



The road to Soil Health: Farming in the 21st Century



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United States Department of Agriculture
Natural Resources Conservation Service

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Agricultural soils do not have a water erosion/runoff problem, they have a water infiltration problem.



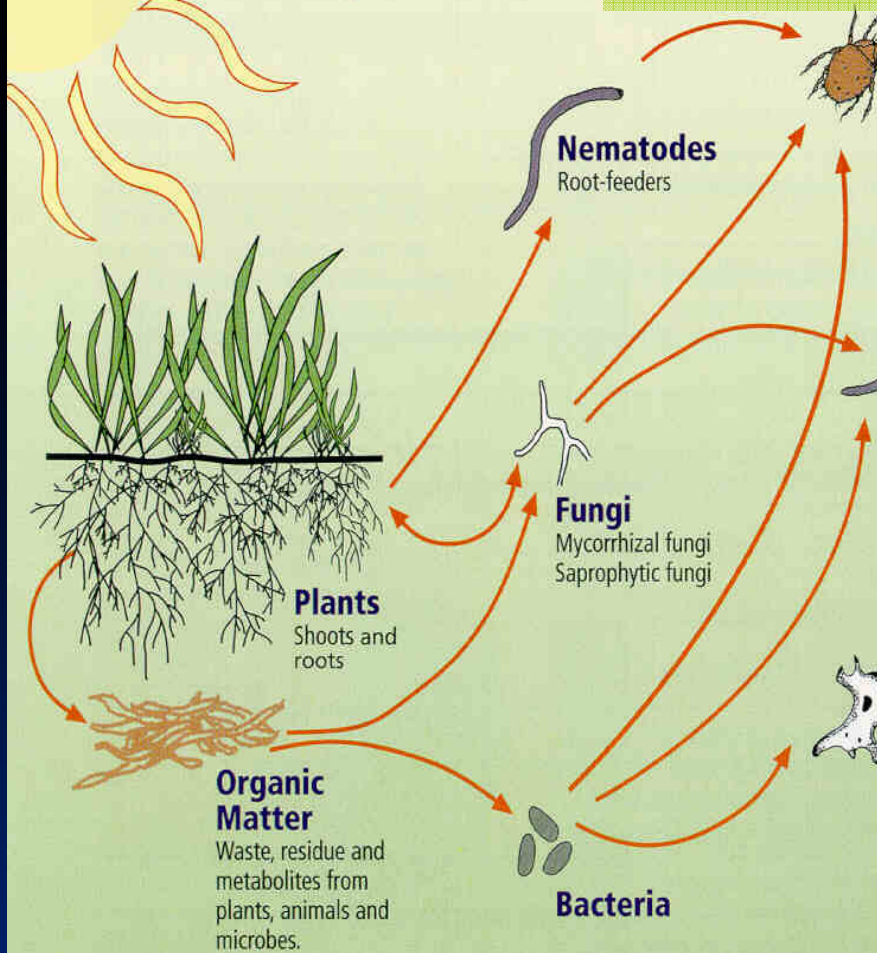
SOIL QUALITY/HEALTH is

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

The Soil Food Web

Is complex

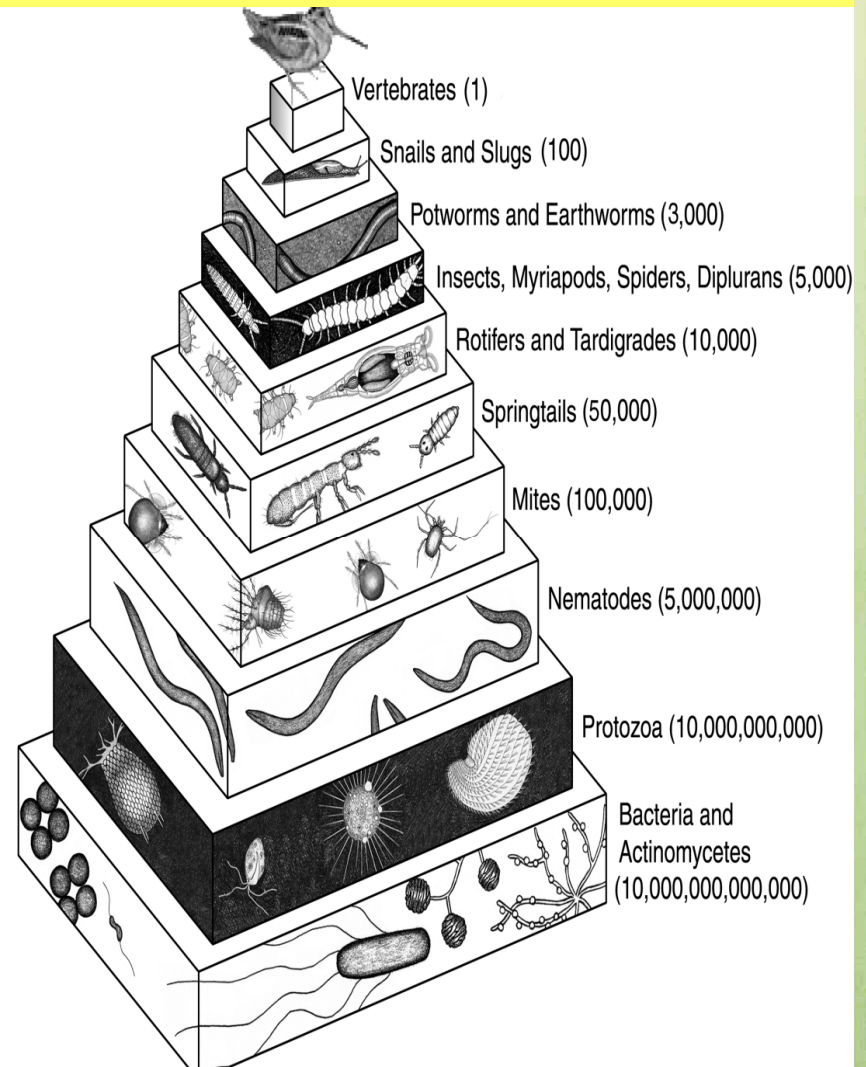
Every trophic level must function for the soil food web to function!



