuel burning (7.5) and in the fact that more carbon is leaving (62 + 0.5) than entering (60) the soil. These imbalances are only partially offset by increased absorption of carbon by the oceans. The end result is that a total of 221.5 Pg/yr enters the atmosphere while only 215 Pg/yr of carbon is removed. It is easy to see why carbon dioxide levels in the atmosphere are rising. [Data from IPCC (2007); soil carbon estimate from Batjes (1996)]

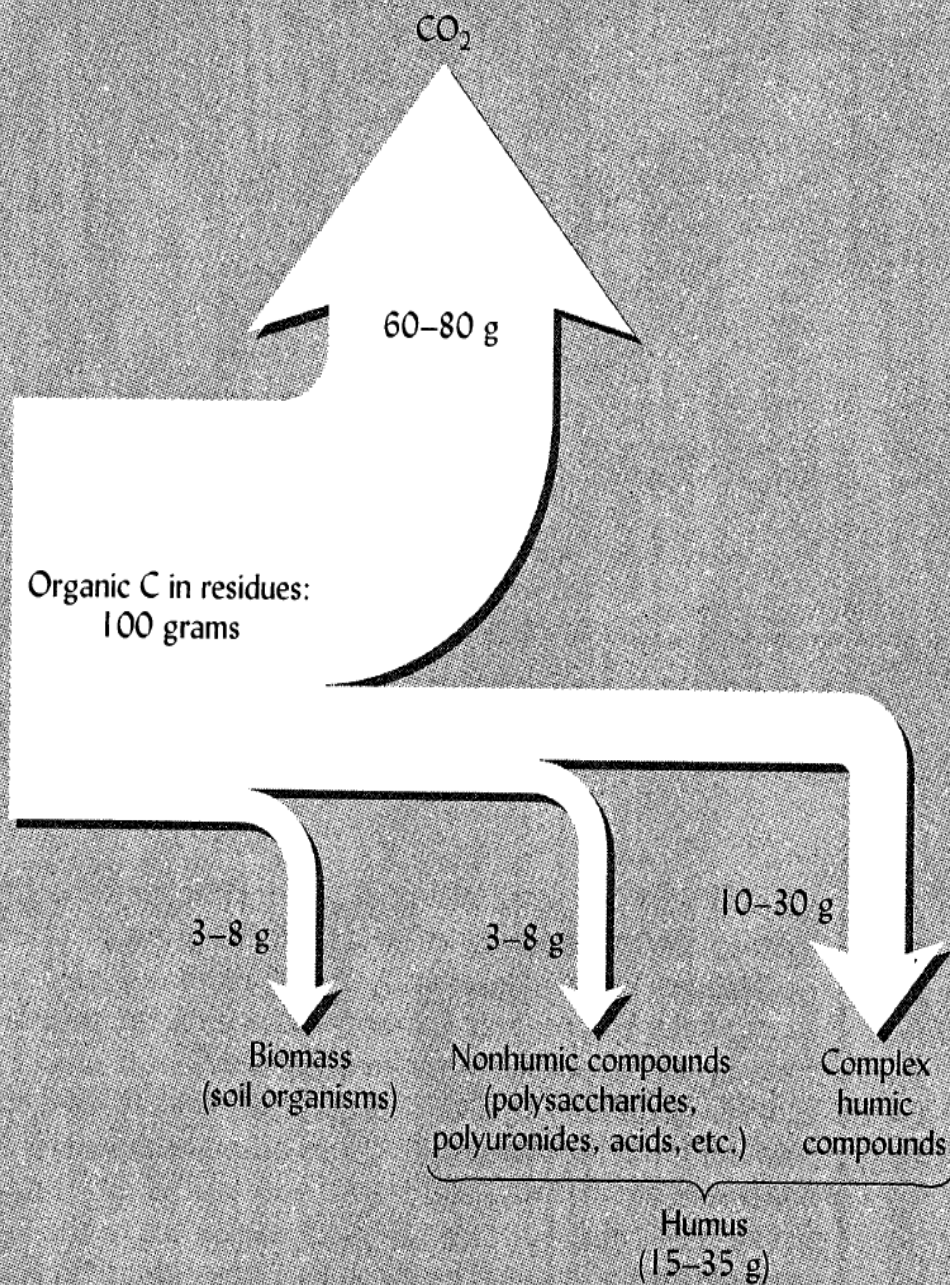


FIGURE 12.12 Disposition of 100 g of organic carbon in residues one year after they were incorporated into the soil. More than two-thirds of the carbon has been oxidized to CO₂, and less than one-third remains in the soil—some in the cells of soil organisms, but a larger component as soil humus. The amount converted to CO₂ is generally greater for aboveground residues than for belowground (root) residues. (Estimates from many sources)

