



Soil Health 101

***Farming in the 21st Century
a practical approach to improve
Soil Health***

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Why in 2013?

- World population is estimated to be at 9.1 billion by 2050
- To sustain this level of growth, food production will need to rise by 70 percent
- Between 1982-2007, 14 million acres of prime farmland in the U.S. was lost to development
- Energy demands
 - Increase use of biofuels (40% of corn used for ethanol)
 - Increase use of fertilizer (use of Anhydrous up 48%, Urea up 93%)



Soil Health What is It?

- The continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals, and humans
 - Nutrient cycling
 - Water (infiltration & availability)
 - Filtering and Buffering
 - Physical Stability and Support
 - Habitat for Biodiversity

Soil is a Living Factory



- **Macroscopic and microscopic organisms**

- Food
- Water
- Shelter
- Habitat
- Powered by sunlight

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

- Tillage
- Fertilizer
- Pesticides
- Grazing
- Plant Diversity



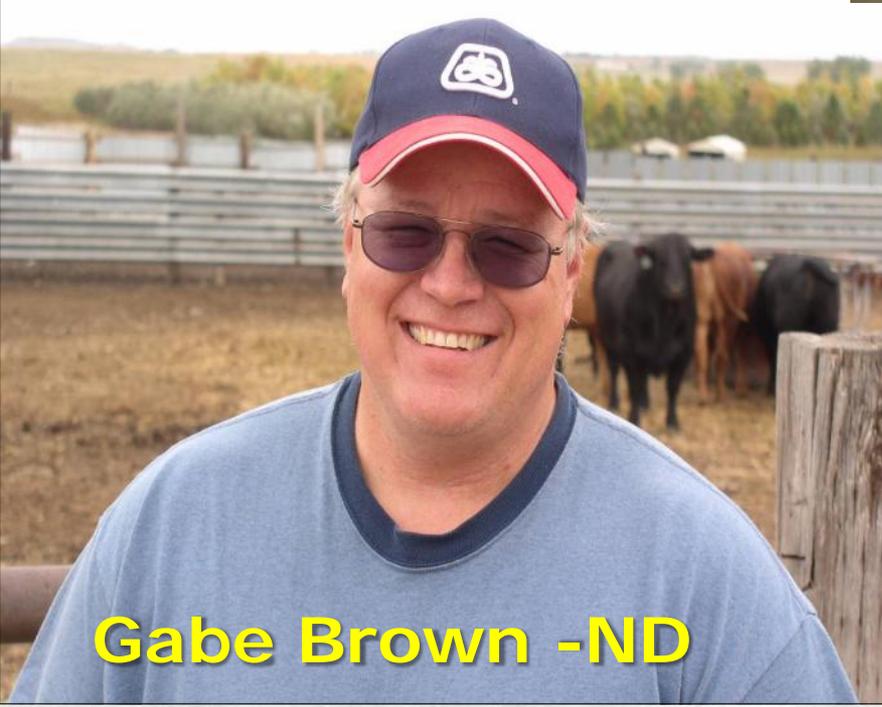
Ray Styer -NC



**Dave Brandt -
OH**



**Brendon
Rockey -CO**



Gabe Brown -ND

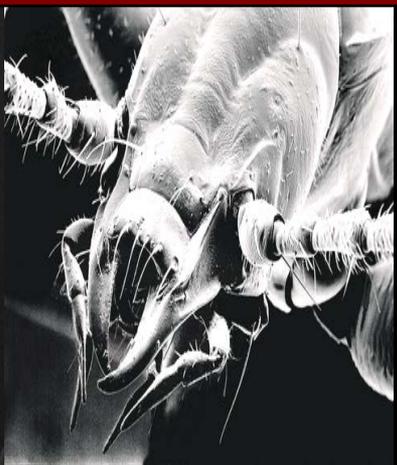
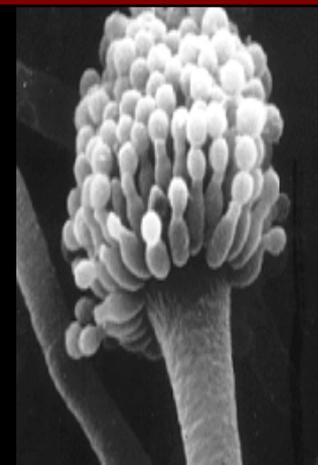
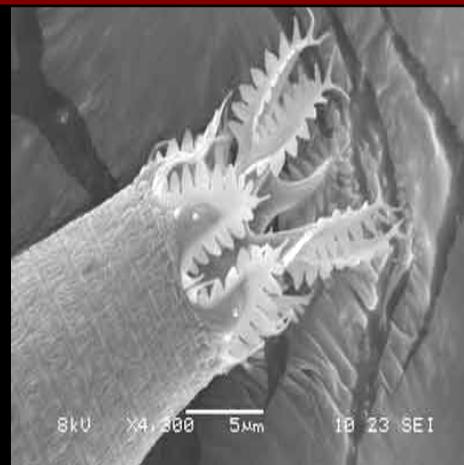
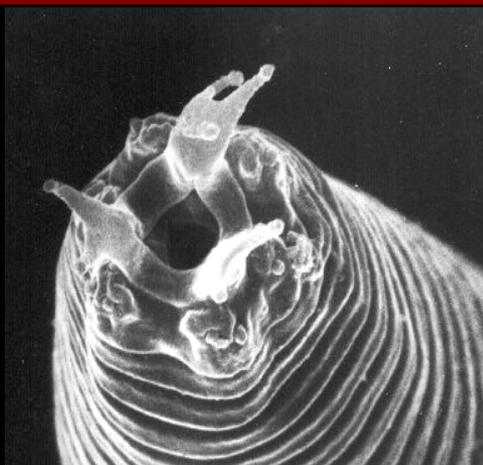


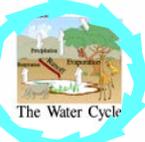
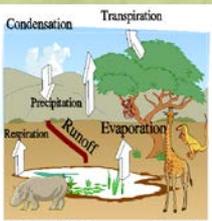
Ray McCormick -IN



Ecology:
the study of
relationships between
people, animals, and
plants, and their
environment.
Interconnectedness

