Unlocking the Secrets In Soil:

How soil works and the management principles of high functioning soil

SOIL SCHOOL 2018

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USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

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_2O to enter quickly
- Drain well to avoid drowning plant roots
- Store H_2O for future plant use
- Resist pests, pathogens, and disease
- Help plants grow during ‘stressful’ events

The Soil Food Web

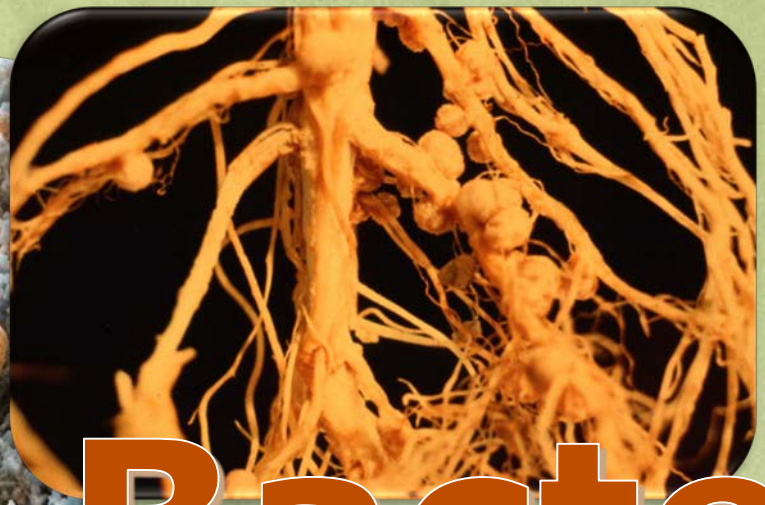
First trophic level:
Photosynthesizers

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

Third trophic level:
Shredders
Predators
Grazers

Fourth trophic level:
Higher level
predators

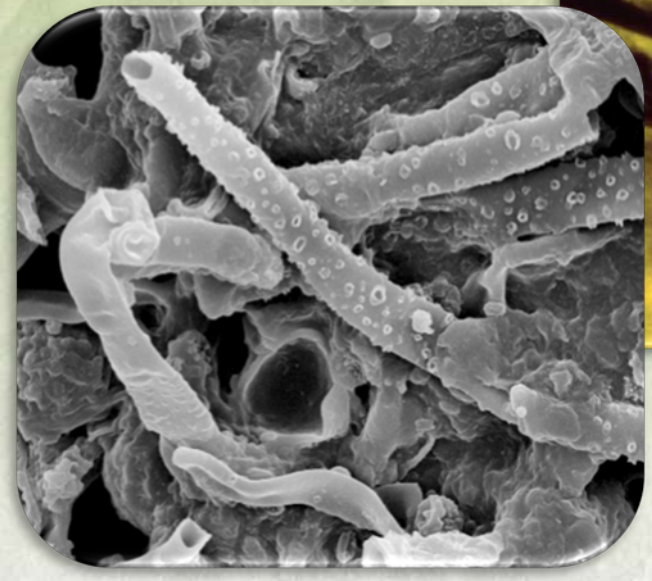
Fifth and higher trophic levels:
Higher level
predators