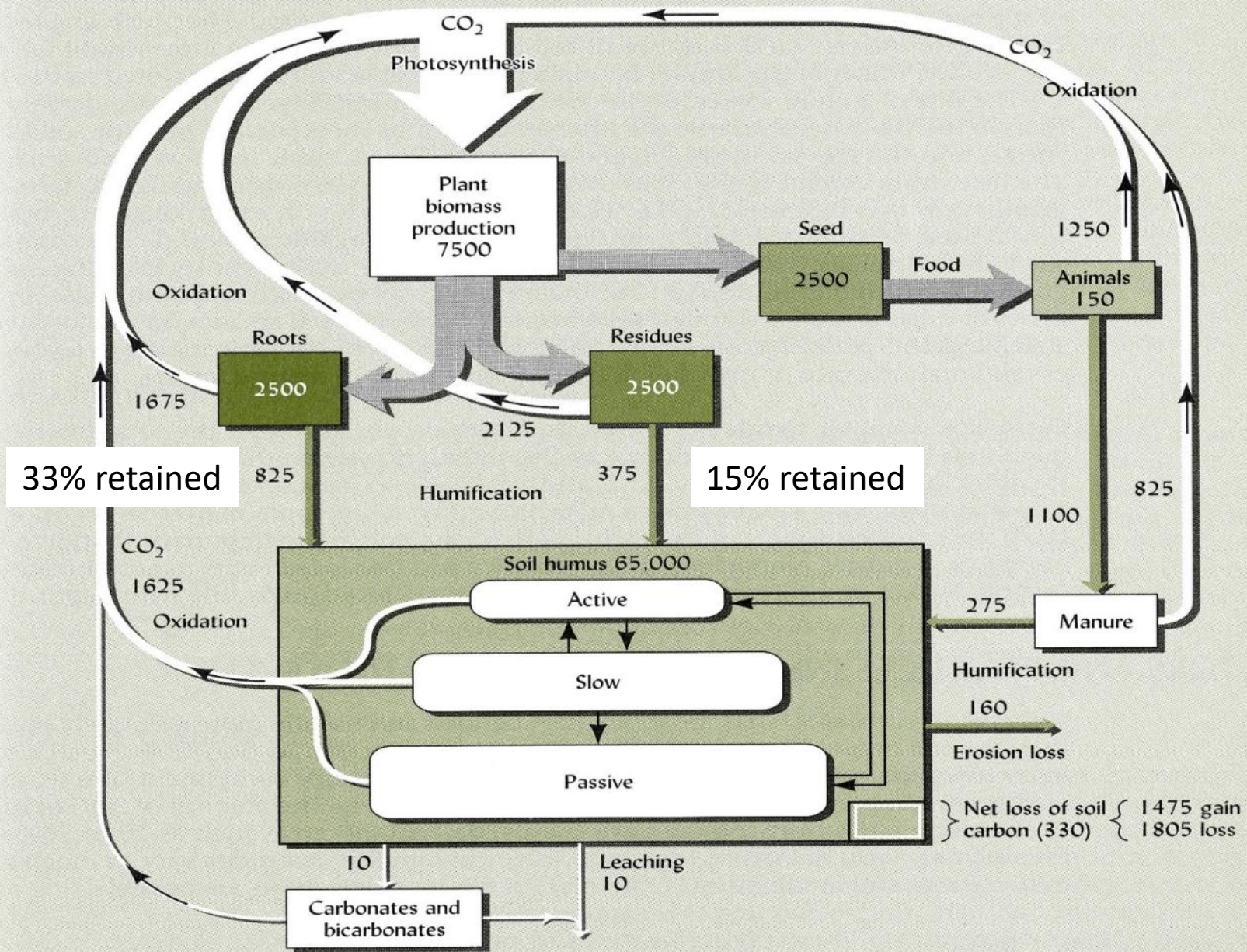


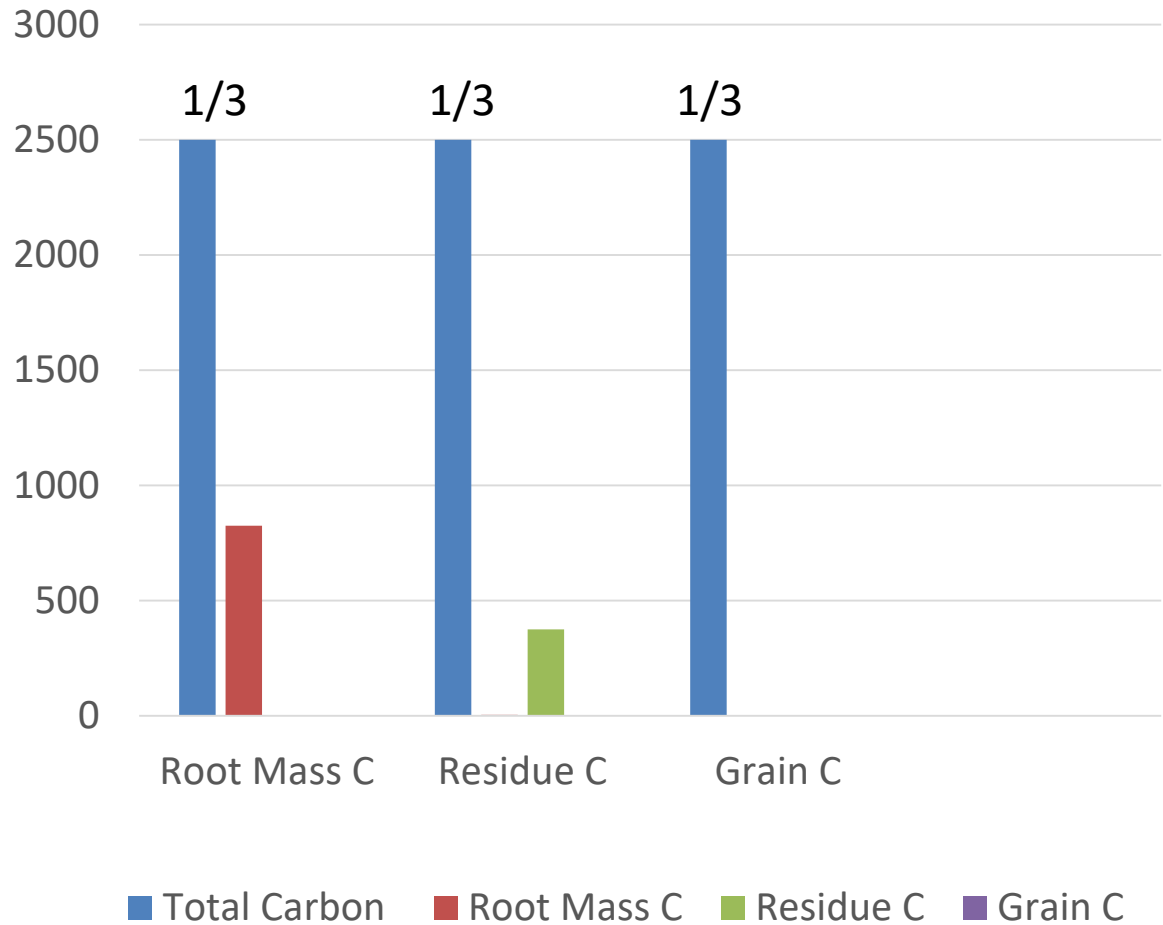
FIGURE 12.18 Carbon cycling in an agroecosystem.



