USDA United States Department of Agriculture

Building Resilience in your Soil to Weather any Extreme

Candy Thomas, Regional soil health specialist for KS and NE

Salina, KS

Candy.thomas@usda.gov

Phone 785-309-6991

- Our traditions in agriculture are deeply rooted.
- Early management necessitated working with natural systems.

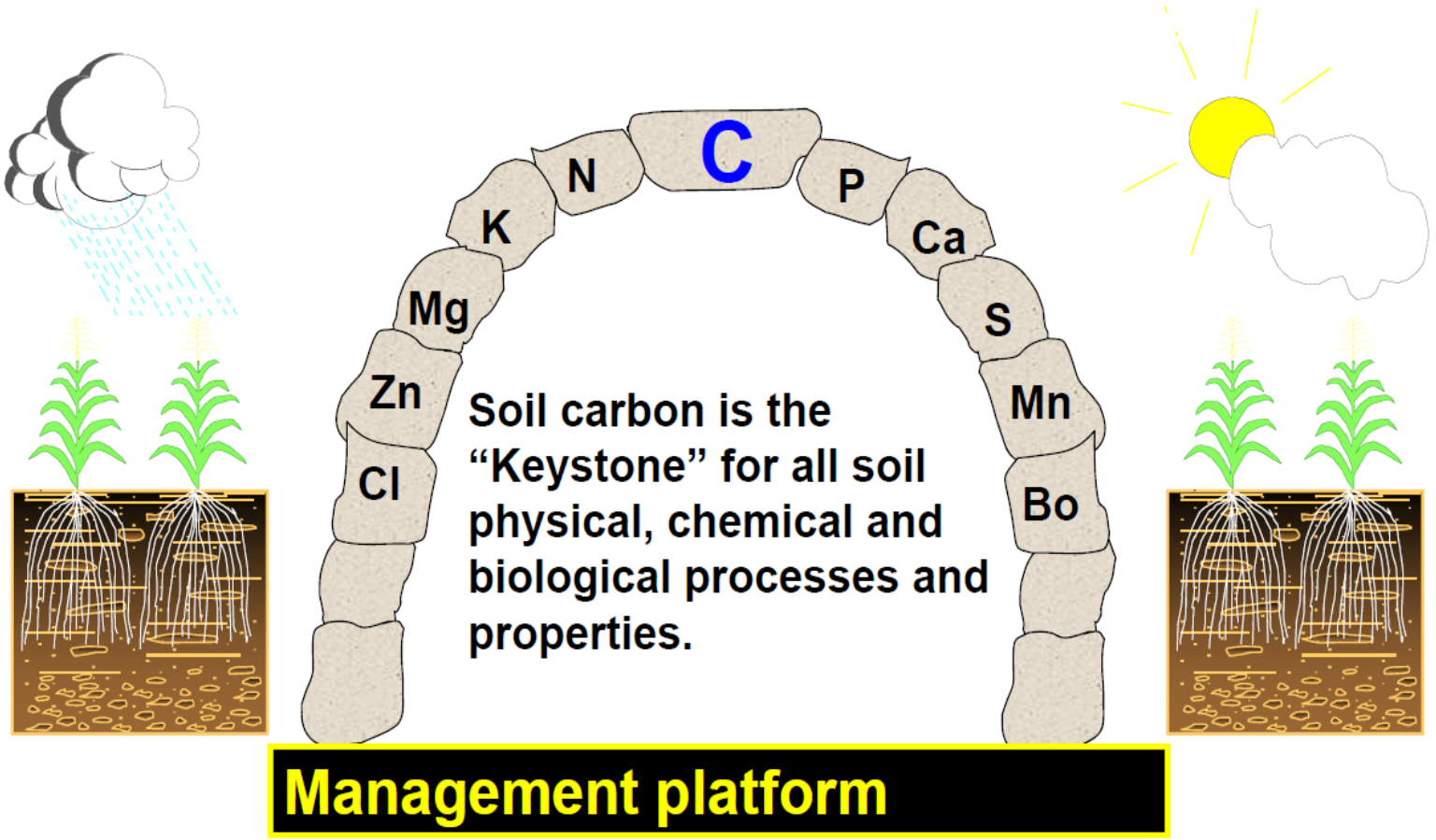
- As mechanization advanced and scale and intensity grew our management principles became focused on altering natural systems to meet our needs.

USDA United States Department of Agriculture

Linearization of Agriculture

Energy

Fossilized Energy



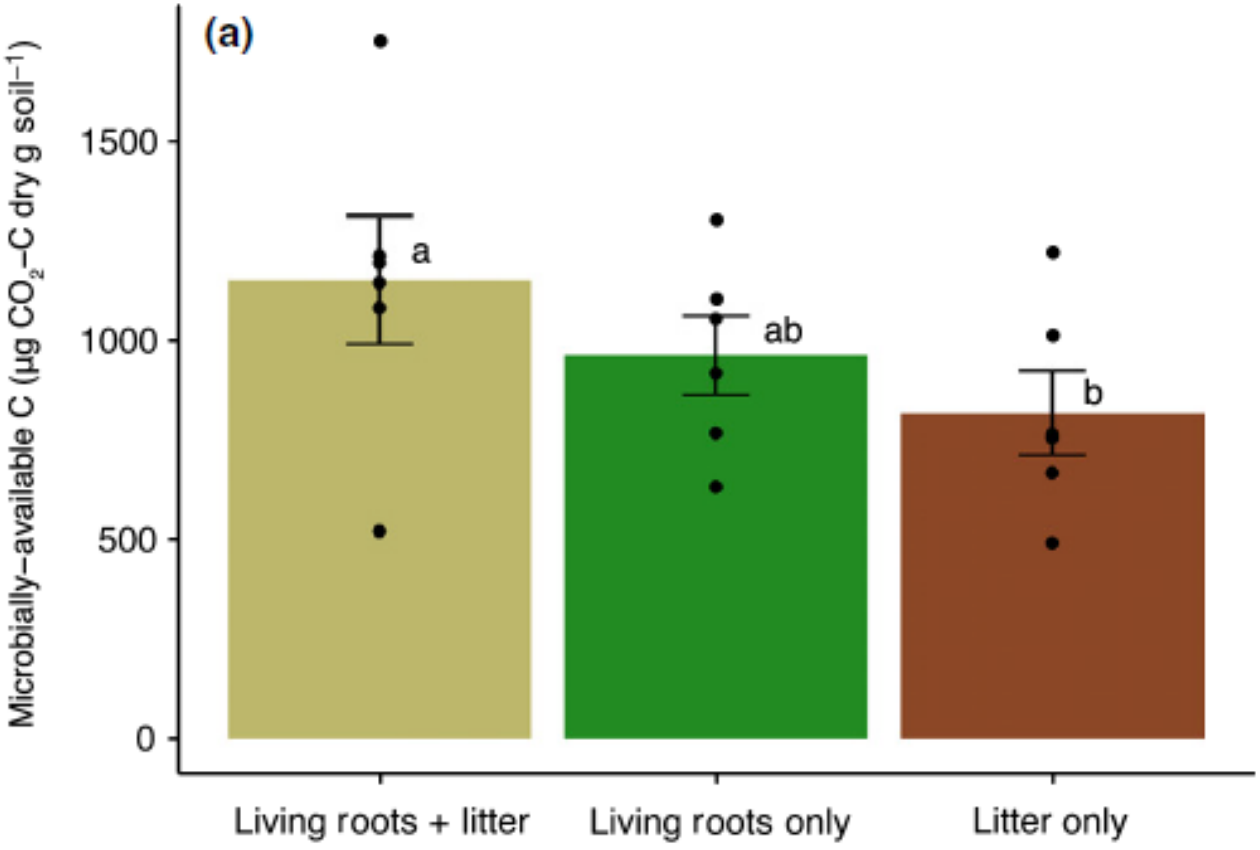
Dr. D.C. Reicosky, ARS, Morris, MN.

