



# Unlocking the Secrets In Soil:

How soil works and the management  
principles of high functioning soil

**SOIL SCHOOL**  
**2017**

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**What do you want your  
soil to do for you?**



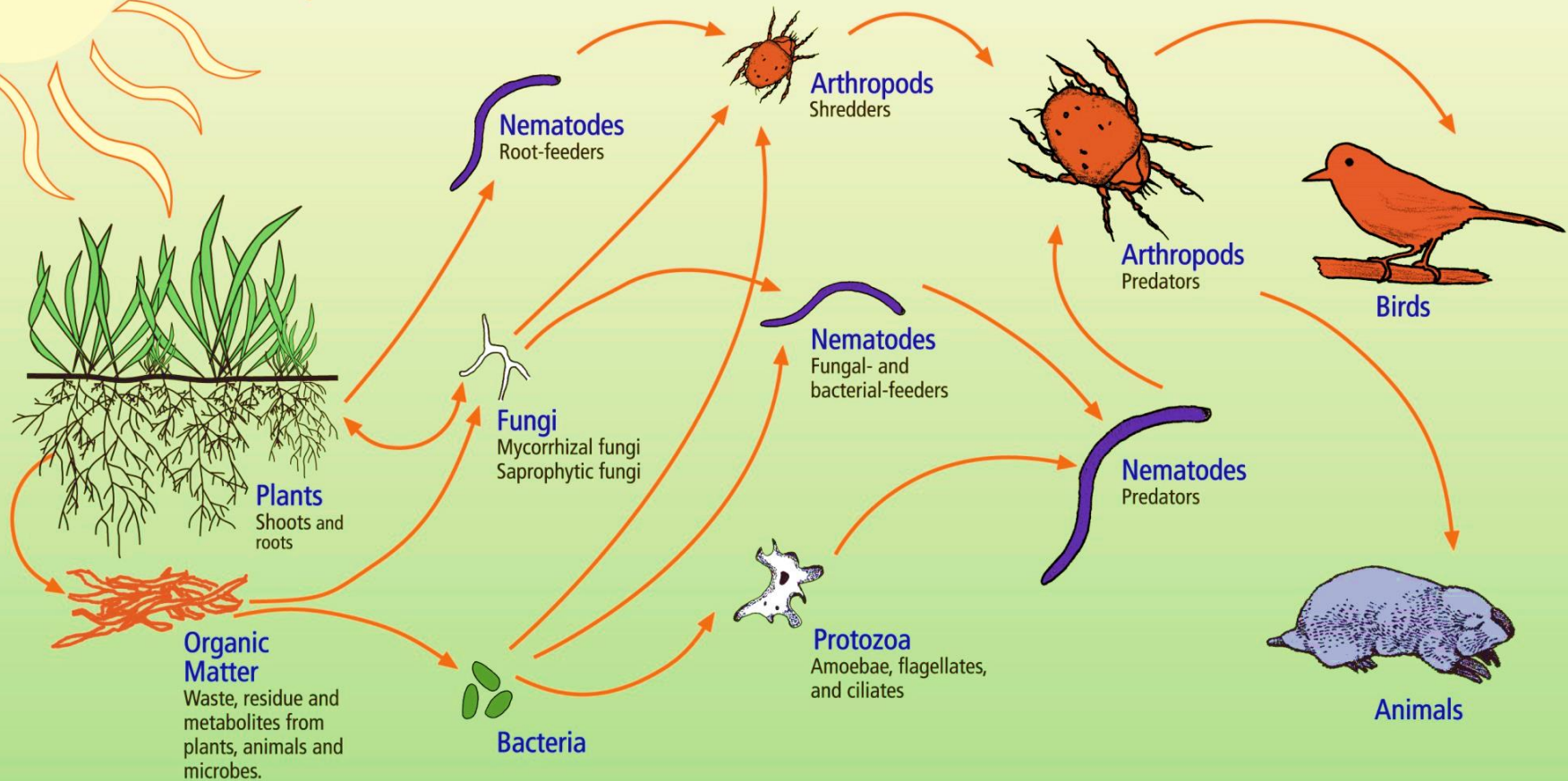
**What do you want your  
soil to do for you?**