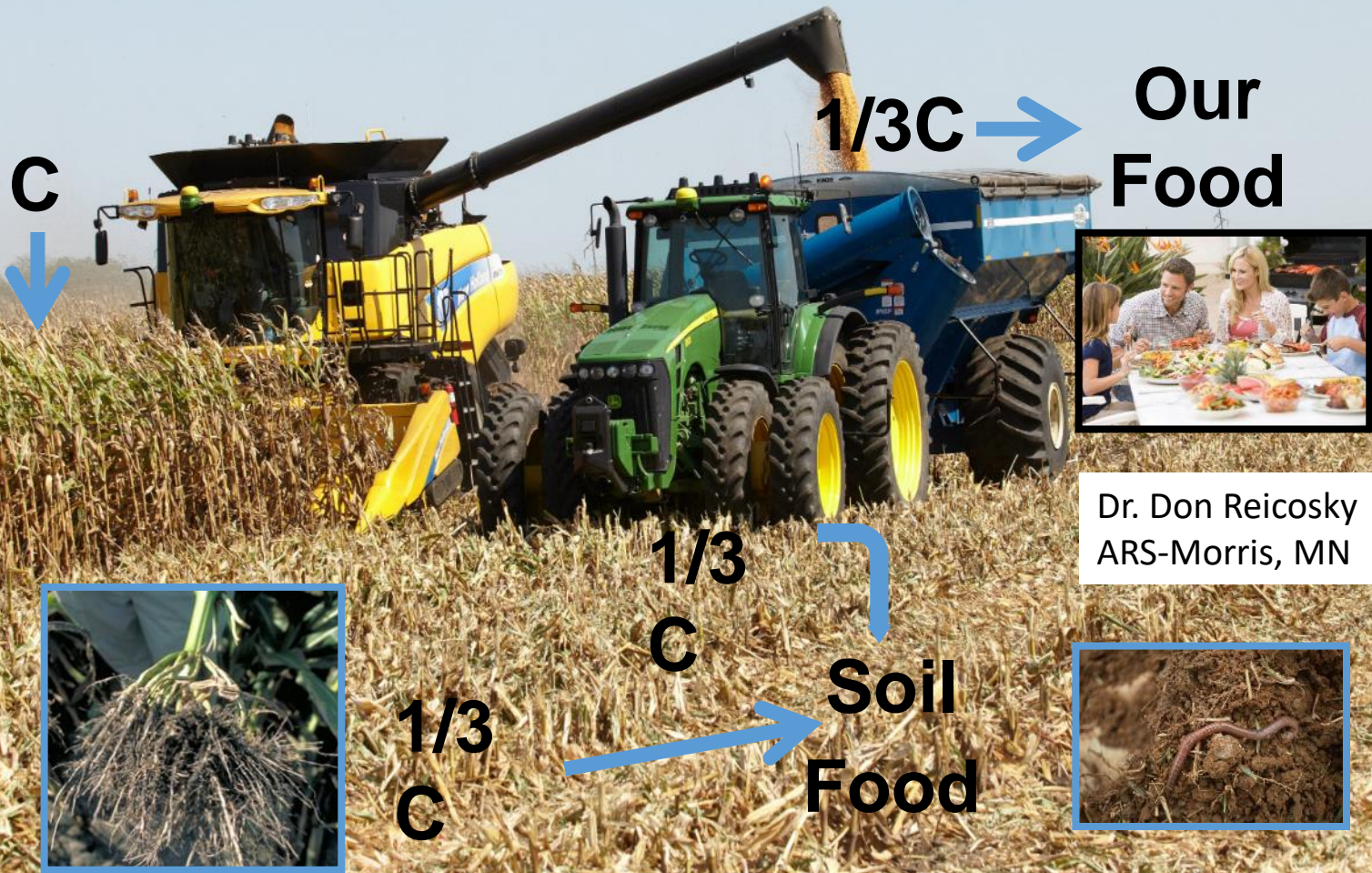
Total Carbon Produced and Approximate Amount Retained in the Soil

Corn Crop
7500 kg/ha Carbon

- Root Mass – 2500 kg/ha
- Residue – 2500 kg/ha
- Grain/Cattle – 2500 kg/ha




Agriculture is a carbon exporter from the landscape in the form of our food. **About** one third of the carbon fixed in photosynthesis is exported in the grain yield used for our consumption.





Exporting Carbon & Nutrients
Menoken Farm





“Roots are constantly exposed to a range of biotic and abiotic stresses at the root–soil interface, and they respond to these stresses by **secreting a different blend of chemicals** to protect against negative influences and encourage positive interactions.”

Source:

Regulation and function of root exudates

DAYAKAR V. BADRI & JORGE M. VIVANCO

07 May 2009

Regulation of Root Excreting Phytochemicals



Table 1. Classes of compounds released in plant root exudates

Carbohydrates

Amino acids

Organic acids

Flavonols

Lignins

Coumarins

Aurones

Glucosinolates

Anthocyanins

Indole

Fatty acids

Sterols

Allomones

Proteins and enzymes


Source:

Regulation and function of root exudates

DAYAKAR V. BADRI & JORGE M. VIVANCO

07 May 2009

Table 1




“Up to 30% of the photosynthetic energy accumulated by a plant is dumped into the root zone as sugars, proteins and carbohydrates.”

<http://www.soilsforlife.org.au/why-carbon-flows-with-alan-lauder/plants-dont-just-sit-there-and-take-it>

“This represents an energy cost to the plant
.....as much as 5 to 30% of its total photosynthate
production to its mycorrhizal fungal symbiont”

The Nature and Properties of Soils, Fourteenth Edition, Chapter 11,
Soil Organic Matter-Page 472
by Brady and Weil



“Root exudation clearly represents a significant carbon cost to the plant (Marschner 1995), with young seedlings typically exuding about 30–40% of their fixed carbon as root exudates”
(Whipps 1990).

Source:

Regulation and function of root exudates

DAYAKAR V. BADRI & JORGE M. VIVANCO

07 May 2009

Introduction



“For crops, belowground C allocation was maximal during the first 1–2 months of growth and decreased very fast thereafter.”