Carbon Drives the System- Builds Resiliency

Plants Build the Carbon

- Leak out exudates
- Create biomass
- Build root systems

How do we get carbon in our Soil?



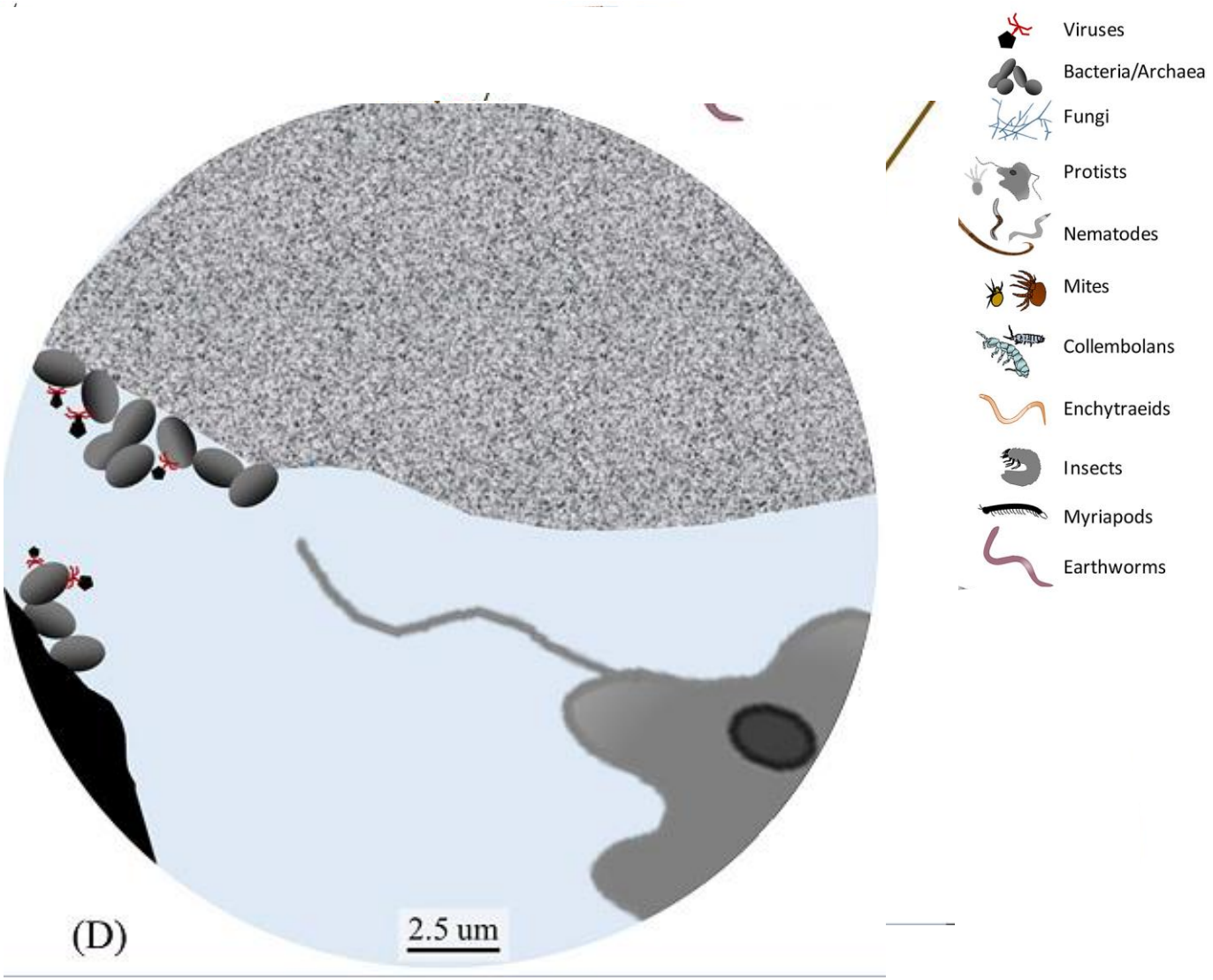
Sokol et al 2018

USDA United States Department of Agriculture

Decomposition builds soil carbon

- Oxidation
- Release
