Unlocking the Secrets In Soil:
How soil works and the management principles of high functioning soil

SOIL SCHOOL 2018

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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$_2$O to enter quickly
- Drain well to avoid drowning plant roots
- Store H$_2$O for future plant use
- Resist pests, pathogens, and disease
- Help plants grow during ‘stressful’ events
One cup of soil holds as many bacteria as there are people on Earth.

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
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.
The whole is greater than the sum of its parts!
Soil Organisms Are the Engines Driving Soil Functions

- Organic Matter Dynamics
- Enhance Soil Structure
- Drivers of Nutrient Cycling
- Modify atmospheric composition
- Plant Protection
- Enhance Plant Growth
- Detoxify Pollutants

Photo credit: Aaron Roth, NRCS-OR; Slide design: Jen Moore Kucera, NRCS-SHD
AGGREGATES ARE HABITAT!
Soil Food Web Benefits: Formation & Stabilization of Aggregates

- 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

How do soil aggregates form?

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
Soil Food Web Benefits: Formation & Stabilization of Aggregates

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

How do soil aggregates form?

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

Glycoproteins on soil aggregates
Dr. Nichols, USDA-ARS

Bacteria (ovals) with ‘sticky’ polysaccharides (red arrows)

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

- Organic Matter
  - Modify atmospheric composition
  - Enhance Soil Structure & Stability
  - Influence soil temperature
  - Nutrient Storage & Release

- Soil Organisms
  - H₂O flow, storage, purity
  - Ecosystem Resiliency/Resistance
  - Detoxify Pollutants
  - Plant Protection
  - Influence soil pH

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

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

- Integrating Managed Grazing
- Minimizing Disturbance
- Maximizing Soil Cover
- Maximizing Diversity

Living Roots
Living Roots

Minimize Disturbance

Maximize Diversity

Maximize Soil Cover
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
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
Integrate Managed Grazing

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Cattle as catalysts for carbon!
Integrate Managed Grazing
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<th>Soil Health Principle</th>
<th>Orchard Management Practices</th>
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<td>MAXIMIZE COVER</td>
<td>• Cover crop between rows</td>
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<td></td>
<td>• Mulch in tree row</td>
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<tr>
<td>MAXIMIZE DIVERSITY</td>
<td>• Think between the rows</td>
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<td>MINIMIZE DISTURBANCE</td>
<td>• No-till</td>
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<td>LIVING ROOTS</td>
<td>• Cover crop</td>
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<td>• Think diversity</td>
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<td>Soil Health Principle</td>
<td>Pasture Management Practices</td>
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| 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!
Scale and Management Opportunities!
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