First trophic level:
Photosynthesizers

Second trophic level:
Decomposers
Mutualists
Pathogens, parasites
Root-feeders

Third trophic level:
Shredders
Predators
Grazers



Soil is a Living Factory



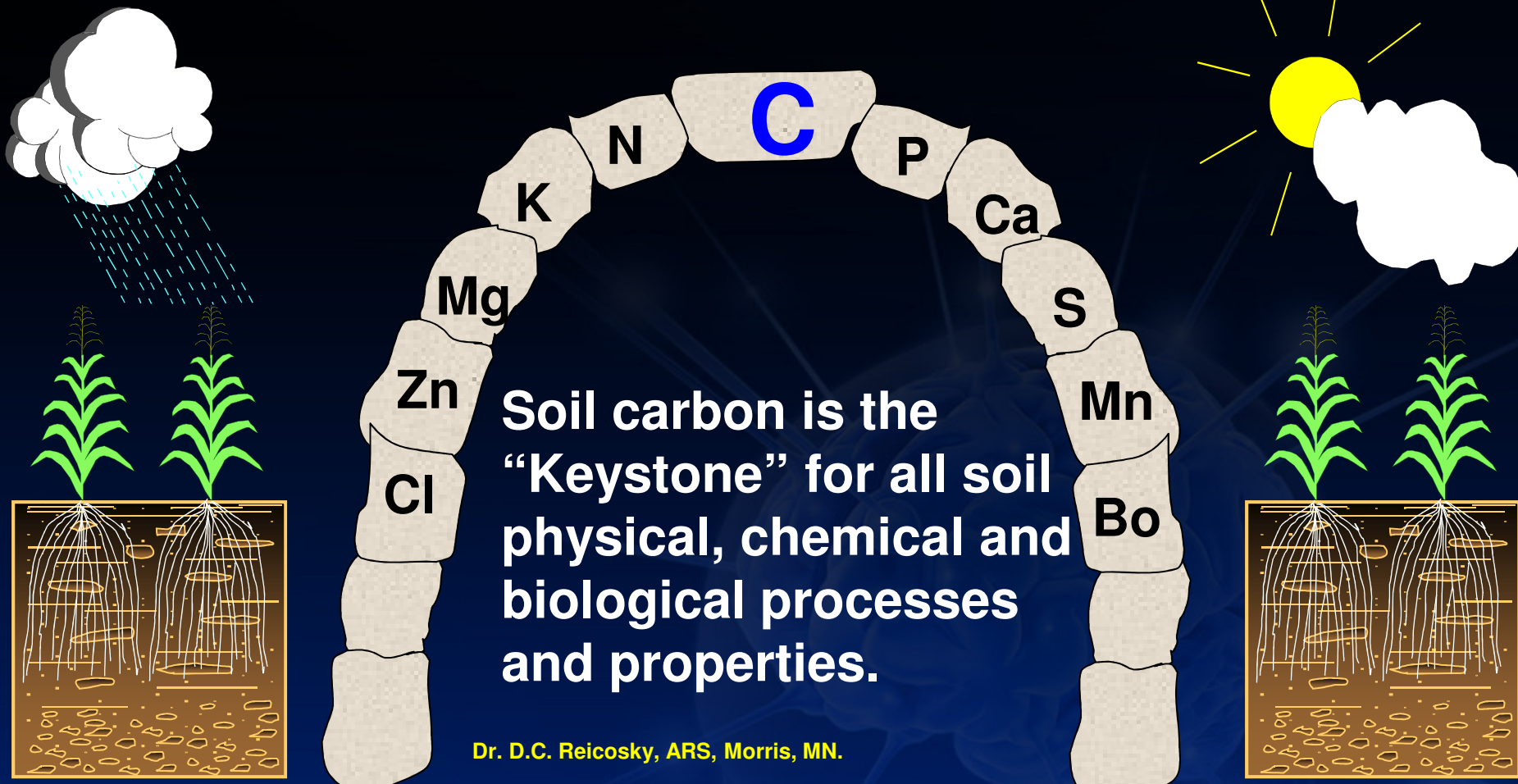
- **Macroscopic and microscopic organisms**

- Food
- Water
- Habitat
- Powered by sunlight

- **Management can improve or degrade soil health**

- Tillage
- Fertilizer
- Livestock
- Pesticides

Carbon is a “keystone” in nutrient cycling!