- Synthesis
- Protection

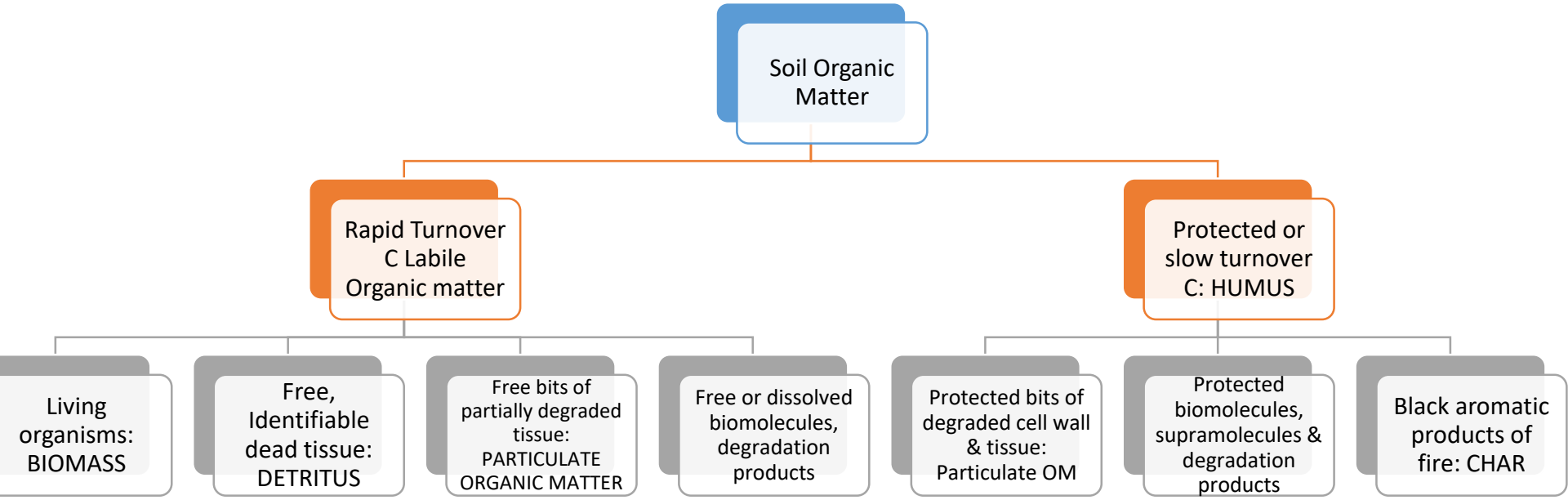
Microbes do this!



Geisen et al. 2019

USDA United States Department of Agriculture

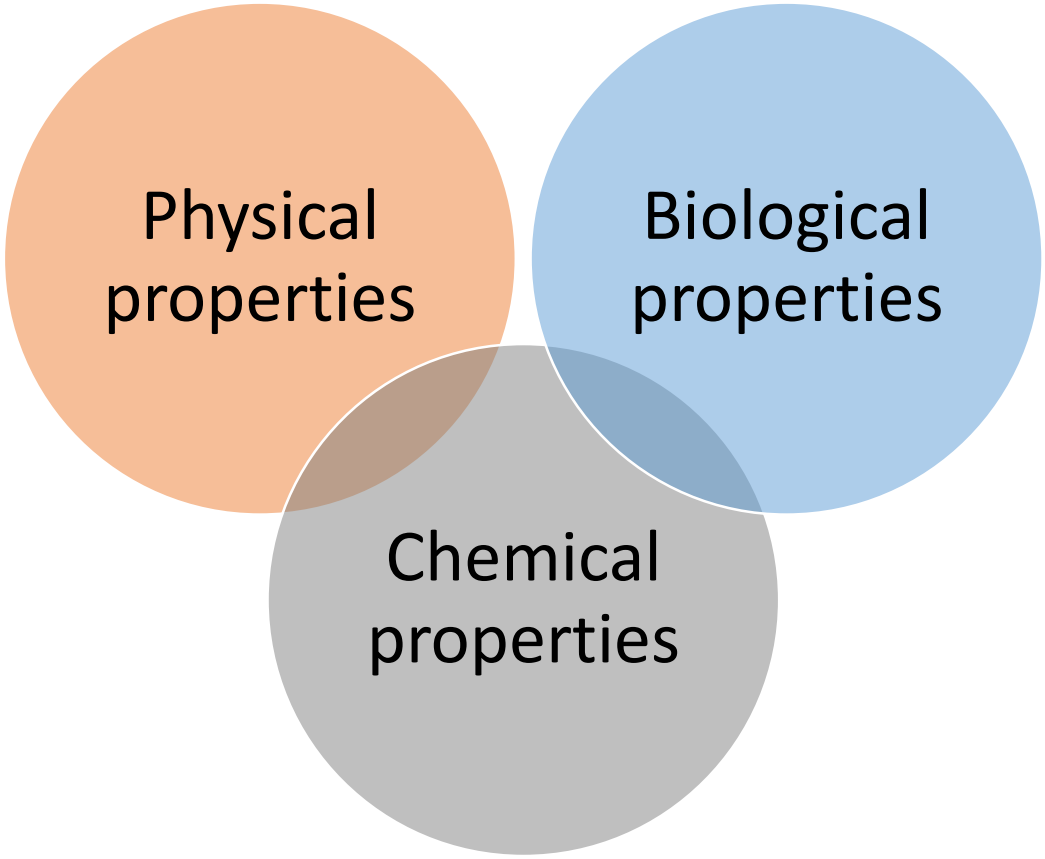
Soil Organic Matter



USDA United States Department of Agriculture

What impact does SOM have on resiliency?

- Influence on:



USDA United States Department of Agriculture

Physical Properties

- Improved soil color
- Improved porosity
- Increased water holding capacity

USDA United States Department of Agriculture

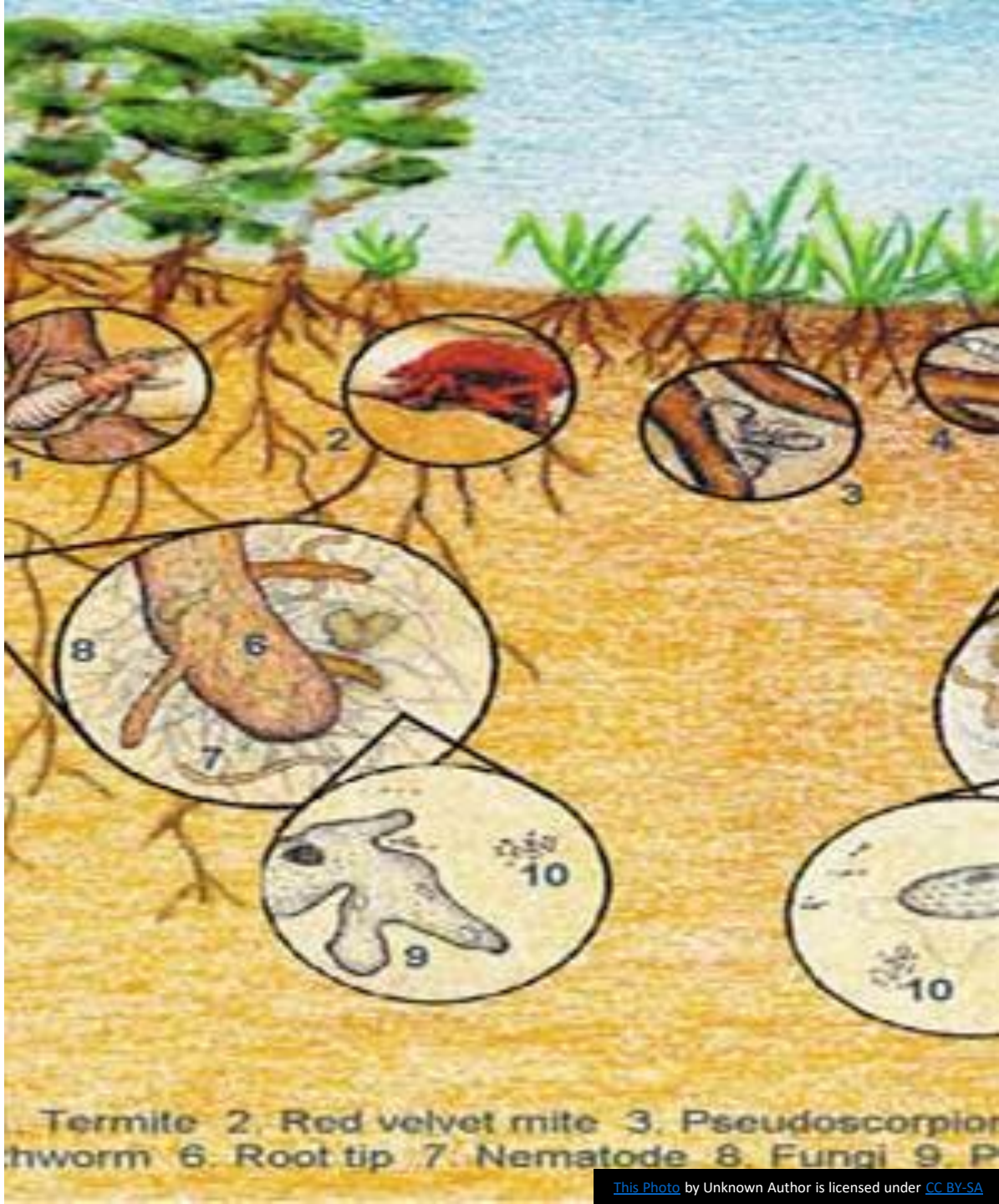
Chemical Properties

- Increased Cation exchange capacity
- pH buffering capacity
- Storage of N, P, and micros

USDA United States Department of Agriculture

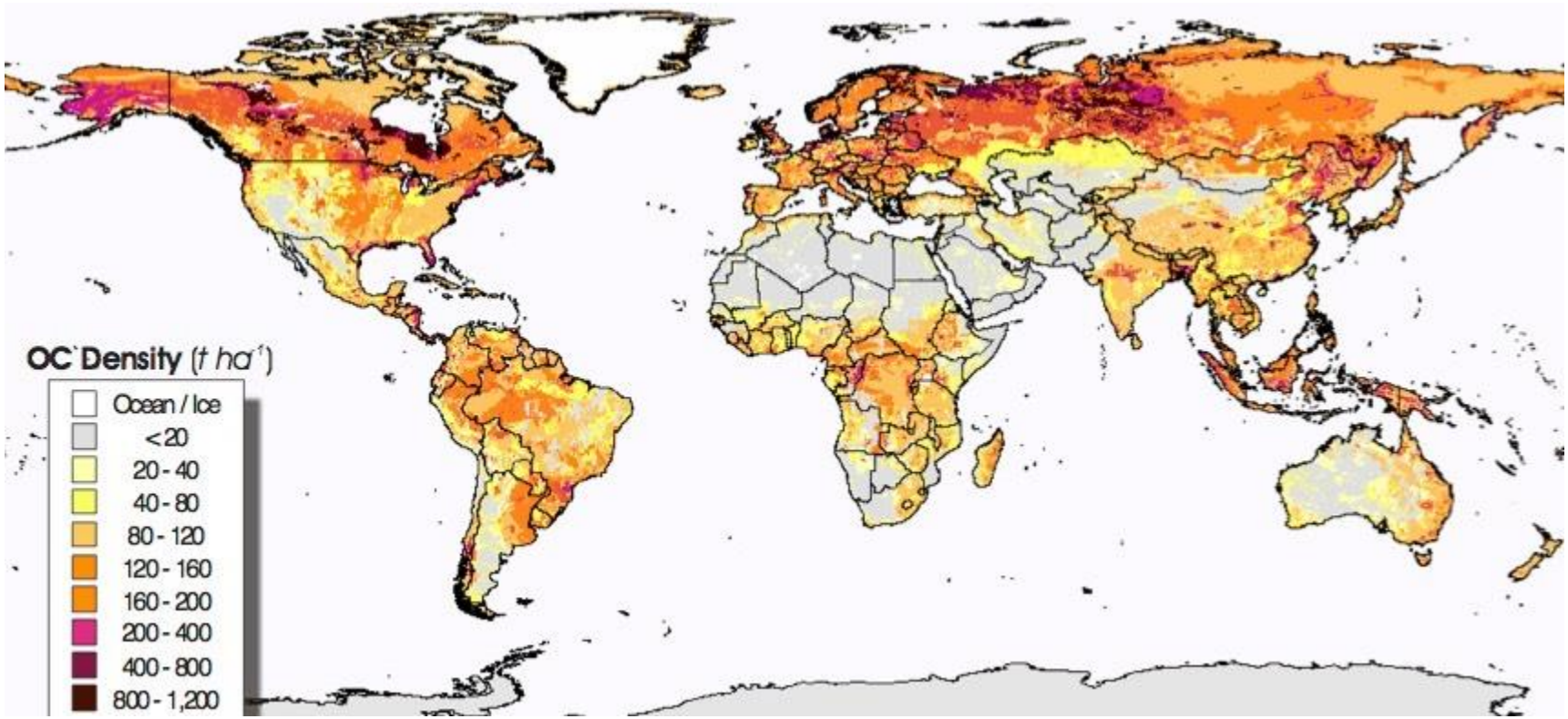
Biological Effects

- Increased food source
- Increased diversity
- Increase nutrient cycling



Factors in soil that impact SOM

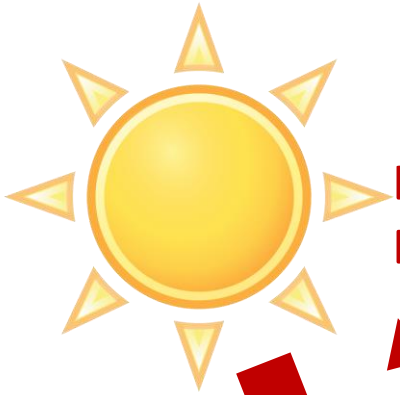
- Differing soil orders
- Temperature
- Moisture
- Influence of natural vegetation
- Effects of soil texture and drainage



