



Soil Health 101

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

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Treasure Valley Irrigation Conference



Why in 2014?

- 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 (53% of corn used for ethanol)
 - Increase use of fertilizer (use of Anhydrous up 48%, Urea up 93%)
 - **We need to begin solving the problem of poor soil health instead of treating the symptoms.**

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



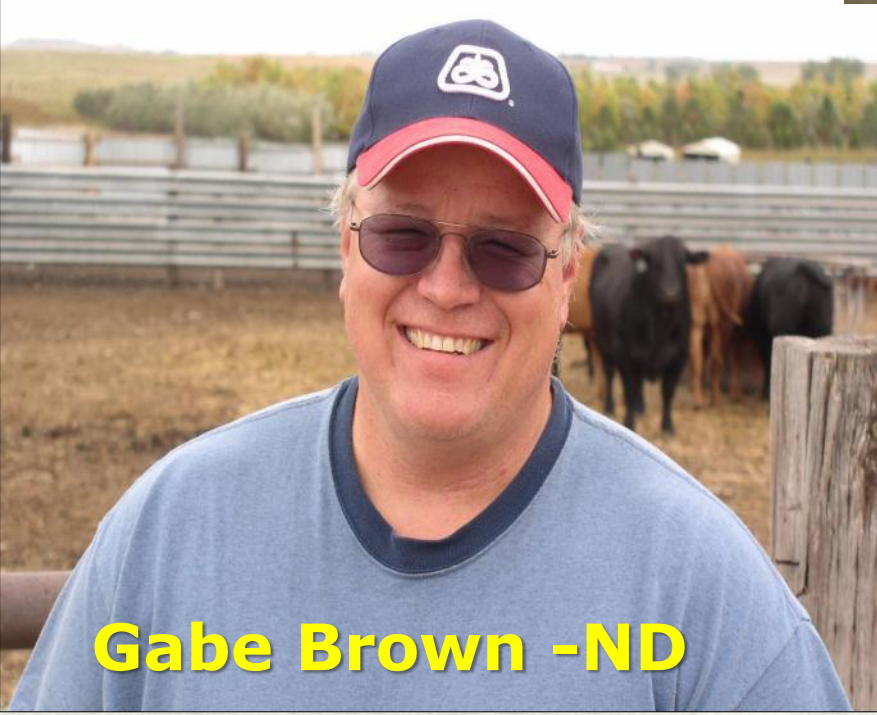
Ray Styer -NC



**Dave Brandt -
OH**



**Brandon
Rockey -CO**



Gabe Brown -ND

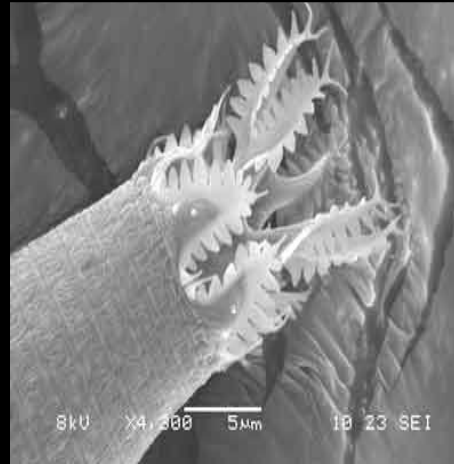
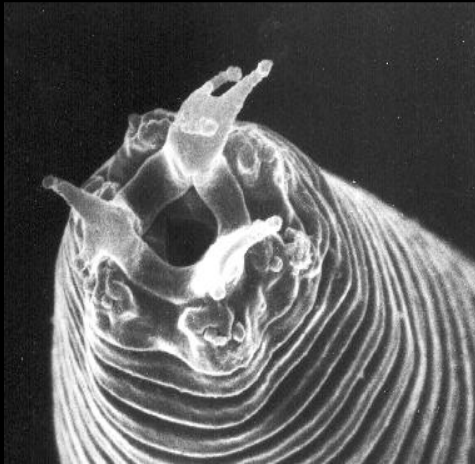


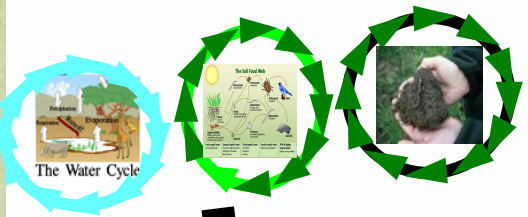
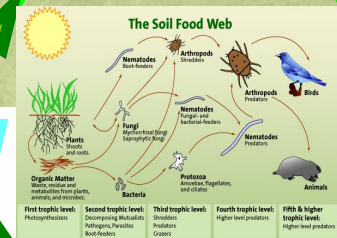
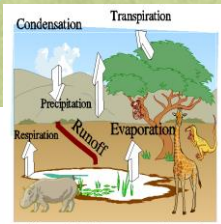
Ray McCormick -IN

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

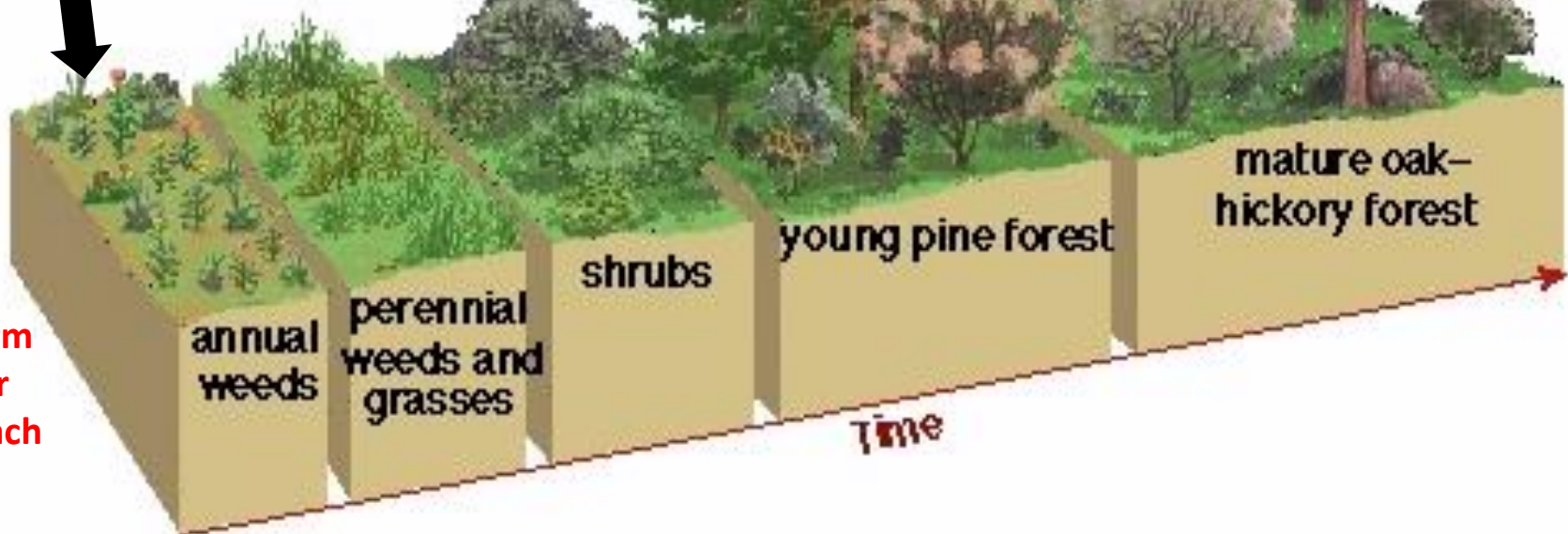


Soil Surface





Farm
or
Ranch



How do these Ecosystem flourish without human inputs?