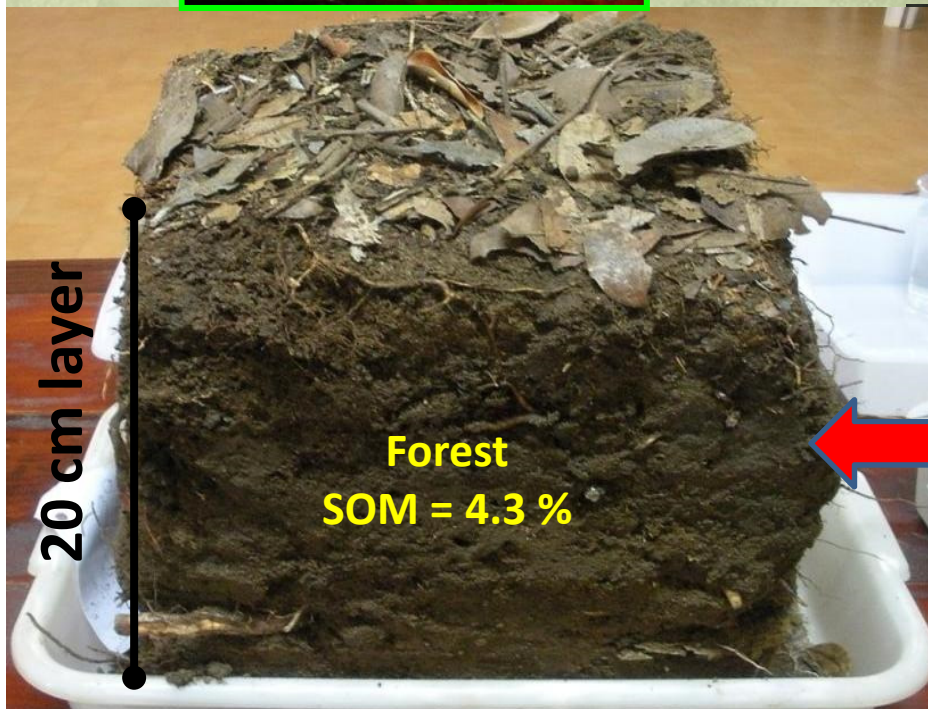


Management platform

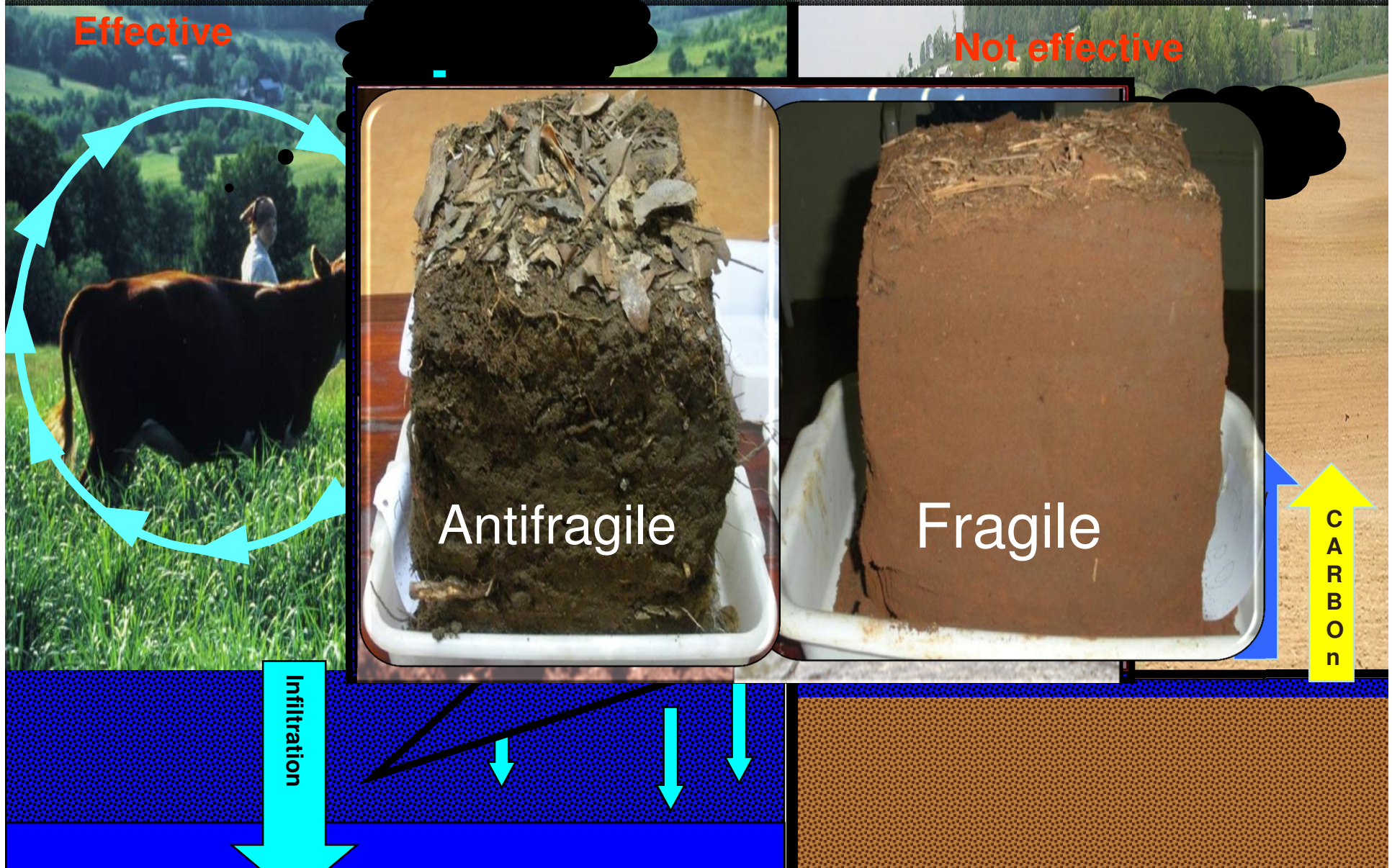
Management Changes Soil Properties & Capacity of Soil to Function



62.8% loss
of SOM after
17 yr
intensive
tillage



Chronic Physical, Chemical, and Biological Stress: diminishes ecosystem processes



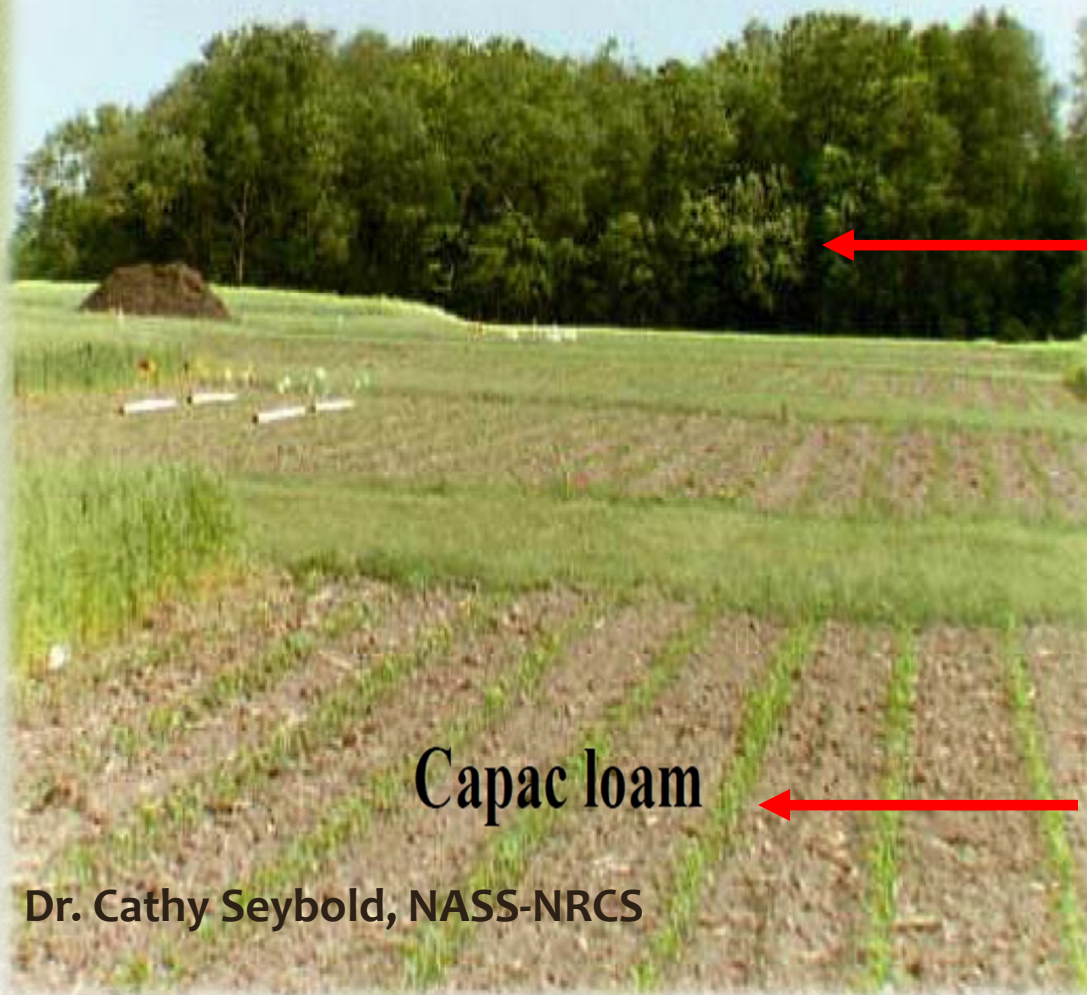
Study: Use-dependent Soil Properties



Land uses:

Woodland

Cropland: Conventional tillage, corn-soybean rotation



Wooded Soil: Bulk Density- 1.01
g/cm³

Infiltration rate

**Soil Nitrate
loss**

50 in./hr

1.8 lbs. N/ac.

Conventional Tillage- Corn-
Soybean: Bulk Density- 1.40 g/cm³

Infiltration rate

**Soil Nitrate
loss**

.50 in./hr

15 lbs. N/ac.

Capac loam

Dr. Cathy Seybold, NASS-NRCS

Soil Organic Matter & Available Water Capacity

Percent SOM	Sand	Silt Loam	Silty Clay Loam
1	1.0	1.9	1.4
2	1.4	2.4	1.8
3	1.7	2.9	2.2
4	2.1	3.5	2.6
5	2.5	4.0	3.0

Inches of Water/One Foot of Soil
1 acre inch = 27,150 gallons of water

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

Soil OM Changes

Table 1.—Soil measurements from Lamar Black's farm (Millen, GA), 11/15/01.