## **Important Soil Functions**

- Support productive plants and livestock
- Be stable and resist erosion
- Efficient at cycling nutrients internally
- Allow H<sub>2</sub>O to enter quickly
- Drain well to avoid drowning plant roots
- Store H<sub>2</sub>O for future plant use
- Resist pests, pathogens, and disease
- Help plants grow during 'stressful' events

# The Soil Food Web



**First trophic level:**  
Photosynthesizers

**Second trophic level:**  
Decomposers  
Mutualists  
Pathogens, Parasites  
Root-feeders

**Third trophic level:**  
Shredders  
Predators  
Grazers

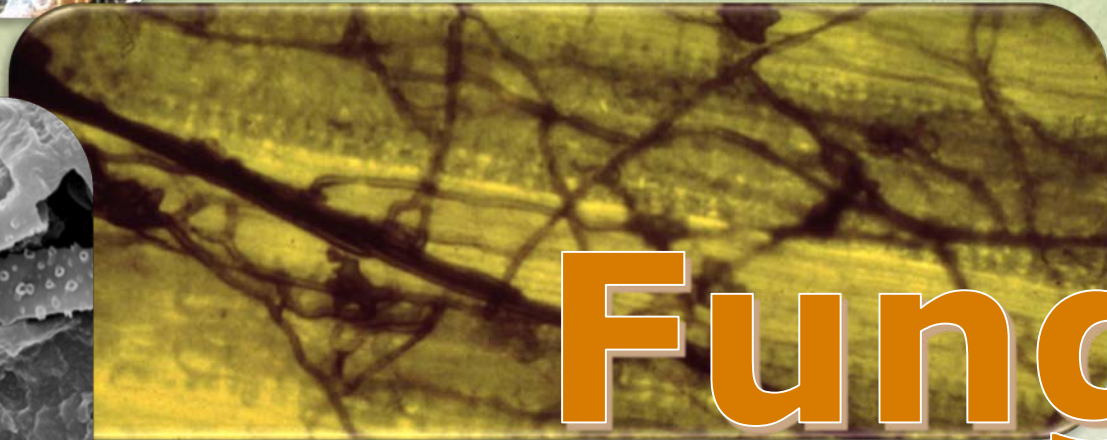
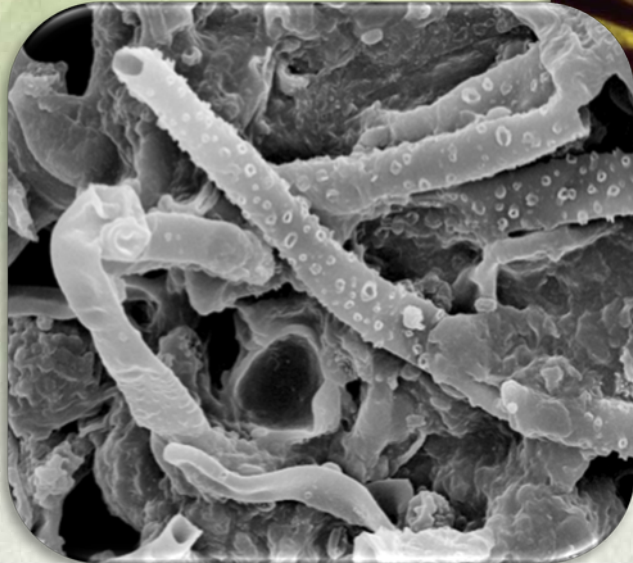
**Fourth trophic level:**  
Higher level predators