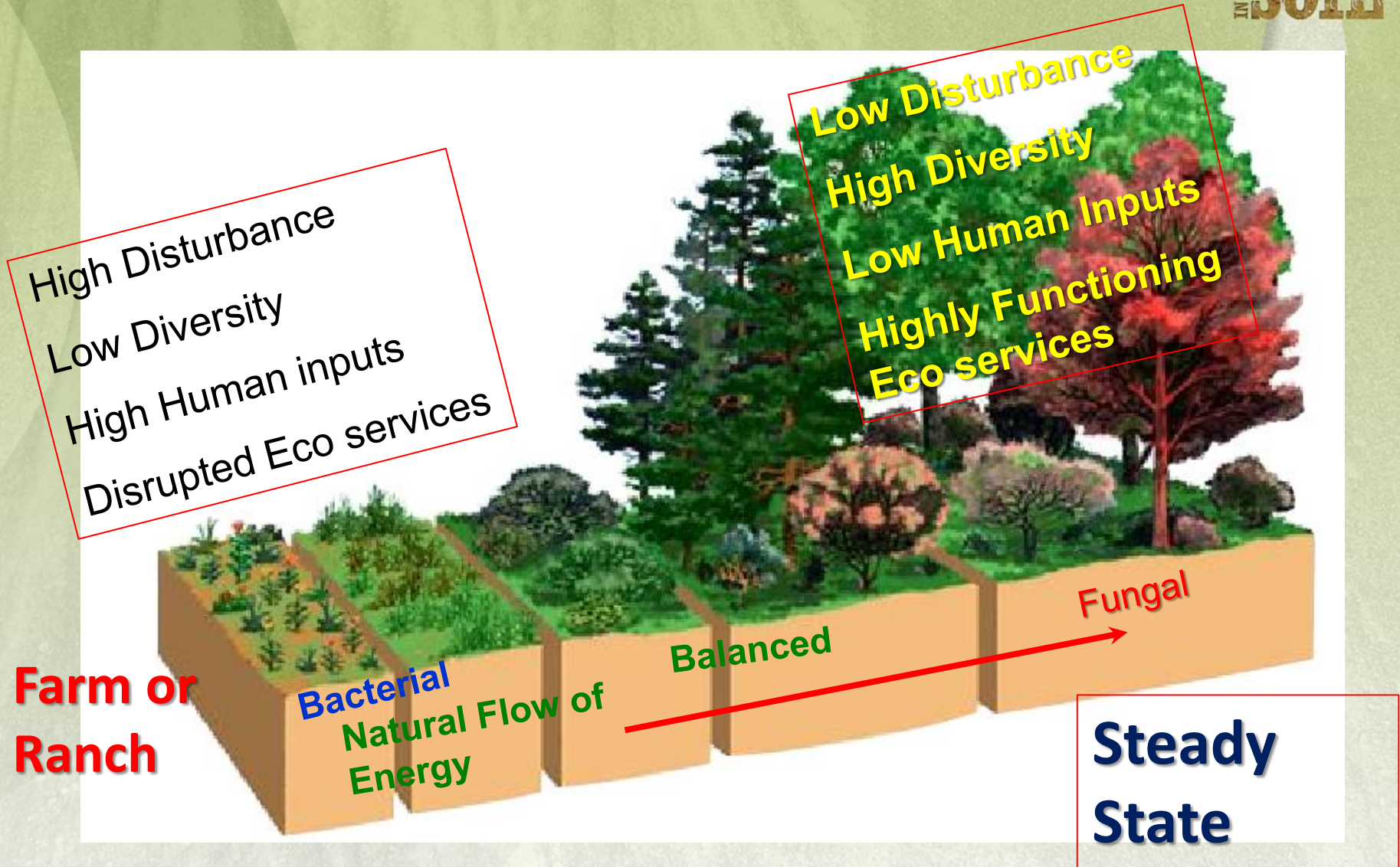
Prairie



Forest



Characteristics of a Stable Ecosystem



What Functions Do You Expect Your Soil to Perform?

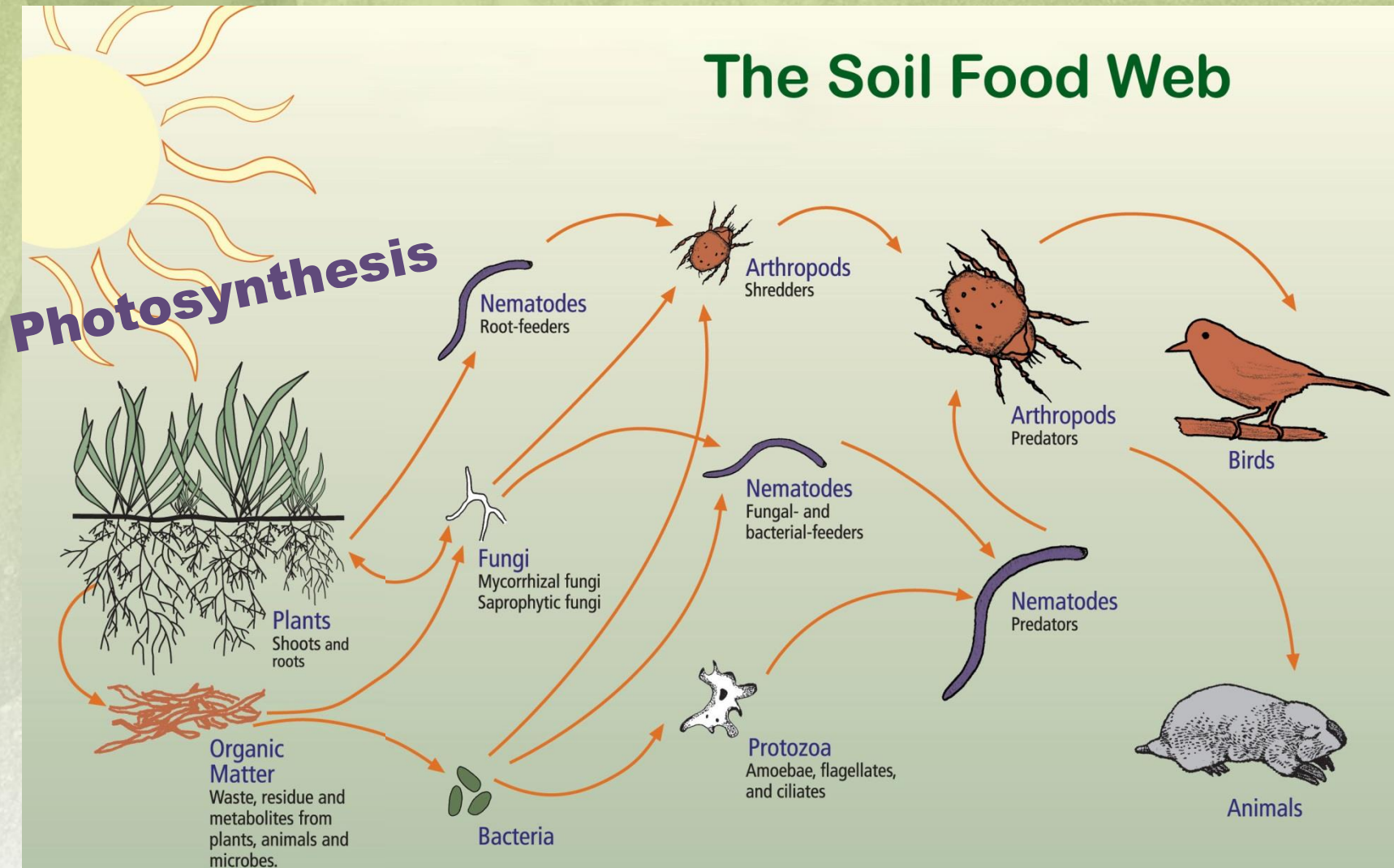


- Grow Crops
 - Infiltrate Water
 - Supply Nutrients
 - How does soil perform these functions?

How does the soil function?

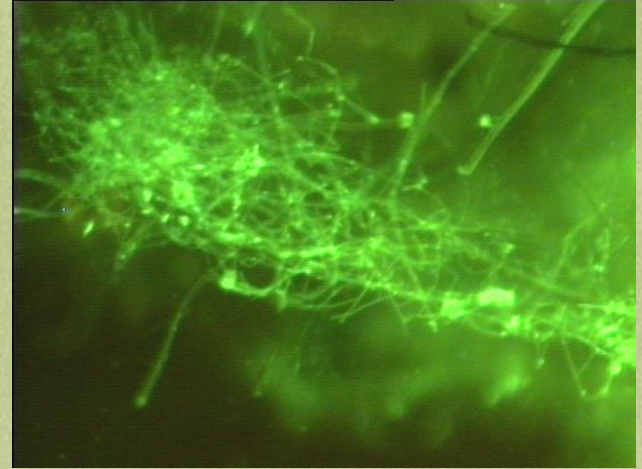


What is the main element in this diagram?