Soil Surface





Farm or Ranch

annual weeds

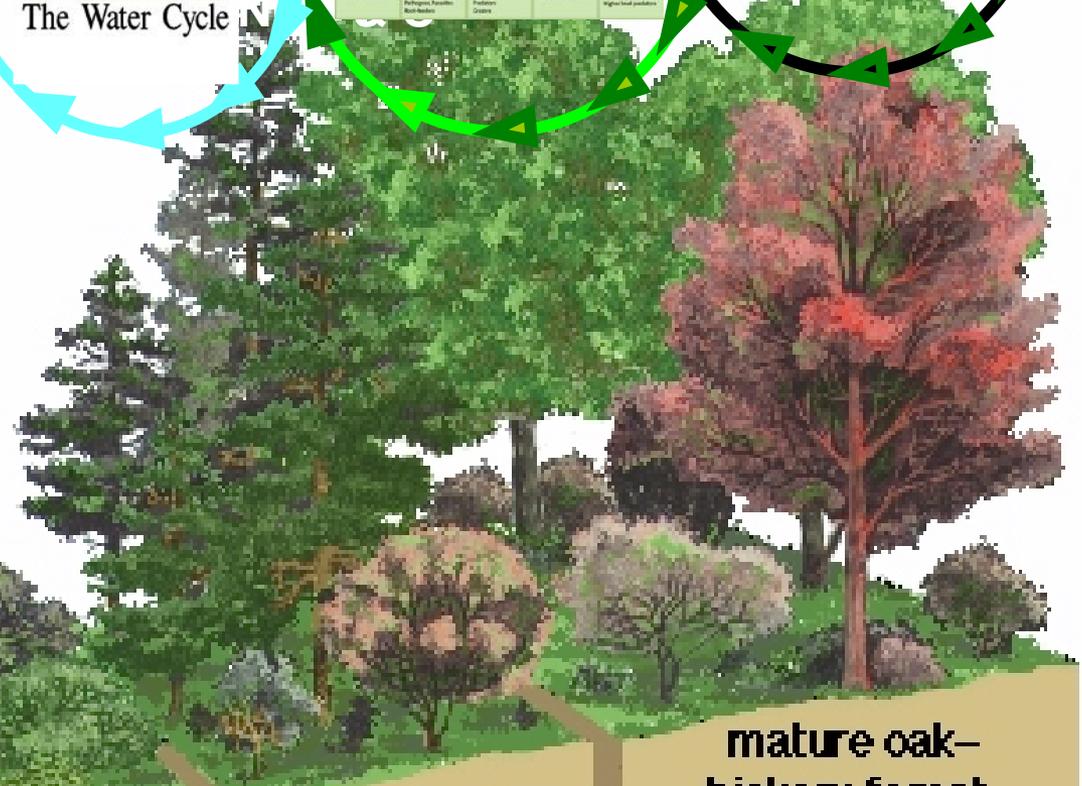
perennial weeds and grasses

shrubs

young pine forest

mature oak-hickory forest

Time



ok the
NETS
NETS

How do these Ecosystem flourish without human inputs?



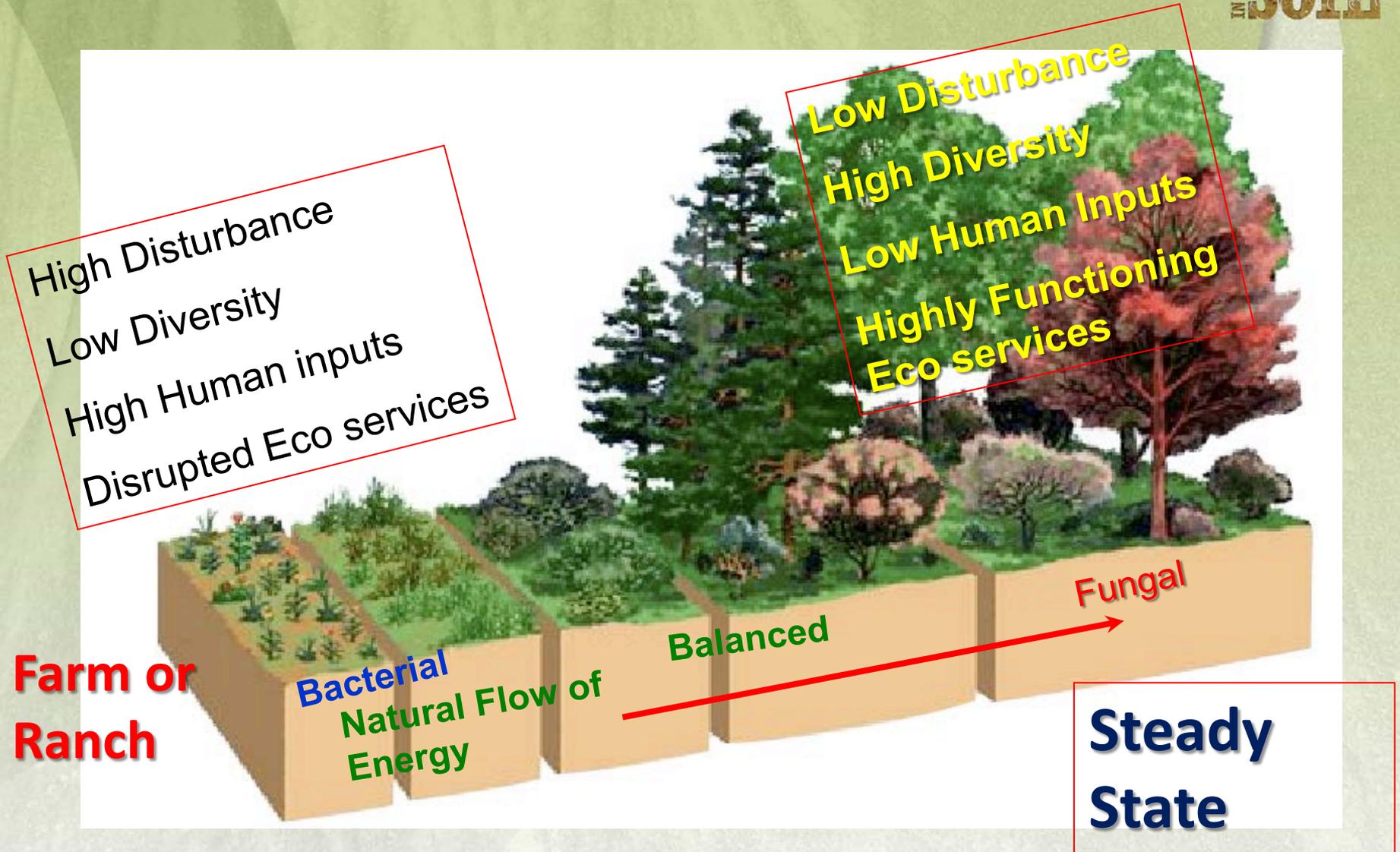
Prairie



Forest



Characteristics of a Stable Ecosystem





This soil is naked, hungry, thirsty and running a fever!

Ray Archuleta 2007

Erosion from bare fields into river



Oklahoma October 2012 I-35

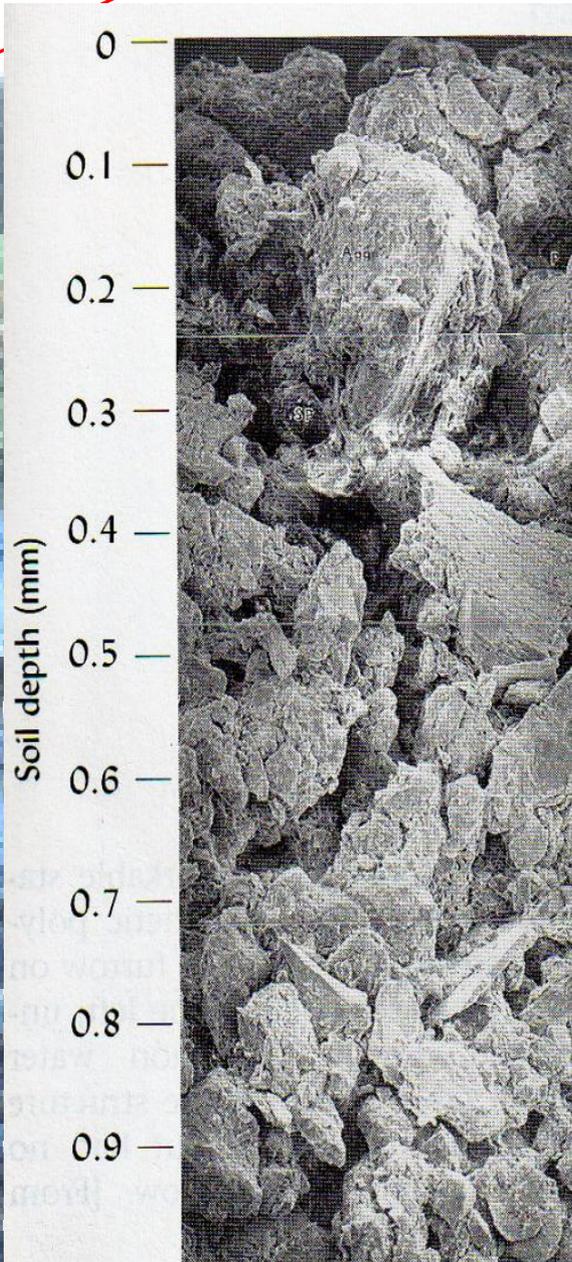
Sediment is still the largest water quality pollutant by volume