“Despite its fundamental role for carbon (C) and nutrient cycling, rhizodeposition remains ‘the hidden half of the hidden half’: it is highly dynamic and rhizodeposits are rapidly incorporated into microorganisms, soil organic matter, and decomposed to CO₂. Therefore, rhizodeposition is rarely quantified and remains the most uncertain part of the soil C cycle and of C fluxes in terrestrial ecosystems”

Source:

Carbon input by roots into the soil: Quantification of rhizodeposition from root to ecosystem scale

Johanna Pausch^{1,2} | Yakov Kuzyakov^{2,3,4}

14 July 2017, Page 1 Abstract

A group of people, including men and women, are gathered in a lush green cornfield. They are leaning over and examining the corn plants closely. The people are wearing jackets, some in dark colors and others in teal. The background shows a dense forest of trees under a grey, overcast sky. The overall scene suggests a field study or a farm tour.

Tasting Sugar Exudates
Murray and TJ Haw Dairy Farm

Source:

The Nature and Properties of Soils,
Fourteenth Edition, Chapter 12
Soil Organic Matter-Page 511
by Brady and Weil

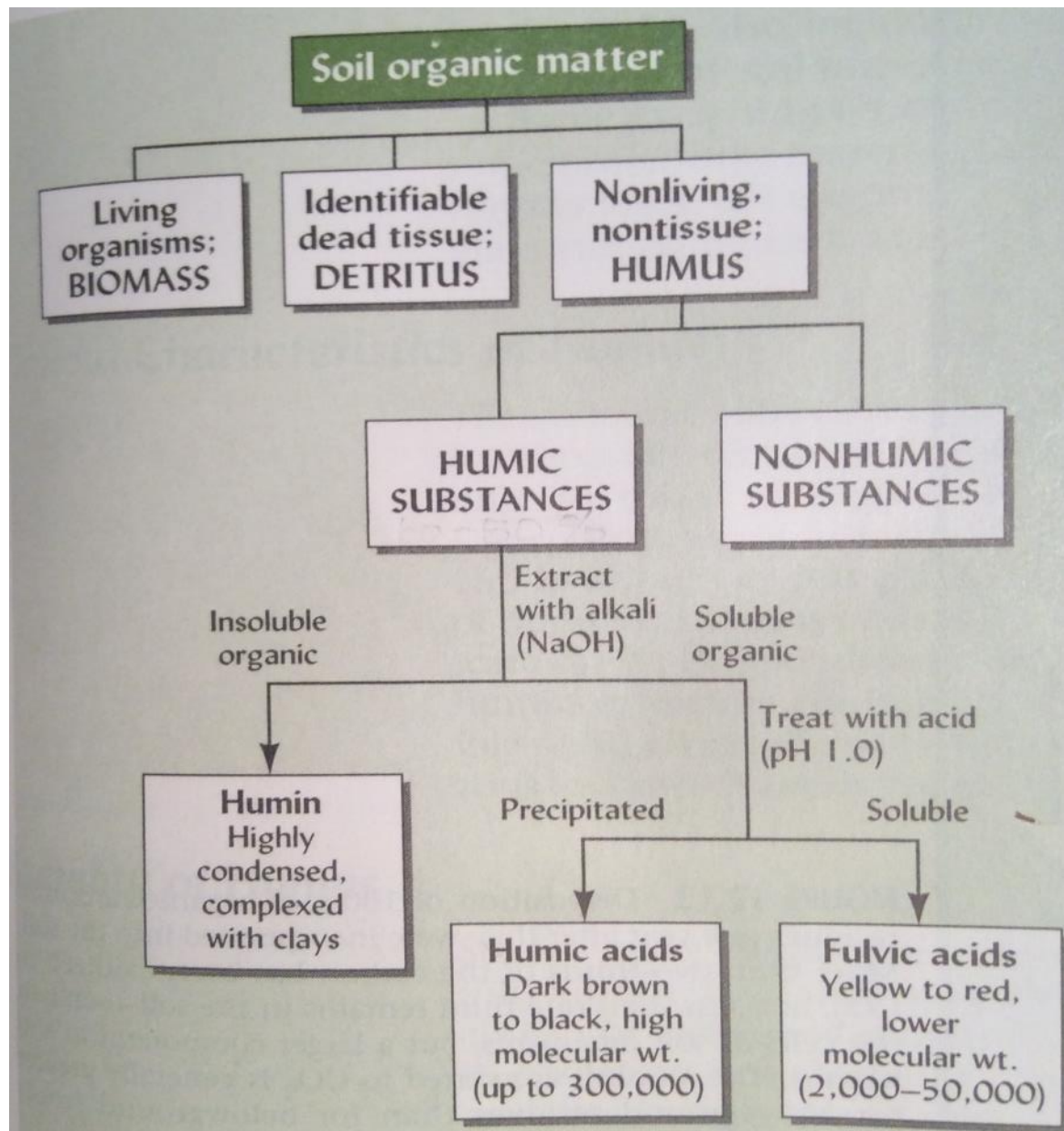




Table 9.2 Usual Range for the Elemental Composition of Humic Substances

Element	Humic Acids	Fulvic Acids
Carbon	53.8 - 58.7%	40.7 – 50.6%
Oxygen	32.8 – 38.3	39.7 – 49.8
Hydrogen	3.2 – 6.2	3.8 – 7.0
Nitrogen	0.8 – 4.3	0.9 – 3.3
Sulfur	0.1 – 1.5	0.1 – 3.6

Source:

Humus Chemistry – Genesis, Composition, Reactions

Chapter 9, Page 213

F.J. Stevenson



Soil Biology – Plant Interaction
Soil Aggregates last for
Days-Weeks-Months
Menoken Farm



Soil Organic Matter



What Does Soil Organic Matter Consist Of:

- The Living – Microorganisms
- The Dead – Fresh Residues
- The Very Dead - Humus

1 % Soil Organic Matter:

10,000 units carbon

1,000 units organic nitrogen

100 units phosphorous

Soil Organic Matter:

An acre of soil 6 inches (15.2 cm) deep weighs approximately 2,000,000 pounds, which means that **1 percent SOM weighs about 20,000 pounds per acre**. Under average conditions it takes at least 10 pounds of organic material to decompose into 1 pound of organic matter, so it takes at least 200,000 pounds (100 tons) of organic material applied or returned to the soil to add 1 percent stable organic matter under favorable conditions

Source: Soil Organic Matter- Guides for Educators

https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053264.pdf

Soil Organic Matter

Table 1. Ratio of carbon, nitrogen, phosphorus, and sulfur and average mineralization factor in soil organic matter (Doran 2012).

