

May Corino  
Conservationist  
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NDA, NRCS

Word cloud text: produce, care, replace, greening, Holmgren, develop, Mollison, res, project, profit, cat, makes, change, garden, southern, internal, enhance, produce, replace, greening, Holmgren, develop, Mollison, res, project, profit, cat, makes, change, garden, southern, internal, enhance.



*Ray Corino*  
*District Conservationist*  
*Windham County*  
*USDA, NRCS*



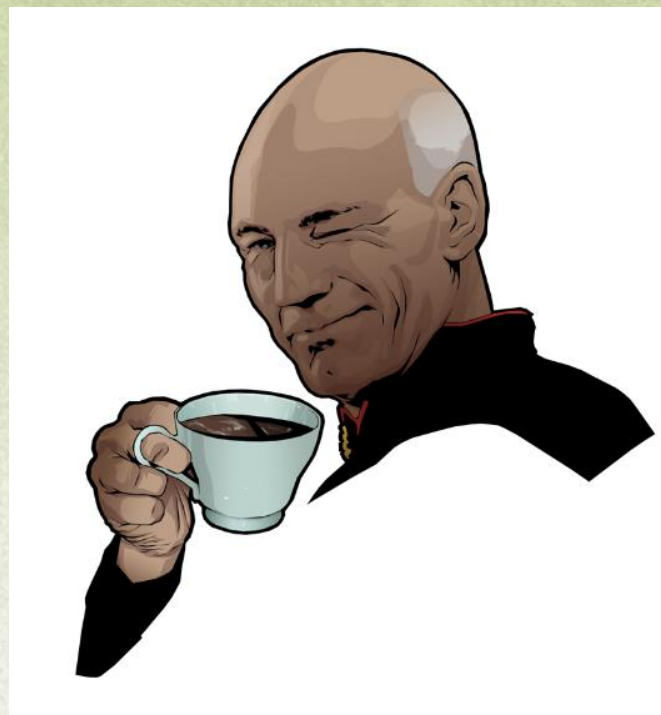


# Real Solutions

Grow your own self reliance.

Arm yourself with knowledge.

There is no free lunch... or is there?





# SOIL QUALITY/HEALTH:



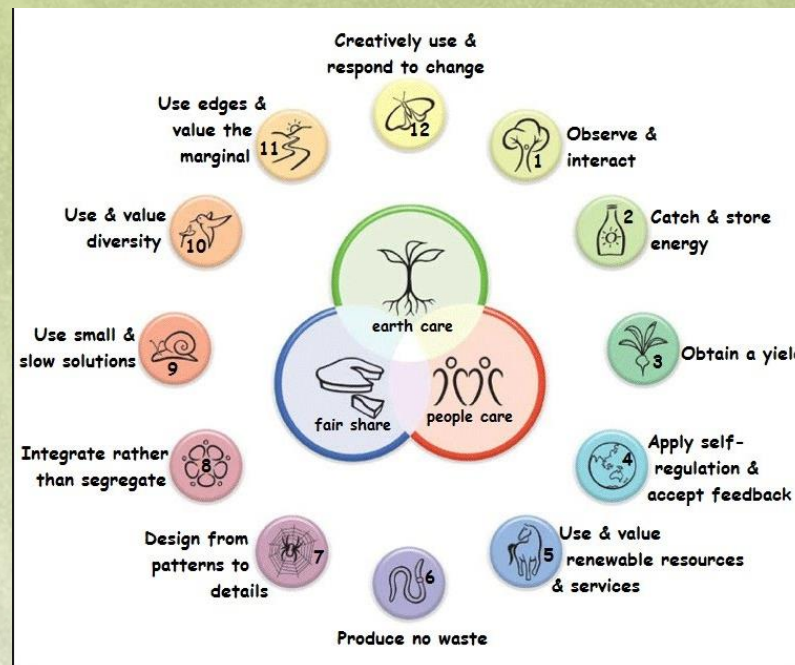
The continued capacity of the soil to function as a vital living system that sustains plant, animal, and human health.





# Permaculture Principles

- 1. Care for the Earth
  - All systems, all life
- 2. Care for the people
  - All should have access to a bountiful harvest
- 3. Return the surplus
  - There is no waste in nature



– Term “Permaculture” coined by Bill Mollison and David Holmgren in 1978

# Typical Soil Test

Lab Number: 135418SO

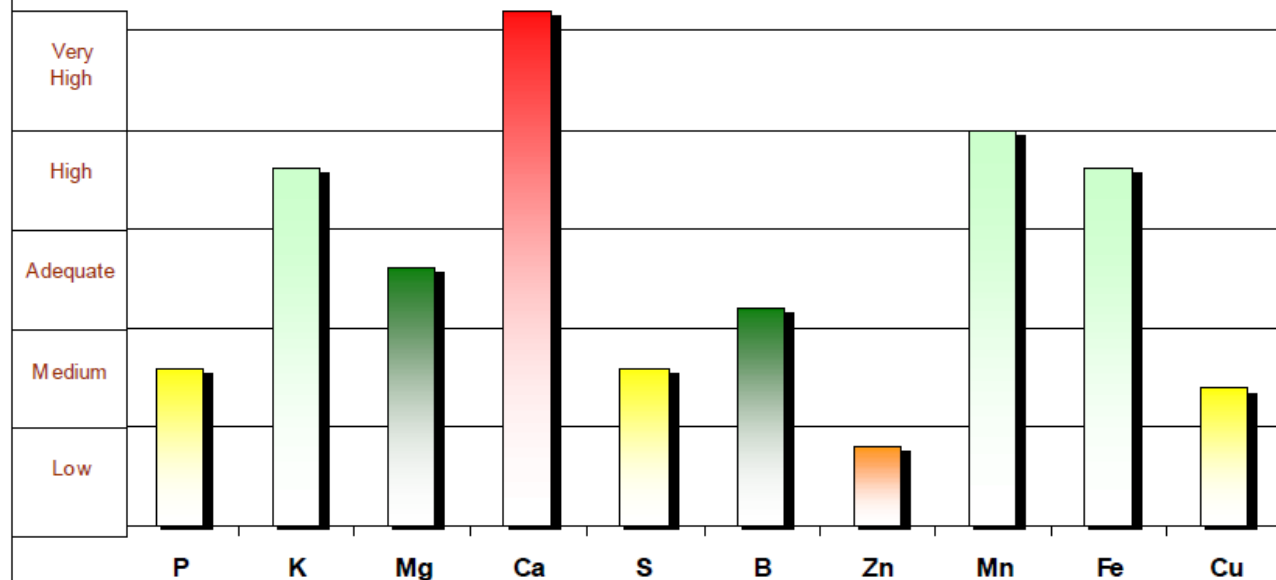
## Lab Results lbs. per Acre

Target pH: 6.5

Test Method: Mehlich III

P Phosphorus	K Potassium	Mg Magnesium	Ca Calcium	Soil pH	Buffer pH	S Sulfur	B Boron	Zn Zinc	Mn Manganese	Fe Iron	Cu Copper
72 <b>M</b>	379 <b>H</b>	201 <b>A</b>	2407 <b>VH</b>	5.6	7.50	36 <b>M</b>	1.6 <b>A</b>	3.1 <b>L</b>	395 <b>H</b>	282 <b>H</b>	2.0 <b>M</b>
Aluminum	Sodium	Nitrate N	Soluble Salts mmhos/cm	Organic Matter 3.02 %	ENR 60.4						