**Fifth and higher trophic levels:**  
Higher level predators



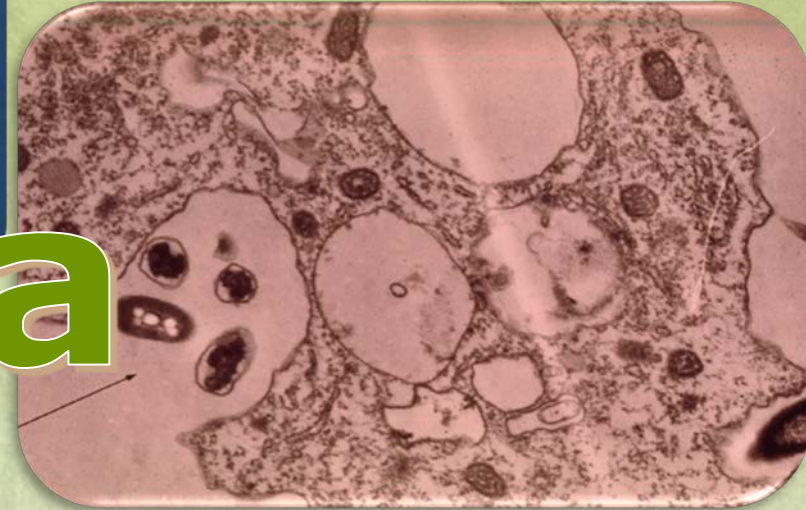
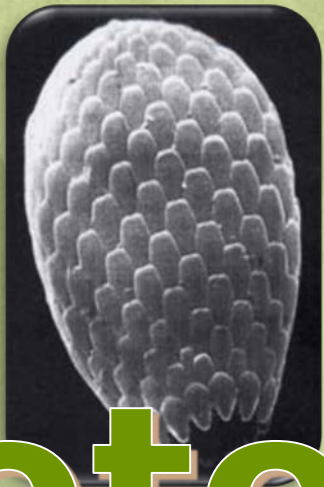
One cup of  
soil holds as  
many  
bacteria as  
there are  
people on  
Earth.

# Bacteria



# Fungi

A teaspoon of Ag soil = 10 yards  
A teaspoon of Forest soil = 10 miles



We know more about the movement of celestial bodies than about the soil underfoot – Da Vinci



# Protozoa

# Nematodes



# Arthropods

Every time you take a step in a mature Oregon forest, your foot is being supported on the backs of 16,000 invertebrates held up by an average of 120,000 legs. – Dr. Moldenke OSU



Earthworms can turn over the top 6 inches of soil in 10-20 years.