	Carbon	Nitrogen	Phosphorus	Sulfur
Ratio in Soil Organic Matter	100	10	1	0.25-0.50
Carbon:Element Ratio	1:1	10:1	100:1	200-400:1 (avg.=300:1)
Element Percent of Soil Organic Matter	58%	5.8%	0.58%	0.15-0.29 (avg.=0.22)

Annual Mineralization Factor (may need to be adjusted for local conditions)

Mineralization Factor for Soil Organic Matter Nutrients: 1.5% per year under average conditions (.015 factor)

Source: Soil Organic Matter- Guides for Educators

https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053264.pdf

Nutrient Cycling

Carbon/Nitrogen Ratios

- Soil Microorganisms, Bacteria * 5/1
- SOM, Mollisol Ap horizon * 11/1
- Rotted barnyard manure * 20/1
- Mature Alfalfa Hay * 25/1
- Protozoa ** 30/1
- Corn Stover * 57/1
- Wheat Straw * 80/1
- Newspaper * 120/1
- Deciduous Wood ** 300/1

Source:

*The Nature and Properties of Soils, fourteenth Edition.

DR. Nyle C. Brady and DR. Ray R. Weil

** DR. Elaine R. Ingham, Soil Food Web

Monitoring Data



Menoken Farm

Cropping System – Soil Monitoring

Spring of 2016 - 2018

- Organic Carbon PPM C
 - PLFA Ng/g
 - %SOM

All Fields Planted No-till Since 2009

Field	Organic C PPM C 2016 Spring	PLFA Ng/g 2016 Spring	% SOM 2016	Organic C PPM C 2017 Spring	PLFA Ng/g 2017 Spring	% SOM 2017	Organic C PPM C 2018 Spring	PLFA Ng/g 2018 Spring	% SOM 2018
1E	131	2721	3.2	189	5462	3.5	252	3766	3.5
1W	129	642	3.4	147	2636	4.1	232	5955	3.8
2E	125	2264	3.9	203	3217	3.1	200	3253	3.4
2W	112	3061	3.2	142	3896	3.2	197	2543	3.5
3E	100	3081	4.1	120	3305	5.0	180	4601	4.3
3W	93	2850	4.3	148	2212	4.2	144	2596	3.8
4E	126	1613	4.3	202	3330	4.2	222	3414	4.3
4W	130	1847	3.2	162	2687	3.9	194	2752	3.6
5E	157	2323	3.8	174	2623	3.9	205	3662	3.9
5W	157	1133	5.0	158	2976	4.7	243	3035	5.4
6E	142	2003	4.3	157	2337	4.4	247	3803	5.2
6W	138	720	3.5	139	1845	3.3	191	2334	3.6
7E	130	1027	4.5	153	2223	4.5	282	2544	4.6
7W	121	1751	3.7	161	1250	4.0	191	4063	4.1



Factors Affecting the Balance between Gains and Losses of Organic Matter in Soils.

Factors Promoting Gains

- Green manures or cover crops
- Conservation tillage
- Return of plant residues
- Low temperature and shading
- Controlled grazing
- High soil moisture
- Surface mulches
- Application of compost & manure
- Appropriate nitrogen level
- High plant productivity
- High plant root:shoot ratio