Treatment	Bulk density (g/cm³)	Aggregate stability (%)	Slaking (class)	Soil carbon (%)	Approx. soil org. matter* (%)	Moisture content (g/g)
Long-term cover crop/strip till	1.40	39	5.8	1.4	2.4	0.13
Short-term cover crop/strip till	NA	36	6.0	1.3	2.2	NA
2-year conventional tillage	1.46	12	5.0	0.5	0.9	0.02
Monocrop cotton conventional	1.58	21	3.8	0.7	1.2	0.03





Reduce
Chemical,
Biological, and
Physical
Stress

Synergize with
Diversity: Crop
Rotations and
Cover Crops

Understanding
how soil
functions

Cover The
Soil at all
times

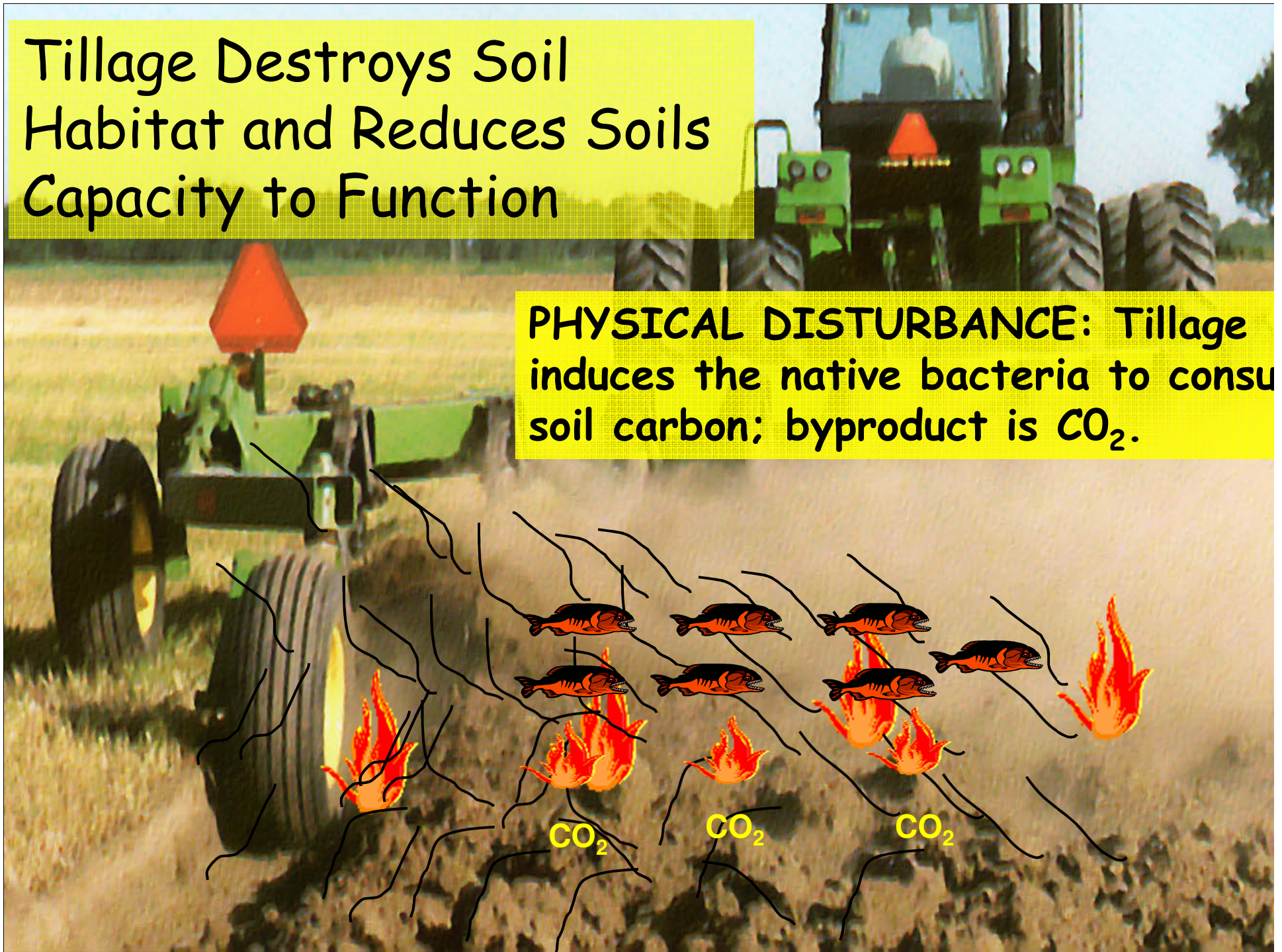
Grow a Living
Root 24/7

Protect the Habitat

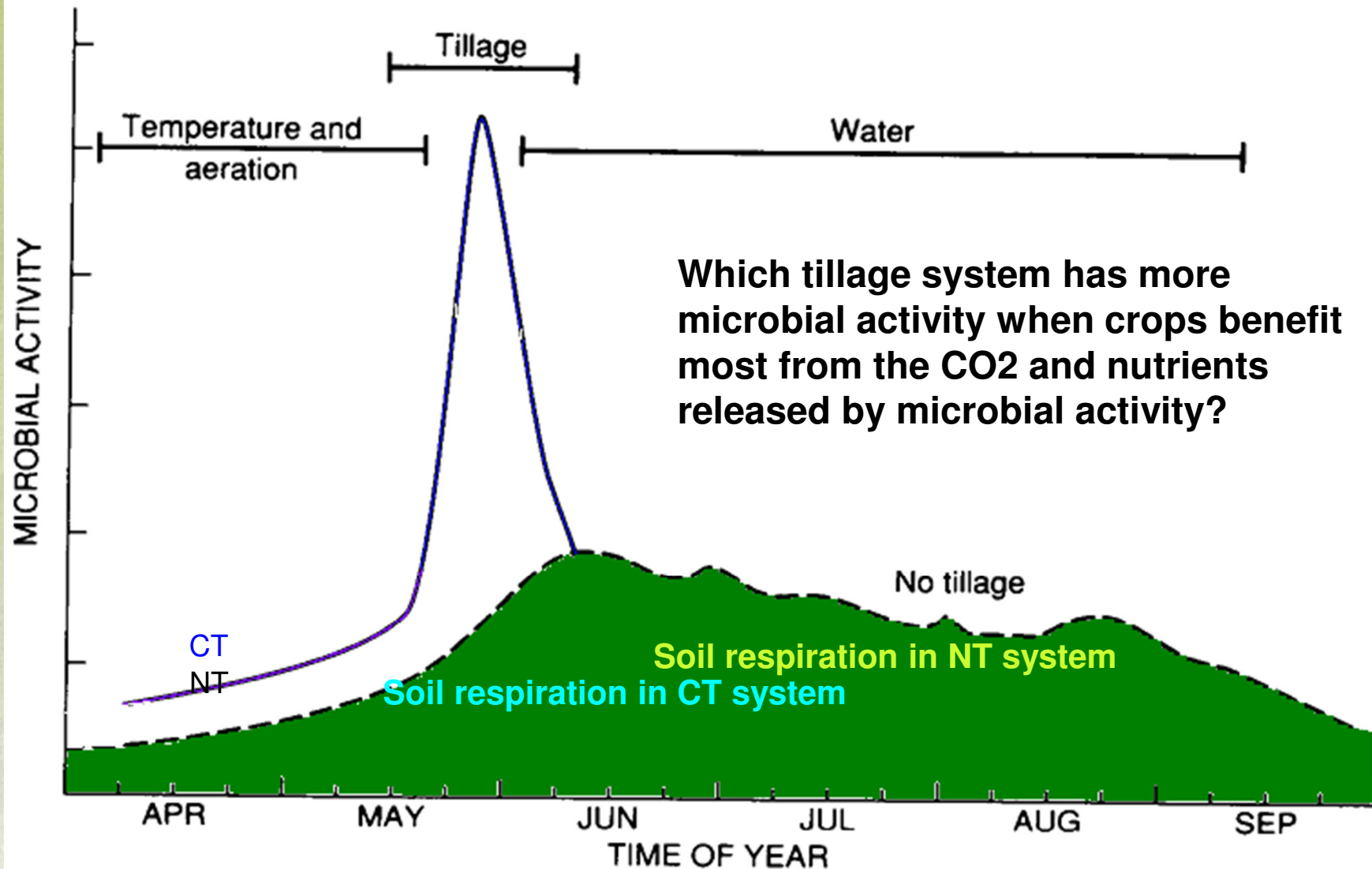
Reduce Chemical,
Biological, and
Physical Stress