# Earthworms

# The Soil Food Web

**The whole is greater  
than the sum of its  
parts!**

Plant  
Roots  
Fungi  
Bacteria

Small  
invertebrates  
Protozoa  
Nematodes  
Microbes

Large  
invertebrates  
Earthworms  
Moles

Large  
invertebrates  
Moles  
Earthworms

Large  
invertebrates  
Moles  
Earthworms

# Soil Organisms Are the Engines Driving Soil Functions



**Organic  
Matter  
Dynamics**

**Plant  
Protection**

**Enhance Soil  
Structure**

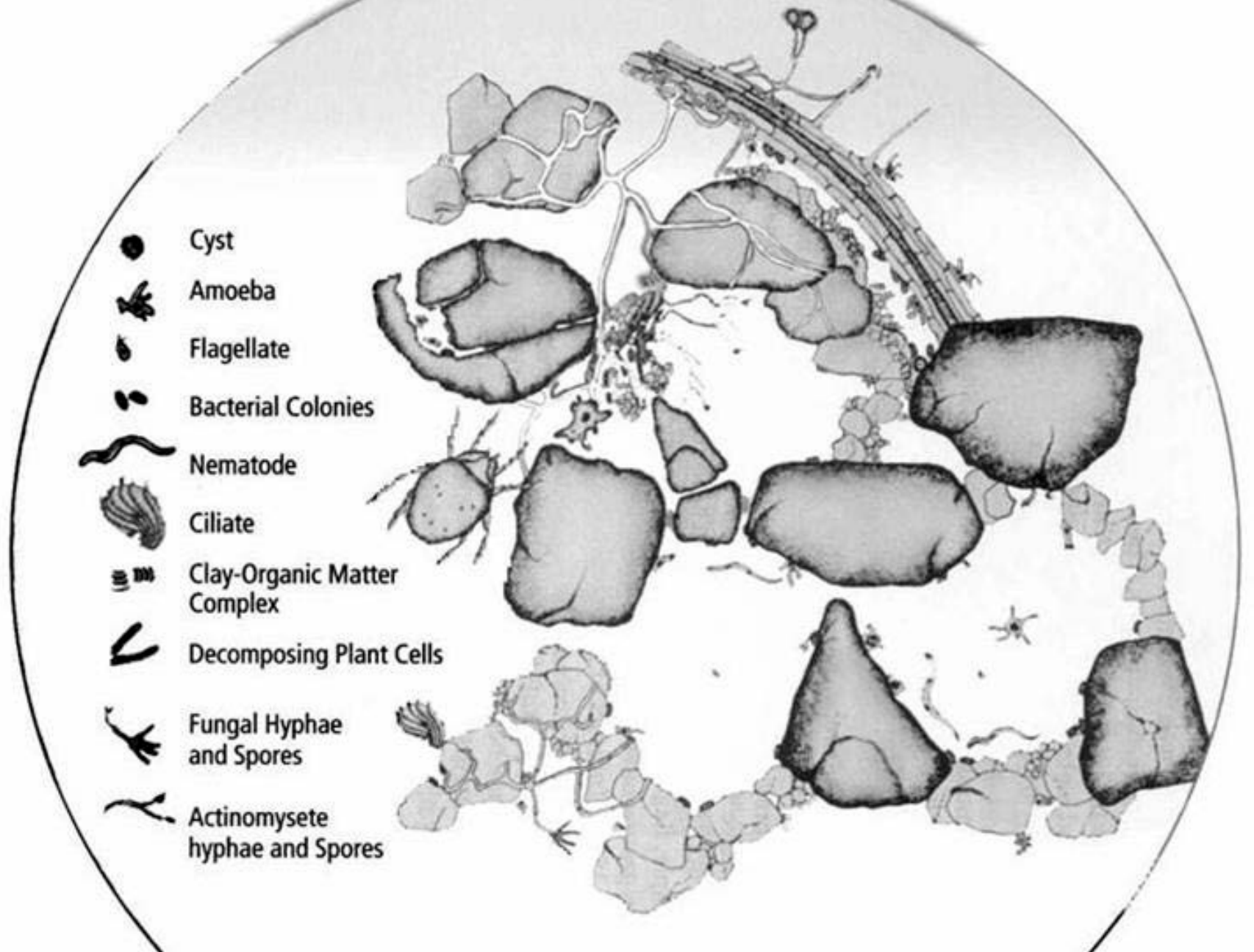
**Enhance Plant  
Growth**

**Drivers of  
Nutrient Cycling**

**Detoxify  
Pollutants**

**Modify  
atmospheric  
composition**

# AGGREGATES ARE HABITAT!





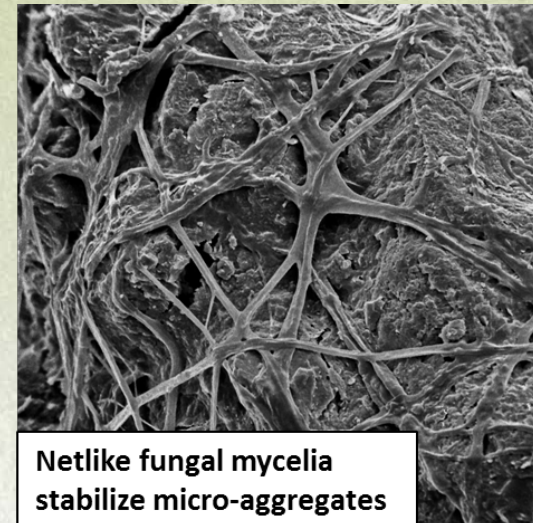
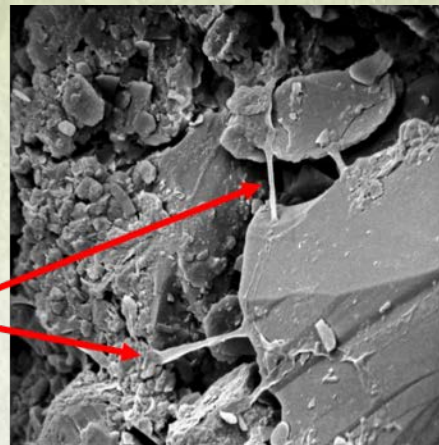
# Soil Food Web Benefits: Formation & Stabilization of Aggregates



How do soil  
aggregates form?