Glue-makers

- It's all about the Food
- Bacteria – stick it to me.
 - microaggregation
- Fungi – seal the pipes.
 - Macroaggregation
- Aggregates are habitat
- Microbes must be fat to make good aggregates.





What the Soil Foodweb Does

- Plant nutrient immobilization / cycling
- Creates stable soil aggregates
 - Water infiltration / retention
 - Habitat for soil foodweb
 - Root movement
 - Nematode, microarthropod movement
 - Air movement
- Less than .1% of the organisms that live in the soil have been identified and described.



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

Ray Archuleta 2007

Erosion from bare fields
into river



Oklahoma October 2012 I-35

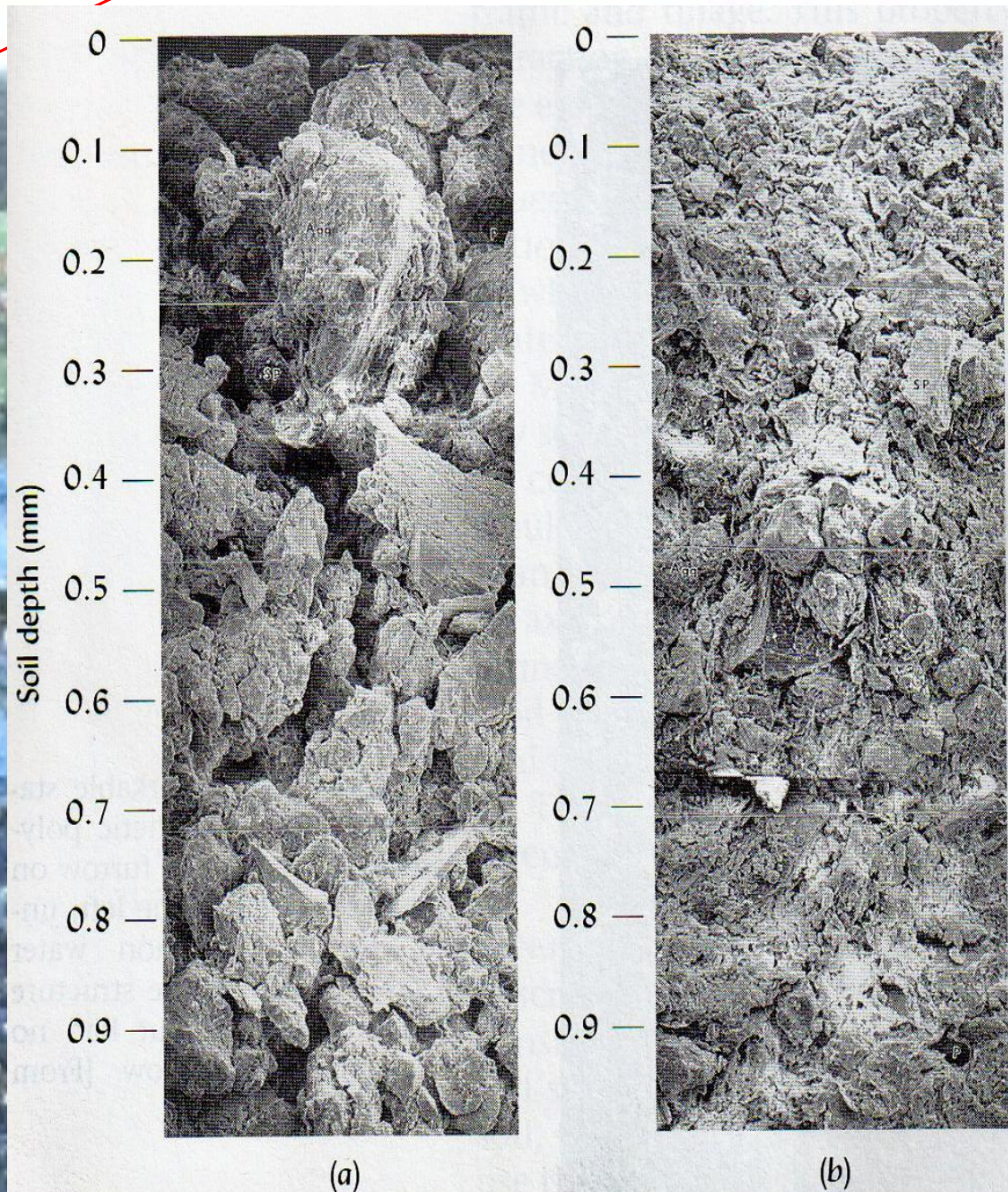
Aberdeen ID 2013



Lubbock Texas Oct. 17, 2011



The Battle is Won or Lost Here





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 1940 by E.H. Faulkner



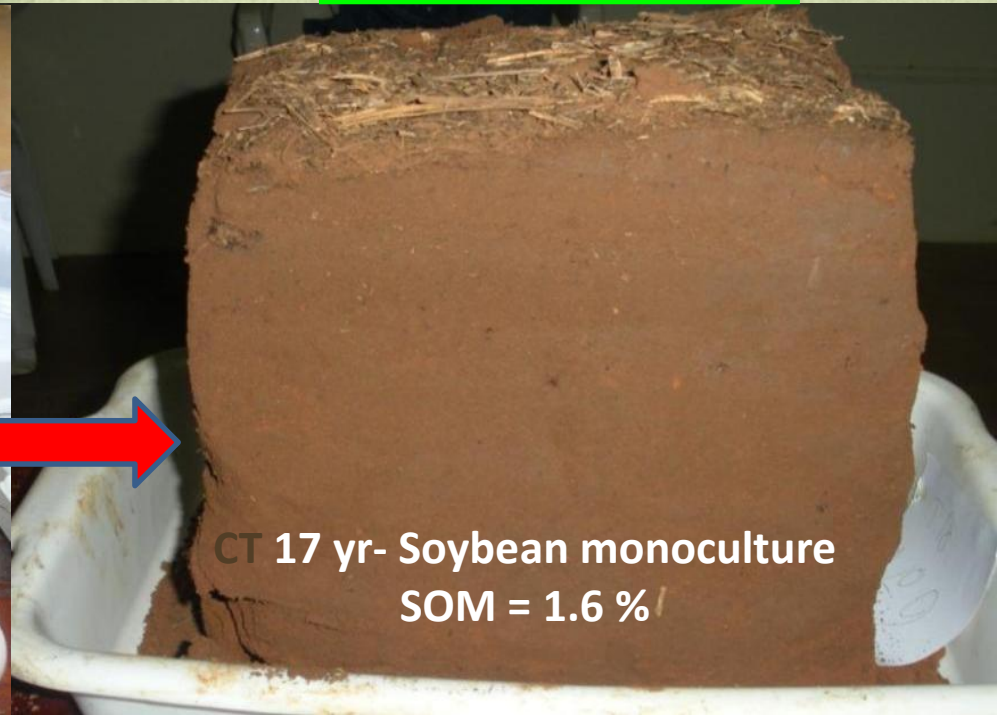
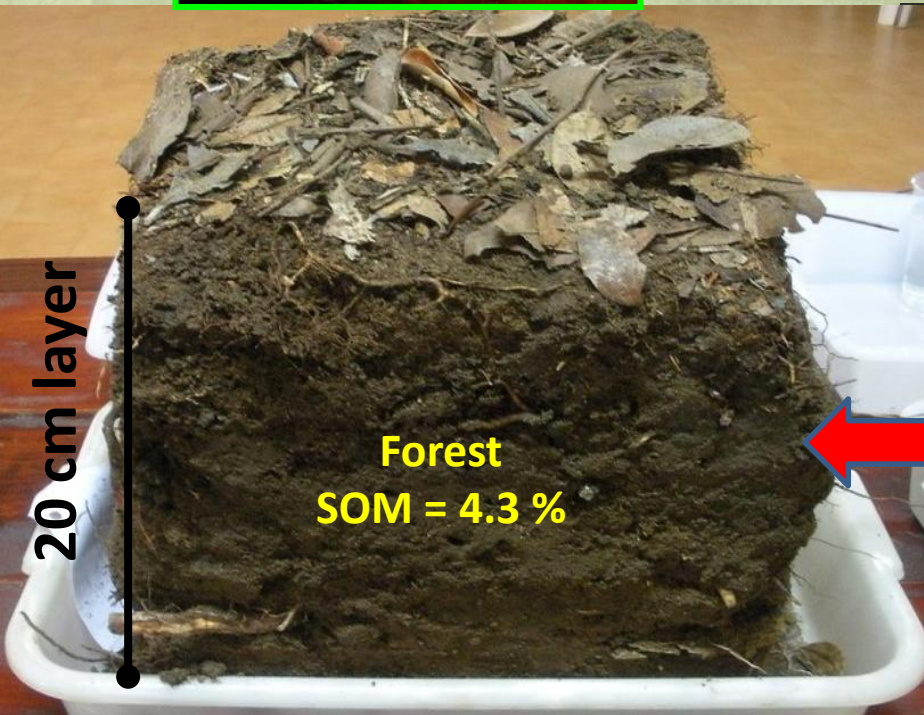
“We have equipped our farmers with a greater tonnage of machinery per man than any other nation. Our agricultural population has proceeded to use that machinery to the end of destroying the soil in less time than any other people has been known to do it in recorded history.”