Tillage Destroys Soil Habitat and Reduces Soils Capacity to Function

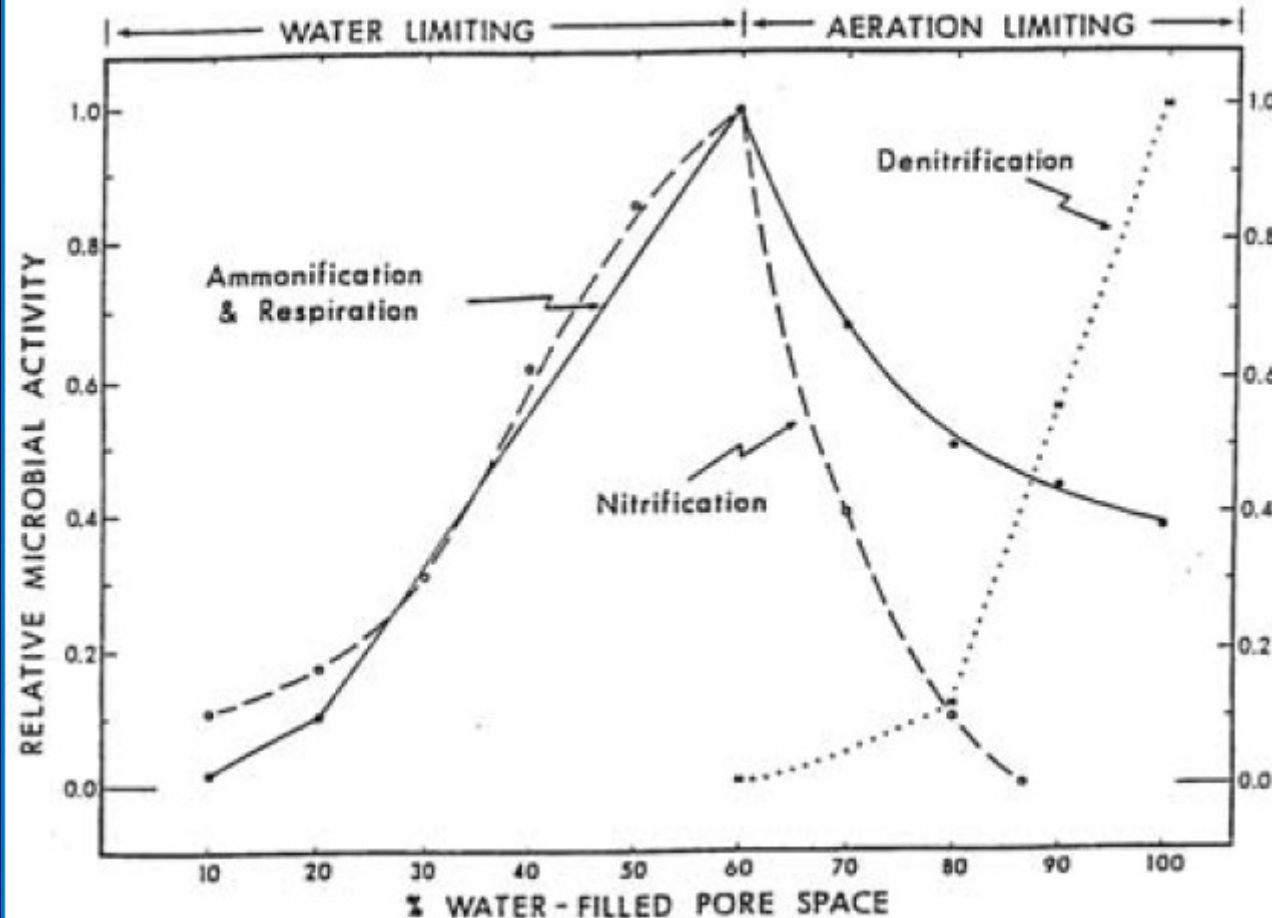
PHYSICAL DISTURBANCE: Tillage induces the native bacteria to consume soil carbon; byproduct is CO_2 .



Effect of tillage on microbial activity



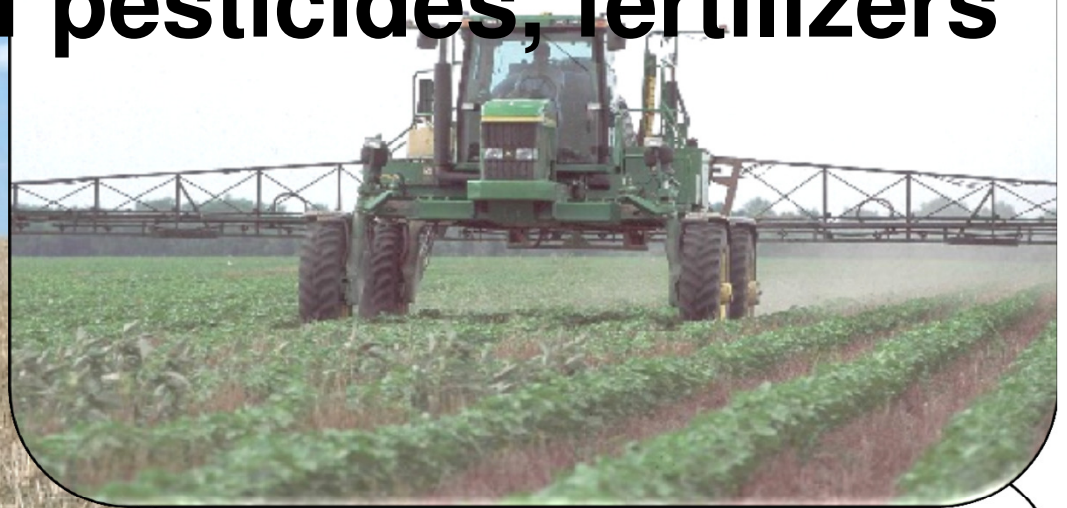
Factor Affecting Respiration



- Respiration peaks at field capacity
- 60% of pore spaces field
- >80% pore space water filled
- Anaerobic organisms use Nitrate instead of Oxygen