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

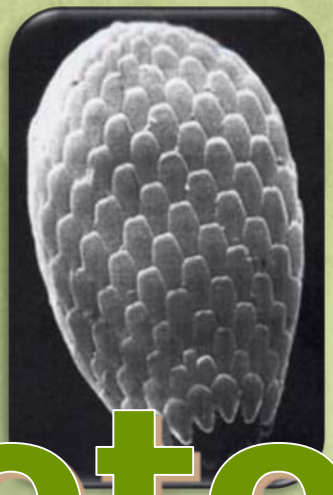
Bacteria

Fungi

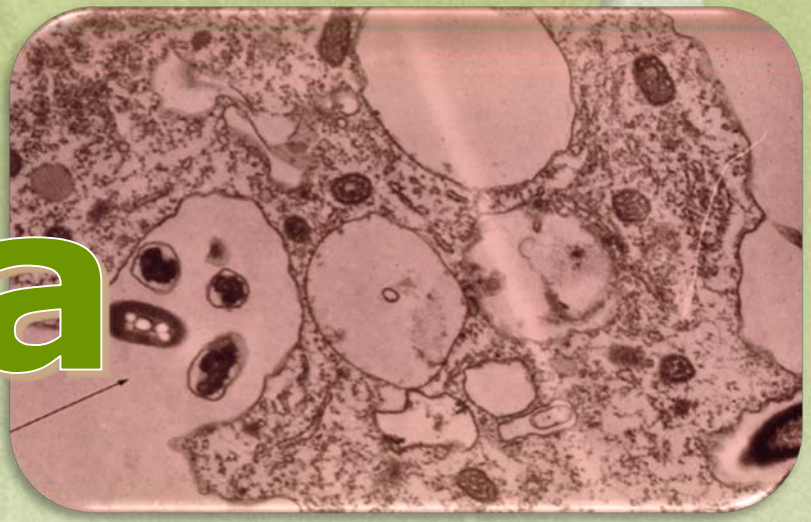


A teaspoon of Ag soil = 10 yards

A teaspoon of Forest soil = 10 miles

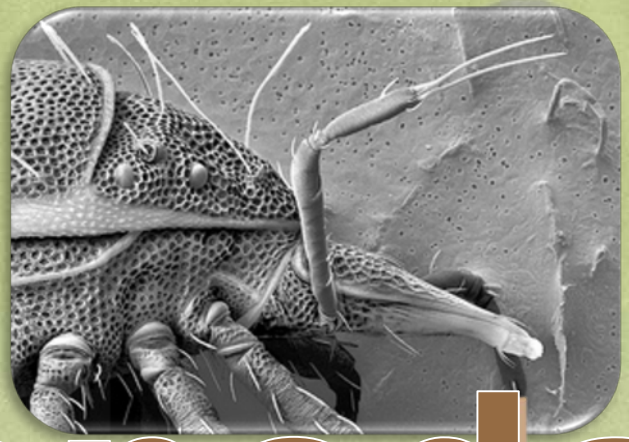


Protozoa



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

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!

