Basic Soil Health

Doug Peterson
MO/IA NRCS Regional Soil Health Specialist
What is the most limiting natural resource in your forage/crop production system?

Sunshine?
Minerals?
Water?
What is the most important item in the water cycle???
The Water Cycle
-Is it broken?
This is the same soil - What happened?

Both soils started with the same **Inherent** soil Properties soil:

- **climate** (precipitation and temperature)
- **topography** (shape of the land)
- **biota** (native vegetation, animals, and microbes)
- **parent material** (geologic and organic precursors to the soil)
- **time** (time that parent material is subject to soil formation processes)

62.8% loss of SOM after 17 yr intensive tillage

SOM = 4.3% in CT 17 yr - Soybean monoculture SOM = 1.6%
Dynamic properties depend both on land management and inherent properties of the soil:
• organic matter,
• soil structure,
• infiltration rate,
• bulk density,
• and water and nutrient holding capacity.

62.8% loss of SOM after 17 yr intensive tillage
After adding water

Water stable aggregates

photo by Ray Weil
If we know tillage degrades the soil so badly then why is tillage so engrained into our society?
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Why did tillage start?
Start of Tillage
Big Changes
Two Things Create Aggregation

1. “Biotic Glues” from Soil Organisms
Two Things Create Aggregation

2. “Exudates” from Plant Roots.
If We Focus On The Problem Of Poor Soil Health
The Symptoms Are Taken Care Of!!
Ranching/Farming in the 21st Century - a practical approach to soil health

- Manage more by disturbing less
- Diversity is Critical
- Feed your soil livestock all year long
- Keep the soil covered
- Integrate livestock
Using Cover Crops means understanding C:N Ratios and Mineralization and Immobilization
# Carbon to Nitrogen Ratio’s

<table>
<thead>
<tr>
<th>Material</th>
<th>C:N Ratio</th>
</tr>
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<tbody>
<tr>
<td>rye straw</td>
<td>82:1</td>
</tr>
<tr>
<td>wheat straw</td>
<td>80:1</td>
</tr>
<tr>
<td>oat straw</td>
<td>70:1</td>
</tr>
<tr>
<td>corn stover</td>
<td>57:1</td>
</tr>
<tr>
<td>rye cover crop (anthesis)</td>
<td>37:1</td>
</tr>
<tr>
<td>rye cover crop (vegetative)</td>
<td>26:1</td>
</tr>
<tr>
<td>mature alfalfa hay</td>
<td>25:1</td>
</tr>
<tr>
<td>Balanced Microbial Diet</td>
<td>24:1</td>
</tr>
<tr>
<td>rotted barnyard manure</td>
<td>20:1</td>
</tr>
<tr>
<td>daikon radish</td>
<td>19:1</td>
</tr>
<tr>
<td>legume hay</td>
<td>17:1</td>
</tr>
<tr>
<td>beef manure</td>
<td>17:1</td>
</tr>
<tr>
<td>ryegrass (vegetative)</td>
<td>15:1</td>
</tr>
<tr>
<td>young alfalfa hay</td>
<td>13:1</td>
</tr>
<tr>
<td>hairy vetch cover crop</td>
<td>11:1</td>
</tr>
<tr>
<td>soil microbes (average)</td>
<td>8:1</td>
</tr>
</tbody>
</table>
Nitrogen Mineralization

**Bacteria**
C:N ratio about 5:1

**Bacteria Feeding Nematode**
C:N ratio about 10:1
Nitrogen Mineralization

Bacteria
C:N ratio about 5:1

Bacteria Feeding Nematode
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Consume two bacteria to get enough carbon for function and reproduction
Nitrogen Mineralization

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Only Needs 1 part N
Nitrogen Mineralization

Bacteria
C:N ratio about 5:1

Consume two bacteria to get enough carbon for function and reproduction

Bacteria Feeding Nematode
C:N ratio about 10:1

Only Needs 1 part N

Excrete 1 part N to soil solution as Plant Available N
Plant available Nitrogen, exactly what we want...right???
Reduce N losses

- Nitrate mineralized from crop residues and soil OM is highly soluble through the winter
- N Leaching can exceed 50lb/ac. even without a fall N application.