Chemical disturbances: over-application of pesticides, fertilizers and manures



Feed the soil diverse food
(carbon)

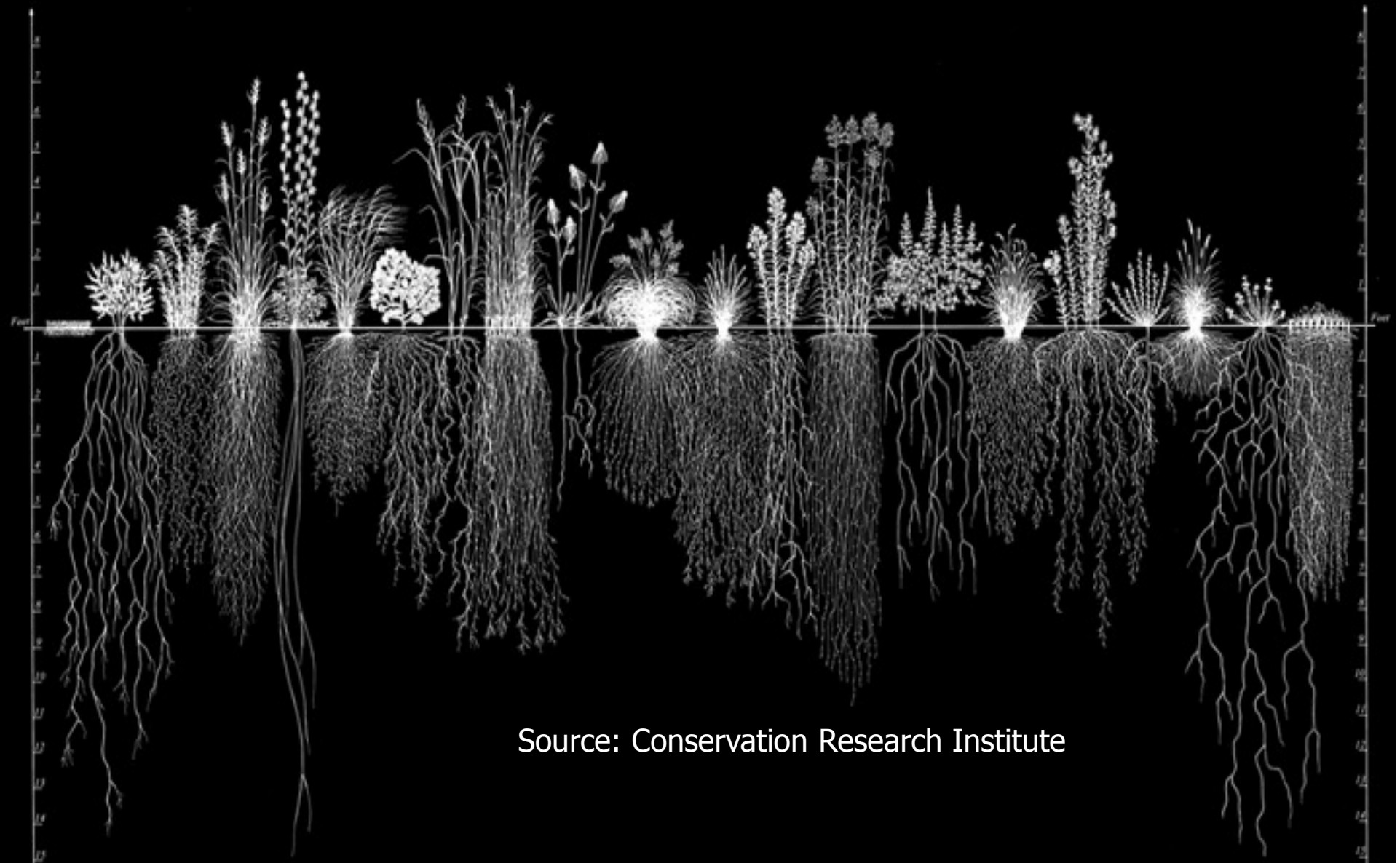


Synergize with
Diversity: Crop
Rotations and
Cover Crops

Diversify with Crop Diversity

- Plants interact with particular microbes
 - Trade sugar from roots for nutrients
- Microbes convert plant material to OM
- Requires a diversity of plant carbohydrates to support the variety of microbes
- Lack of plant diversity will drive system to favor some microbes more than others

Ecological Architecture:



Source: Conservation Research Institute

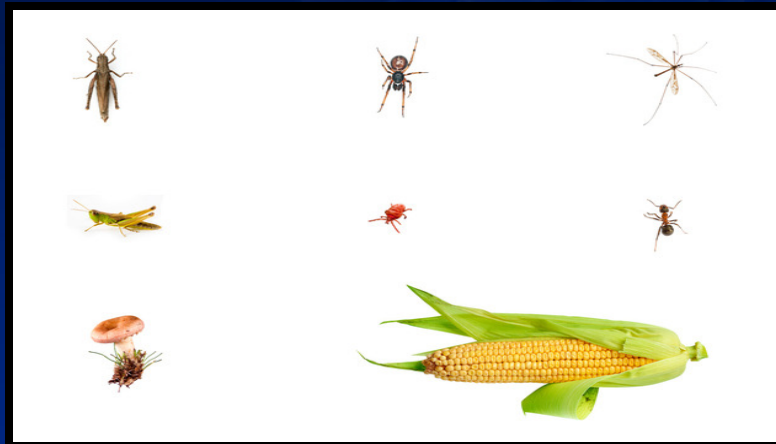
Costa Rica
150 Plants & Animals
24 Hours - Forest