“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



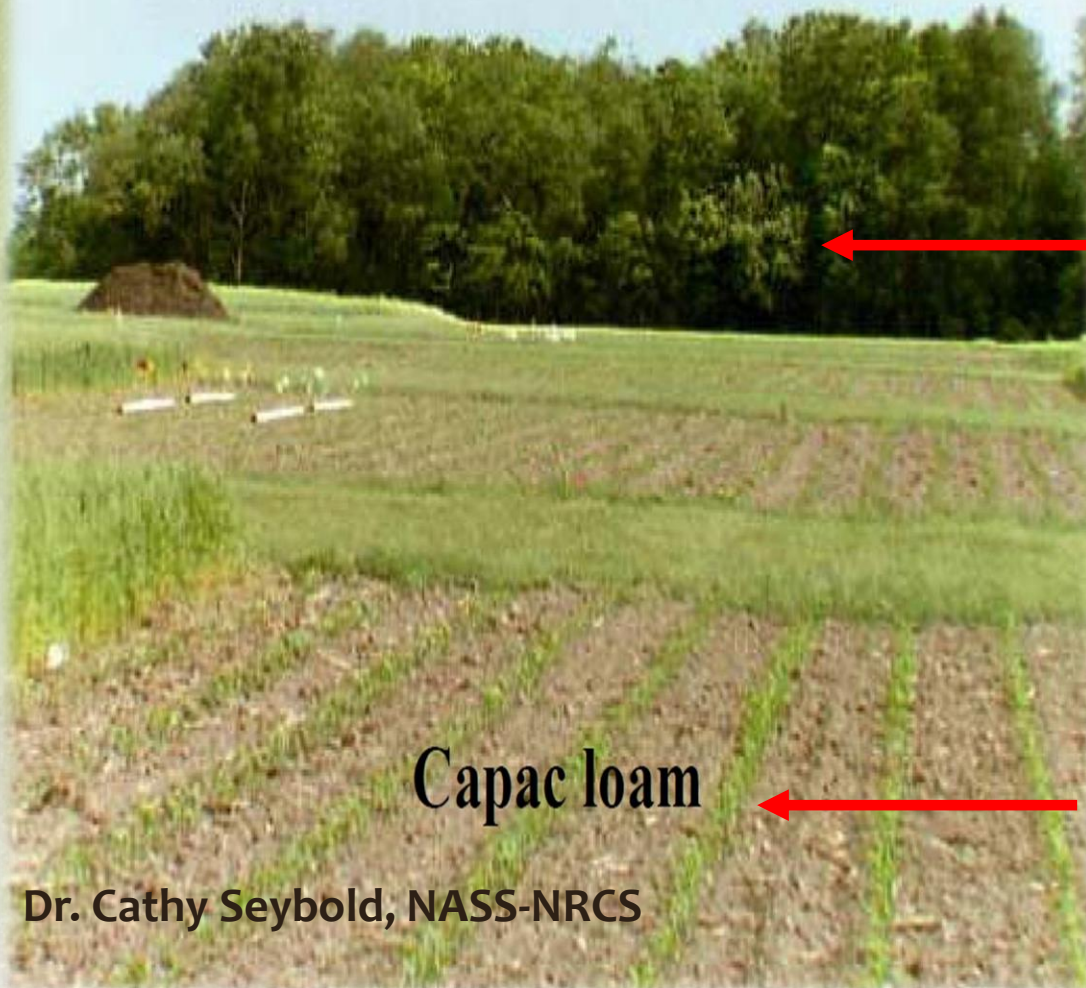
Study: Use-dependent Soil Properties



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

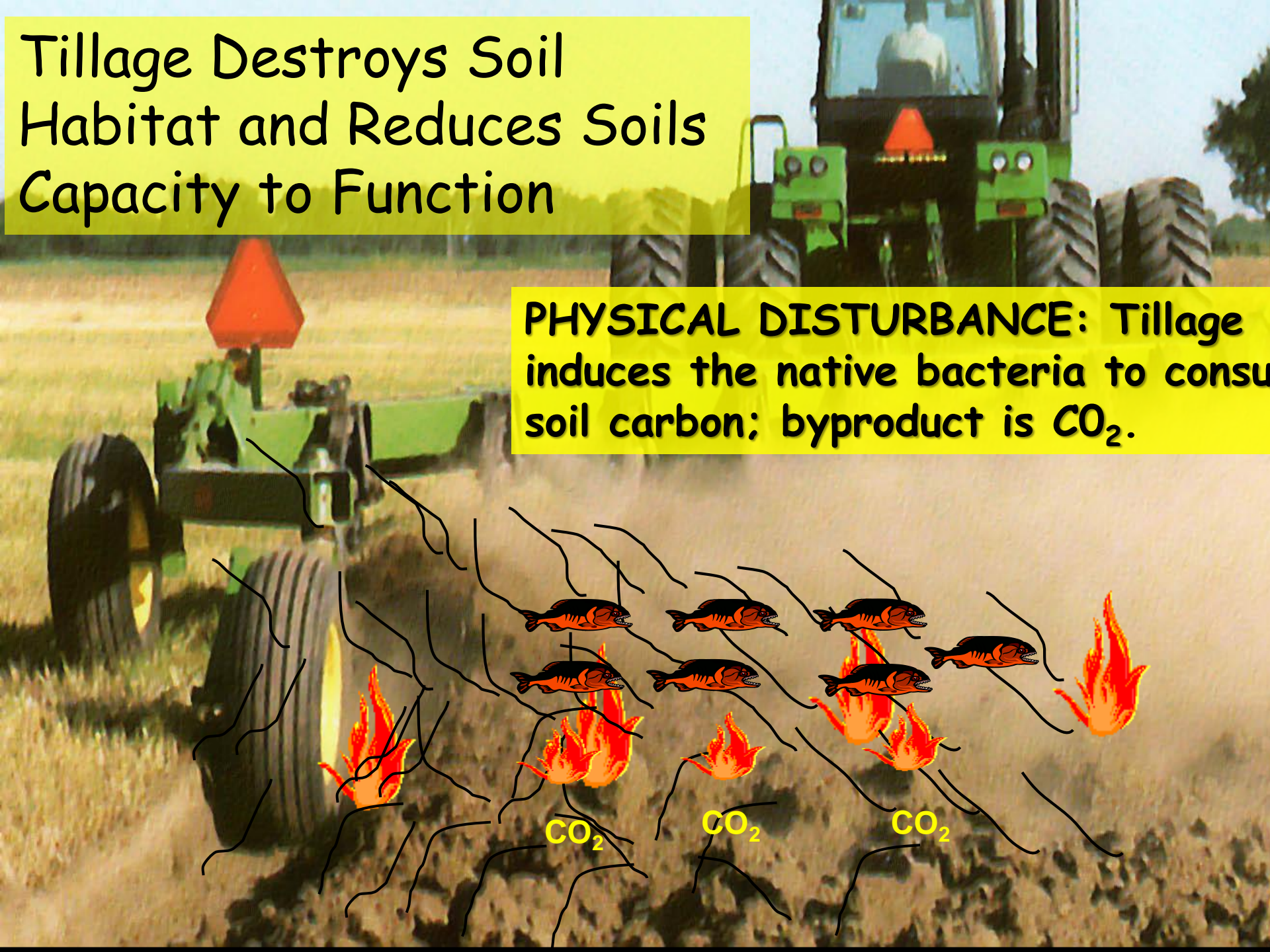
15 lbs. N/ac.