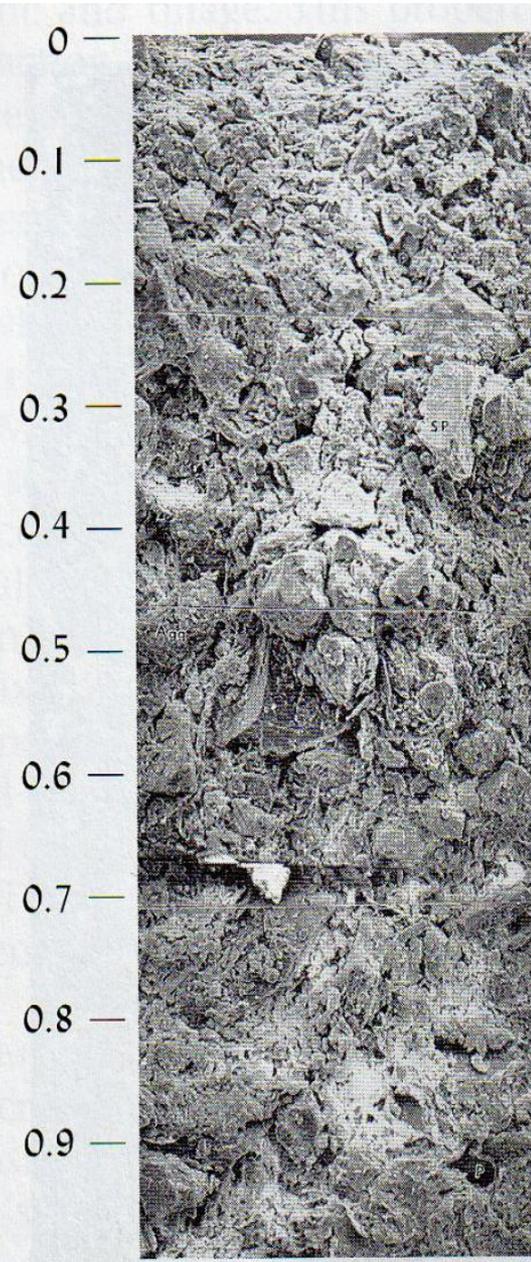
Lubbock Texas Oct. 17, 2011



The Battle is Won or Lost Here



(a)



(b)





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

Soil Disturbances that Impact Soil Health



- Physical
 - Tillage
 - Compaction
- Biological
 - Lack of Plant Diversity
 - Over grazing
- Chemical
 - Misuse of fertilizer, pesticides, manures and soil amendments





What is Tillage?

The physical manipulation of the soil for the purpose of:

- Management of previous crop residue
- Control of competing vegetation (weeds)
- Incorporation of amendments (fertilizer/manure)
- Preparation of a soil for planting equipment
- Recreation for folks who don't fish or golf.



What Tillage does to the Soil

- Destroys aggregates
- Exposes organic matter to decomposition
- Compacts the soil
- Damages soil fungi
- Reduces habitat for the Soil Food Web
- Disrupts soil pore continuity
- Increases salinity at the soil surface
- Plants weed seeds

“The truth is that no one has ever advanced a scientific reason for plowing”

Ploughman's Folly by E.H. Faulkner (1940)



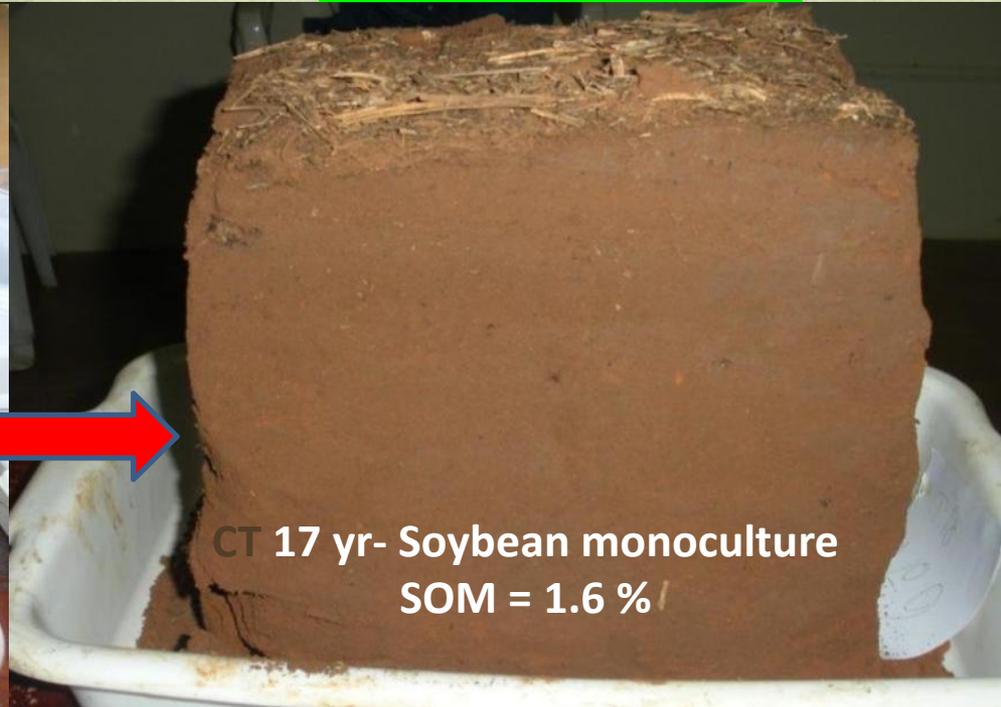
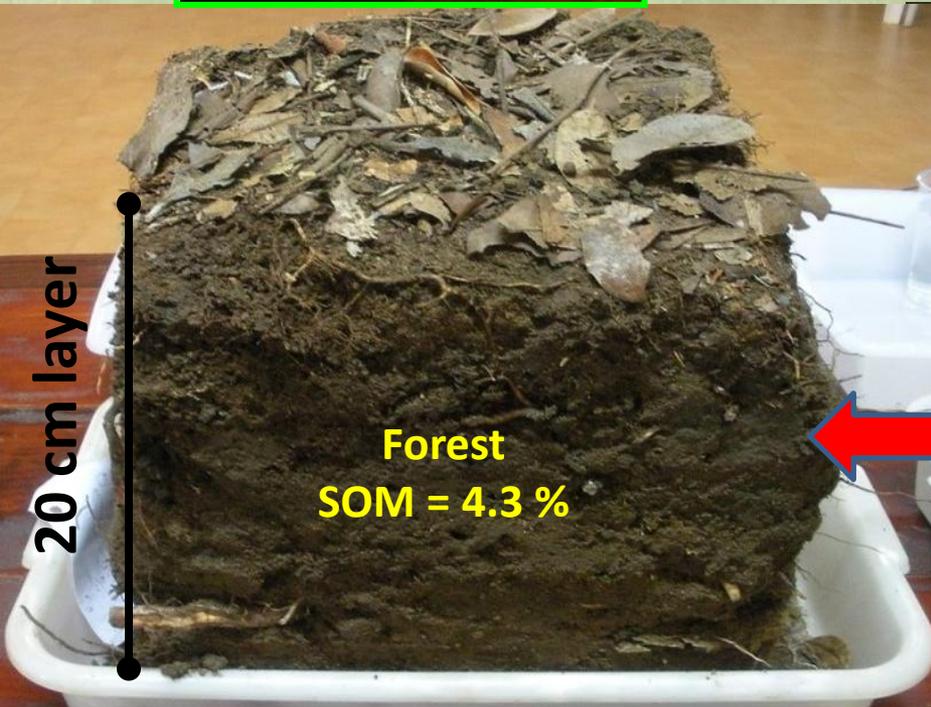
“We have equipped our farmers with a greater tonnage of machinery per man than any other nation. Our agricultural population has proceeded to use that machinery to the end of destroying the soil in less time than any other people has been known to do it in recorded history.”