Cape Town, South Africa
100 Plants & Animals
24 Hours - Grassland



Iowa Corn Field
8 Plants & Animals
24 Hours

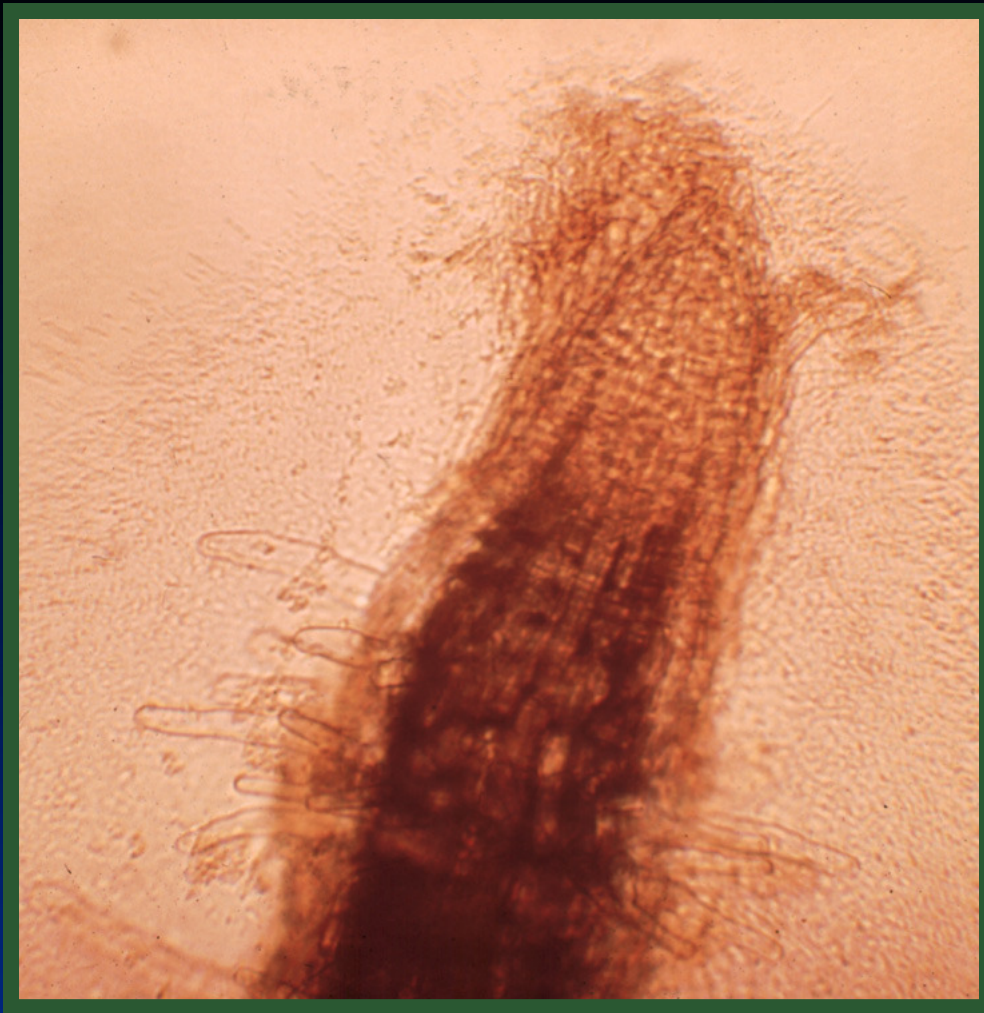


Build the Habitat

Grow a Living Root
24/7

Rhizosphere

Where Roots Meet Soil



Zone of
Concentrated
Biological Activity

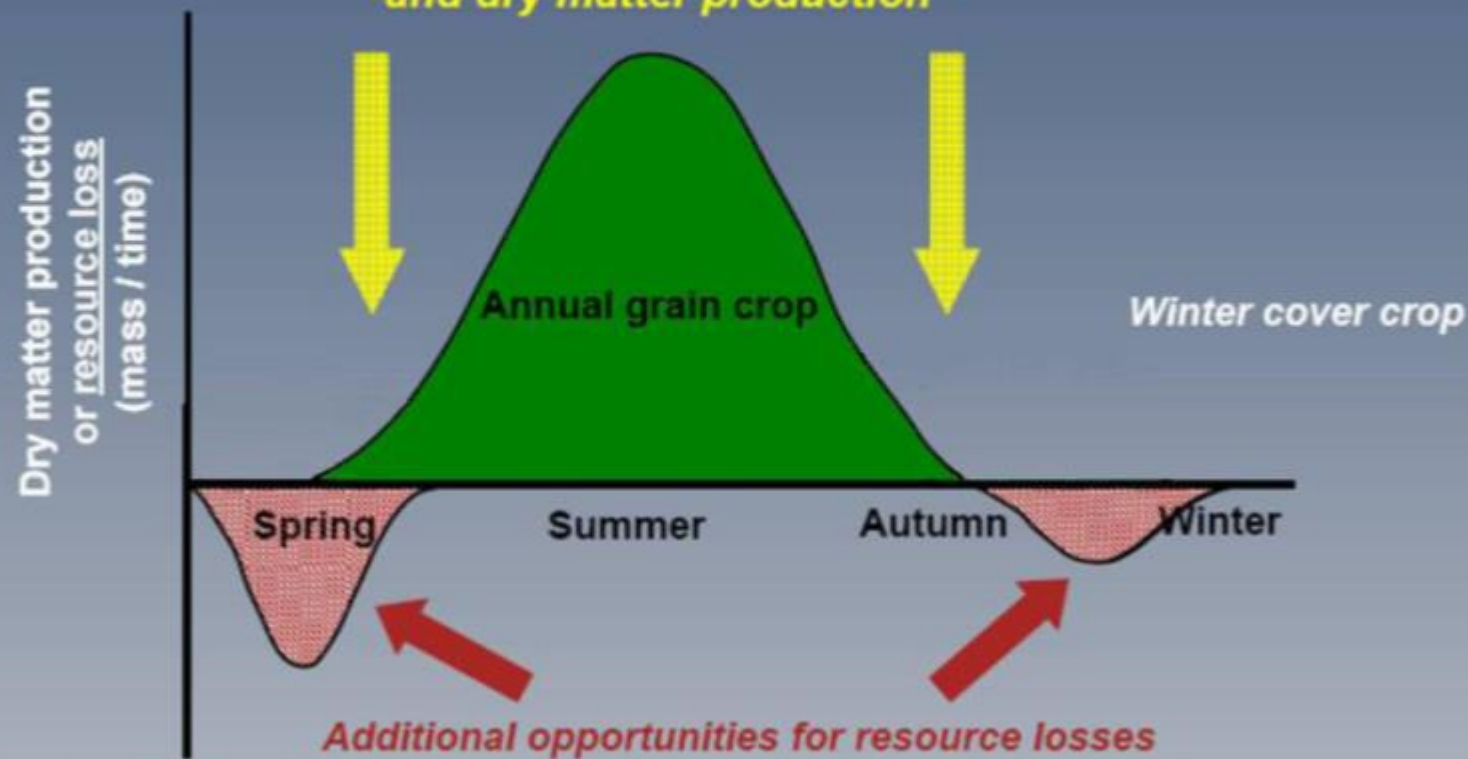
- Bacteria
- Fungi
- Protozoa
- Nematodes