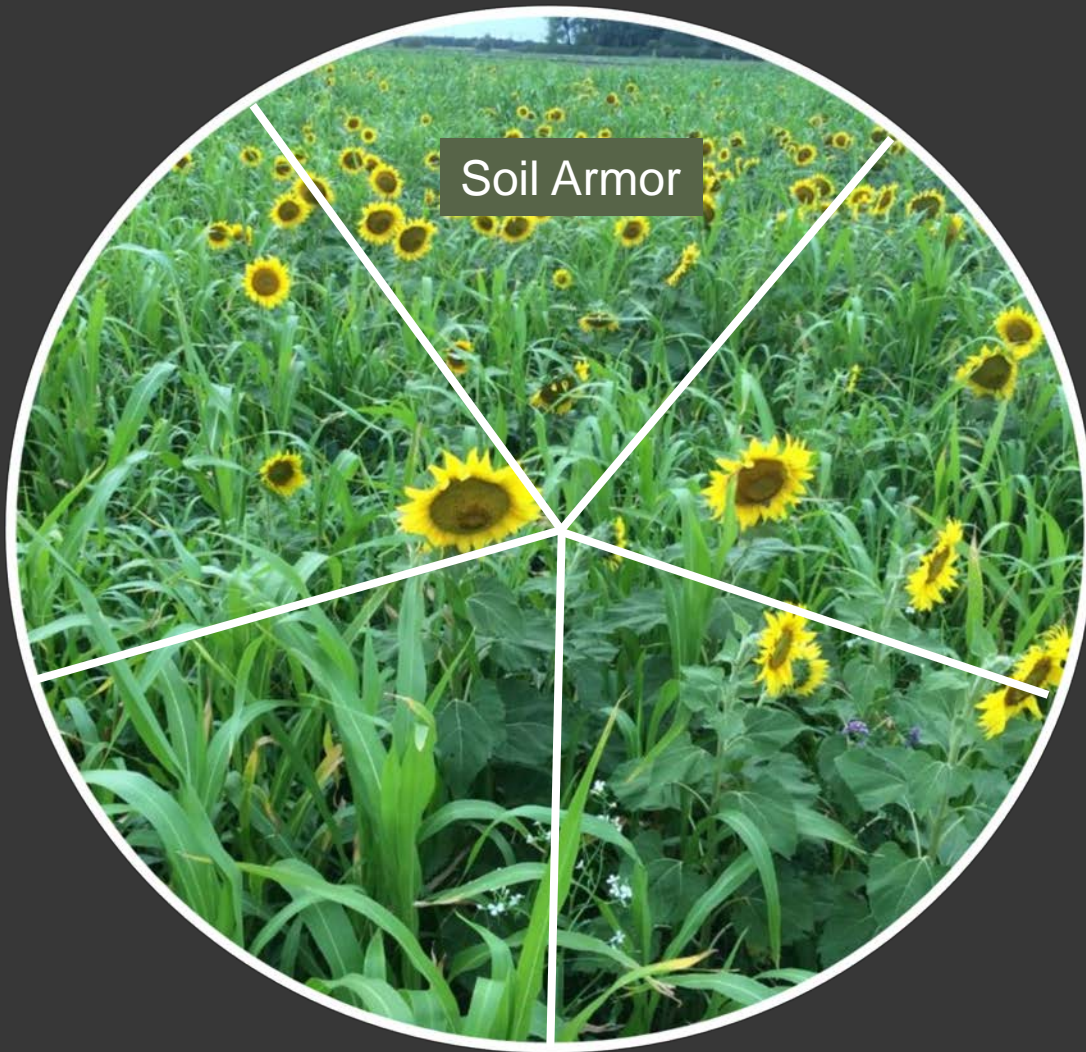
Factors Promoting Losses

- Erosion
- Intensive tillage
- Whole plant removal
- High temperatures & sun exposure
- Overgrazing
- Low soil moisture
- Fire
- Applying only inorganic materials
- Excessive mineral nitrogen
- Low plant productivity
- Low plant root:shoot ratio

Source: The Nature and Properties of Soils, 14th Edition
Chapter 12 , Table 12.5, Page 520 by Brady and Weil



The Way Forward



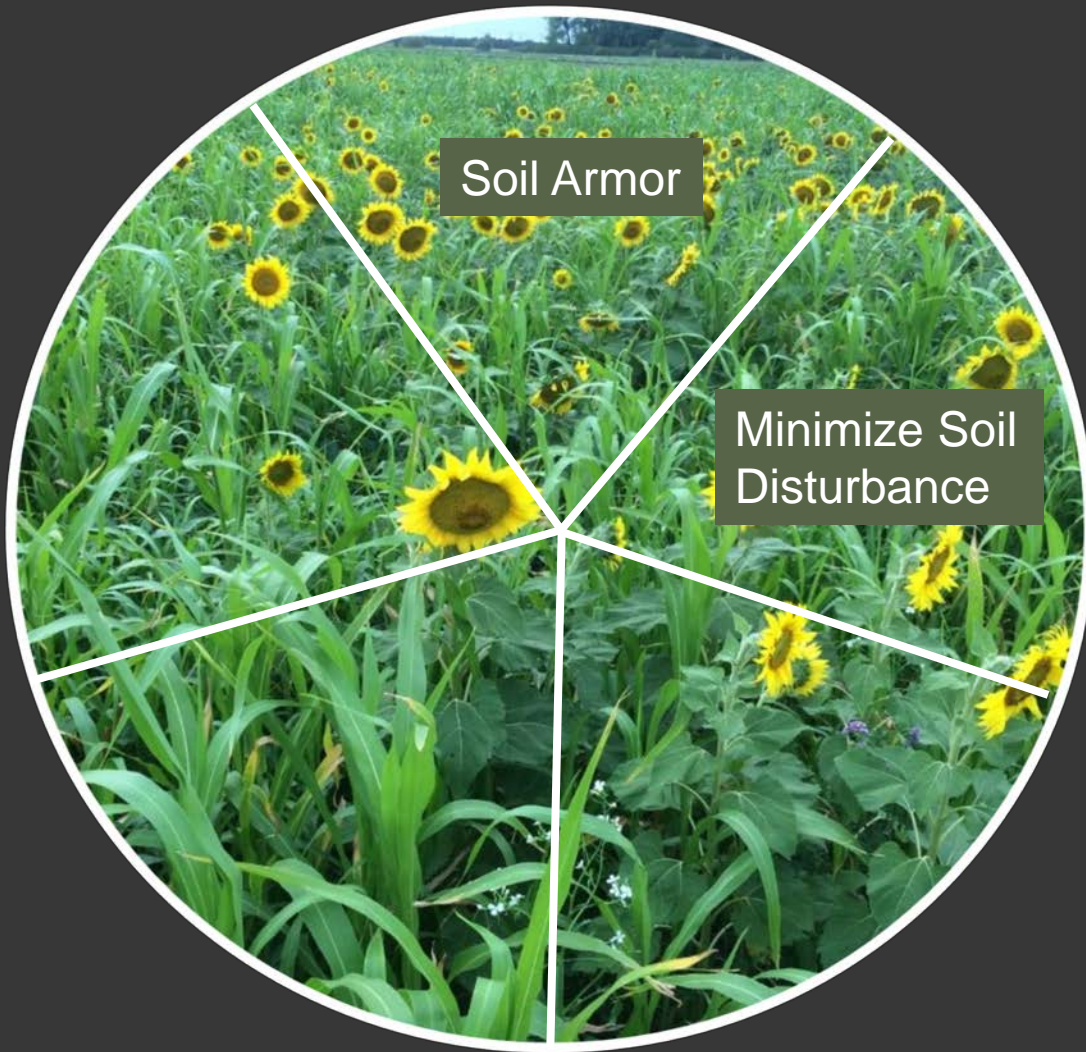
Soil Health Principles

Systems Approach

Soil Health: the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.



Fall Seeded Cover Crop
Passive Armor and Active Armor
Menoken Farm



Soil Armor

Minimize Soil Disturbance

Soil Health Principles

Systems Approach

Soil Health: the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.