“The chief trouble with our farming is that we have concerned ourselves with the difficult techniques of supplying our farm crops with new materials for growth, when we could easily take full advantage of the almost automatic provisions of nature for supplying plants with complete rations in secondhand form. We have made a difficult job of what should be an easy one”

Management Changes Soil Properties & Capacity of Soil to Function



62.8% loss
of SOM after
17 yr
intensive
tillage



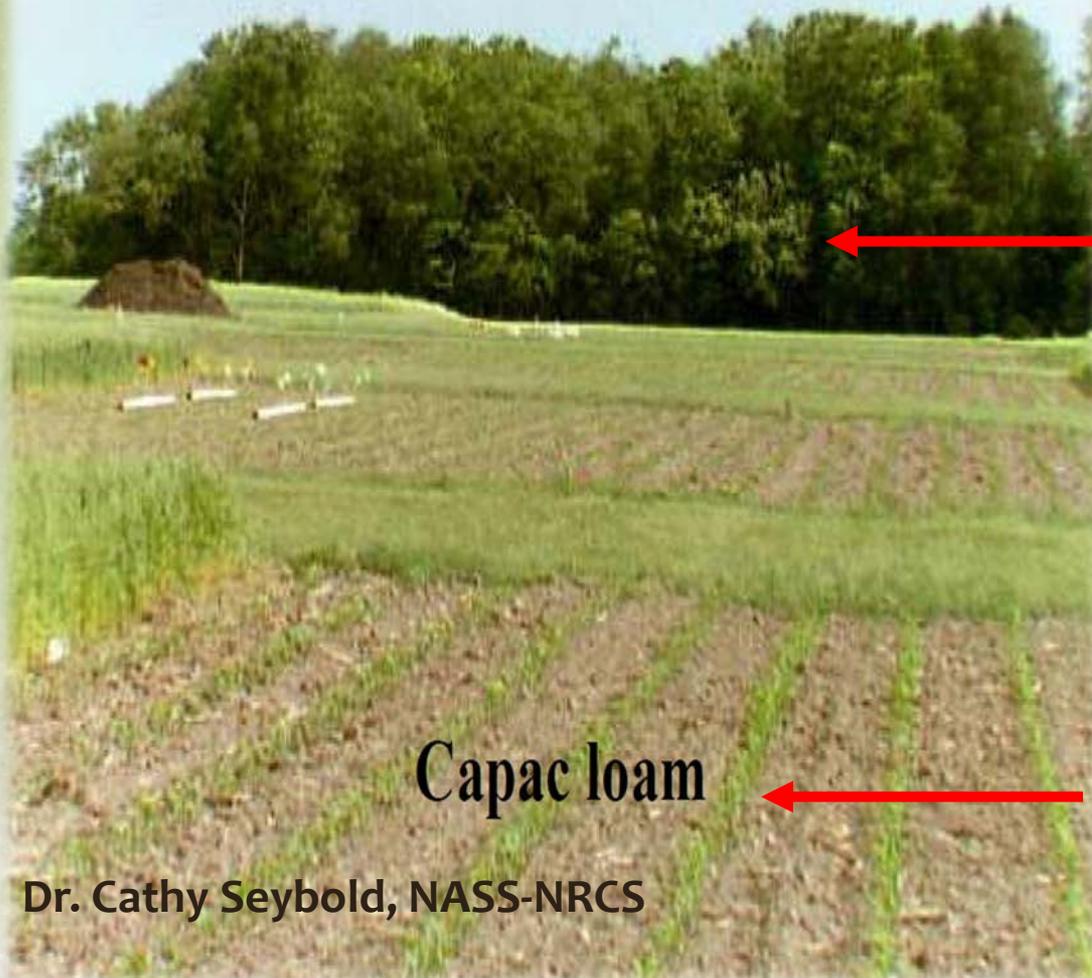
Study: Use-dependent Soil Properties



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

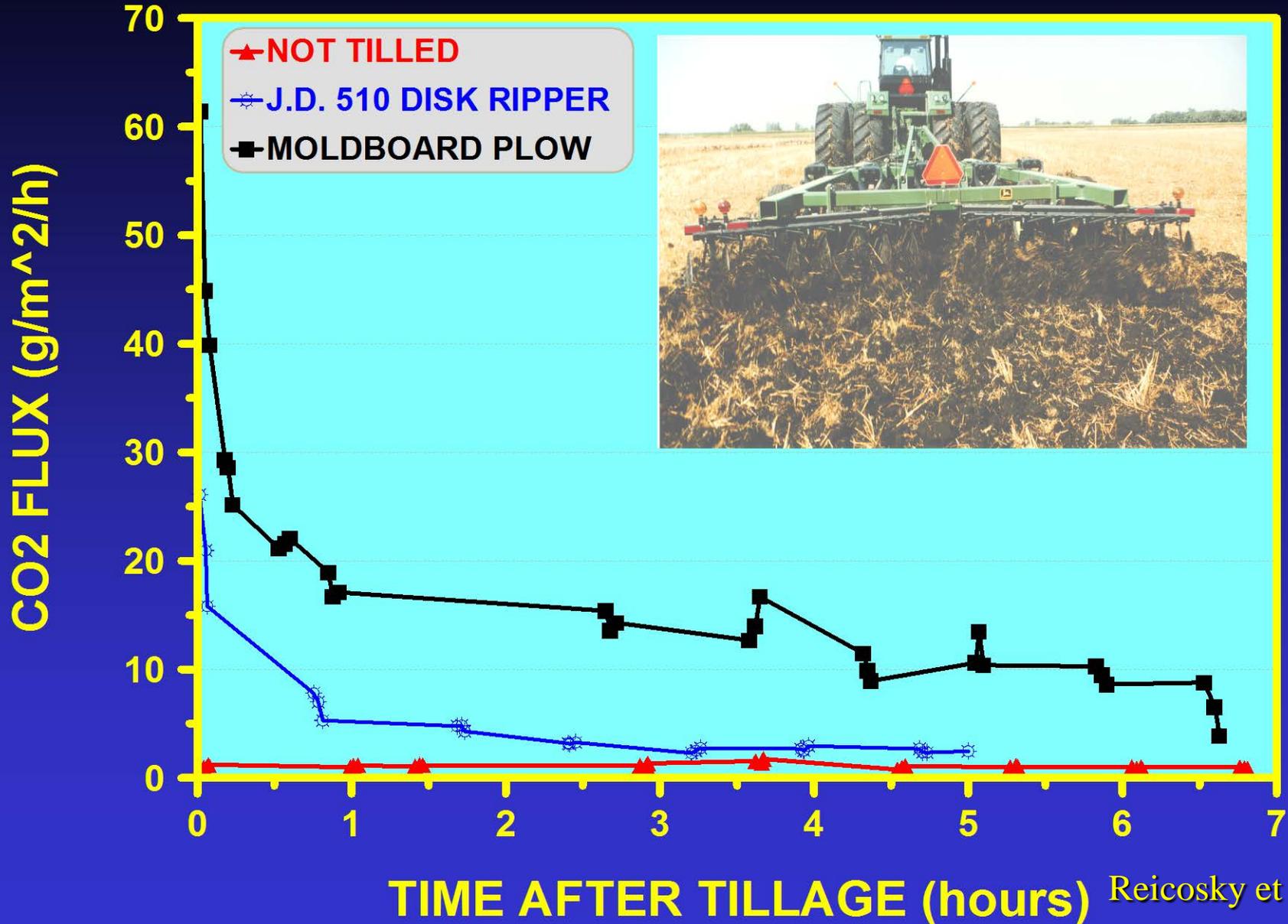
Tillage Destroys Soil Habitat and Reduces Soils Capacity to Function