Biomass Production

Annual Cropping Systems



*Missed opportunities for resource assimilation
and dry matter production*



after A.H. Heggenstaller

A. H. Heggenstaller, University of Alberta

Broadcast while defoliating cotton



Broadcast while defoliating cotton



Seeded a multi-species
cover crop mix

- Cereal rye
- Crimson clover
- Hairy Vetch



Mid October



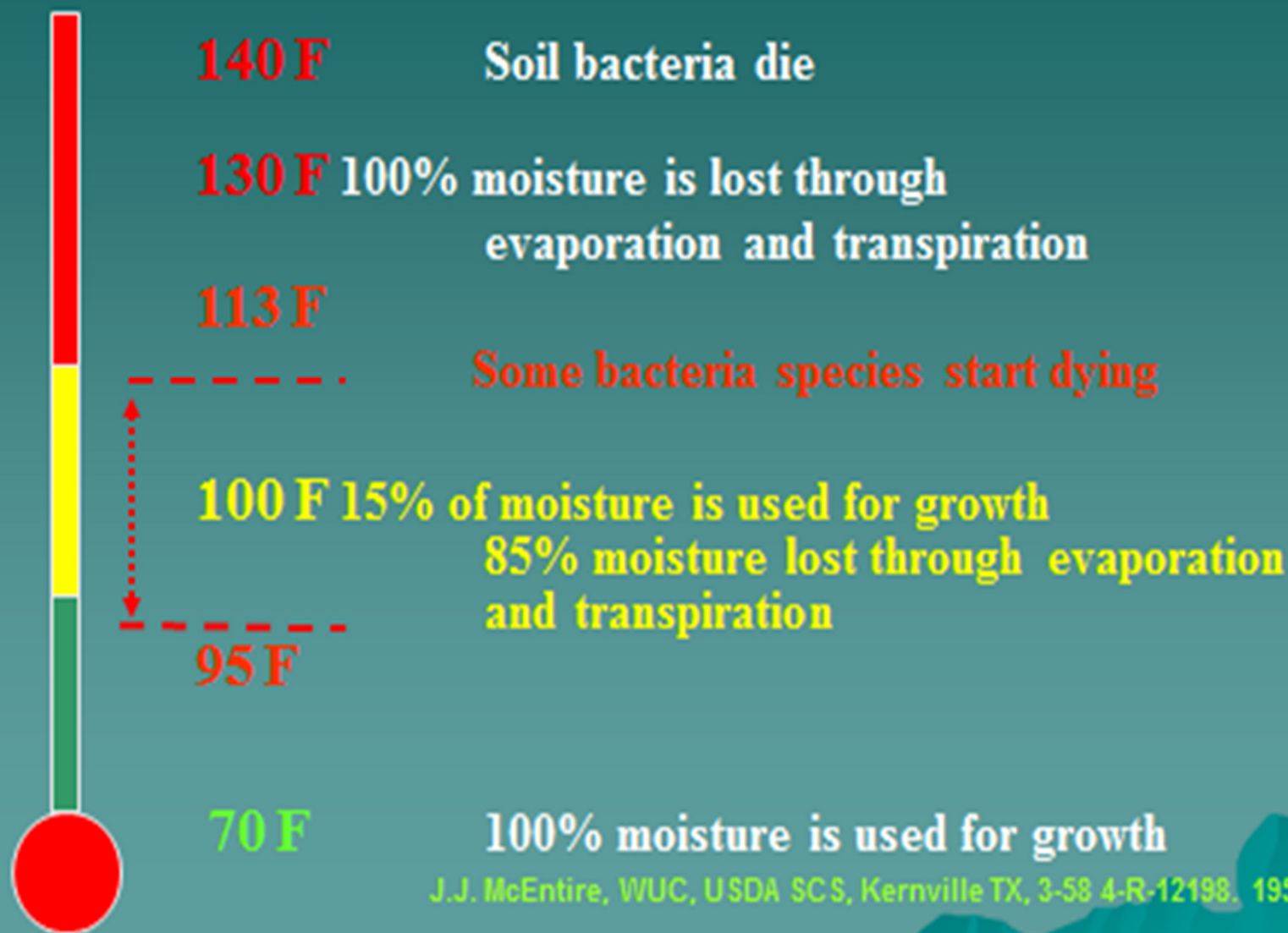
Protect the Habitat



Cover The Soil at
all times



When soil temperature reaches...

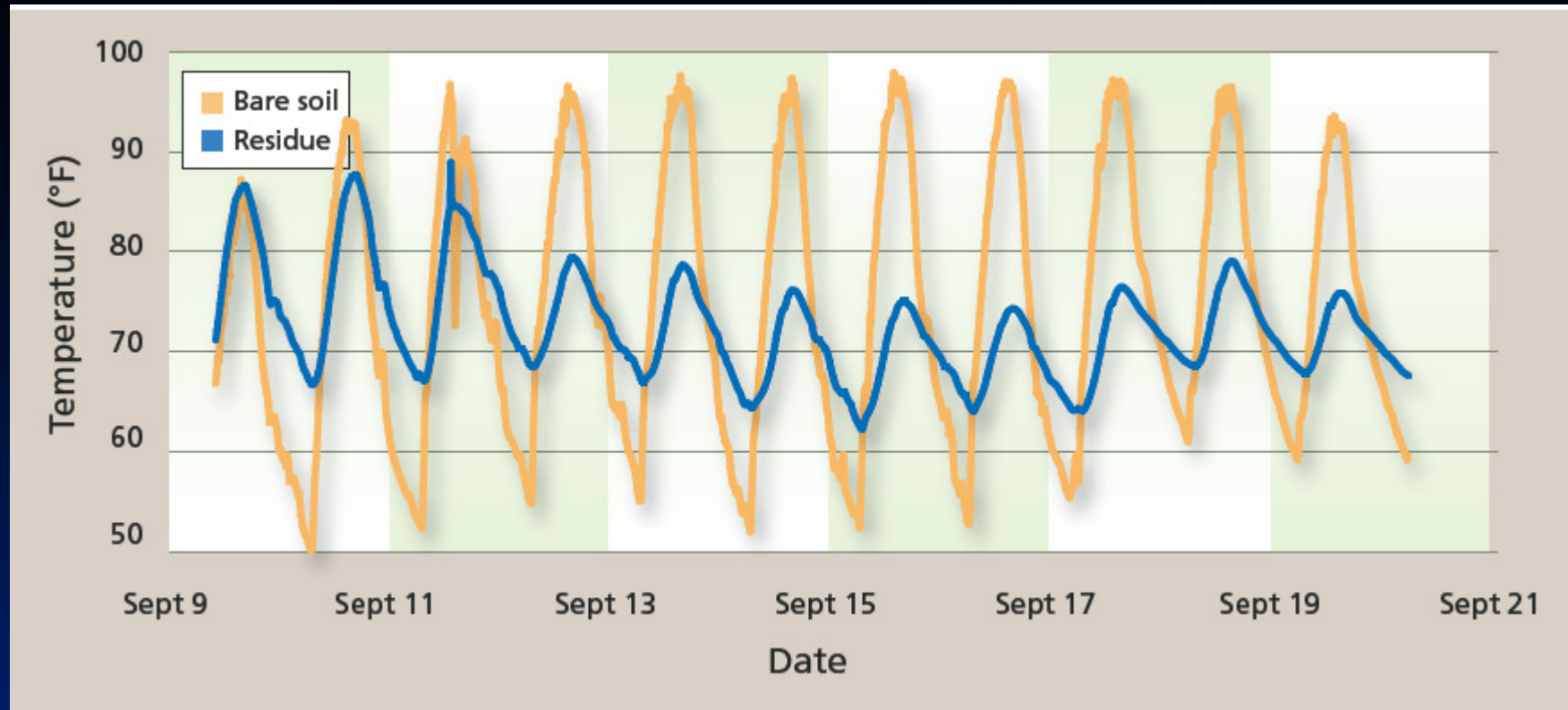


J.J. McEntire, WUC, USDA SCS, Kernville TX, 3-58 4-R-12198, 1956

Soil Temperature



Soil temps at 1 cm



**3 Bales Per
Acre**