Capac loam

Dr. Cathy Seybold, NASS-NRCS

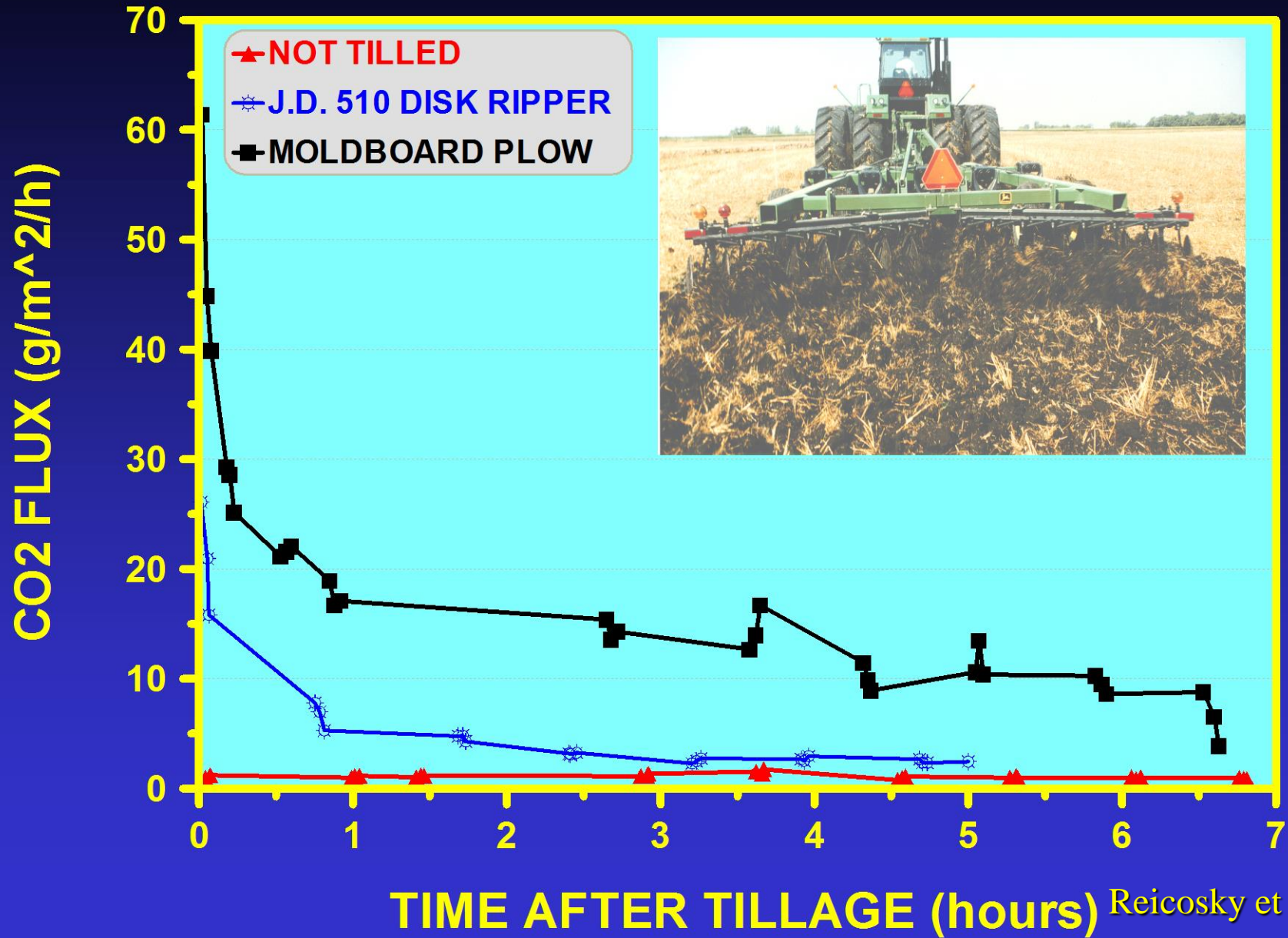
Tillage Destroys Soil Habitat and Reduces Soils Capacity to Function