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



JOHN DEERE 510 DISK RIPPER CO2 FLUX DATA

SWAN LAKE TILLAGE DEMONSTRATION AUGUST 24, 1994



Reicosky et al., 1995



Subsoil tillage

Moldboard plow

Chisel plow

3X

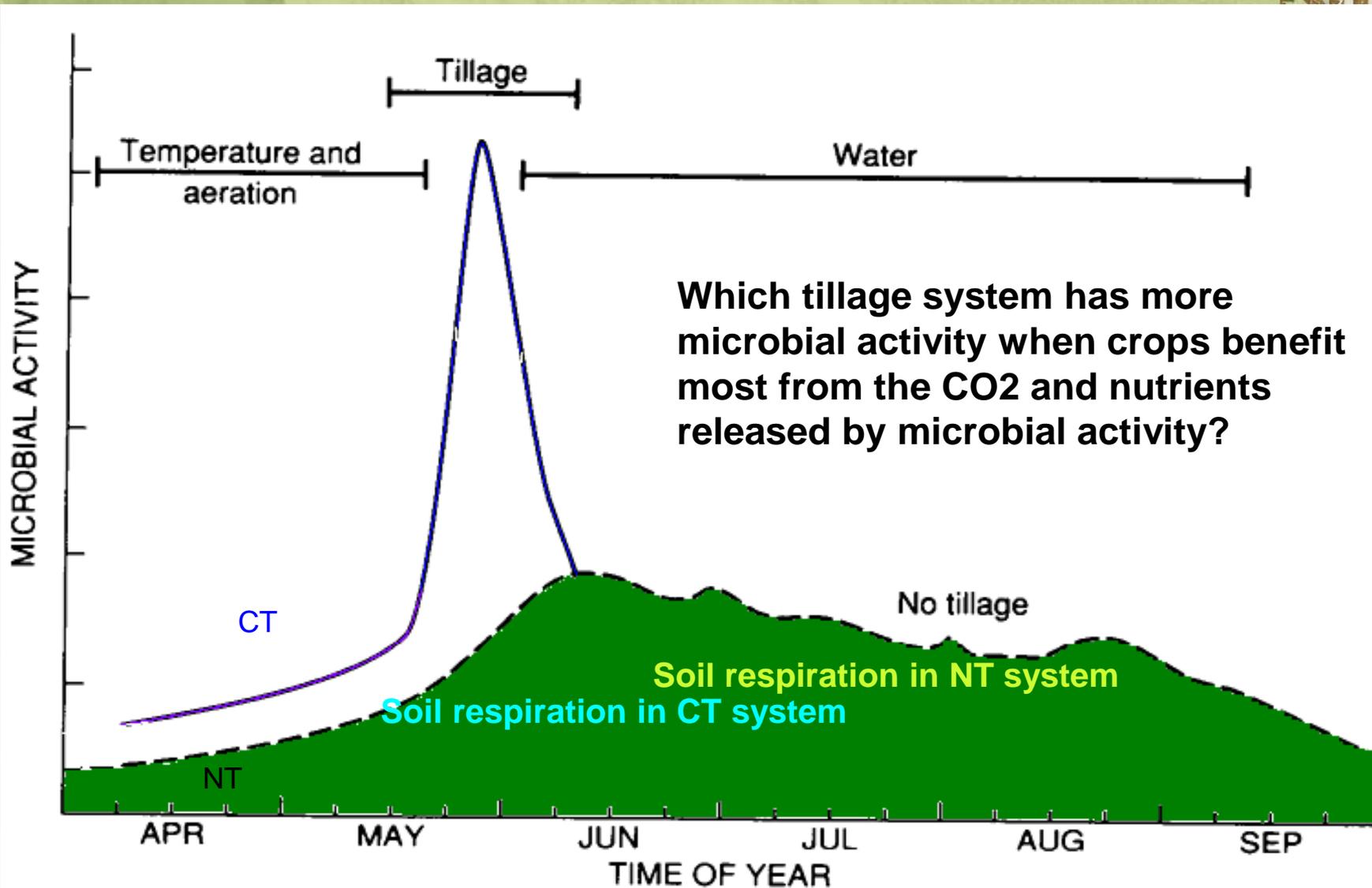
2X

1X

Different tillage = Different rates of Carbon loss



Effect of tillage on microbial activity





Biological Disturbance

- No crop rotation diversity
 - Growing single species or few crops in rotation
 - Lack of diversity limits diversity of plant root exudates
 - Hampers the development of a diverse soil biota
- Overgrazing
 - Plants are exposed to intensive grazing for extended periods of time, without sufficient recovery periods

Biological Disturbance of Overgrazing



1. Reduced root mass
2. Increased weeds
3. Reduced soil fungi
4. Reduced water infiltration
5. Increased soil temperature
6. Diminished soil habitat

Alternative water sources & controlled access to stream but no control of grazing time on watershed



Chemical disturbances:
over-application of
pesticides, fertilizers,
amendments & manures



Impact of Pesticides on Soil Health



- Impacts non-target organisms
 - not well understood
 - Fungicide takes out mycorrhizal fungi
- Pesticides simplify, not diversify
- May restrict crop rotation
- May restrict cover crop diversity (plant back restrictions)



Impact of Fertilizer on Soil Health

- Short-circuits the rhizosphere & P cycle
- Depresses activity of natural N fixers
- Stimulates bacterial decomposition of SOM
- Excess N at risk for leaching or denitrification
- Increased soil salinity (Synthetic fertilizers are salts)

Impact of Manure on Soil Health

- Can add organic matter and carbon
- Build up of P to excessive levels
 - Greater than 100 ppm discourages plants from feeding mycorrhizal fungi
- Other issues
 - Heavy metals
 - Salts
 - Pathogens
 - Soil compaction from application/incorporation



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



Paradigm Shifts

- Paradigm shift #1 Stop treating the symptoms of dysfunctional soil; solve the problem of dysfunctional soil.
- Paradigm shift #2 Restoring soil function can be accomplished without going broke.
 - Apply basic principles of ecology to create quality habitat.
 - There is no waste in Nature.
- Paradigm shift #3 Conservation practices do not restore soil health, understanding soil function restores soil health.

Managing for Soil Health



- Minimize Disturbance of the soil
- Maximize Diversity of plants in rotation/ cover crops
- Keep Living Roots in the soil as much as possible
- Keep the soil covered at all times with plants and plant residues
- Create the most favorable habitat possible for the soil food web

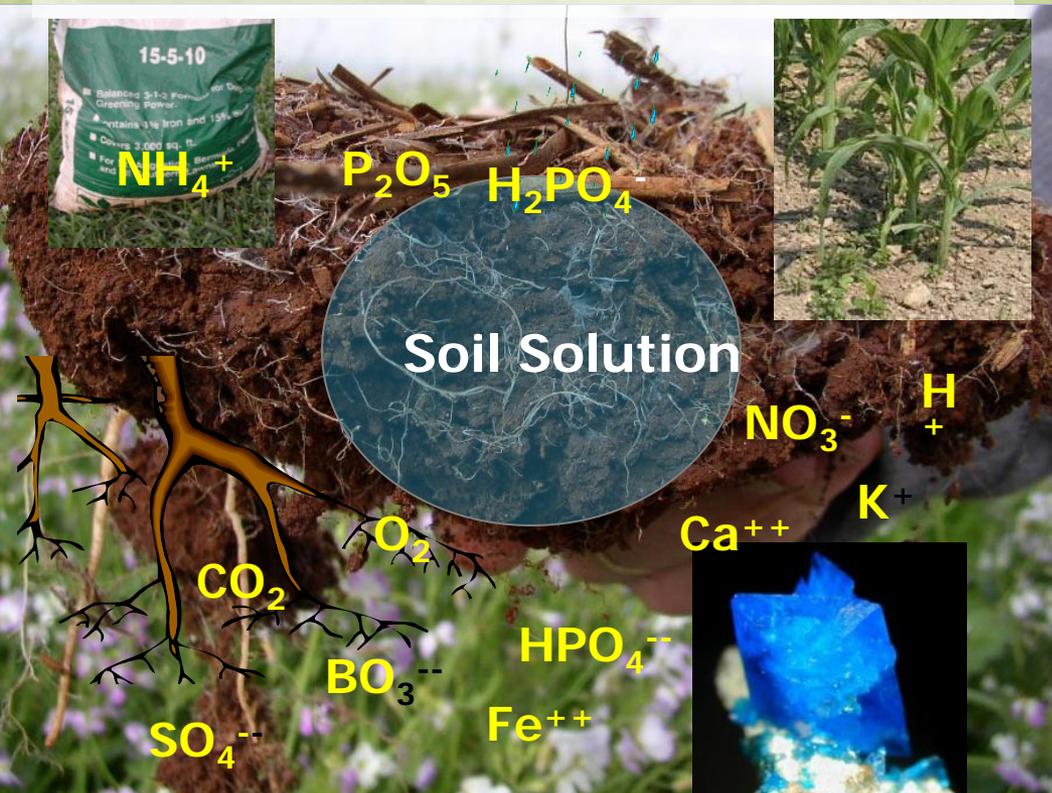
Soil Health Is Understanding How the Soil is Designed to Function and Managing it Accordingly