USDA United States Department of Agriculture

Energy Flows

Nutrients Cycle



Loss of Energy

Secondary Consumers (Carnivores)

decomposers

Primary consumers (herbivores)

Loss of Energy

Producers (plants)

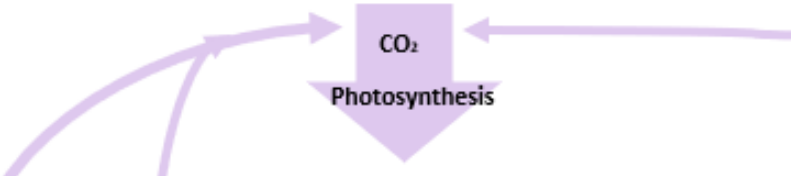
USDA United States Department of Agriculture

Contrasting Food Production

1. Traditional Agriculture, based on human animal power and circular flows – loops- of fertility , labor-energy , and seeds.
2. Industrial Agriculture, powered by fossil fuels and based on linear flows.

How do we combine them?

Qualman, 2019



Bringing back balance

Brady and Weil
2015

Build resiliency

Inputs	Practices to Max	Losses	Practices to minimize
Above ground	Return all residues	Oxidation	Reduce/eliminate tillage
Plant residues	Fert with sufficient nutrients		Moderate soil temp
	Optimize plant spacing		Grow recalcitrant litter
	Add cover crops		Grow deep rooted crops
	Grow perennials		Grow high root:shoot plants
	Use complex rotations		Mulch
	Manage grazing		Avoid excess N
	Manage fire to max char		Make biochar and manage fire to minimize combustion loss

Brady and Weil 2017

continued

Inputs	Practices to Max	Losses	Practices to minimize
Animal inputs	Recycle bedding and manure	Removal	Remove only economic plant parts
	Urine and manure from grazing		Mulching-mow lawn to leave clippings
Recycled offsite biomaterials	Apply bio-wastes from food, biofules & forestry	Erosion	Use no-till
	Sewage sludge If allowed		Use mulch
	Composted municipal wastes		Grow cover crops
	Apply mulch		Grow perennials
	Biochar application		Grow trees(permacluture agroforestry

Brady and Weil 2017

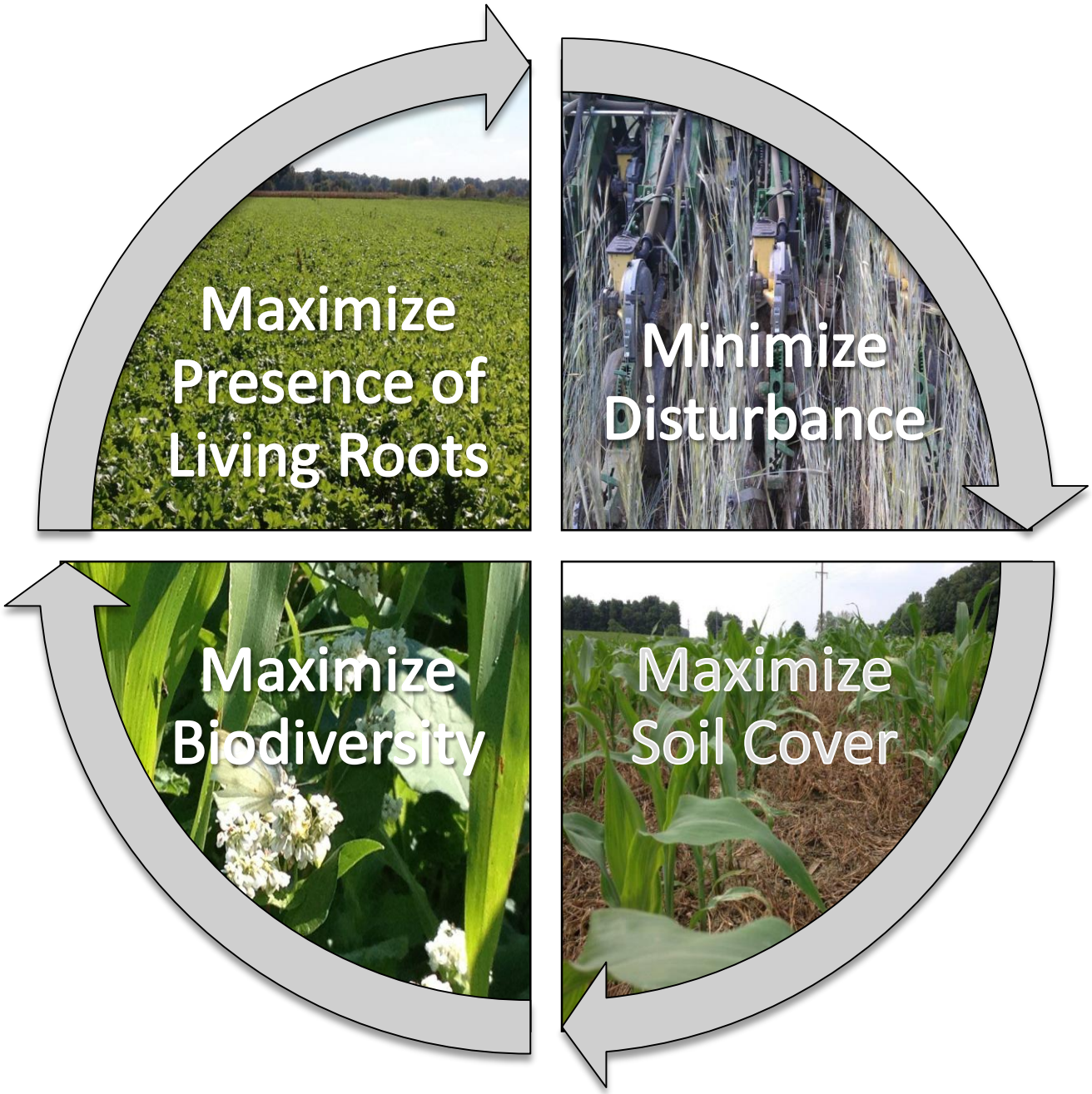
USDA United States Department of Agriculture

Continued

Inputs	Practices to Max	Losses	Practices to minmize
Root Residues	Plant high root BM	Leaching	Max ET during wet
	Grow more perennials		Grow cover crops
	Rotationally graze		Manage soil water
Rhizodeposition	Manage plants for enhanced root growth		Manage plants for root exudates
	Manage soil microbial community		Manage for mycorrhizae