- Physical interactions
  - Plant roots enmesh soil particles
  - Earthworms (casts) and termites (mounds)
  - Soil fungi and some Actinobacteria produce filaments that physically enmesh soil particles together

**Stabilization of soil  
structure by actinomycete  
(bacterial) filaments**



**Netlike fungal mycelia  
stabilize micro-aggregates**

Slide courtesy: Dr. Jen Moore Kucera,  
NRCS-SHD  
Soil image with worm: Aaron Roth,  
NRCS-OR

SEM photo source (accessed on 6/2/2016): Eickhorst, Thilo & Tippkoetter, Rolf. Micropedology – The hidden world of soils. University of Bremen, Germany. <http://www.microped.uni-bremen.de>



# Soil Food Web Benefits: Formation & Stabilization of Aggregates



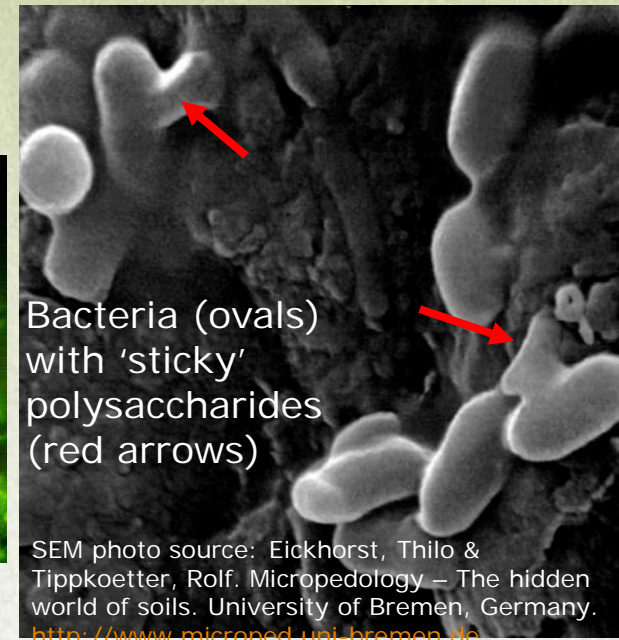
How do soil  
aggregates form?

- Chemical interactions
  - Polysaccharides (sugars) and glycoproteins released by soil microbes act like glues to bind particles.



Glycoproteins on soil aggregates

Dr. Nichols, USDA-ARS



Bacteria (ovals)  
with 'sticky'  
polysaccharides  
(red arrows)

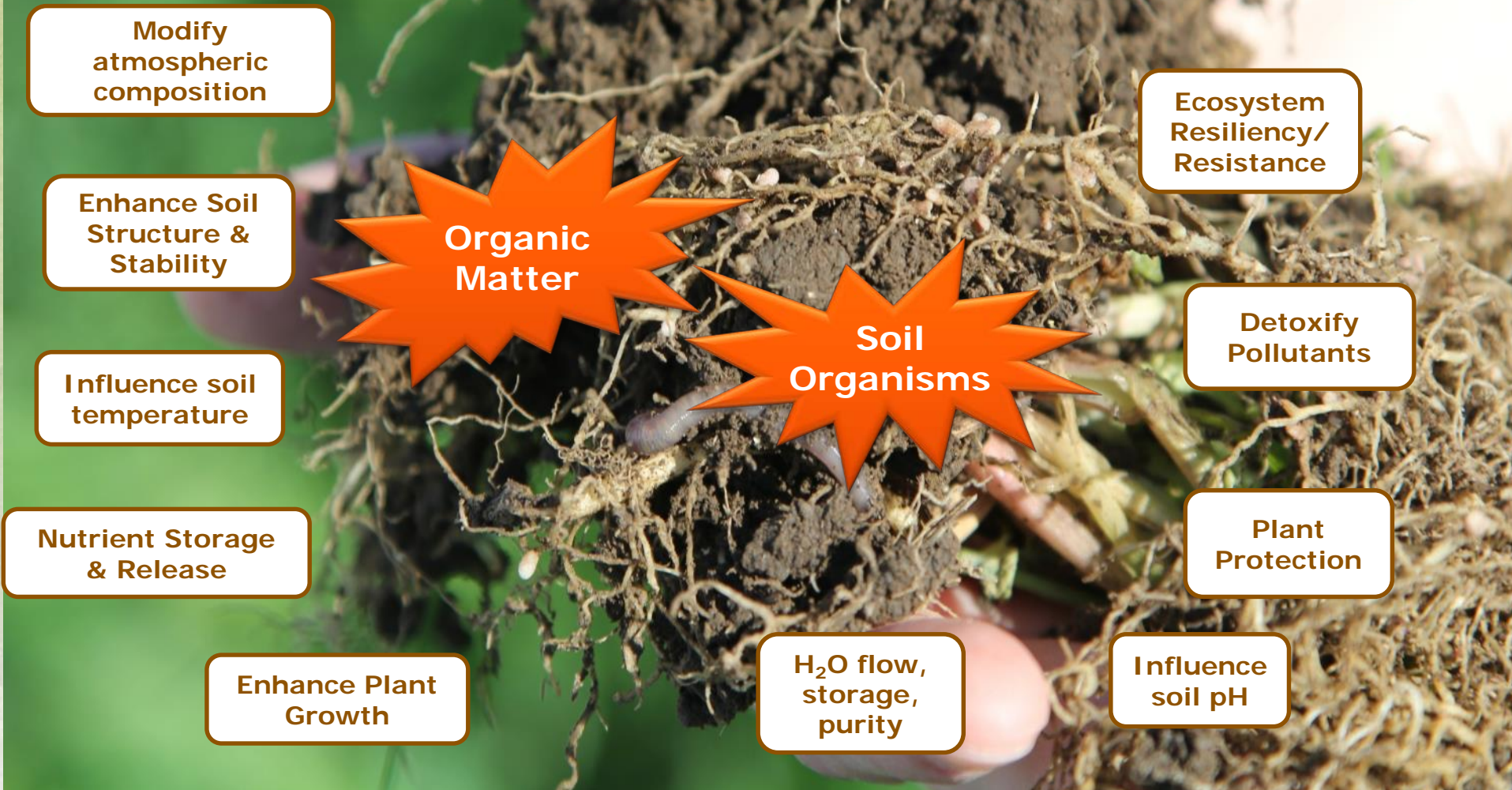
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# Inputs and land-use decisions that help provide habitat and food for soil organisms → healthy soils