Soil Organisms Are the Engines Driving Soil Functions

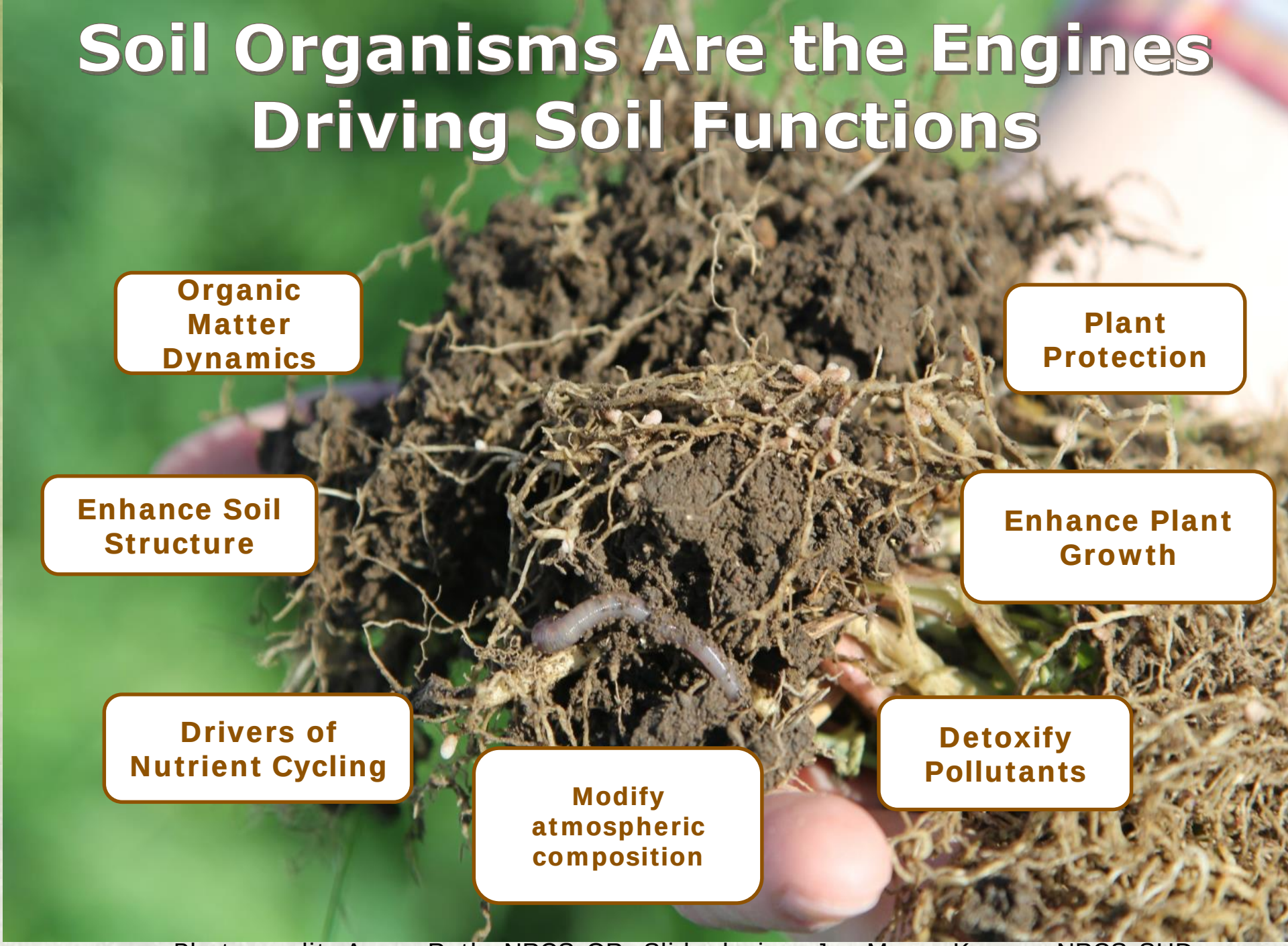
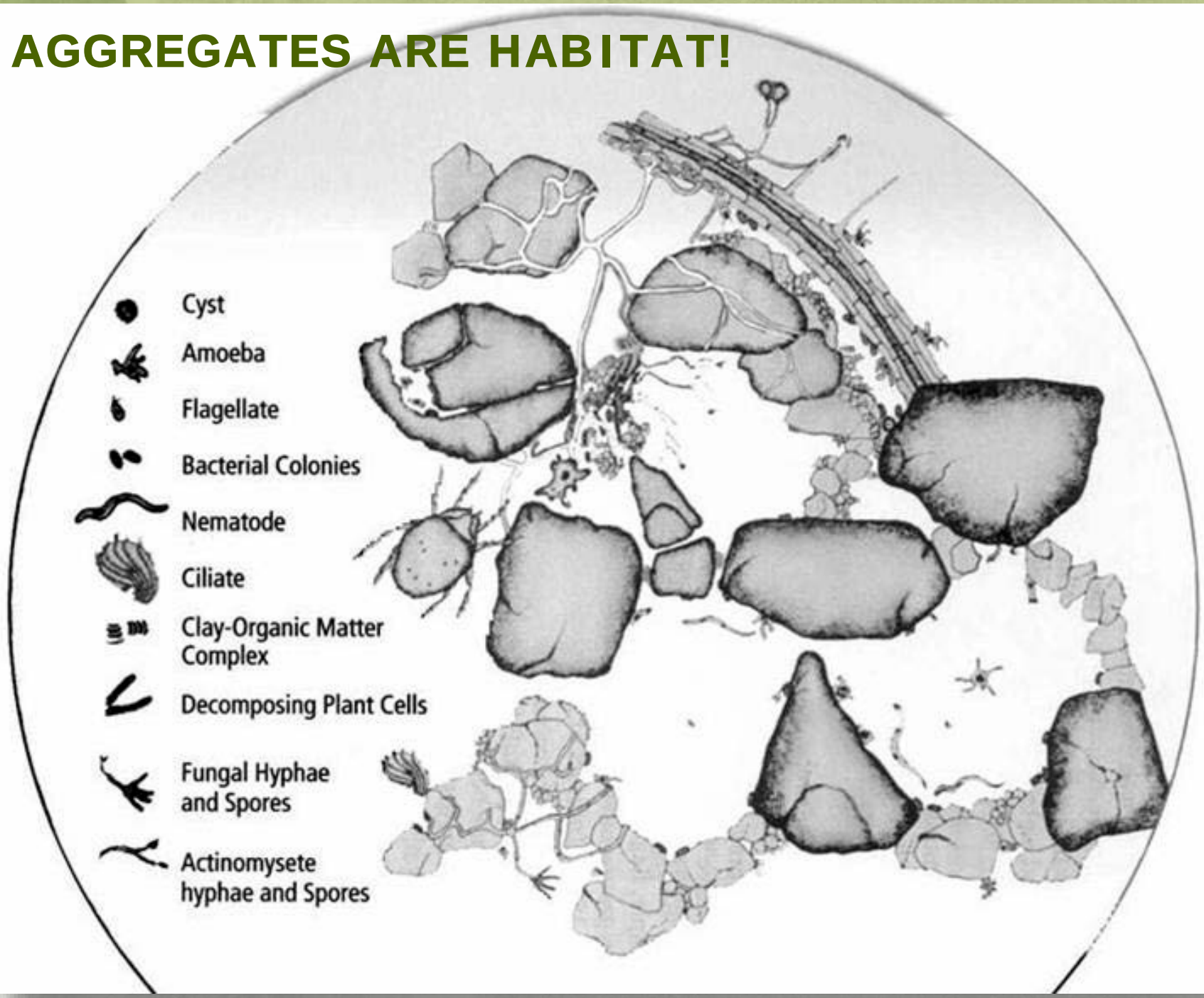


Photo credit: Aaron Roth, NRCS-OR; Slide design: Jen Moore Kucera, NRCS-SHD

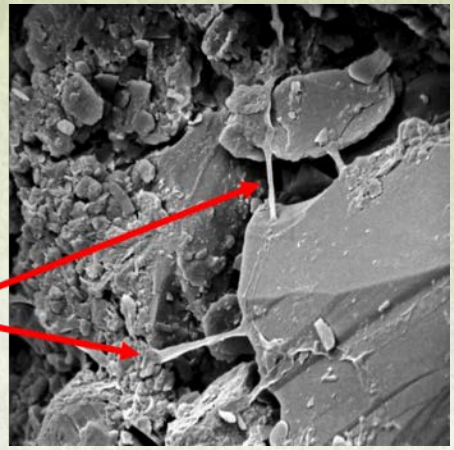
AGGREGATES ARE HABITAT!