## Soil Analysis Ratings

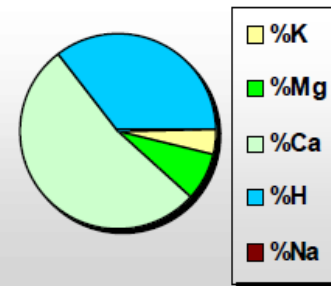


Cation Exchange Capacity **11.3** meq/100g

Base Saturation

K: 4.3 %  
Mg: 7.4 %  
Ca: 53.1 %  
H: 35.3 %  
Na: %

## Base Saturation



Lab Number: 135419SO

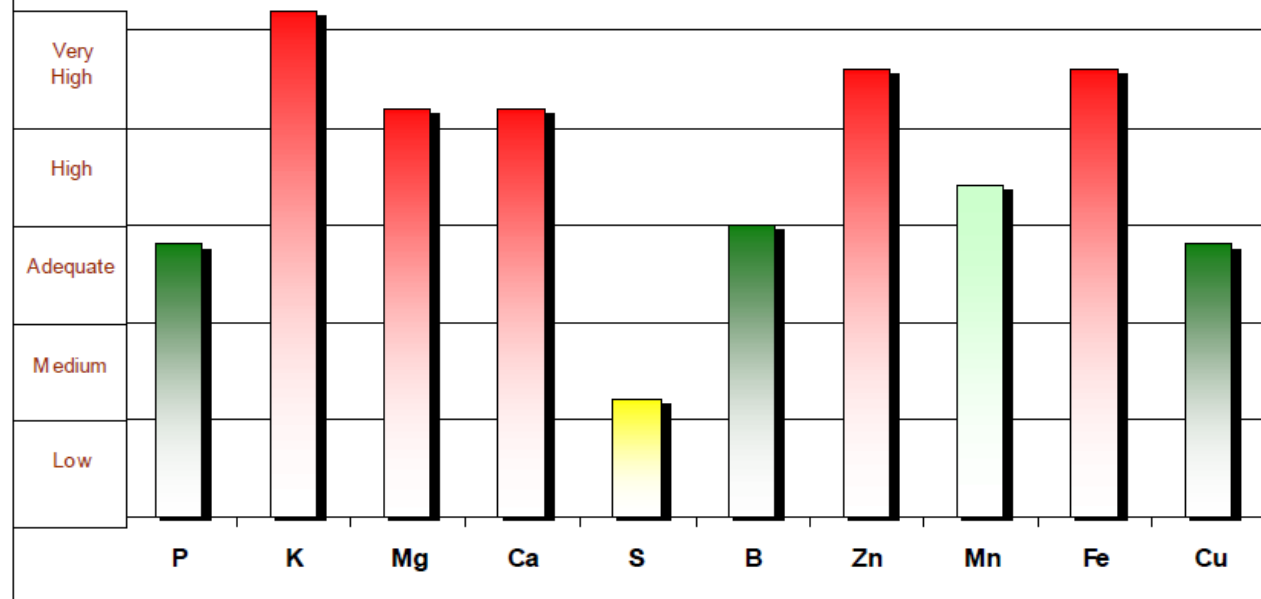
## Lab Results lbs. per Acre

Target pH: 6.5

Test Method: Mehlich III

P Phosphorus	K Potassium	Mg Magnesium	Ca Calcium	Soil pH	Buffer pH	S Sulfur	B Boron	Zn Zinc	Mn Manganese	Fe Iron	Cu Copper
131 <b>A</b>	628 <b>VH</b>	309 <b>VH</b>	1951 <b>VH</b>	5.5	7.55	30 <b>M</b>	2.0 <b>A</b>	17.0 <b>VH</b>	260 <b>H</b>	509 <b>VH</b>	4.9 <b>A</b>
Aluminum	Sodium	Nitrate N	Soluble Salts mmhos/cm	Organic Matter 3.98 %	ENR 79.6						

## Soil Analysis Ratings



Cation Exchange Capacity **10.6** meq/100g

Base Saturation

K: 7.6 %

Mg: 12.2 %

Ca: 46.1 %

H: 34.1 %

Na: %

## Base Saturation



%K  
%Mg  
%Ca  
%H  
%Na





# Why a Soil Health push now?

- Because we finally are recognizing how the soil is designed to function – biologically / ecologically.
- Economics of energy & labor
- Pressure of environmental regulations
- World population is estimated to be 9 billion by 2050, need 70% more food.
- Between 1982-2007, 14 million acres (21,875sq miles) of **prime** farmland in the U.S. was lost to development.
  - That's the size of CT, MA, RI and Southern VT



# Why Should We Care?









# It's about the Ecology

- Think Holistically.
- “Soil without Biology is Geology” – Ray Archuleta
- Garden / Farm- in Nature's Image
- Mimic Nature
  - Biomimicry







# 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.







# Do not accept a degraded soil!



**Soil function can be restored (with proper management) in a dog's lifetime.**

Replace “I’ll believe it when I see it” with  
“I’ll be able to see it when I believe it can be done.”



# What Functions Do You Expect Your Soil to Perform?

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



# Properties of Soil Heath:

## Inherent Properties:

Physical properties that usually cannot be changed without much difficulty

- Soil texture
- Type of clay
- Depth to bedrock
- Drainage class



## Dynamic Properties:

Management dependant properties that we do have the ability to change relatively easily

- Organic matter content
- Biological activity
- Aggregate stability
- Infiltration
- Soil fertility
- Soil reaction (pH)



# Indicators of Soil Health:

Physical indicators commonly used to assess agronomic soil quality include:



- Aggregate stability
- Available water holding capacity
- Bulk density
- Infiltration
- Slaking
- Soil crusts
- Soil structure and macropores