Brady and Weil 2017

Soil Health Principles



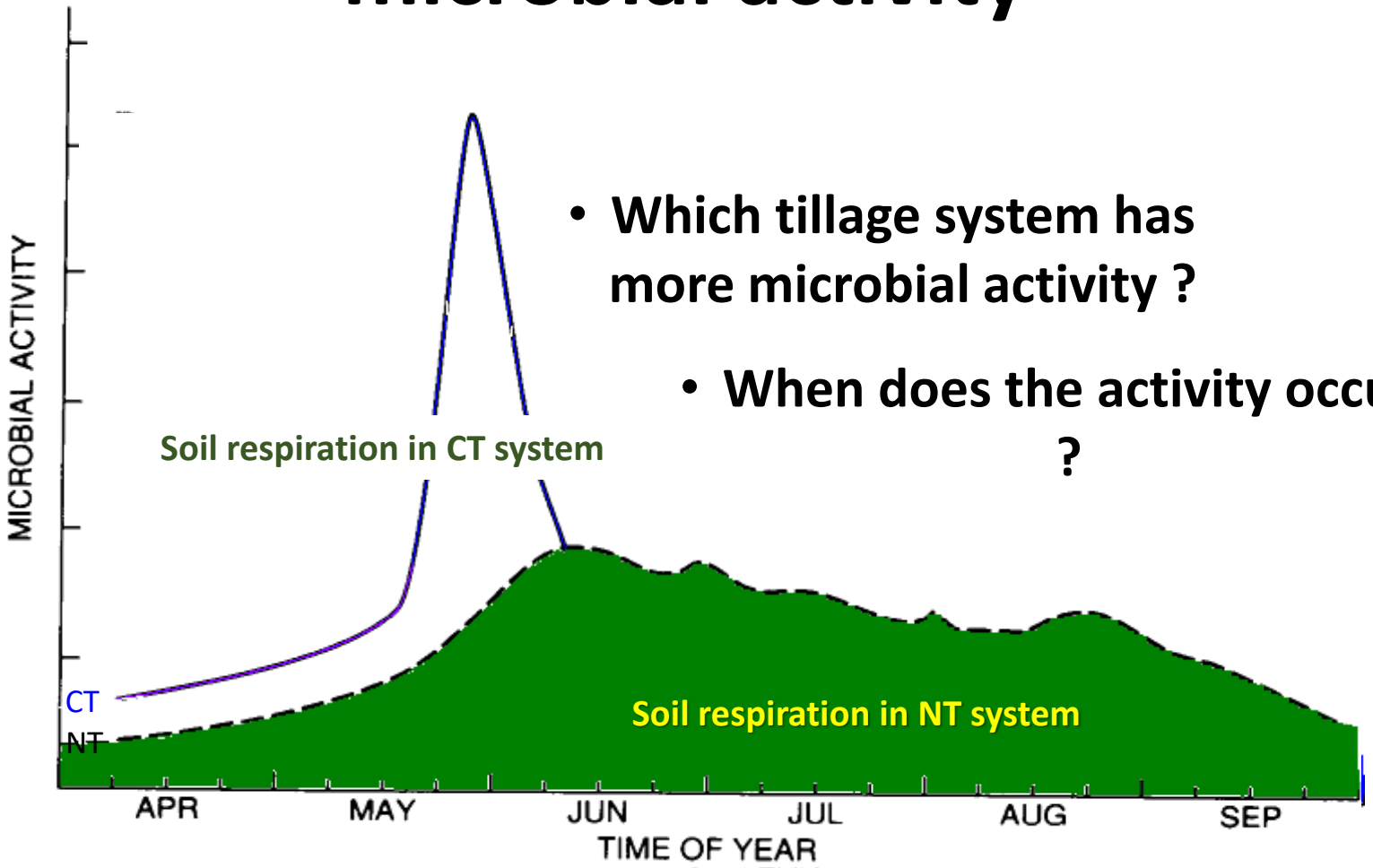
USDA United States Department of Agriculture

Soil Health Principles To Support High Functioning Soils

- **Feed** diverse, continuous inputs (C sources, energy)

- **Protect** habitat (aggregates and organic matter)

Effect of tillage on microbial activity



- Which tillage system has more microbial activity ?
- When does the activity occur ?

Havlin et al. (1999)

A Common *Myth* about inorganic fertilizers: *They feed the plant directly*

Fertilizer Nitrogen applied Kg/ha (pounds/ac) 	**Corn Grain Yield Mg/ha (Bu/ac)**	**Total N in corn plant Kg/ha (pounds/ac)**	**Fertilizer derived N in Corn Kg/ha (pounds/ acre)**	**Soil-derived N in corn, in Kg/ha (pounds/ acre)**	**Fertilizer-derived N in corn as percent of total N in corn %**	**Fertilizer-derived N in corn as percent of N applied %** 
50 (45)	3.9 (62)	85 (77)	**28 (25)**	60 (54)	**33**	56
100 (90)	4.6 (73)	146 (131)	**55 (50)**	91 (81)	**38**	55
200 (180)	5.5 (88)	157 (141)	**86 (78)**	71 (63)	**55**	43

Nature & Properties of Soil 13th Edition

USDA United States Department of Agriculture

Value of Soil Organic Matter

Assumptions: 2,000,000 pounds soil in top 6 inches
1% organic matter = 20,000#

Nutrients Content:

- Nitrogen: 1000#
- Phosphorous: 100#
- Potassium: 100#
- Sulfur: 100#
- Carbon: 10,000# or 5 ton