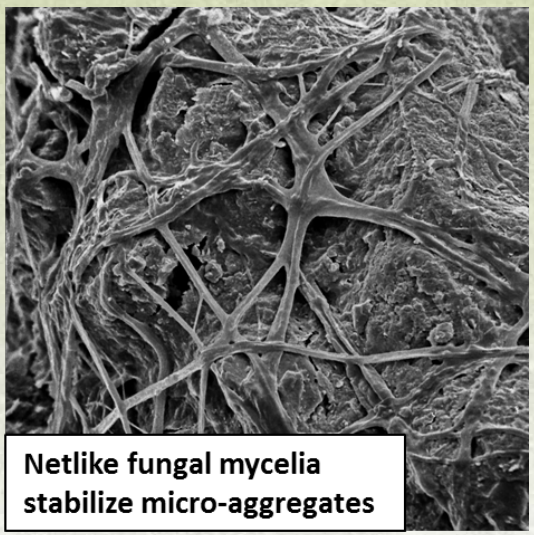
Soil Food Web Benefits: Formation & Stabilization of Aggregates

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

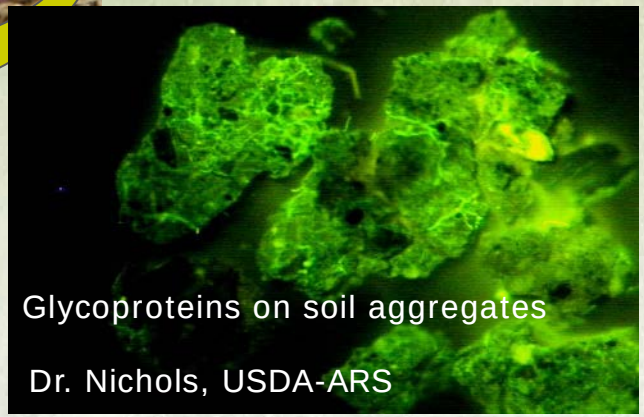
Slide courtesy: Dr. Jen Moore Kucera, NRCS-SHD
Soil image with worm: Aaron Roth, NRCS-OR

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

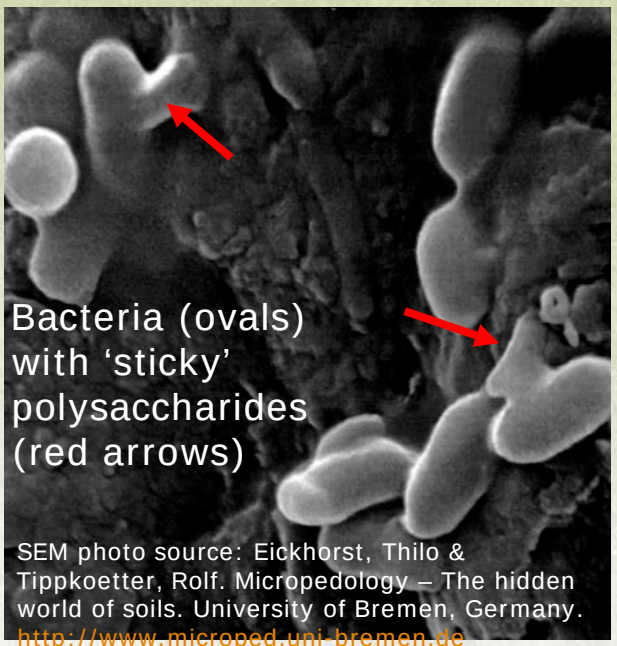
How do soil aggregates form?

- 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)

SEM photo source: Eickhorst, Thilo & Tippkoetter, Rolf. Micropedology – The hidden world of soils. University of Bremen, Germany. http://www.microped.uni-bremen.de