# Soil is a Living Factory



- **Macroscopic and microscopic organisms**

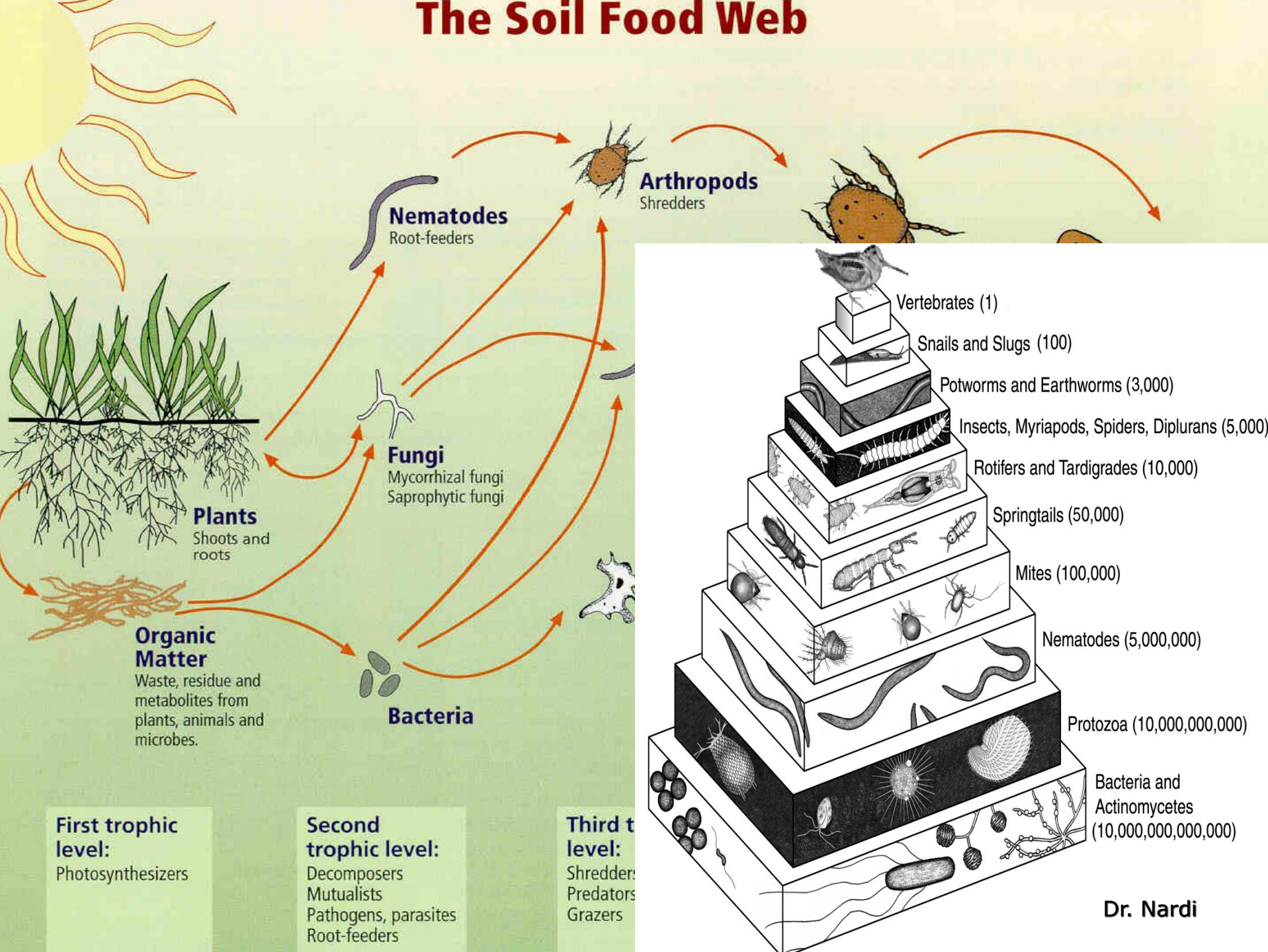
- Food
- Water
- Shelter
- Habitat
- Powered by sunlight

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

- Tillage
- Fertilizer
- Pesticides
- Grazing
- Plant Diversity



# The Soil Food Web





- [illegible]



# Zones





# Plan Growing Areas

- Sunlight
- Water Sources
- Location, location, location





# Stacking Functions:

Each piece in the design should serve multiple purposes





# Square Foot Growing

- At any scale, plan by the square foot.
- Kitchen Gardens
  - Who goes where, growth habits, irrigation and harvest
- Crop fields
  - Cover crops





# Grow food, not lawns

"You can fix all the world's problems... in a garden." - Geoff Lawton



*"Almost any garden, if you see it at just the right moment, can be confused with paradise."*

- Henry Mitchell

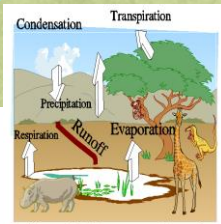
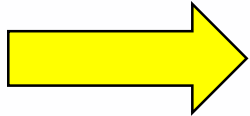
*"Almost any garden, if you see it at just the right moment, can be confused with paradise."*



# Seven Basic Principles of Permaculture Design

1. Conservation – use only what is needed
2. Stack Functions – each design element should have multiple yields
3. Repeat Functions – meet every need in a redundant way
4. Reciprocate – Use yields of one system to meet the needs of another
5. Scale – the system should be designed based on the need of the person
6. Diversify – resilience in diversity
7. Share the surplus – create abundance

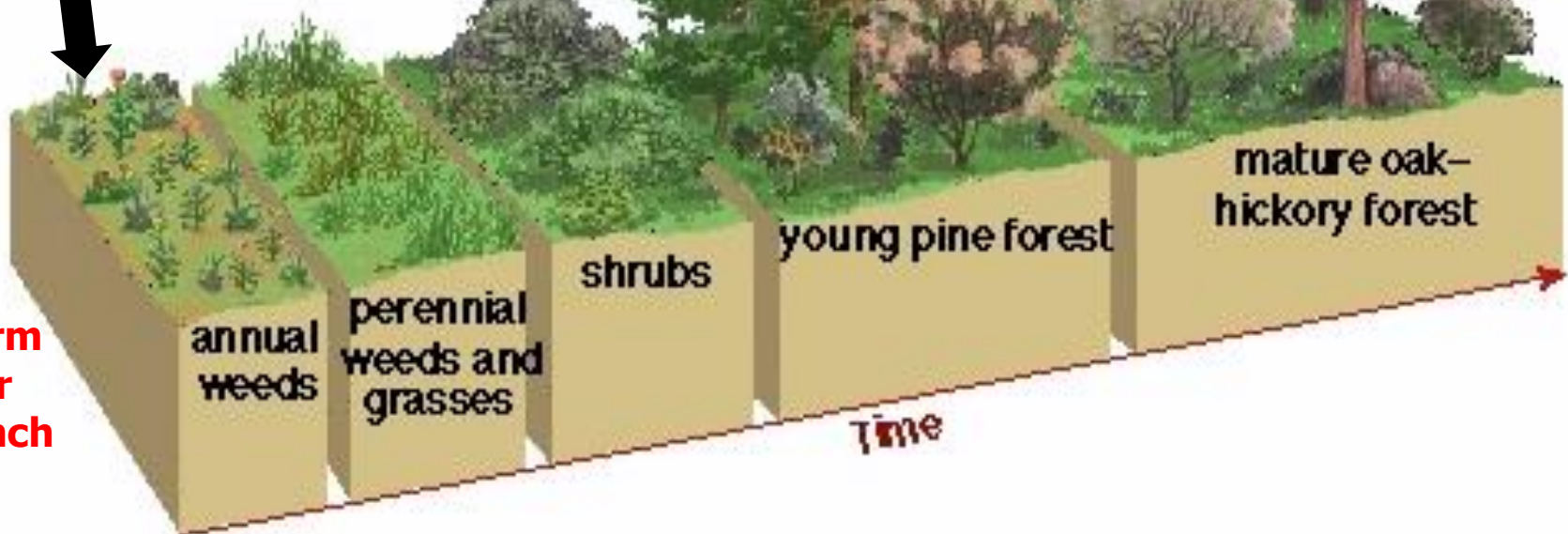




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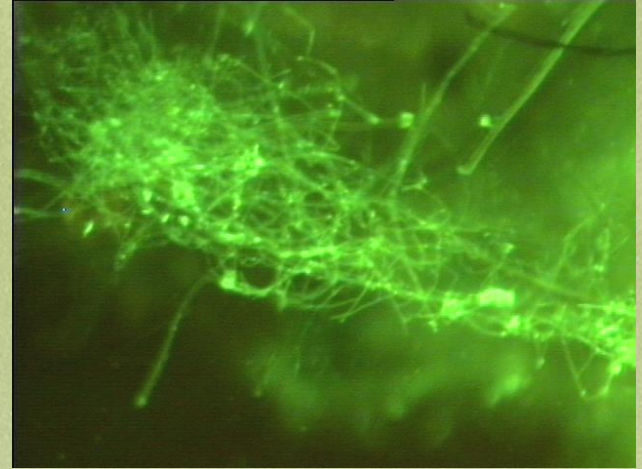
**Farm  
or  
Ranch**