Consider Cover Crops
“Catch and Release” Nutrients
Cover Crop Mgt for N Retention
Cover Crop Mgt for N Retention
Nitrogen Immobilization

Cover Crop
C:N ratio about 40:1

Bacteria
C:N ratio about 5:1
Nitrogen Immobilization

Cover Crop
C:N ratio about 40:1

Bacteria
C:N ratio about 5:1

Consume enough carbon from the rye for respiration & body structure
Nitrogen Immobilization

Cover Crop
C:N ratio about 40:1

Bacteria
C:N ratio about 5:1

Consume enough carbon from the rye for respiration & body structure
Nutrient Efficiency
Nutrient Efficiency
Nutrient Efficiency

Nitrogen Efficiency:
- 30-50% conventional
- Increase to 80-90% with Cover Crop & No-till

Phosphorus Efficiency:
- 50% conventional
- Increase to 80-90% with Cover Crop & No-till

Healthy Soils are FERTILE Soils
Healthy Soils mean Clean Water
Direct linkage between soil health and nutrient management/water quality issues

• Plant available sources of Nitrogen (Ammonium, Nitrate) are easily lost to groundwater or the atmosphere.

• Living cover crop is critical to Immobilizing N

• Nutrient management must be linked with soil health practices to be effective
Contact Information

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Ranching/Farming in the 21st Century - a practical approach to soil health

- Manage more by disturbing less
- Diversity is Critical
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Physical Disturbance in the form of tillage destroys the biological and ecological integrity of the soil ecosystem.

1. Disturbance stimulates the first responders - increased weed population

2. Destroys soil pores by shearing and smashing - impacts infiltration

3. Diminishes the soil's ability to respire

4. Disrupts the habitat of most microorganisms arthropods

5. Simplifies the soil fauna over time - fungi don’t like disturbance - Mycorrhizal fungi – uptake of P, Zn, Cu, Fe
No-till Systems are the Beginning of Cropland Soil Health
Chemical disturbances: excessive or repeated applications of pesticides, fertilizers and manures
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What does diversity really mean?

Cool Season Grass
Warm Season Grass
Cool Season Broadleaf
Warm Season Broadleaf
A Balanced Diet in Cropland?
A Balanced Diet in Cropland??
A Balanced Diet with Cover Crops

Oats and Radishes
A Balanced Diet of Crops in our Rotation?
A Balanced Diet of Crops in our Rotation?
A Balanced Diet of Crops in our Rotation?
Root Diversity

[Image of various plant root systems labeled with different species names]
<table>
<thead>
<tr>
<th>Depth</th>
<th>Ca</th>
<th>Mg</th>
<th>K</th>
<th>OM</th>
<th>pH(salt)</th>
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<tbody>
<tr>
<td>0-8</td>
<td>4560</td>
<td>484</td>
<td>234</td>
<td>3.5</td>
<td>6.1</td>
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<tr>
<td>8-13</td>
<td>2480</td>
<td>580</td>
<td>156</td>
<td>1</td>
<td>4.4</td>
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<tr>
<td>13-21</td>
<td>4600</td>
<td>1210</td>
<td>312</td>
<td>.86</td>
<td>4.3</td>
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<tr>
<td>21-28</td>
<td>4960</td>
<td>1355</td>
<td>312</td>
<td>.69</td>
<td>4.4</td>
</tr>
<tr>
<td>28-43</td>
<td>5120</td>
<td>1258</td>
<td>156</td>
<td>.34</td>
<td>4.9</td>
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<tr>
<td>43-51</td>
<td>6560</td>
<td>1452</td>
<td>78</td>
<td>.34</td>
<td>6</td>
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<tr>
<td>51-67</td>
<td>18360</td>
<td>871</td>
<td>78</td>
<td>0</td>
<td>7.6</td>
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<tr>
<td>67-74</td>
<td>17360</td>
<td>992</td>
<td>78</td>
<td>.17</td>
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<tr>
<td>74-78</td>
<td>15960</td>
<td>1065</td>
<td>78</td>
<td>0</td>
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NRCS Pedon M0717103, Armstrong,
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Soil Health

<table>
<thead>
<tr>
<th>Type of Organism</th>
<th>number/acre</th>
<th>pounds/acre</th>
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<tbody>
<tr>
<td>Bacteria</td>
<td>800,000,000,000,000,000,000,000</td>
<td>2,600</td>
</tr>
<tr>
<td>Actinobacteria</td>
<td>20,000,000,000,000,000,000,000</td>
<td>1,300</td>
</tr>
<tr>
<td>Fungi</td>
<td>200,000,000,000,000,000,000</td>
<td>2,600</td>
</tr>
<tr>
<td>Algae</td>
<td>4,000,000,000</td>
<td>90</td>
</tr>
<tr>
<td>Protozoa</td>
<td>2,000,000,000,000,000</td>
<td>90</td>
</tr>
<tr>
<td>Nematodes</td>
<td>80,000,000</td>
<td>45</td>
</tr>
<tr>
<td>Earthworms</td>
<td>40,000</td>
<td>445</td>
</tr>
<tr>
<td>Insects /arthropods</td>
<td>8,160,000</td>
<td>830</td>
</tr>
</tbody>
</table>

Soil Food Web