Soil image with worm: Aaron Roth, NRCS-OR

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

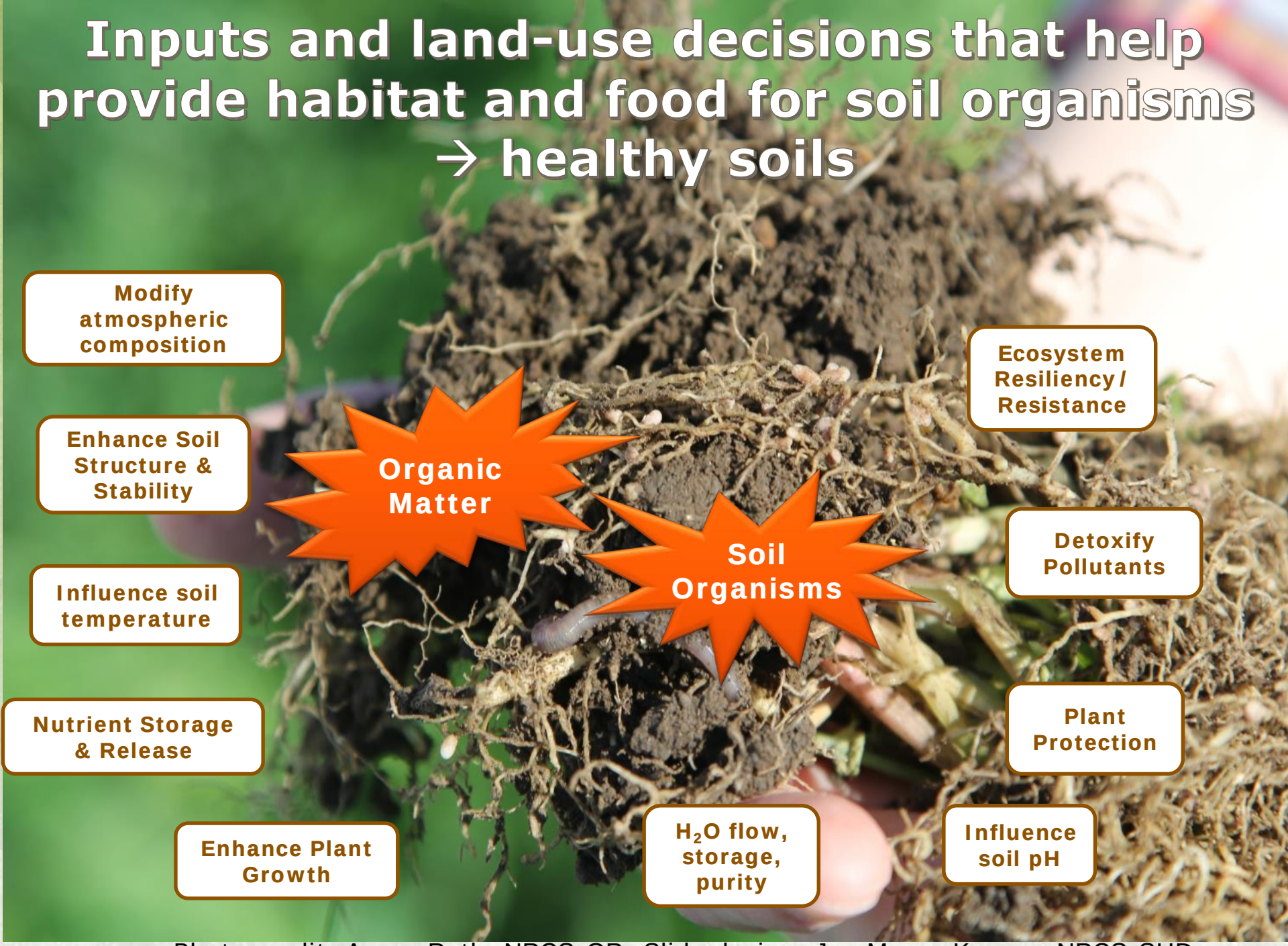


Photo credit: Aaron Roth, NRCS-OR; Slide design: Jen Moore Kucera, NRCS-SHD

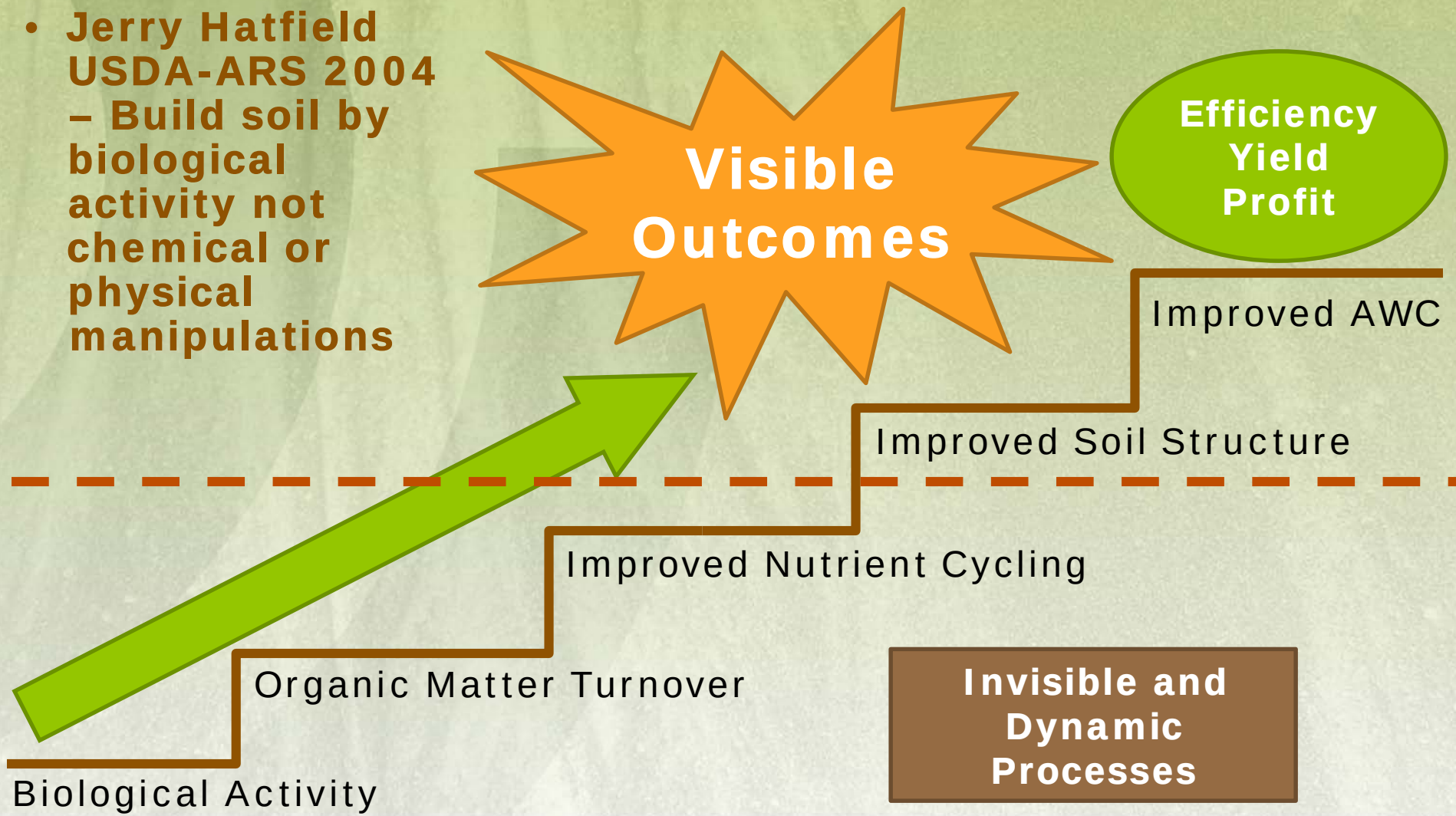
“The formation and maintenance of a high degree of aggregation is one of the most difficult tasks of soil management, yet it is also one of the most important, since it is a potent means of influencing ecosystem function.”