# 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 well fed to make good aggregates.





# What the Soil Foodweb Does

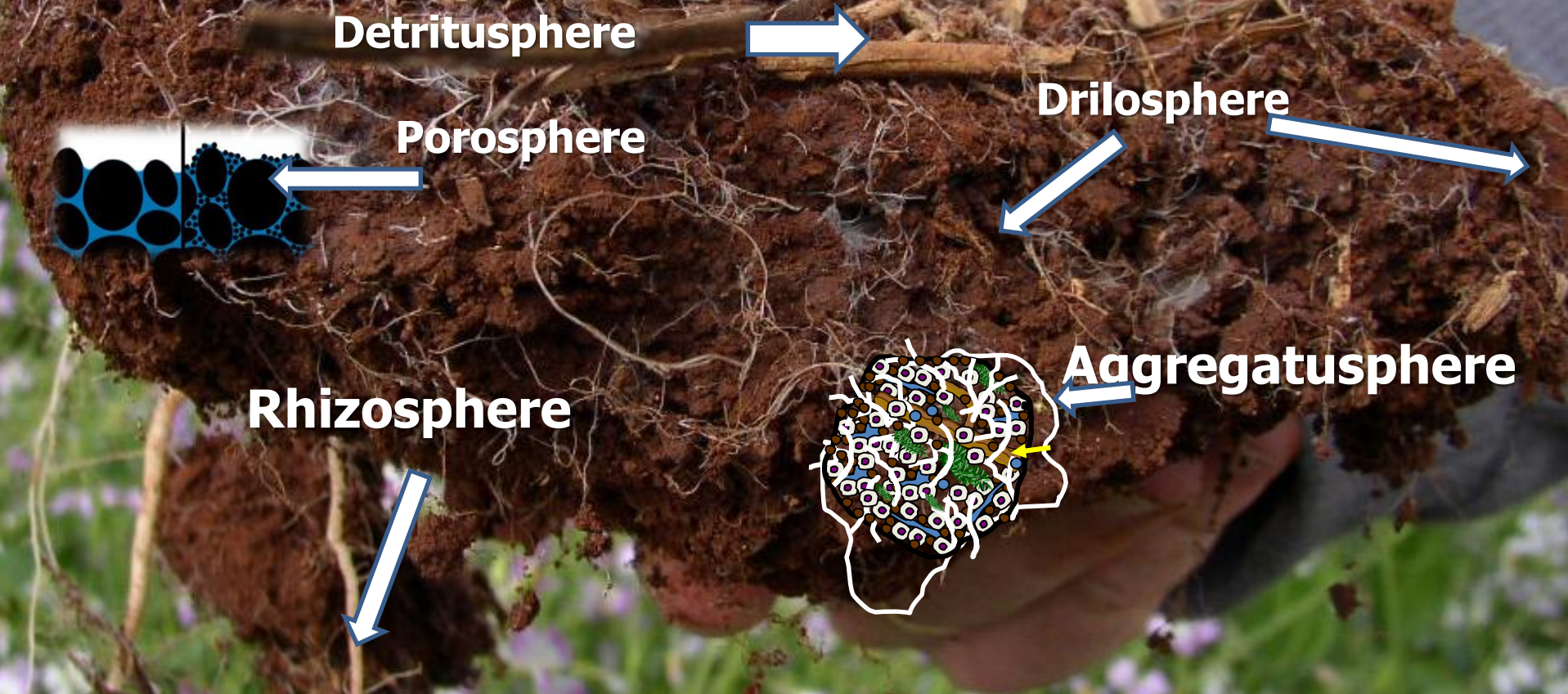
- Plant nutrient immobilization / mineralization
- Creates stable soil aggregates
  - Water infiltration / retention
  - Habitat for soil foodweb
  - Root movement
  - Nematode, microarthropod movement
  - Air movement

What is the most limiting element in the soil for agricultural production?

Where does the Carbon contained in the soil come from?



# Hierarchical Approach to Understanding Soil Function



**Areas of influence resulting from Biological Activities**



# Principles of Managing for Soil Health



- Minimize Disturbance of the soil
  - Maximize Diversity of plants in rotation
  - Keep Living Roots in the soil as much as possible
  - Keep the soil covered with plants and plant residues
  - Know your context
  - Integrate animals where possible.
- 
- Create the most favorable habitat possible for the soil food web