Spring
Planting Green



Spring
Planting Brown



Nurture Nature with System Synergies



No Tillage

Minimum carbon loss



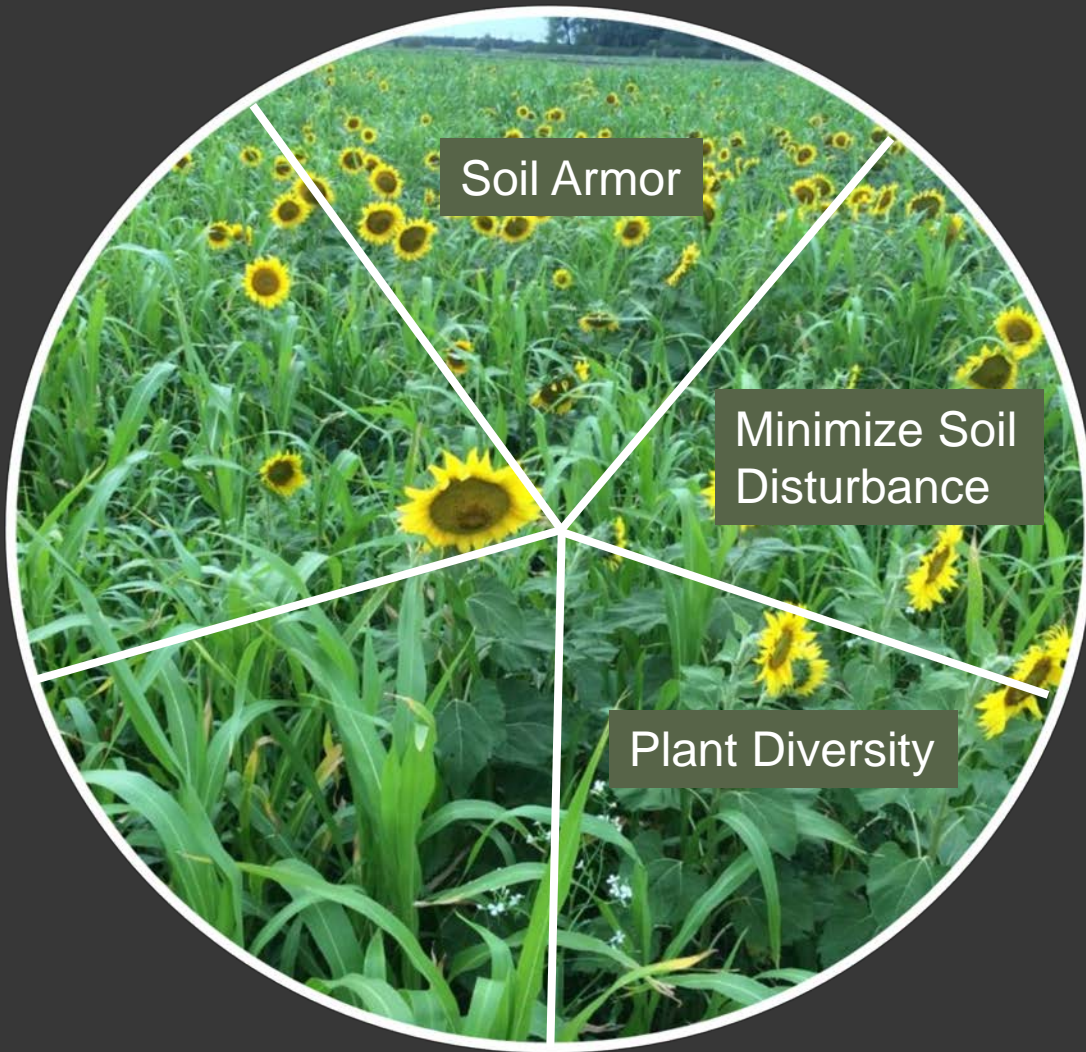
Cover Crops

Maximum carbon input

Carbon management

Sustainability

Dr. Don Reicosky
ARS, Morris, MN



Soil Health Principles

Systems Approach

Soil Health: the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.