Extra slides

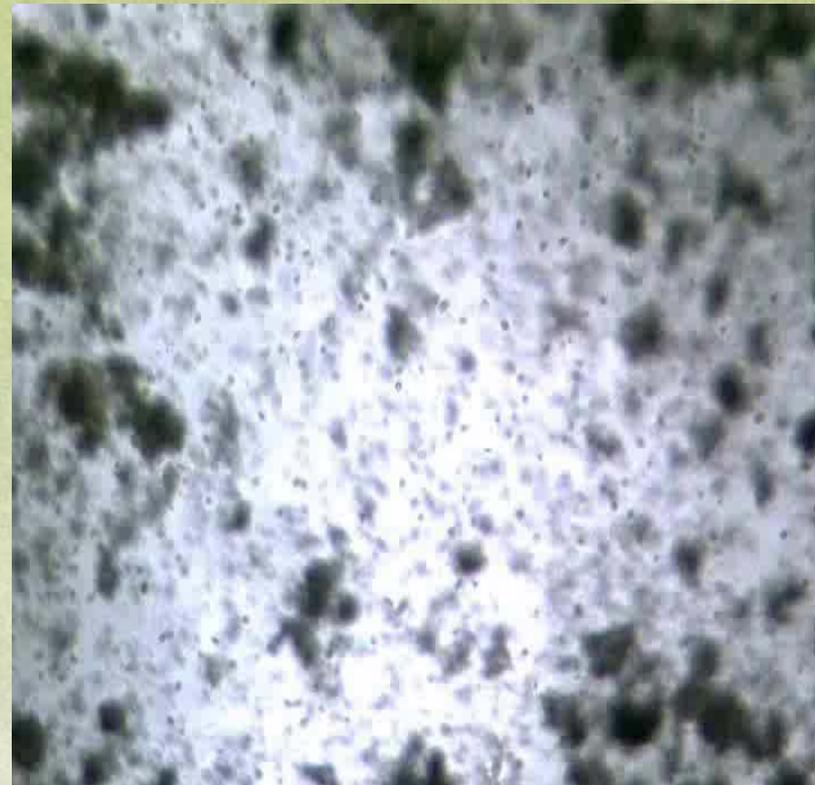


Inorganic Based Soluble State



- 40 to 60 % N and P Loss Cassmen 2002
- Bare fallows 4-8 months
- Decoupled C,N,P cycle (Dr.Drinkwater, Dr. Swift)