Brady & Weil

AGGREGATE STABILITY DEMO

In case you weren’t convinced how awesome aggregates are.

Soil Aggradation Climb

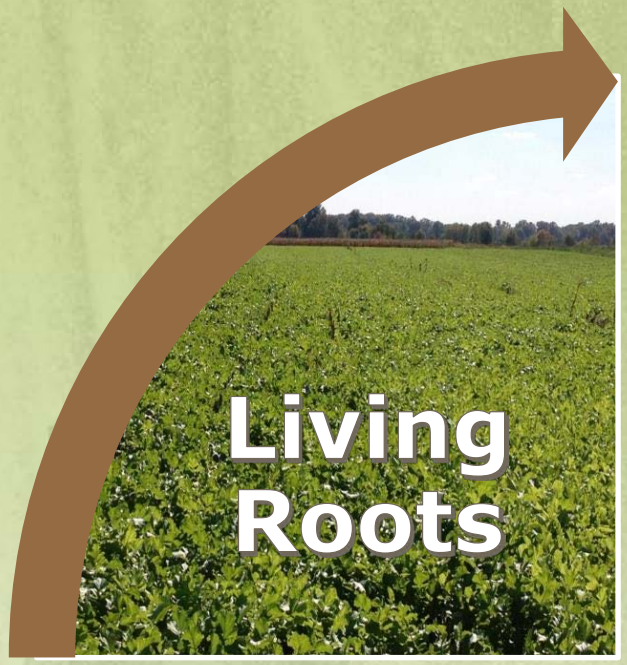
- **Jerry Hatfield USDA-ARS 2004 – Build soil by biological activity not chemical or physical manipulations**



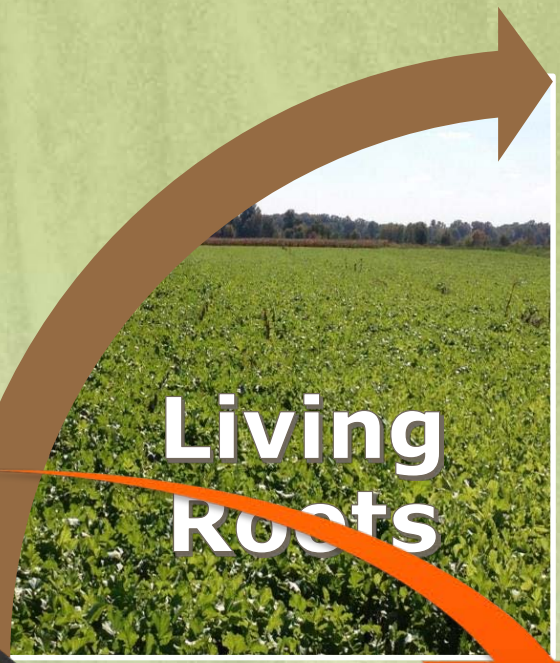
MANAGEMENT PRINCIPLES FOR HIGH FUNCTIONING SOIL

How we make it happen!