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





Subsoil tillage

3X

Moldboard plow

2X

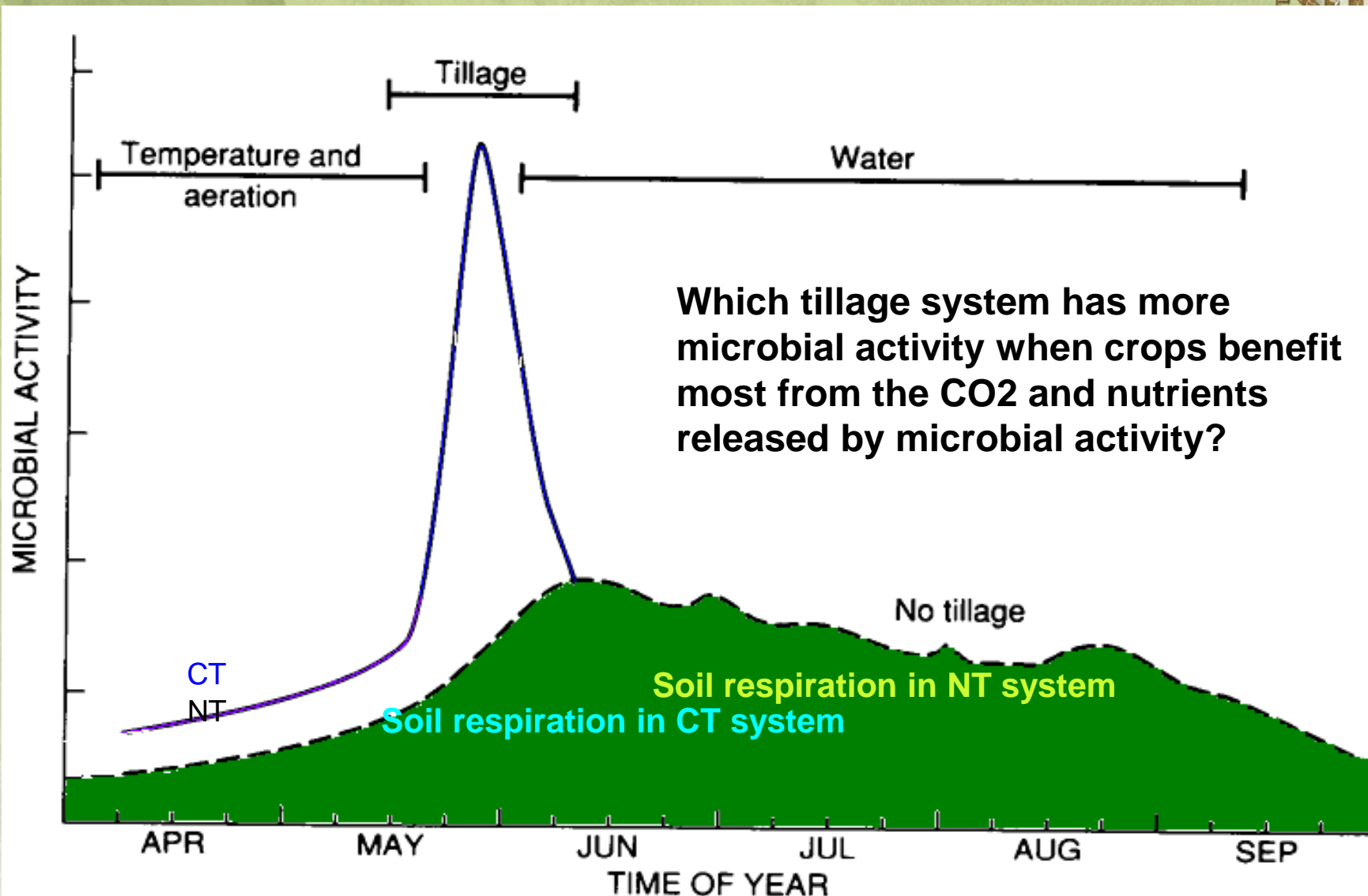
Chisel plow

1X

Different tillage = Different rates of Carbon loss



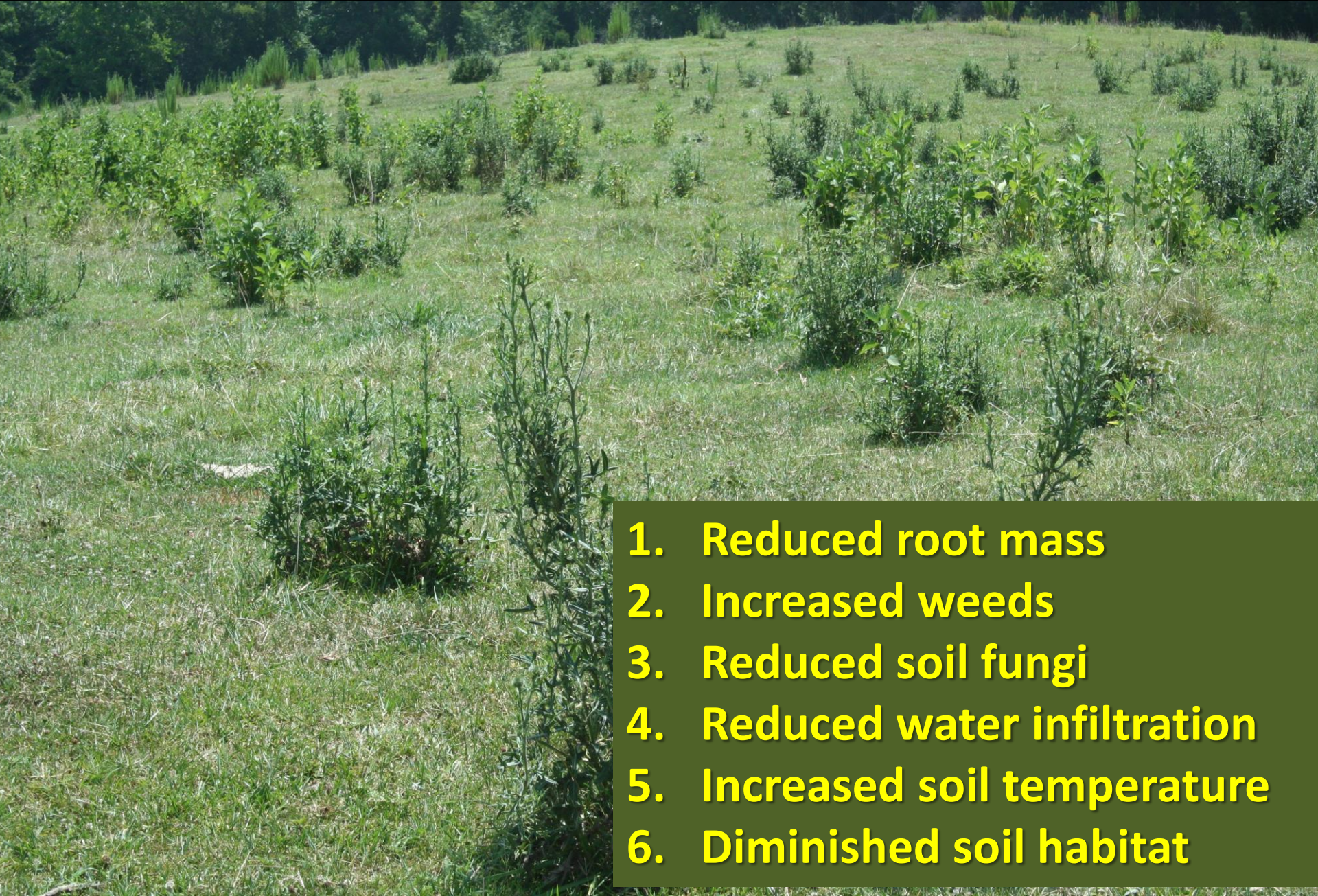
Effect of tillage on microbial activity



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

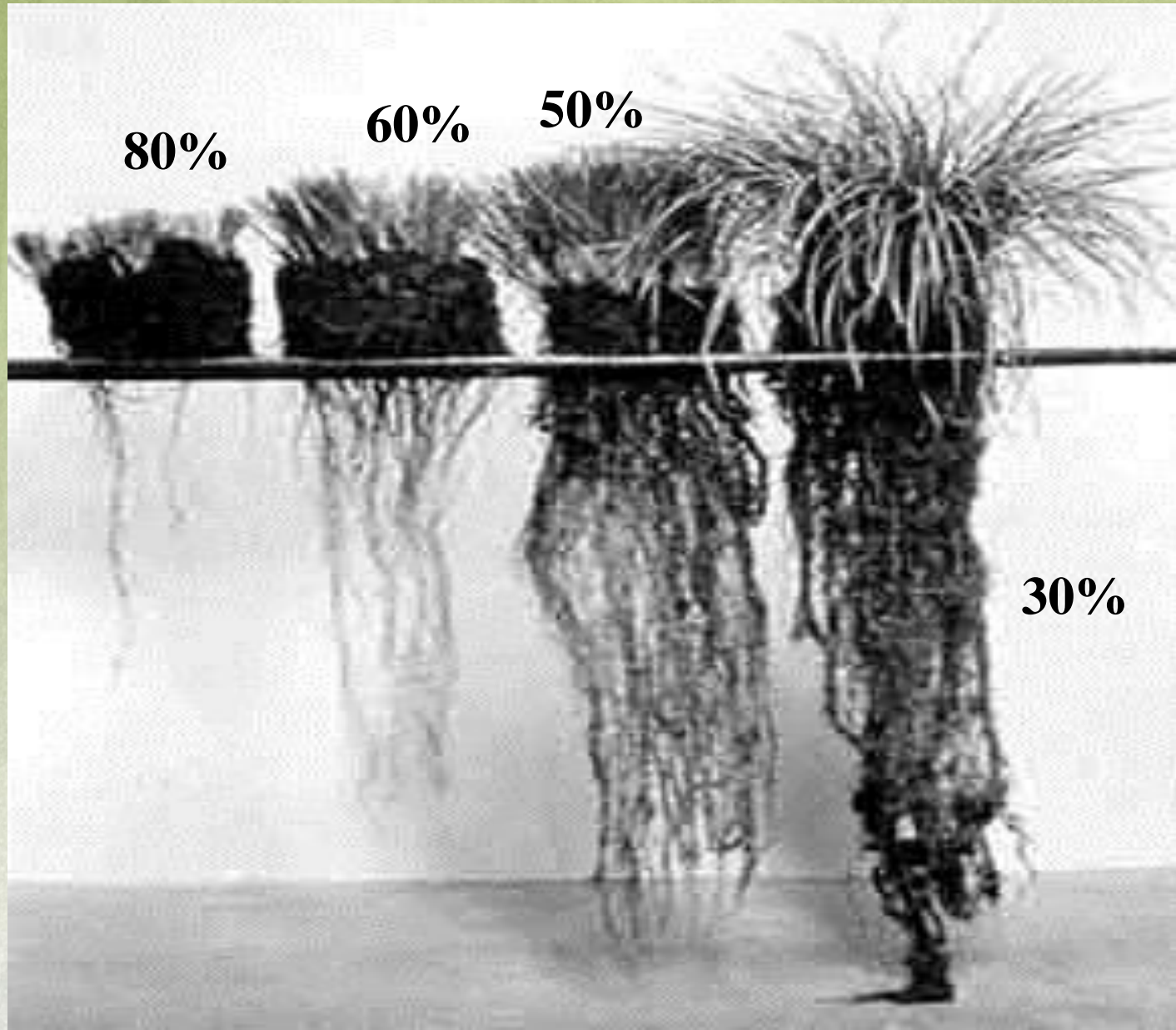
Alternative water sources & controlled access to stream but no control of grazing time on watershed