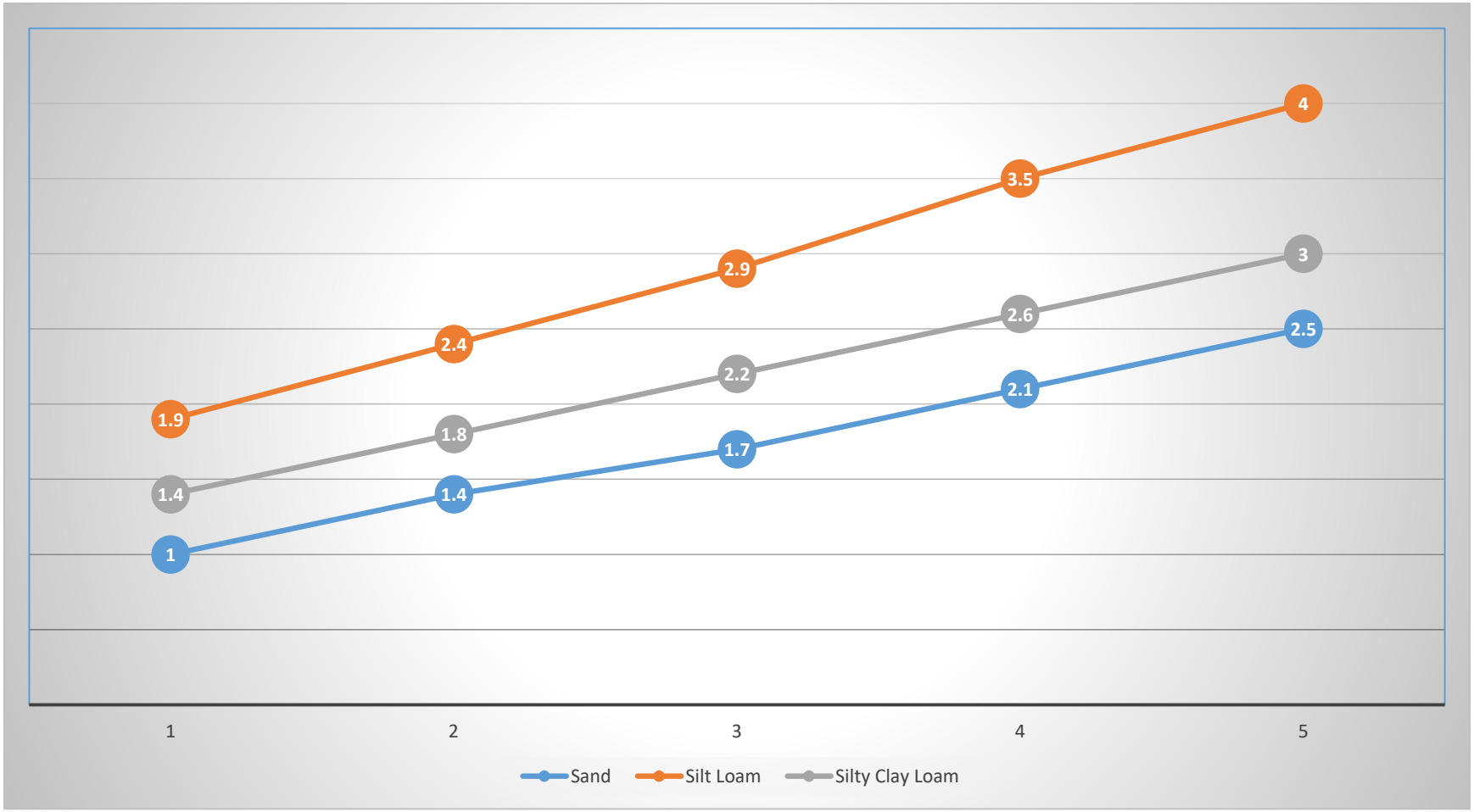
* $0.50/#N = $500
* $0.48/#P = $ 48
* $0.42/#K = $ 42
* $0.50/#S = $ 50
* $2/Ton = $ 10

Value of 1% SOM Nutrients/Acre = $650

Jim Kinsella/Terry Taylor (2006) Jim Hoorman (2011)

USDA United States Department of Agriculture

Soil Organic Matter Available Water Capacity



Berman Hudson Journal Soil and Water Conservation 49(2) 189 194 189-March April 1994 – Summarized by: Dr. Mark Liebig, ARS, Mandan, ND Hal Weiser, Soil Scientist, NRCS, Bismarck, ND

USDA United States Department of Agriculture

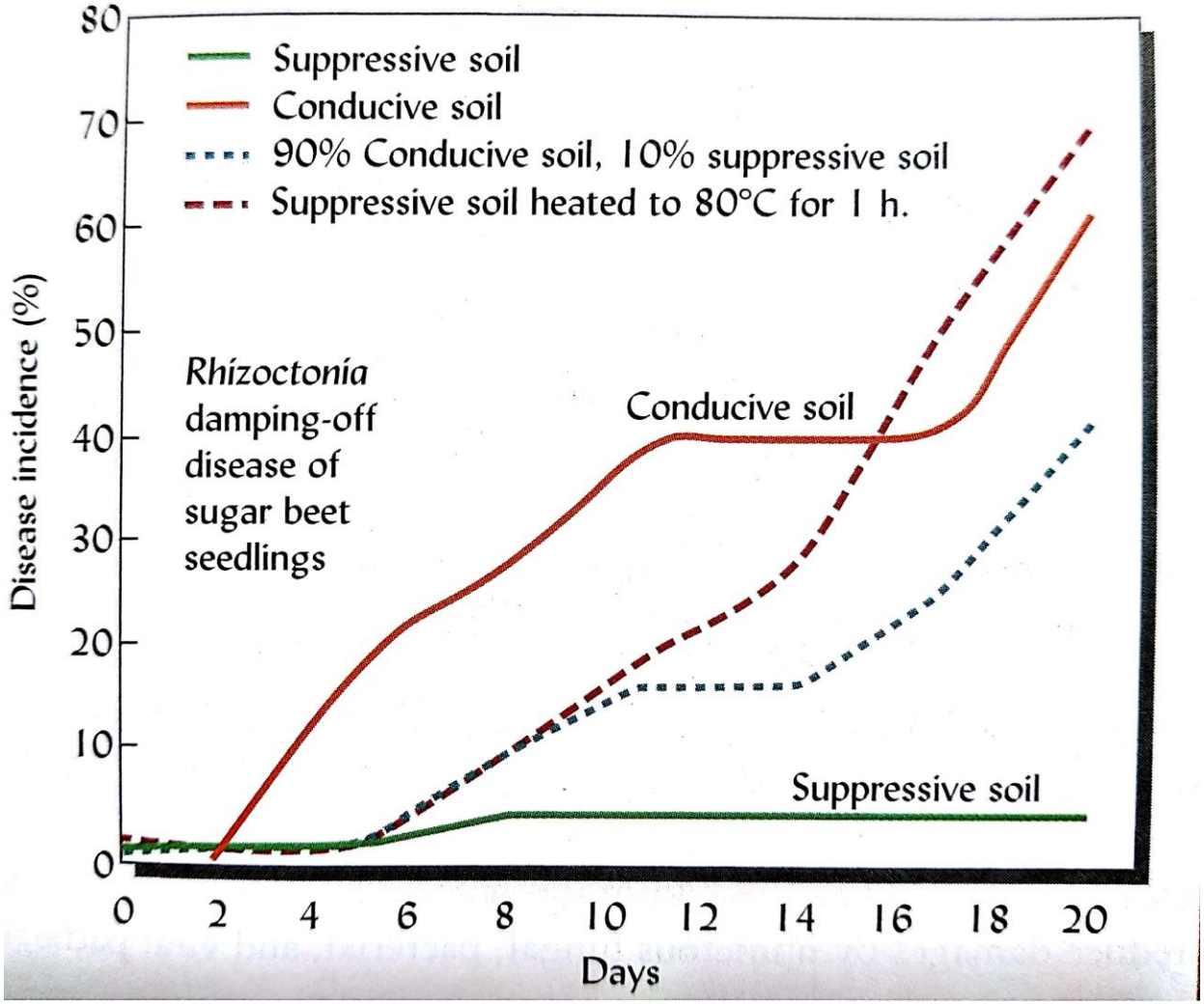
Water Storage Value

- Every 1% SOM hold 1 acre-inch of water
- Value of an acre-inch of water = $12 (varies)
- Value of 6% SOM vs 2% SOM =