**"The formation and maintenance of a high degree of aggregation is one of the most difficult tasks of soil management, yet it is also one of the most important, since it is a potent means of influencing ecosystem function."**

**Brady & Weil**

## **AGGREGATE STABILITY DEMO**

*In case you weren't convinced how awesome aggregates are.*

# Soil Aggradation Climb



- Jerry Hatfield  
USDA-ARS 2004  
– Build soil by  
biological  
activity not  
chemical or  
physical  
manipulations

**Visible  
Outcomes**

**Efficiency  
Yield  
Profit**

Improved AWC

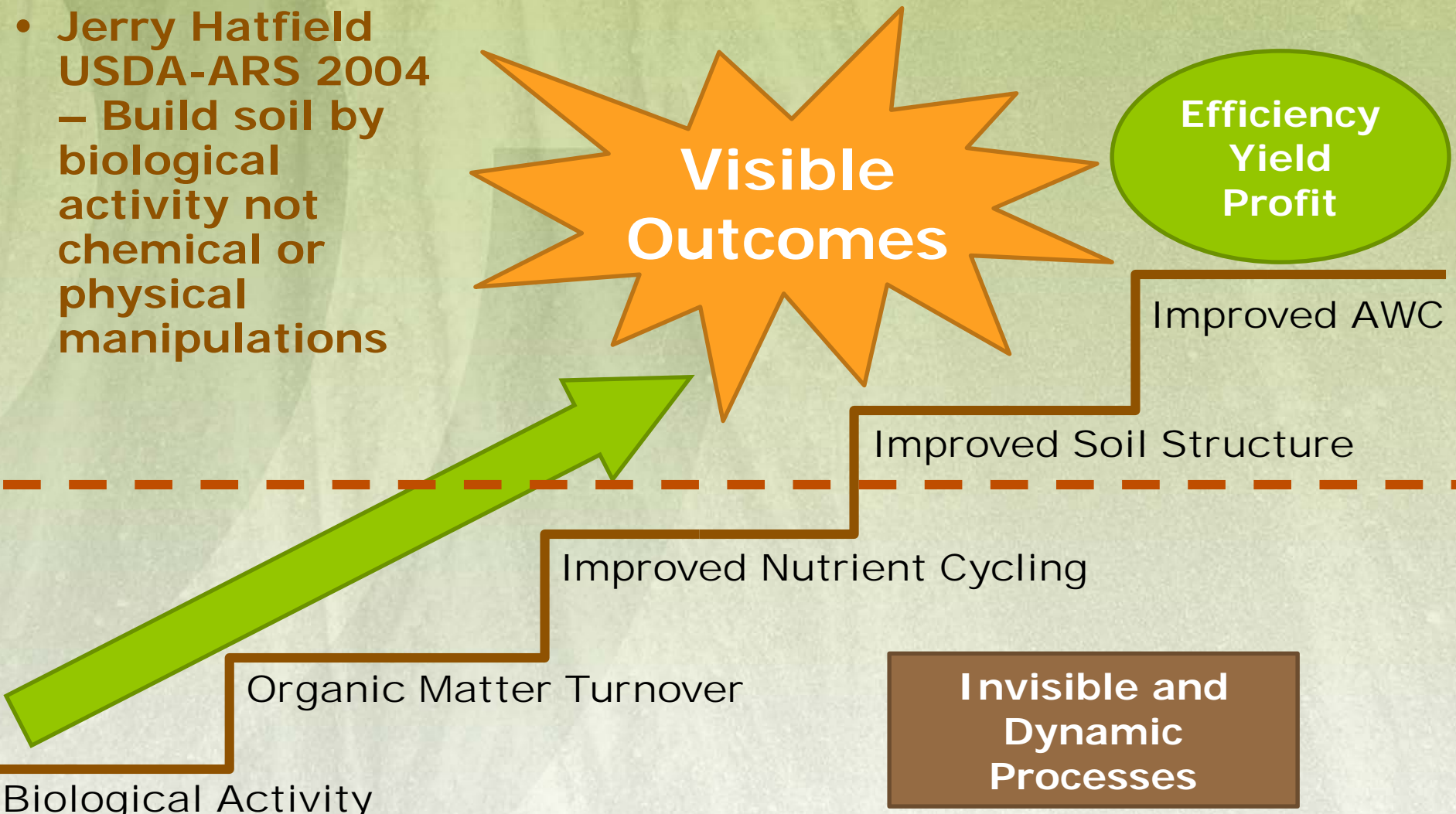
Improved Soil Structure

Improved Nutrient Cycling

Organic Matter Turnover

**Invisible and  
Dynamic  
Processes**

Biological Activity





# **MANAGEMENT PRINCIPLES FOR HIGH FUNCTIONING SOIL**

*How we make it happen!*

# Principles of High Functioning Soils



**Living  
Roots**



**Minimize  
Disturbance**



**Maximize  
Diversity**



**Maximize  
Soil  
Cover**



# Principles of High Functioning Soils

**Living  
Roots**

**Minimize  
Disturbance**

**Integrate  
Managed  
Grazing**

**Maximize  
Diversity**

**Maximize  
Soil  
Cover**



# FEED



**Living  
Roots**



**Maximize  
Diversity**



**Minimize  
Disturbance**



**Maximize  
Soil  
Cover**



# PROTECT

# FEED



**Living  
Roots**

## **KEEP THE CARBON FLOW**

- Forage-Biomass Planting
- Crop Rotation
- Cover Crops
- Perennial Crops



**Maximize  
Diversity**

## **ABOVE FOR BELOW**

- Cover Crops
- Crop Rotation
- Rotational Grazing
- Integrated Pest Management

# PROTECT

## MINDFUL DISTURBANCE

- Timing and Depth