# Rhizosphere...where roots meet soil

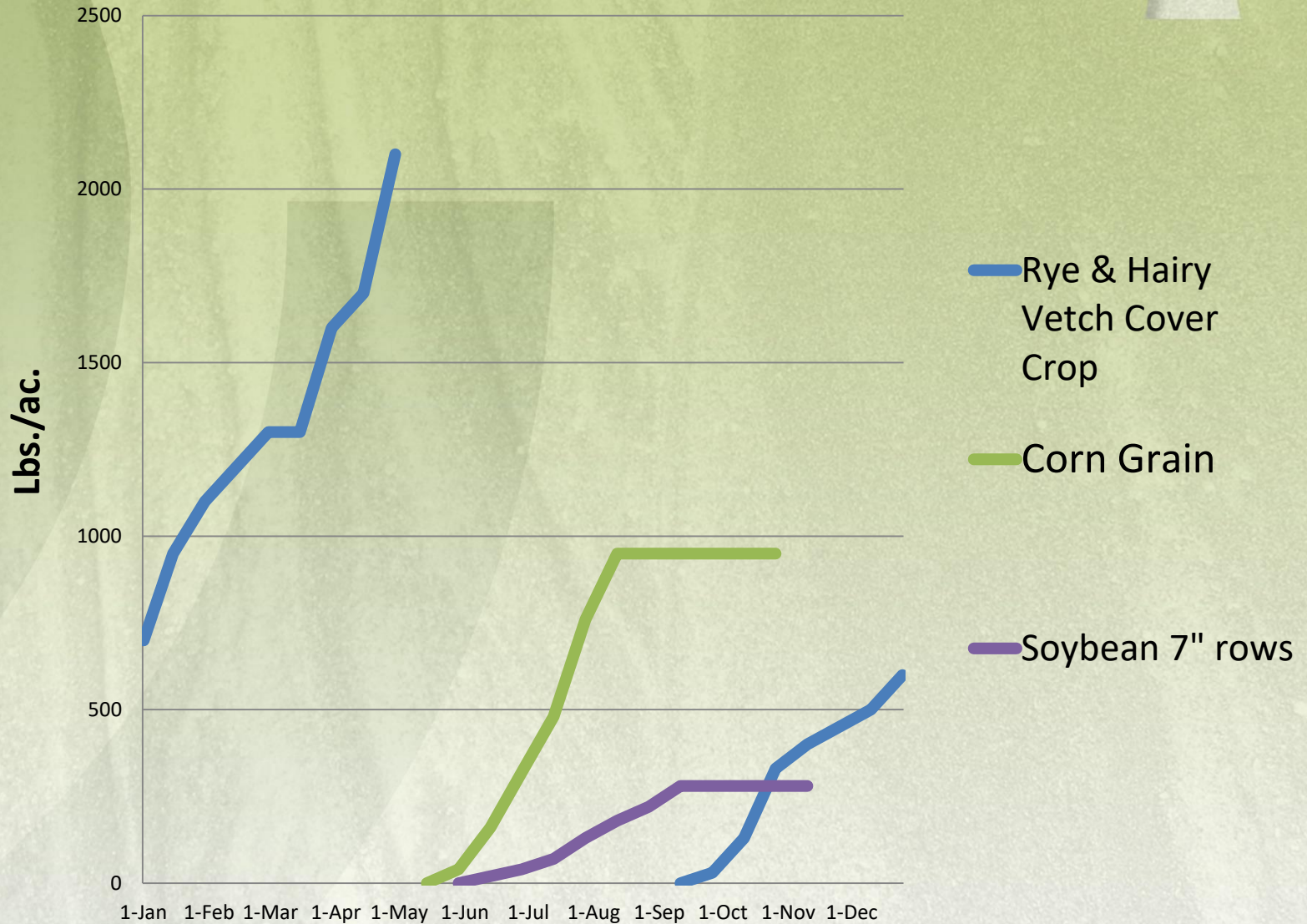


Zone of concentrated biological activity adjacent to the root...

- Bacteria
- Fungi
- Protozoa
- Nematodes
- Microarthropods
- Earthworms



# Root Mass in Top 4" of Soil





# Caution!



- Do not make implementation of tools a goal.
- If your goal is improving soil health; then no-tillage, crop rotation, cover crops, etc. can be excellent tools.
- The devil is in the details, you must become a student of the tools without losing sight of the **goal** of building soil health.



# Soil Health Toolbox

- (No) Tillage
- Crop Rotation Diversity
- Cover Crops
- Degree of Fertilizer use
- Degree of Pesticide use
- Livestock

Which of these tools could positively affect soil health on your farm or in your garden?

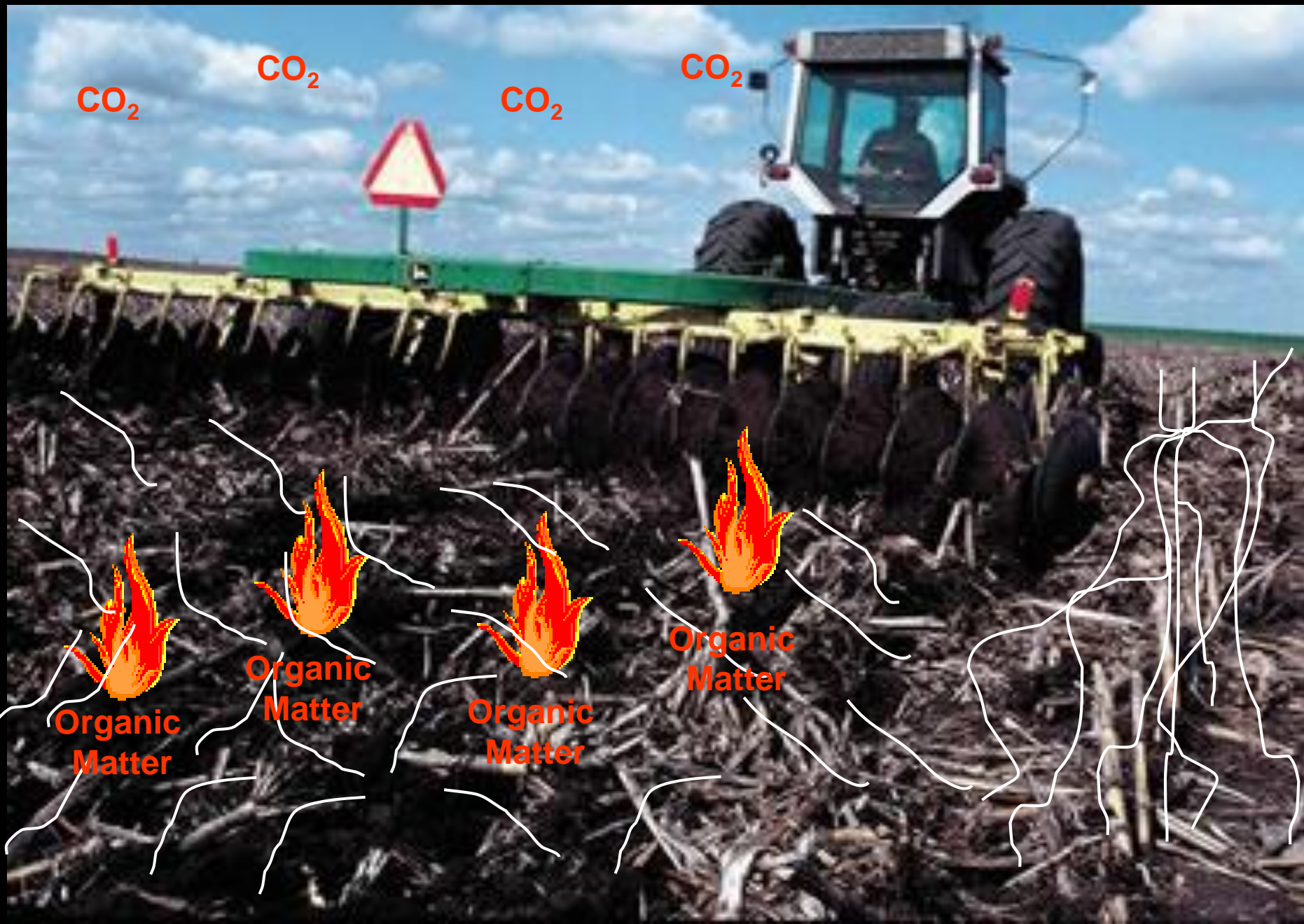


# Reduce/Eliminate Tillage of the Soil



- Tillage is physical soil disturbance
  - Destroys aggregates
  - Exposes organic matter to decomposition
  - Facilitates compaction
  - Damages soil fungi
  - Reduces habitat for all members of SFW
  - Disrupts soil pore continuity
  - Promotes salinity at the soil surface