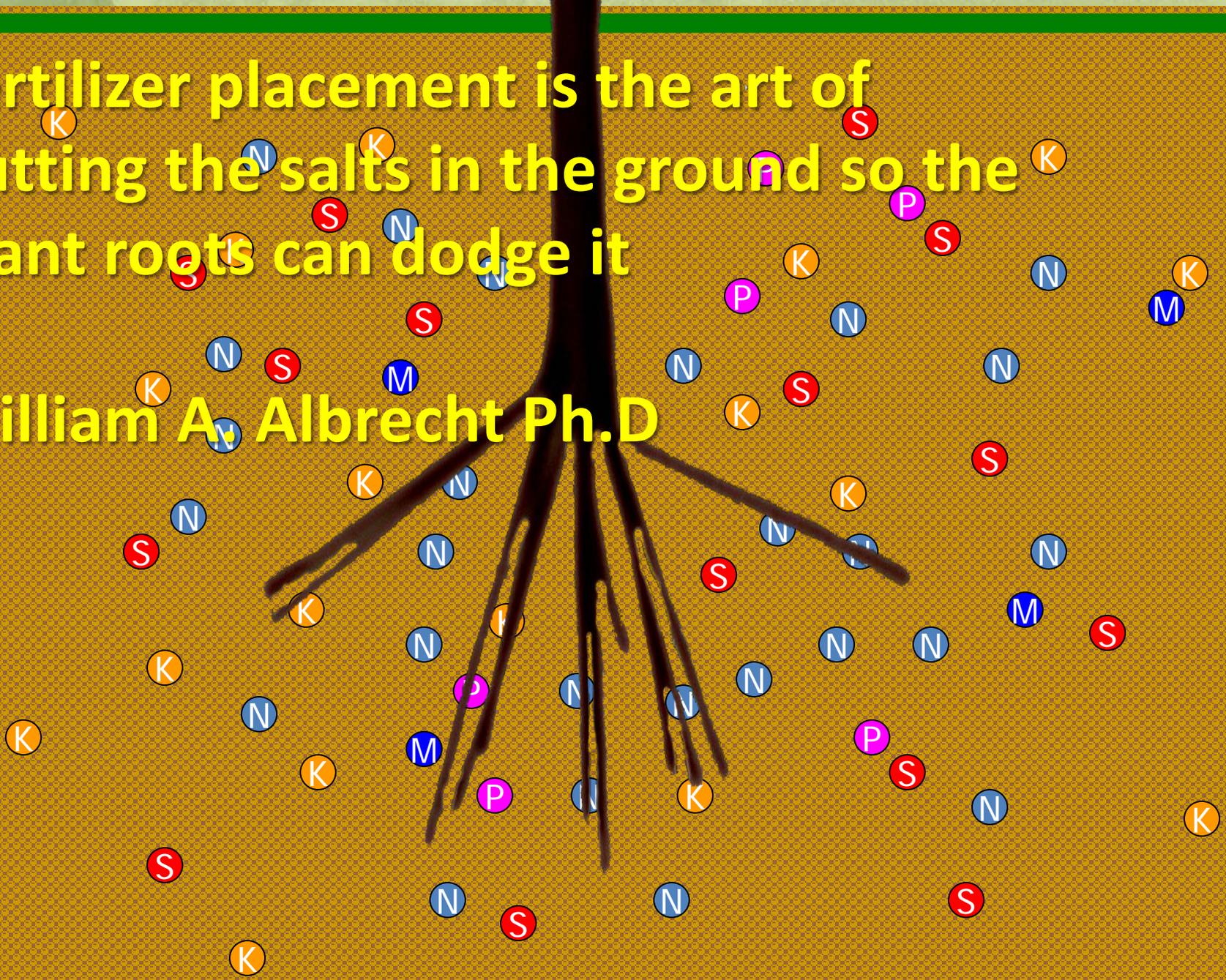
Ecologically Based



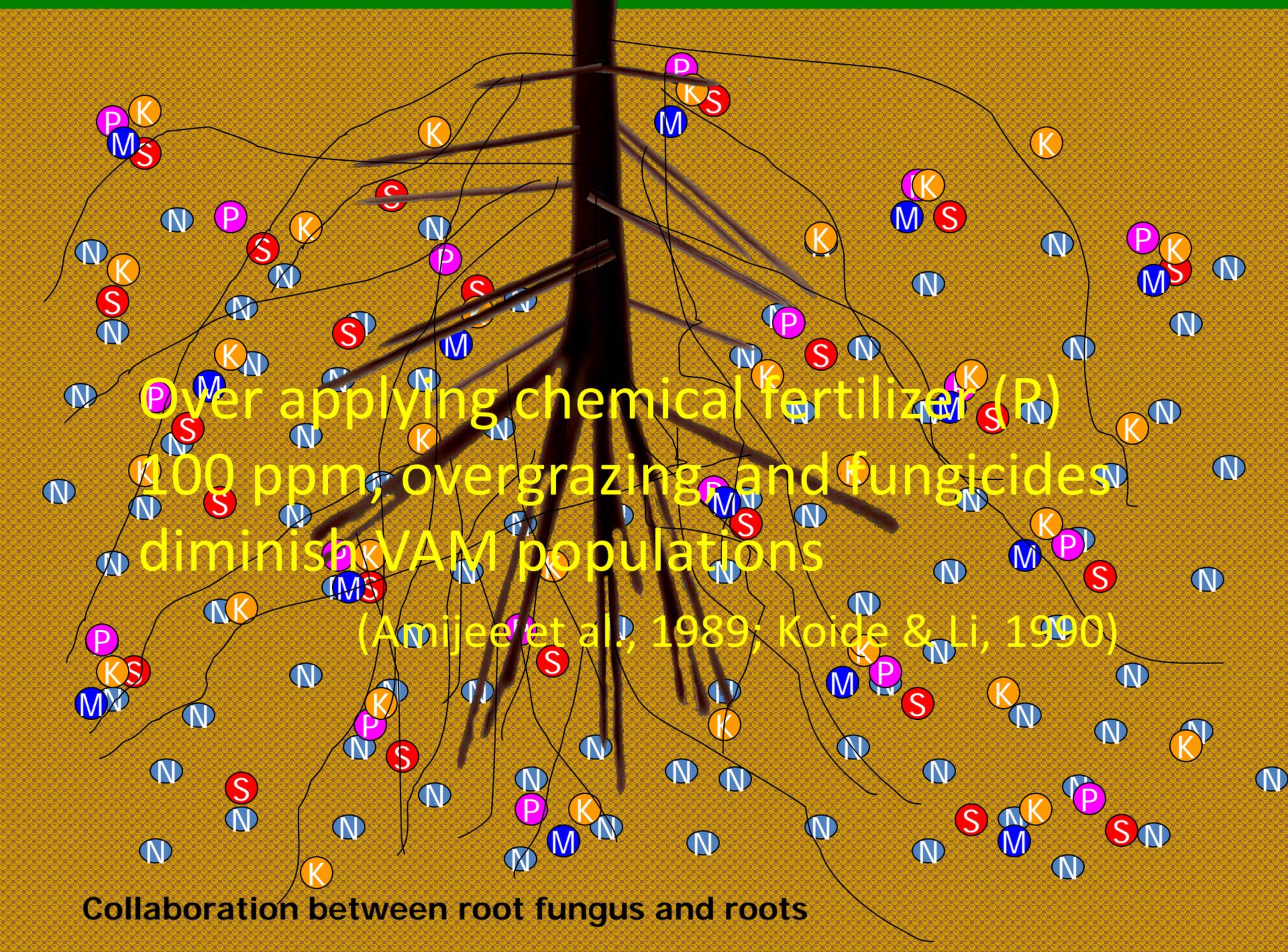
- Organic-mineral pools
- Microbially plant mediated process
- Strategic use of variable nutrients sources

Fertilizer placement is the art of putting the salts in the ground so the plant roots can dodge it

William A. Albrecht Ph.D



What can the plant access alone?

A diagram of a plant root system with a central taproot and several lateral roots. The roots are shown in black. Various colored circles (P, K, S, M, N) are scattered around the roots, representing nutrient uptake. The background is a textured brown color.

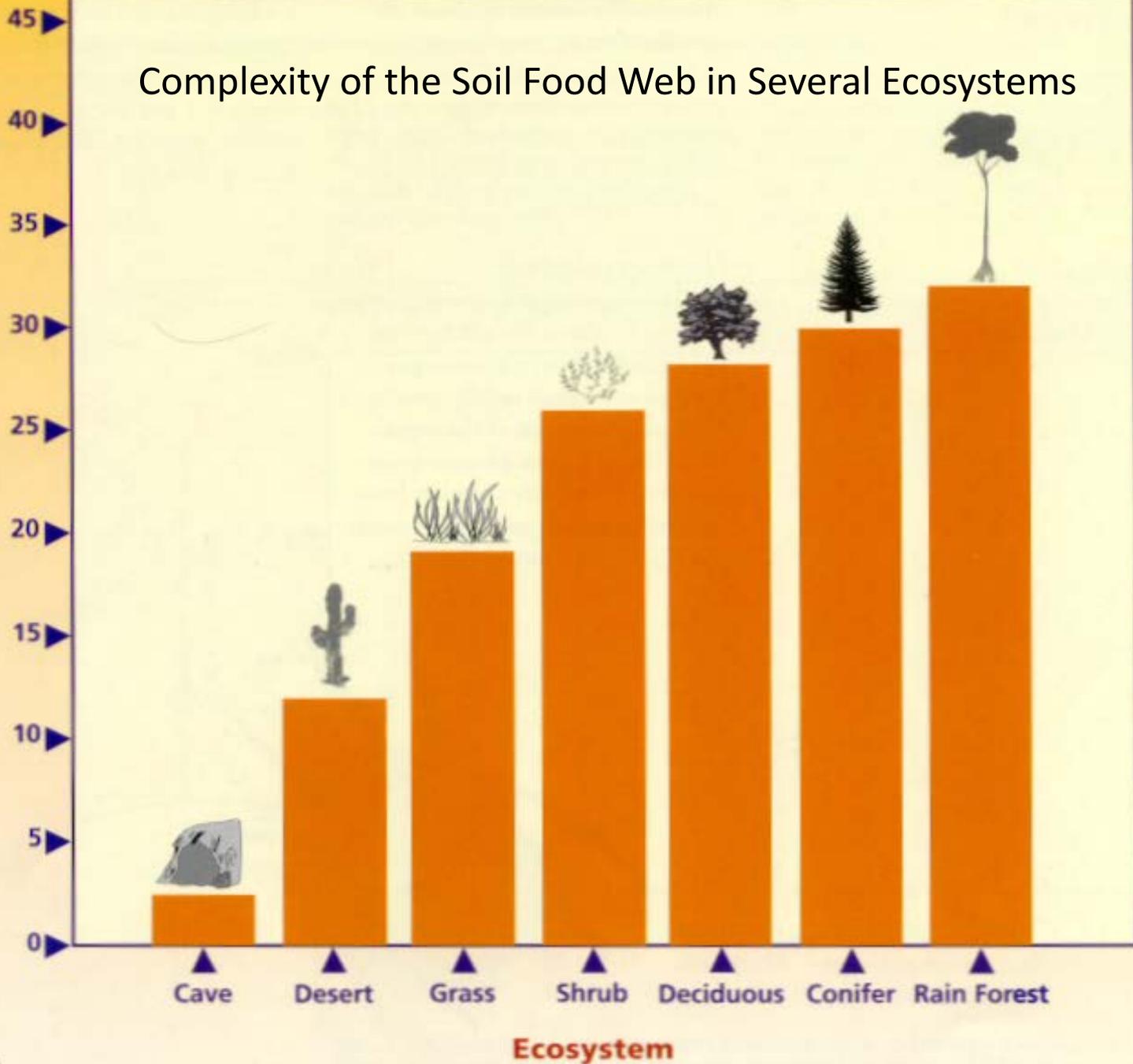
Over applying chemical fertilizer (P)
100 ppm, overgrazing, and fungicides
diminish VAM populations

(Amijee et al., 1989; Koide & Li, 1990)