  4 acre-inches of water * $12/acre-inch=$48
- .1% SOM addition per year =

  .1 acre-inch * $12/acre-inch = $1.2 per year

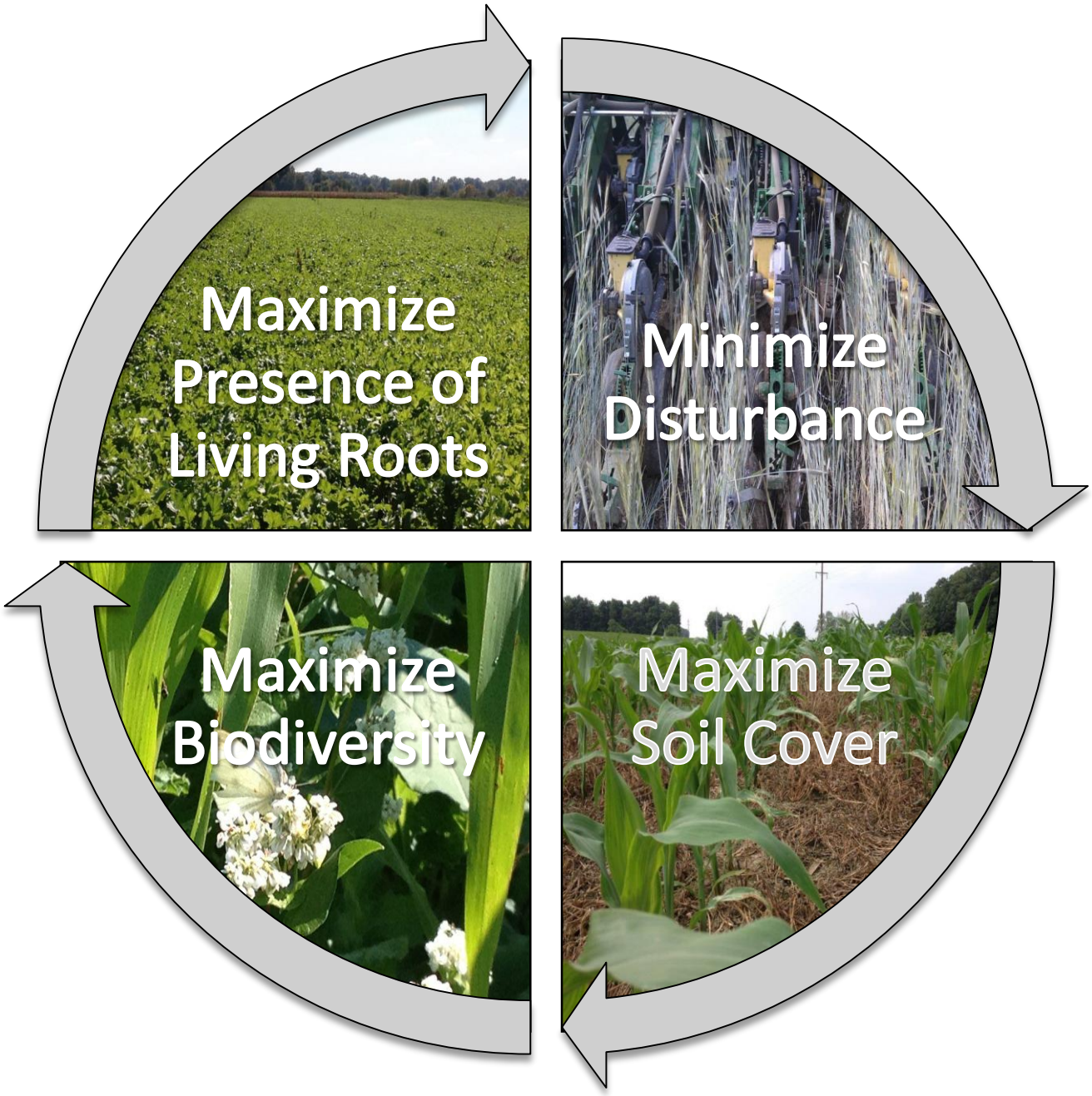
Plants benefit from microbes



Soil microbes suppress crop pathogens!

Weil & Brady, The Nature and Properties of Soils, 15th edition. From data of R. Mendes et al. 2011

Soil Health Principles



USDA United States Department of Agriculture

Questions?

Candy Thomas, Regional soil health specialist for KS and NE

Salina, KS

Candy.thomas@usda.gov

Phone 785-309-6991

Non-Discrimination Statement

In accordance with Federal civil rights law and U.S. Department of Agriculture (USDA) civil rights regulations and policies, the USDA, its Agencies, offices, and employees, and institutions participating in or administering USDA programs are prohibited from discriminating based on race, color, national origin, religion, sex, gender identity (including gender expression), sexual orientation, disability, age, marital status, family/parental status, income derived from a public assistance program, political beliefs, or reprisal or retaliation for prior civil rights activity, in any program or activity conducted or funded by USDA (not all bases apply to all programs). Remedies and complaint filing deadlines vary by program or incident.

Persons with disabilities who require alternative means of communication for program information (e.g., Braille, large print, audiotape, American Sign Language, etc.) should contact the responsible Agency or USDA's TARGET Center at (202) 720-2600 (voice and TTY) or contact USDA through the Federal Relay Service at (800) 877-8339. Additionally, program information may be made available in languages other than English.

To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at How to File a Program Discrimination Complaint and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by:

(1) mail: U.S. Department of Agriculture

Office of the Assistant Secretary for Civil Rights

1400 Independence Avenue, SW

Washington, D.C. 20250-9410;

(2) fax: (202) 690-7442; or

(3) email: program.intake@usda.gov.

USDA is an equal opportunity provider, employer, and lender.