# Chemical Soil Disturbance from Fertilizer

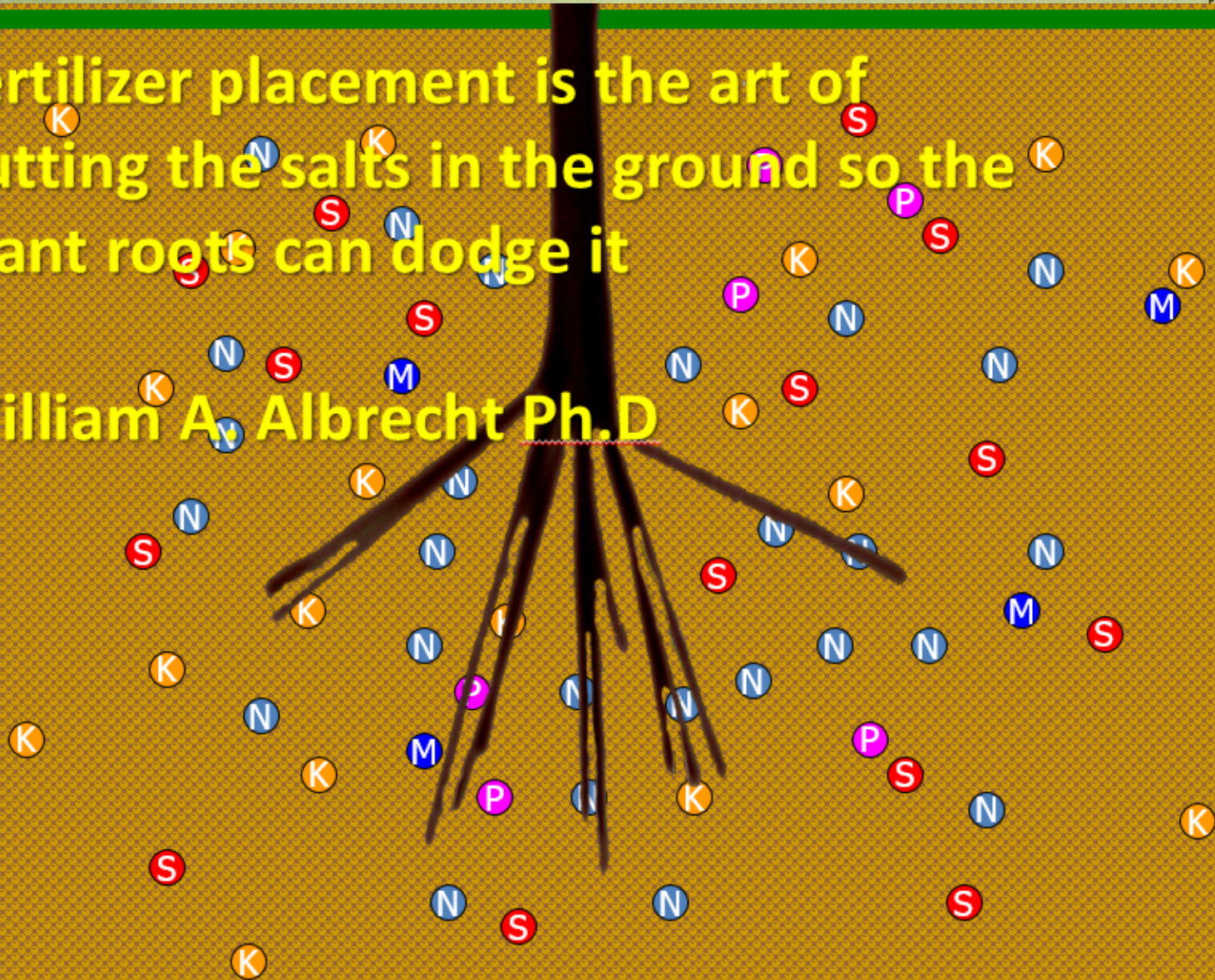


- Excessive nitrogen or phosphorus fertilizer...
  - Short-circuits the rhizosphere
  - Depresses activity of natural N fixers
  - Stimulates bacterial decomposition of SOM
  - N at risk for leaching or denitrification
  - Synthetic fertilizers are salts (salinity)



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?



# Chemical Soil Disturbance from Pesticide use



- Impact of pesticides on non-target organisms not well understood.
- Pesticides simplify, not diversify SFW
  - “cides”
- Crop rotation restrictions
- Cover crop diversity restrictions





# Plant Diversity through crop rotation / cover crops



- Crop diversity = Soil Food Web diversity
- Diversity
  - Balanced/Diverse diet to Soil Food Web
  - Help Reduce pest pressure
  - Help Increase soil nutrient cycling
  - Reduces risk
  - Spreads workload





# Crop Rotation / Cover Crops



- Increased influence of living roots
  - Feeds Soil Food Web
  - Increase soil aggregation and porosity to increase available water holding capacity
  - Use any **excess water** to address salinity
  - Stimulate SFW into increased activity
  - Integrate grazing
  - Nitrogen fixation/recovery



# Keep the soil covered

- Leave crop residues in place after harvest
- Cover crops
- Perennials in rotation
- Balance cover with decomposition
- C:N Ratios
- Mulching







## *Soil Health Principle 4*

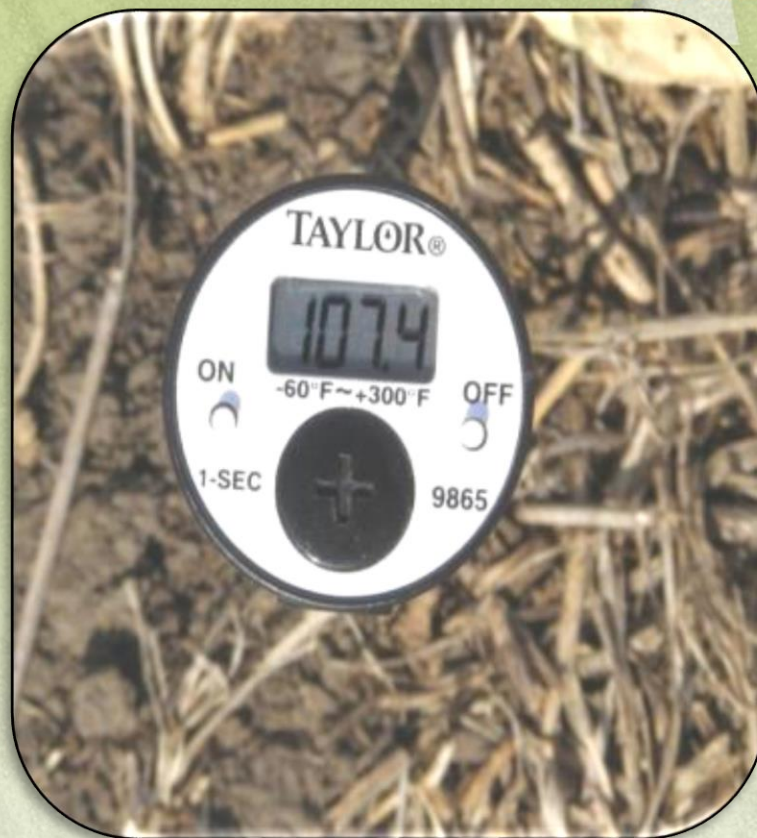
# Keep it Covered as Much as Possible

### Benefits:

- Control Erosion
- Protect Soil Aggregates
- Suppresses Weeds
- Conserves Moisture
- Cools the Soil
- Provides Habitat for Soil Organisms