Principles of High Functioning Soils

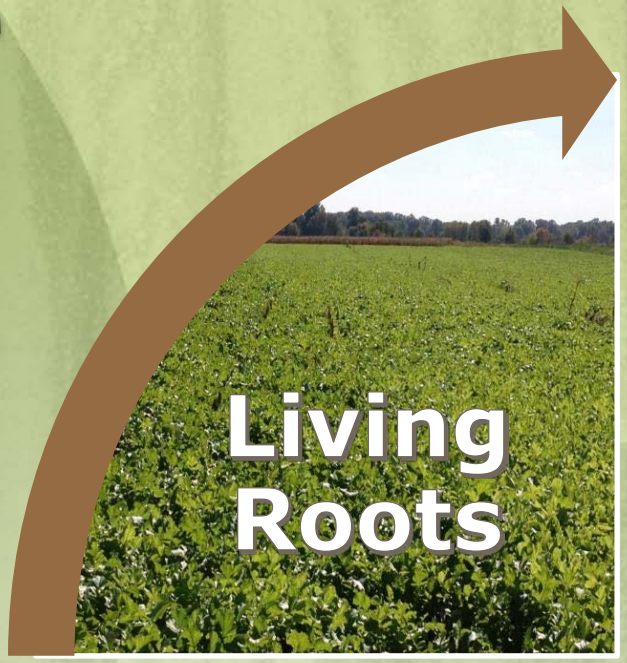


Principles of High Functioning Soils



FEED

PROTECT



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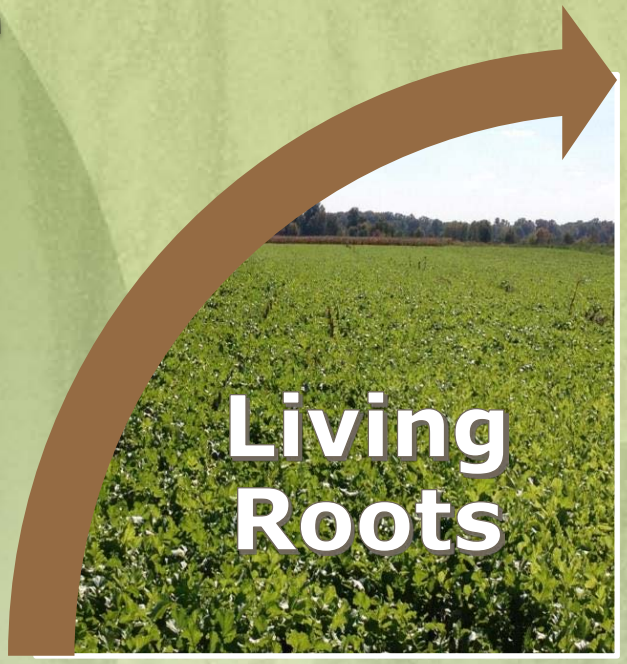