- Equipment Choice
- Control Travel
- Buffer Strips
- Reduced Tillage
- No-Till



**Minimize  
Disturbance**

## JUST SAY NO TO NAKED

- Cover Crops
- Mulching
- Residue Management
- Forage and Biomass



**Maximize  
Soil  
Cover**

# Integrate Managed Grazing



- Turning cattle out to graze in harvested fields was once a common practice.
- Now grazing covers
- Now using short, intense grazing events
- These have the potential to improve the soil health and utilize any remaining nutrients

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- Now using short, intense grazing events
- These have the potential to improve the soil health and utilize any remaining nutrients

**Cattle as catalysts  
for carbon!**

# Integrate Managed Grazing



## Soil Health Principle

## Orchard Management Practices

### MAXIMIZE COVER

- Cover crop between rows
- Mulch in tree row

### MAXIMIZE DIVERSITY

- Think between the rows

### MINIMIZE DISTURBANCE

- No-till
- Conservation tillage

### LIVING ROOTS

- Cover crop
  - Think diversity



## Soil Health Principle

## Pasture Management Practices

### MAXIMIZE COVER

- Proper Utilization – keep the good cover you have
- Prevent erosion on slopes

### MAXIMIZE DIVERSITY

- Will depend on the animal
- A multispecies pasture mix

### MINIMIZE DISTURBANCE

- Livestock distribution – Mind the concentration areas
- Create concentration areas
- Seasonal/Rotational grazing
- Minimize hoof shear

### LIVING ROOTS

- Proper Utilization – Let the plant maintain its root system

# MANAGING FOR THE PRINCIPLES

Diversity



Covered



Living Roots



Disturbance



PROGRESS!