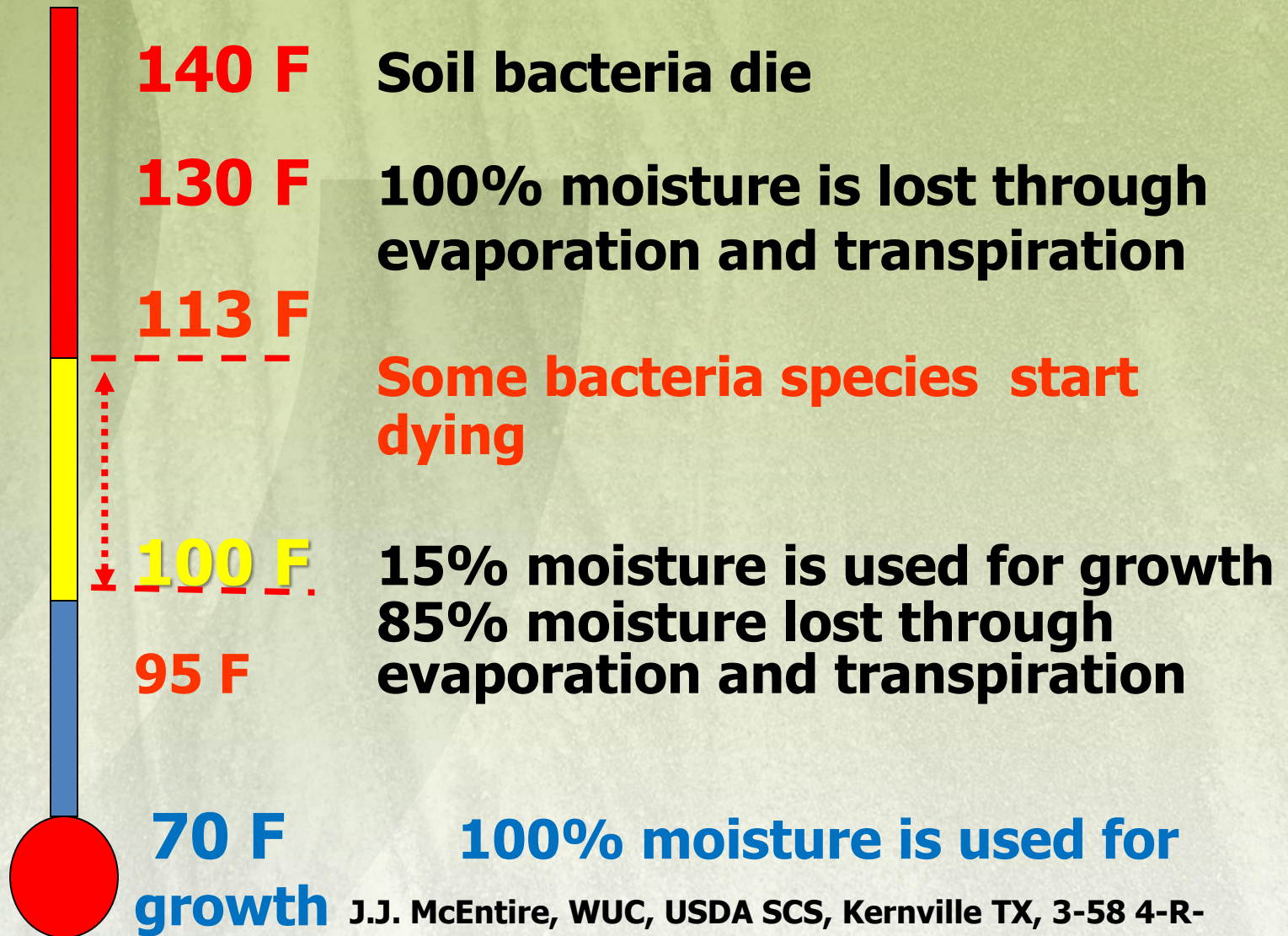
# Soil Temperatures



- Conserve moisture and reduce temperature.
- Crop yields are limited more often by hot and dry, not cool and wet.



# When soil temperature reaches



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



# What happens to residue?

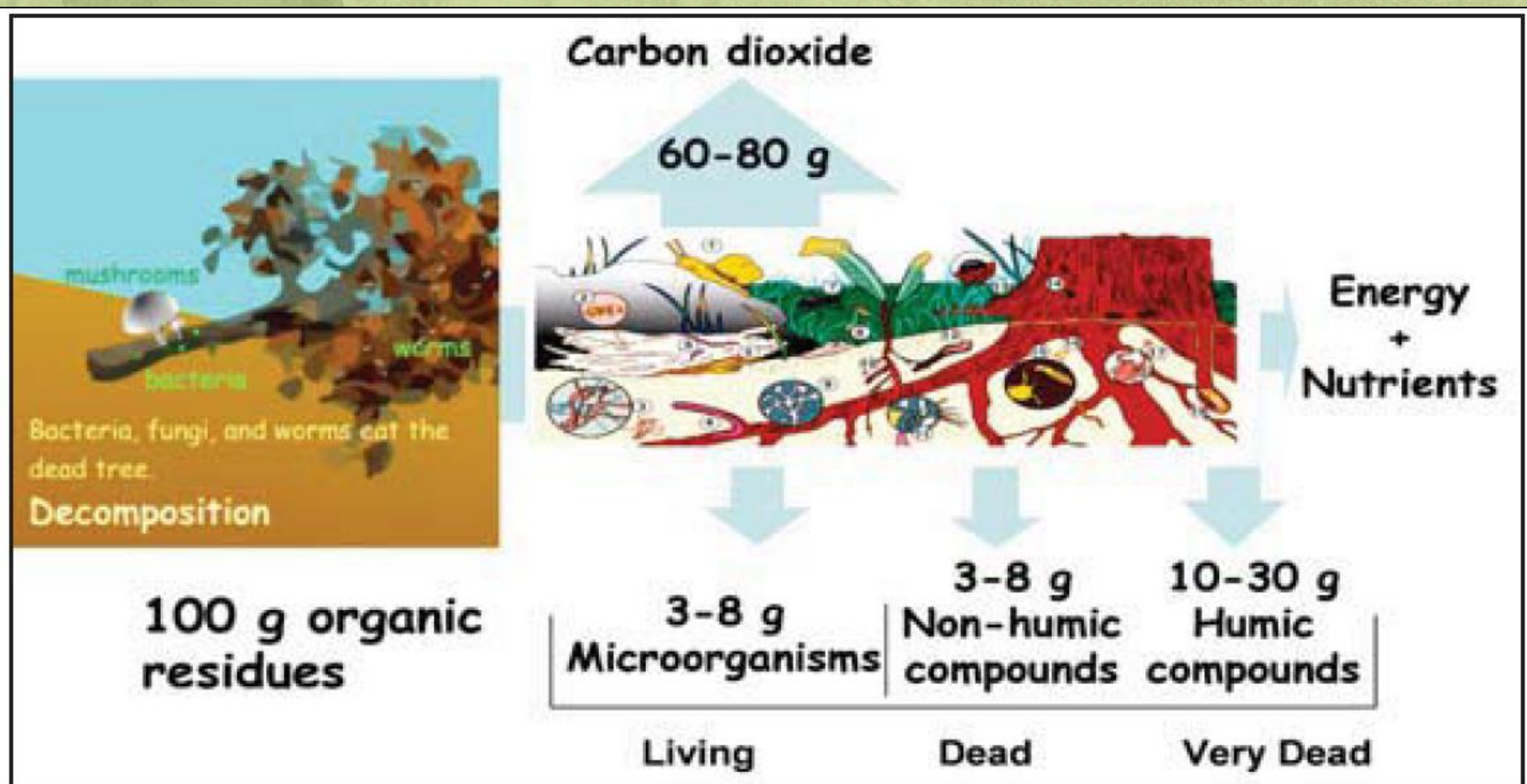
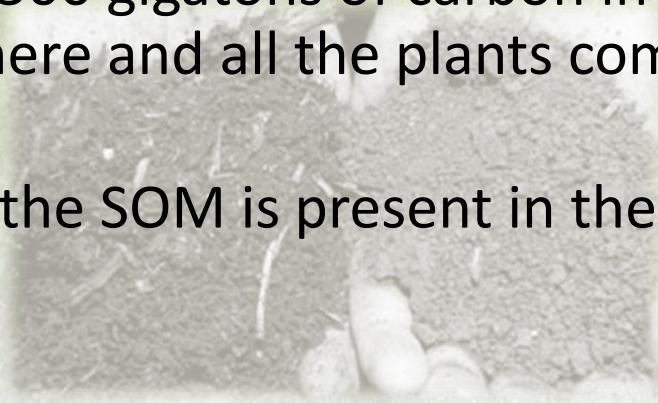