KEEP THE CARBON FLOW

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

ABOVE FOR BELOW

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

MINDFUL DISTURBANCE

- Timing and Depth
- Equipment Choice

- Control Travel
- Buffer Strips

- Reduced Tillage
- No-Till

JUST SAY NO TO NAKED

- Cover Crops

- Mulching

- Residue Management

- Forage and Biomass

PROTECT

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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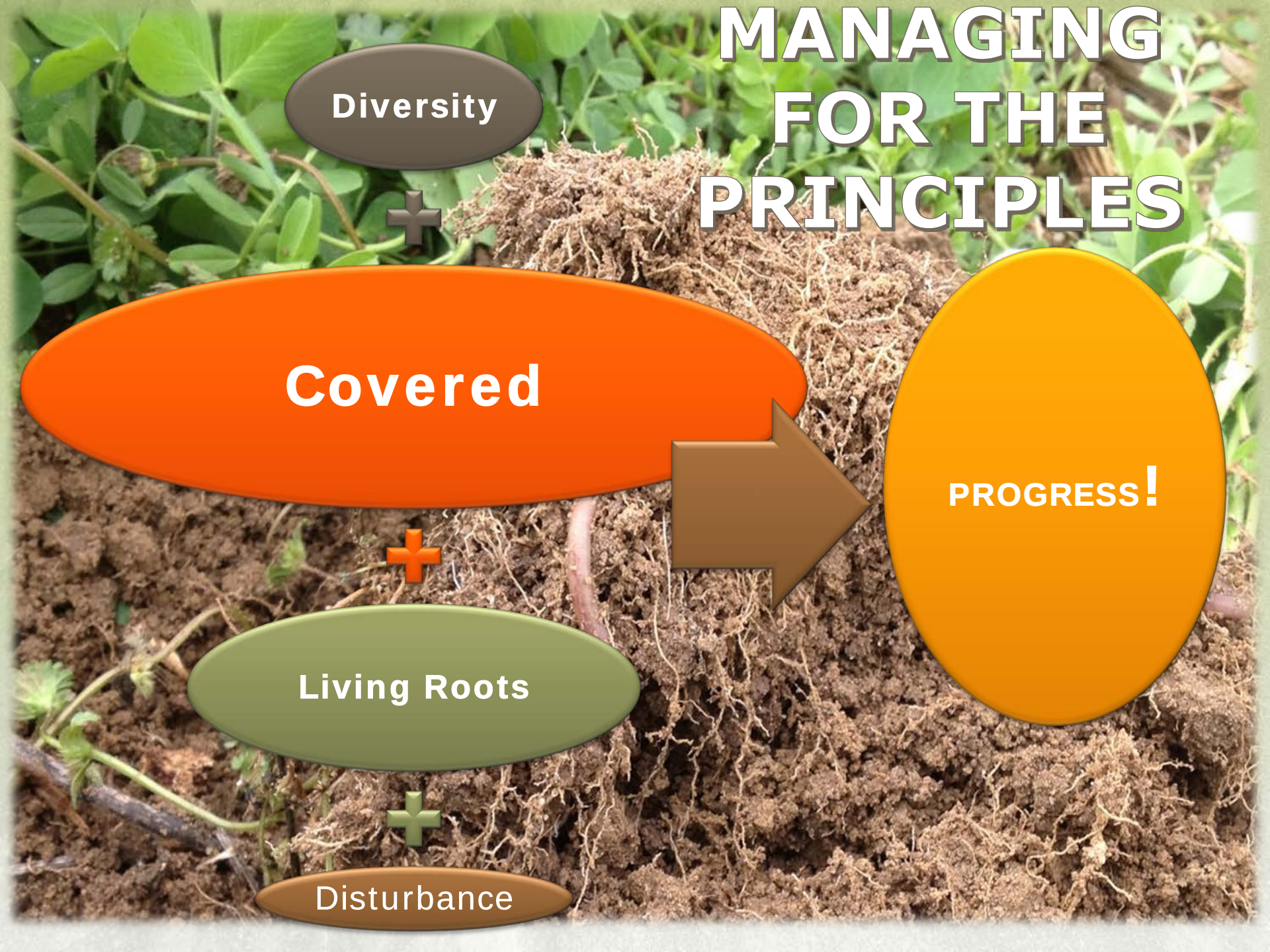
Cattle as catalysts for carbon!

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
Scale and Management Opportunities!
Disturbance


Soil the foundation of nutrition
2015 International Year of Soils
fao.org/soils-2015
Promote plant growth
Improves winter hardiness
Involved in photosynthesis
Increases disease resistance
Reduces plant respiration
Promotes root formation and growth
Increases water-use efficiency
Stimulates microbial activity
Promote nodule formation on legumes
Involved in carbohydrate metabolism and translocation of starches
Promote reproduction
Aid translocation of photosynthesis from leaves to fruiting organs
Acts as an O_2 carrier
Fruit formation
Quickens maturity
Fruit quality
Fruit flavour
Seed formation
Seed quality
Enhances maturity of small grains
Aids in enzyme functionality and plant use of Fe and P
Responsible for enzyme activity
Helps enzyme activity and increases the availability of P and Ca
Role of 18 nutrients necessary for plant growth and human health
Plays a key role in brain and muscle function
Contributes to perception of taste
Needed for immune system health
Key component of protein
Essential for muscle and nerve activity
Important in immune system health, blood clotting and pressure regulation
A component of proteins, DNA, RNA and blood
Promotes digestive process
Maintains acid-base balance
Needed for proper fluid balance
Essential to fetal development and functioning of reproductive system
Key component of enzymes
Helps deliver oxygen to the tissues
Important for healthy bones
A component of enzymes, DNA, RNA, proteins and promotes immune system health
A component of enzymes and involved in Fe metabolism
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
Soil macronutrients
Soil micronutrients
Sustainable soil management for healthy soils, healthy food and healthy people
Reduce erosion
Ensure crop rotation
Keep soil surface covered
Minimize tillage
Increase soil organic matter content
Food and Agriculture Organization of the United Nations
With the financial support of the Russian Federation
Healthy soils for a healthy life

THANKS!

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