Diversity

The diagram features a central, tilted, dark grey rectangular box with the text "Scale and Management Opportunities!". Above this box is an oval labeled "Diversity" connected by a plus sign. Below the box is another oval labeled "Disturbance" also connected by a plus sign. The entire graphic is set against a background of green plants and brown soil with visible roots.



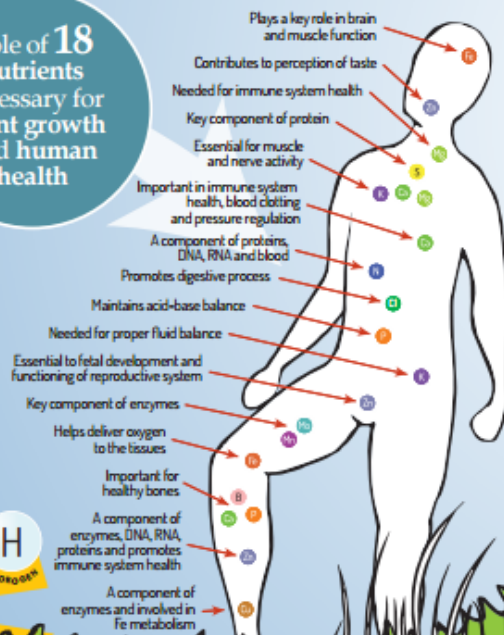
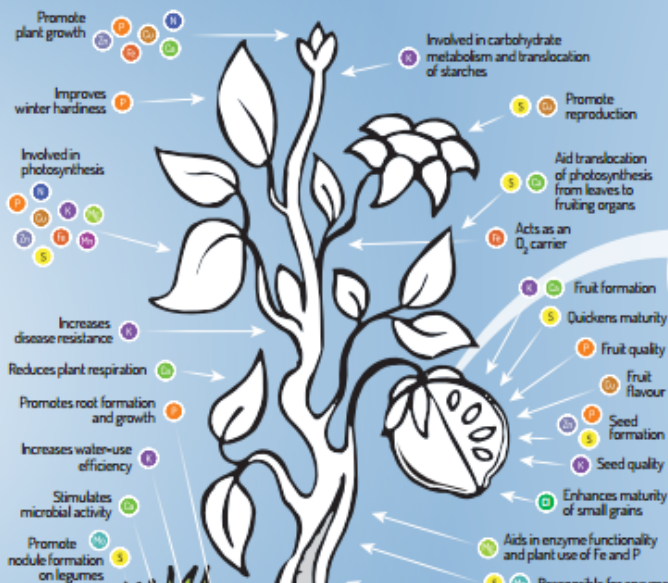
**Scale and  
Management  
Opportunities!**



Disturbance

# Soil the foundation of nutrition

## Role of 18 nutrients necessary for plant growth and human health



**Soil macronutrients**

- P (Phosphorus)
- K (Potassium)
- N (Nitrogen)

**Soil micronutrients**

- Ca (Calcium)
- Si (Silicon)
- Mg (Magnesium)
- Mo (Molybdenum)
- B (Boron)
- Fe (Iron)
- Cu (Copper)
- Na (Sodium)
- S (Sulphur)
- Zn (Zinc)
- Mn (Manganese)

**Soil degradation leads to the loss of soil micro and macronutrients**

**Nutrient-poor soils are unable to produce healthy food with all the necessary nutrients for a healthy person**

**Over 2 billion people suffer from micronutrient deficiencies**

**Sustainable soil management for healthy soils, healthy food and healthy people**

**Ensure crop rotation**

**Reduce erosion**

**Keep soil surface covered**

**Minimize tillage**

**Increase soil organic matter content**

# THANKS!



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