UK_OrchardgrassGrazingTimeLapseVideo1.wmv

Overgrazing: another source of disturbance



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

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



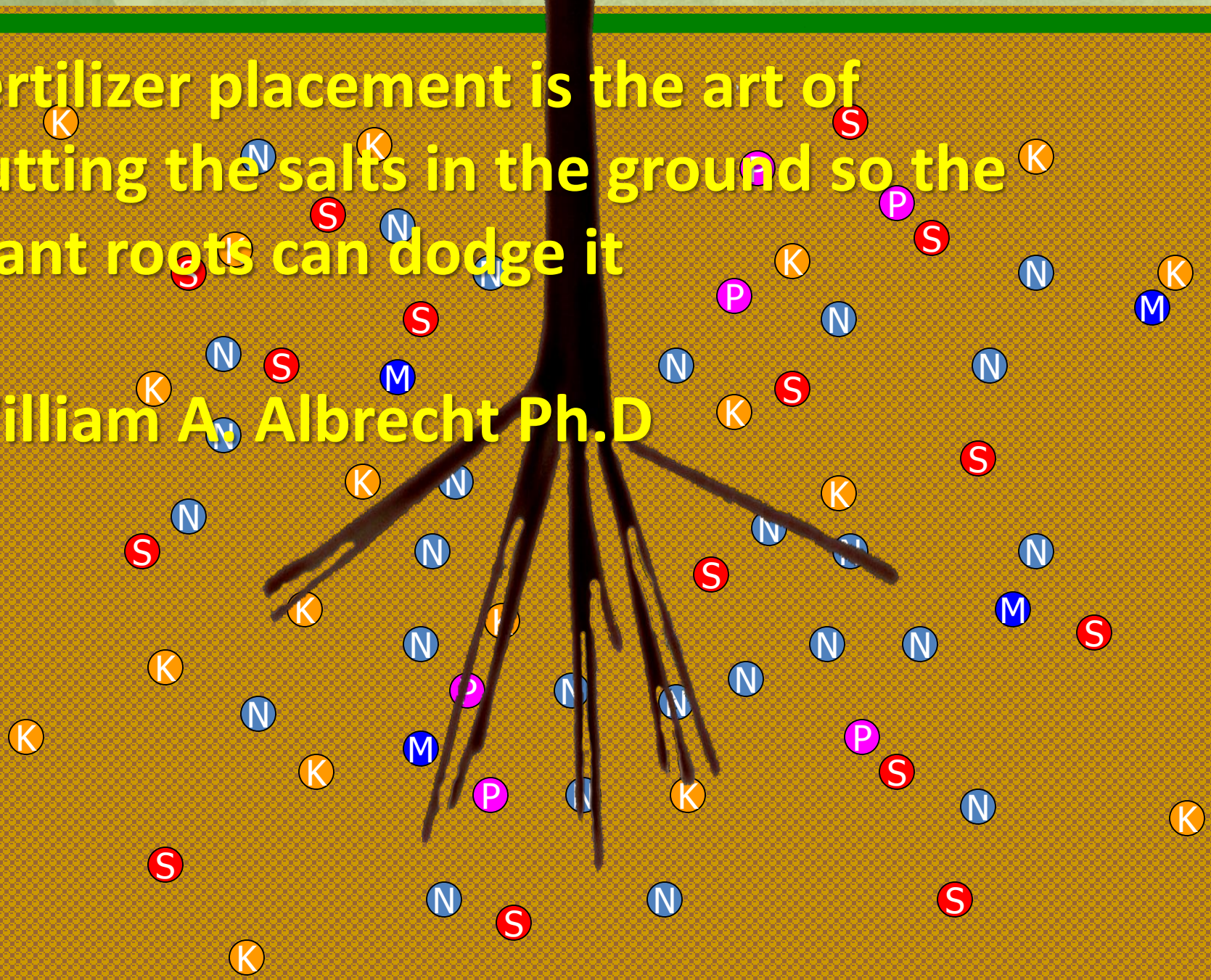
- Minimize Disturbance of the soil
- Maximize Diversity of plants in rotation/ cover crops
- Keep Living Roots in the soil as much as possible
- Keep the soil covered at all times with plants and plant residues
- Create the most favorable habitat possible for the soil food web

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

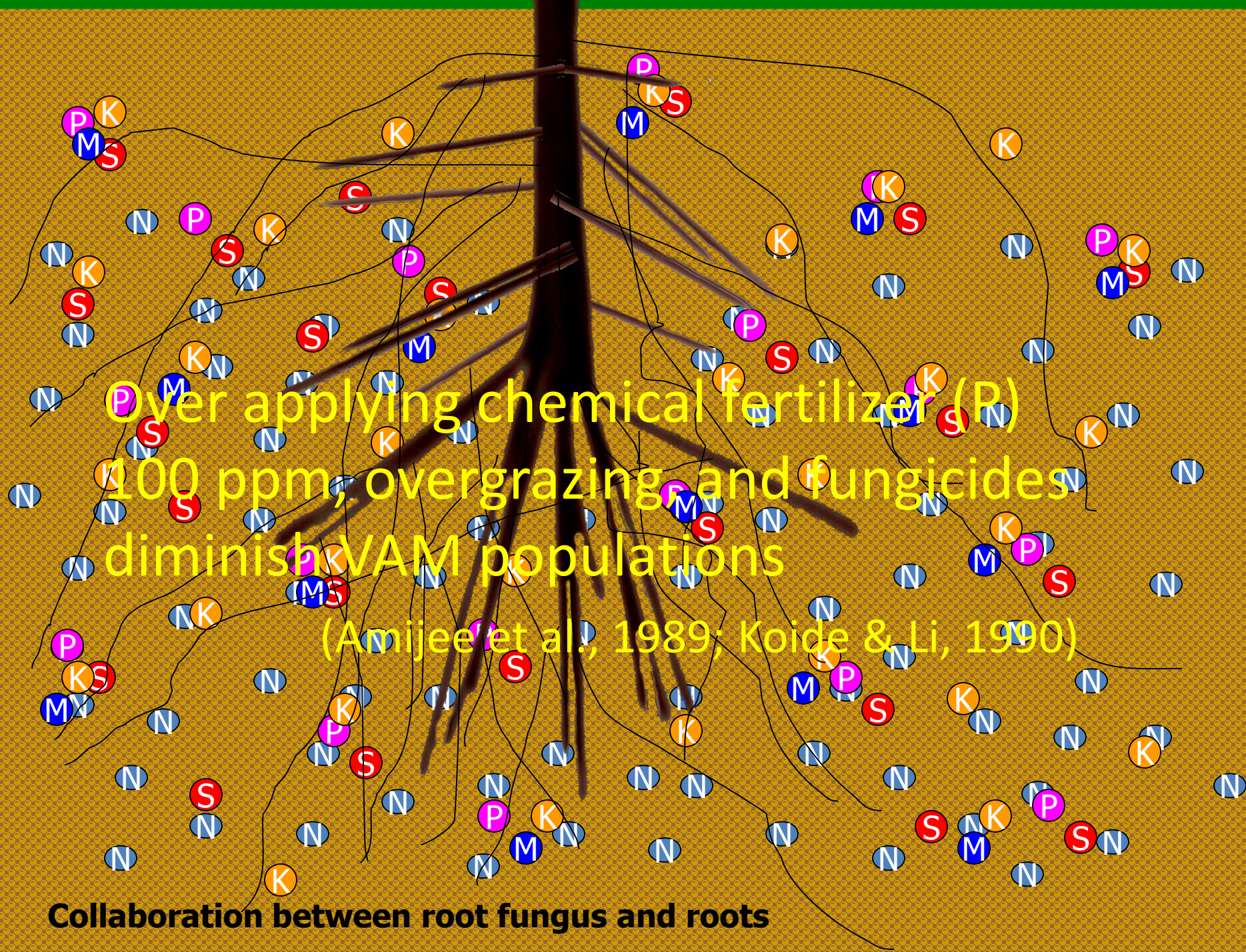


Fertilizer placement is the art of
putting the salts in the ground so the
plant roots can dodge it