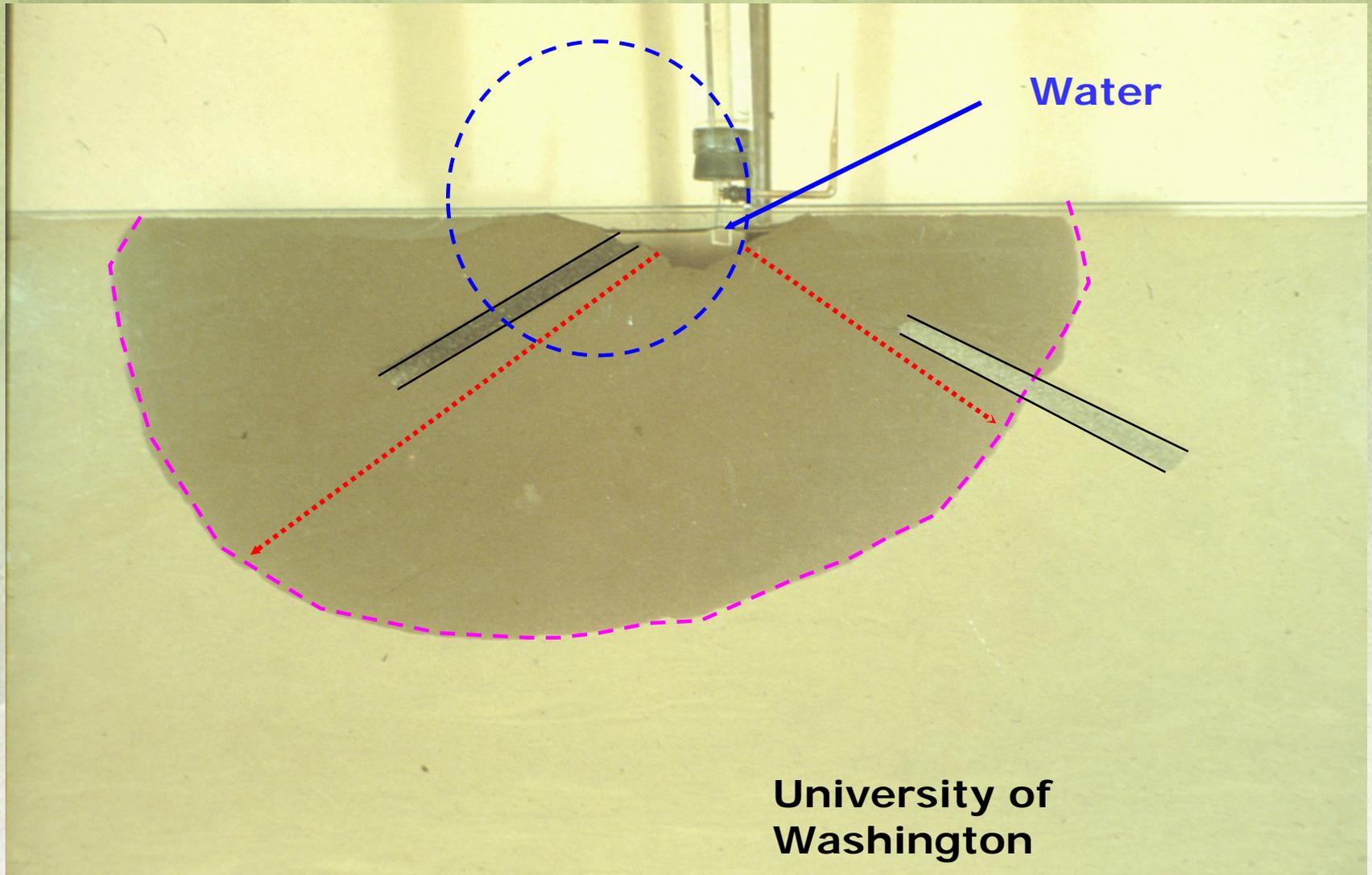
Collaboration between root fungus and roots

Complexity of the Soil Food Web in Several Ecosystems

Belowground Complexity
(Number of functional groups)

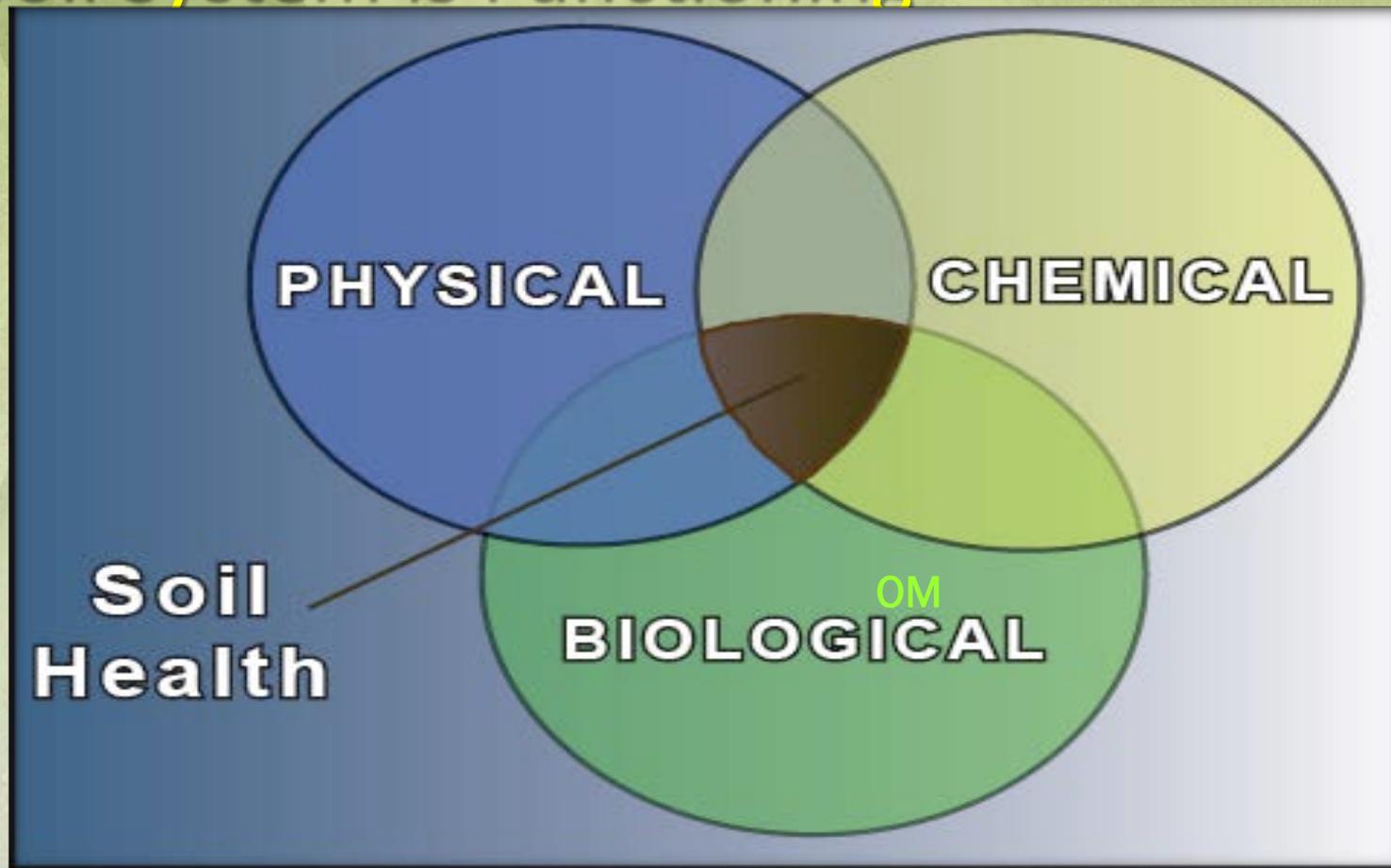


Only Pores Connected to Surface Increase Flow Rate



University of
Washington

Evaluate How Your Soil System is Functioning



All parameters are important; typically we focus on physical and chemical- but Biology is King!