Crop Diversity

Cool-Season Grass



Cool-Season Broadleaf



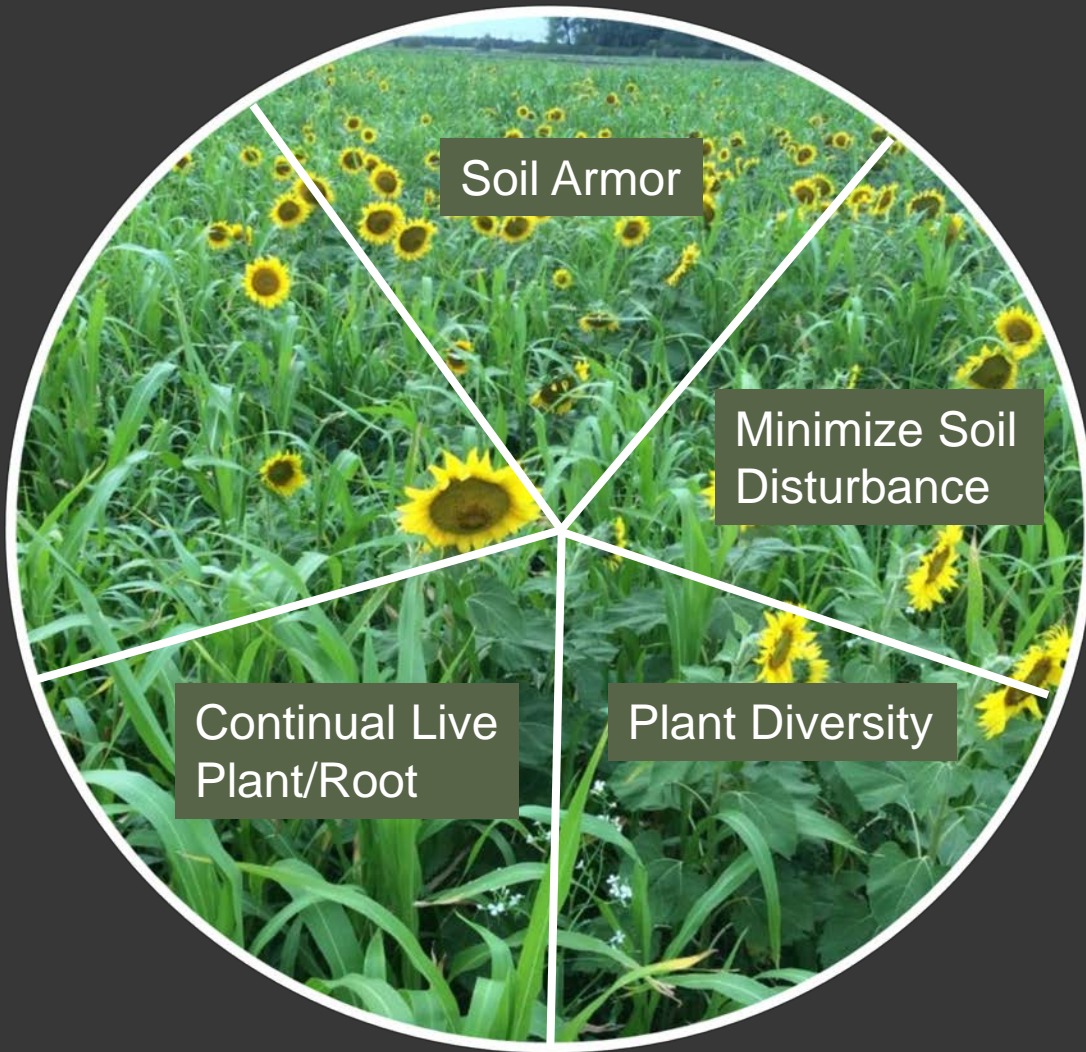
Warm-Season Grass



Warm-Season Broadleaf



“The type and diversity of organic residues added to a soil can influence the type and diversity of organisms that make up the soil community. “ The Nature and Properties of Soils, 14th Edition; Chapter 12, Brady and Weil.

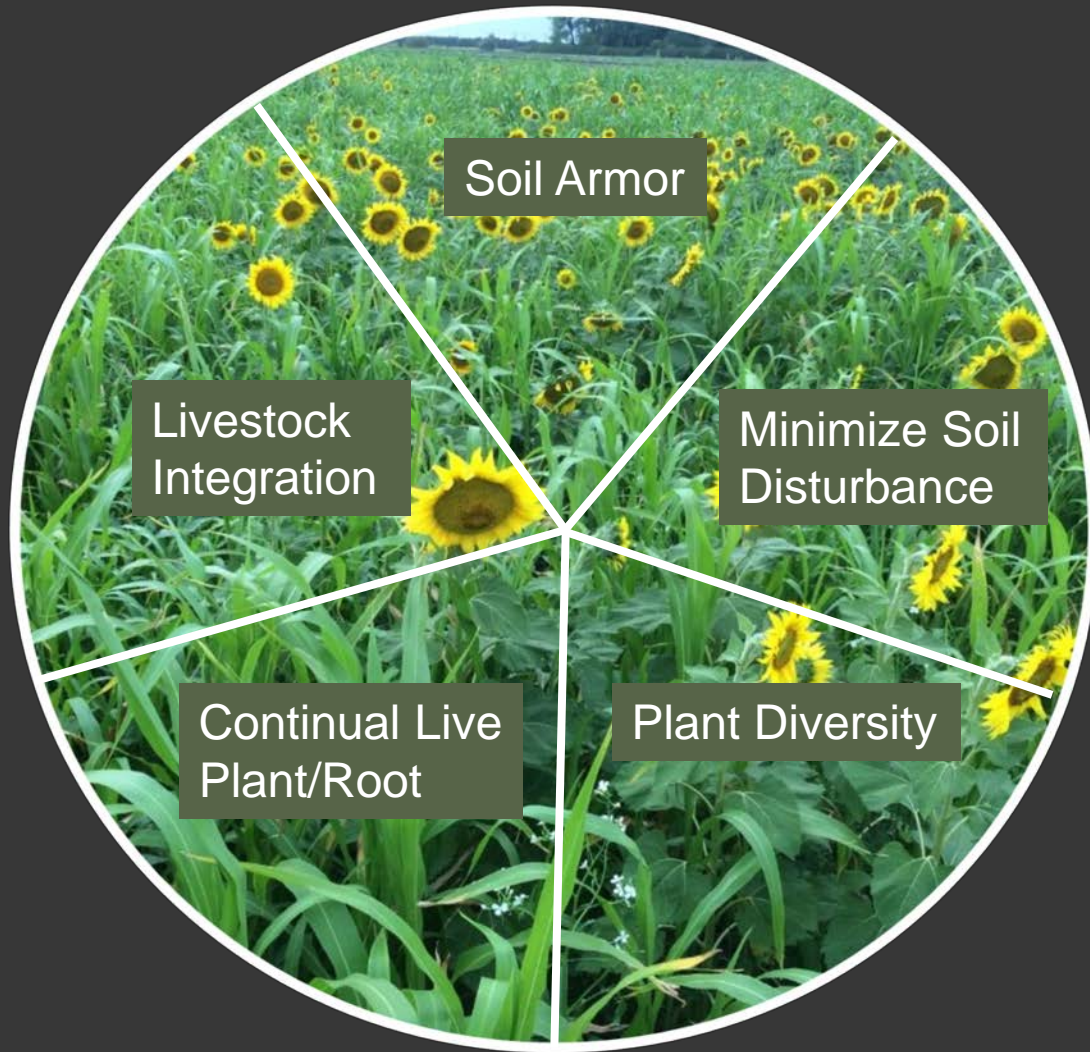


Soil Health Principles

Systems Approach

Soil Health: the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.





Soil Health Principles

Systems Approach

Soil Health: the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.



Open heifers moved into a new paddock.
Menoken Farm



Summary



**Find ways to increase soil
organic carbon, and soil
health will follow.**

Dr. Don Reicosky
ARS-Morris, MN





Self Education

- A Soil Owner's Manual: by Jon Stika
- Growing A Revolution: by David Montgomery
- Dirt to Soil: by Gabe Brown
- Forty Chances: by Howard Buffett
- Humus Chemistry: by F.J. Stevenson
- Soil Microbiology, Ecology, and Biochemistry: by Eldor Paul
- The Soil Will Save Us: by Kristin Ohlson
- The Nature and Properties of Soils – 14th Edition : by Brady and Weil
- Journals of Lewis and Clark
- Buffalo Bird Women's Garden : by Gilbert Wilson
- The One Straw Revolution: by Masanobu Fukuoka
- Managing Cover Crops Profitably 3rd Edition
- A Sand County Almanac: by Aldo Leopold
- Soil Biology Primer: by Elaine Ingham
- Life in the Soil: by James Nardi
- An Agricultural Testament: by Sir Albert Howard
- Dirt – The Erosion of Civilizations: by David Montgomery
- Early Settlement of North Dakota: by Clement Lounsberry
- 1491: by Charles Mann

www.menokenfarm.com

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<https://www.nrcs.usda.gov/wps/portal/nrcs/site/nd/home/>

Menoken Farm
<http://menokenfarm.com/>



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