William A. Albrecht Ph.D

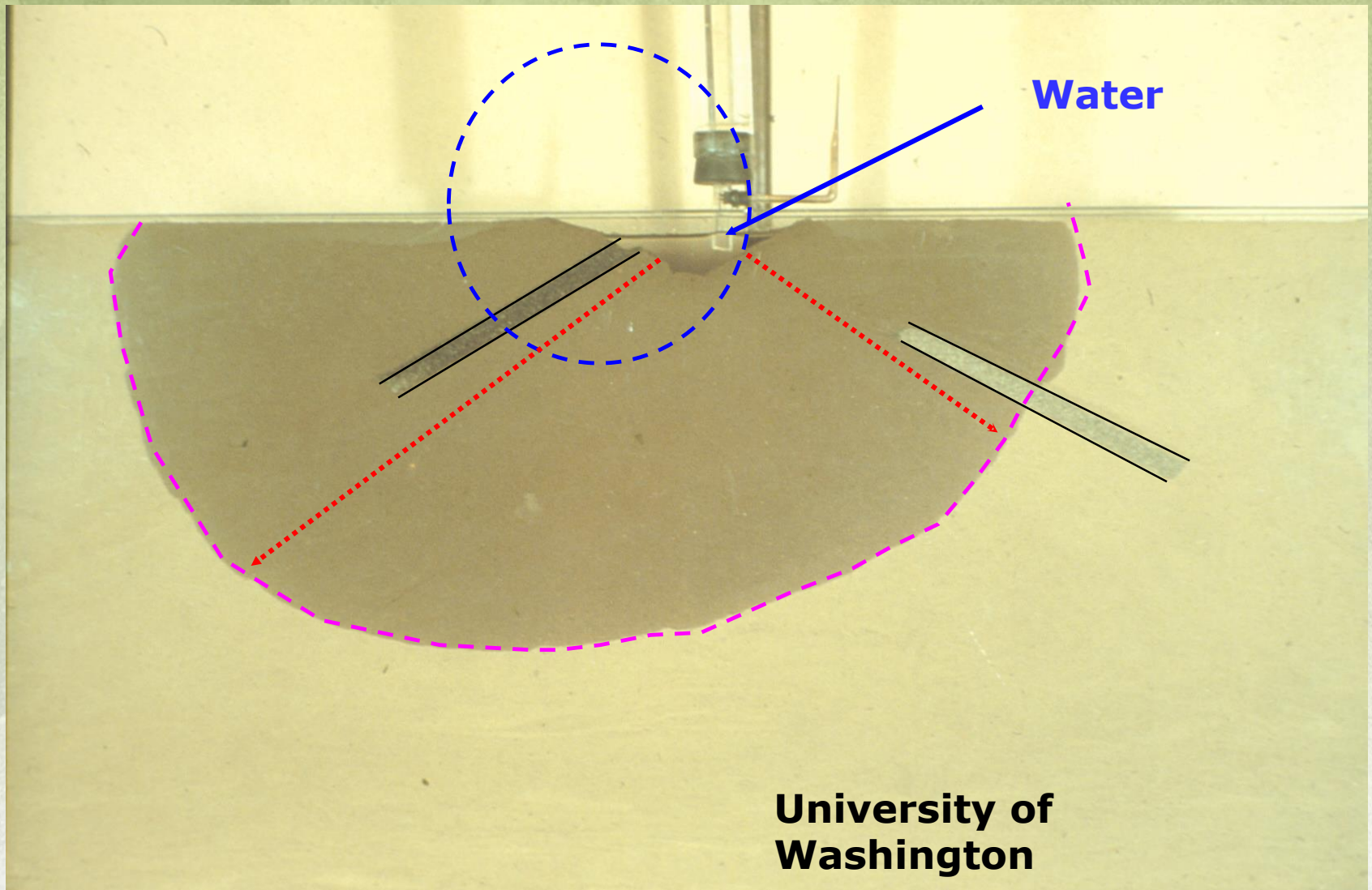


What can the plant access alone?

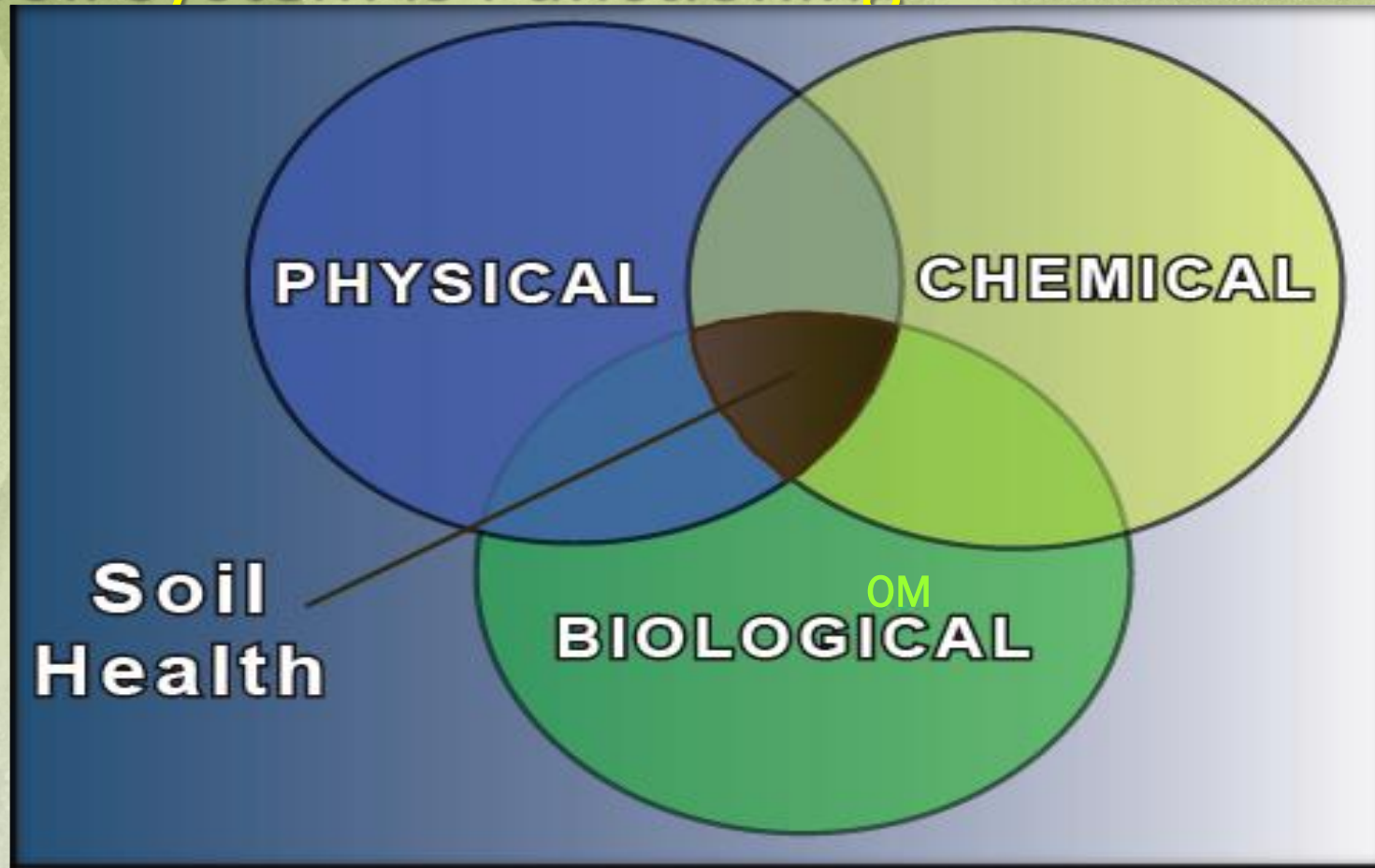


Collaboration between root fungus and roots

Only Pores Connected to Surface Increase Flow Rate



Evaluate How Your Soil System is Functioning



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