Diagram by Dr. Rafiq Islam



# Soil Organic Matter Facts

- Soil organic matter (SOM) is <6% of soil by weight but controls >90% of the function
- Density of SOM: .6 g/cm<sup>3</sup> Density of Soil: 1.45 g/cm<sup>3</sup>
- SOM has less density than soil so it has more space for air and water storage.
- SOM is negatively charged, but binds both cations and anions
- As soil organic matter increases from 1% to 3%, the available water holding capacity of the soil doubles (Hudson, 1994).
- Soils stockpile 1500 gigatons of carbon in SOM, more than Earth's atmosphere and all the plants combined (Dance, 2008).
- The majority of the SOM is present in the top 10 cm of soil





# Livestock / Animal Impact

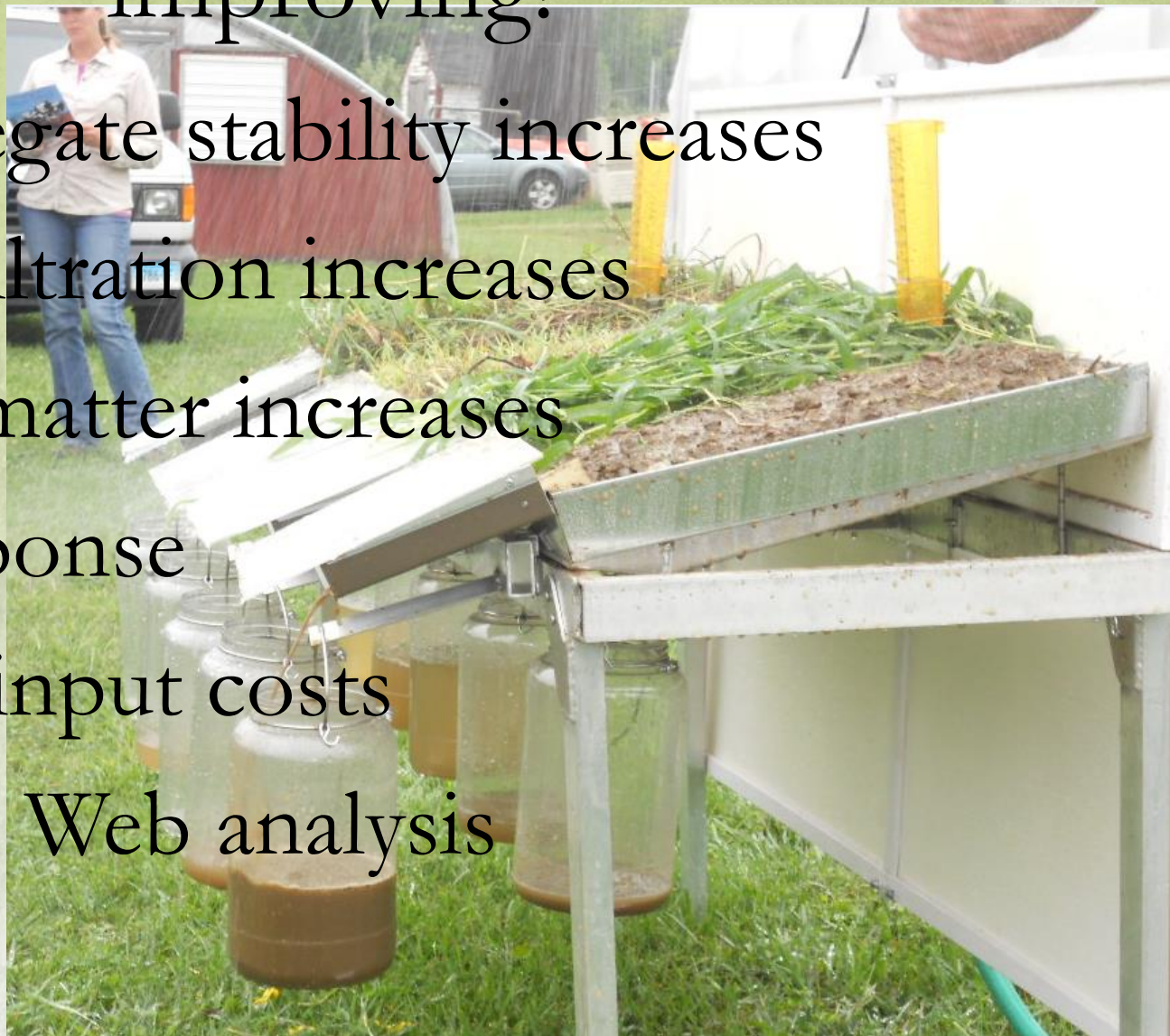
- Add and distribute biology to soil
- Cycle residues, reduce C:N ratios
- Put plant residues in contact with soil
- Opportunity for increased income
- Increase intensity & reduce duration to improve soil health on rangeland





# How do we know if soil health is improving?

- Soil aggregate stability increases
- Water infiltration increases
- Organic matter increases
- Crop response
- Reduced input costs
- Soil Food Web analysis





# Questions / Discussion



"That's here. That's home. That's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives. The aggregate of our joy and suffering, thousands of confident religions, ideologies, and economic doctrines, every hunter and forager, every hero and coward, every creator and destroyer of civilization, every king and peasant, every young couple in love, every mother and father, hopeful child, inventor and explorer, every teacher of morals, every corrupt politician, every 'superstar,' every 'supreme leader,' every saint and sinner in the history of our species lived there - on a mote of dust suspended in a sunbeam."

- Carl Sagan, from a lecture delivered at Cornell University: 10/13/94