Soil Health

How to Lead Change

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Soil Health
Why it Matters
Nevin Dawson
Sustainable Agriculture Coordinator

UNIVERSITY OF MARYLAND EXTENSION
Solutions in your community

NORTHEAST SARE
Sustainable Agriculture Research & Education
Raise your hand if...

- You are a farmer
- You are an ag service provider
- You mostly advise agronomic crop growers
- You mostly advise vegetable growers
- You have a basic understanding of soil health
- You know everything about soil health
Context: Why Now?

- World population is estimated to be at 9.1 billion by 2050
- To sustain this level of growth, food production will need to rise by 70 percent
- Between 1982-2007, 14 million acres of prime farmland in the U.S. was lost to development
- Energy demands
  - Increase use of biofuels (40% of corn used for ethanol)
  - Increase use of fertilizer (use of Anhydrous up 48%, Urea up 93%)
"Modern agriculture diminishes the diversity of soil biota, thereby reducing long-term soil fertility. ... The variety of ways in which soil constituents can be processed and transformed by a diverse soil microbial community provides an energy-efficient, nonleaky, self-regulating system that can adapt to changing environments. ... An agricultural soil ecosystem that more closely approximates the close and efficient cycling in natural ecosystems ... is needed to increase agricultural production to the levels that will be required while minimizing its adverse effects."

Local Context

Building the health of your soil can generate more yield and more income
Soil Health

- The continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals, and humans
  - Nutrient cycling (storage, transformation, etc.)
  - Water (infiltration & availability)
  - Filtering and Buffering
  - Physical Stability and Support
  - Habitat for Biodiversity
Soil Health

- Soil Organisms
- Organic Matter
- Aggregate stability
- Limited Disturbance

What is Soil Health? Why Should I Care?

Soil health is the capacity of a soil to function. How well is your soil functioning to infiltrate water and cycle nutrients to water and feed growing plants?

Soil is a living factory of macroscopic and microscopic workers who need food to eat and places to live to do their work.

There are more individual organisms in a teaspoon of soil than there are people on earth; thus, the soil is controlled by these organisms.

Tillage, fertilizer, livestock, pesticides, and other management tools can be used to improve soil health, or they can significantly damage soil health if not applied correctly.

Managing for soil health (improved soil function) is mostly a matter of maintaining suitable habitat for the myriad of creatures that comprise the soil food web.

Managing for soil health can be accomplished by disturbing the soil as little as possible, growing as many different species of plants as practical, keeping living plants in the soil as often as possible, and keeping the soil covered all the time.

Diversify with Crop Diversity

Sugars made by plants are released from their roots into the soil and traded to soil microbes for nutrients to support plant growth.

The key to improving soil health is assuring that the food and energy chains and webs includes as many different plants or animals as practical.

Biodiversity is ultimately the key to success of any agricultural system. Lack of biodiversity severely limits the potential of any cropping system and disease and pest problems are increased.

A diverse and fully functioning soil food web provides for nutrient, energy, and water cycling that allows a soil to express its full potential.

Above ground diversity = Below ground diversity (plants) (soil food web)
Soil is a Living Factory

![Diagram of soil ecosystem](image-url)
Soil is a Living Factory

Microbes: **FBI**
- **Fungi**
  - Feed on dead OM
  - Attack other microbes
  - Symbiosis w/ plant roots
  - Particle stickiness

Bacteria
- Feed on OM
- Store/cycle nitrogen
- Decompose pesticides

Invertebrates
- Cycle nitrogen
- Shred OM
- Create pores
- Particle stickiness
How do microbes cycle nutrients?

Fertilizer
Compost
Manure

NO₃⁻

Immobilization

NO₃⁻

Mineralization

Mineral N

Organic N

Jarrod Miller, Univ. of MD Extension
Nitrogen Cycle

- **Mineralization** - Plant tissues (organic N) are broken down by microbes, releasing mineral (\(\text{NO}_3^-\), \(\text{NH}_3\)) nitrogen.

- **Immobilization** – Mineral nitrogen is taken up by organisms (plants, microbes)
Soil health

- Organic matter
  - FBI food
  - Nutrient stickiness
  - Particle stickiness
  - Carbon sink
  - Water storage
  - Water infiltration
  - Compaction mitigation
Texture Triangle

Jarrod Miller, Univ. of MD Extension
Soil Texture/Particle size

- Sand and silt – largest particles
- Clay - smallest

Jarrod Miller, Univ. of MD Extension
Why is soil texture important?

- **Sand**
  - Large pores, drains well
  - Low water sorption
  - Low compactability

- **Clay**
  - Small voids, drains slow
  - High water sorption
  - Highly compactable
Soil Structure

- The binding together of separate soil particles
  - Happens naturally
  - Enhanced by organic matter (aggregates)

Jarrod Miller, Univ. of MD Extension
Destroying aggregates affects macropores
Charge and water holding

Arrow is the "attractive" distance of soil particle

Jarrod Miller, Univ. of MD Extension
Soils can hold onto water but gravity pulls it down

Too wet - no air

Too dry – soil holds onto water, roots can’t get it

Jarrod Miller, Univ. of MD Extension
Maximum water held

Field capacity

Available

Unavailable

Maximum unavailable
Soil Water

- Soils that drain faster have
  - More sand
  - Better structure
  - Less dense

- Soils that hold more water have
  - More silt and clay
  - Better structure
  - Less dense

Jarrod Miller, Univ. of MD Extension
To increase water movement/holding

- Add organic matter as compost or manure
  - Builds structure
  - Organic matter also holds water

- Don’t till
  - Tillage destroys structure and large pores

- Avoid compaction
  - You may have to till where you have walked through the garden

Jarrod Miller, Univ. of MD Extension
Cation Exchange Capacity (CEC)

- Soils have negative charge (clay and organics)
- Many soil nutrients \( (\text{Ca}^{+2}, \text{Mg}^{+2}, \text{K}^{+1}, \text{Na}^{+1}) \) have positive charges (cations)
- Therefore, the soil can hold and exchange cations

Jarrod Miller, Univ. of MD Extension
Soil Charge, Texture, and OM

- Sand is usually quartz with low charge and surface area.
- Clay and organic matter have high charge and surface area.

Jarrod Miller, Univ. of MD Extension
Soil Organic Matter

Organic matter is 1-6% of total soil mass

“*The living, the dead, and the very dead*”
Vermont Agric Exp Sta Bullletin 135, 1908
Management Changes Soil Properties & Capacity of Soil to Function

62.8% loss of SOM after 17 yr intensive tillage

Forest
SOM = 4.3%

CT 17 yr- Soybean monoculture
SOM = 1.6%
Soil health

- Aggregate stability
  - Pore space
  - Water infiltration
- Limited disturbance
  - Allow Nature to do its job
  - Limit tillage as much as possible
  - Keep decomposition slow and steady
Soil is alive!

Start with mineral particles of sand, silt, or clays.

Add manures and compost, old leaves, and branches.

Let bacteria & fungi do their work. Feed & excrete, feed & excrete.

Soil binds together in sticky chunks. The ability to hold water and nutrients is increased.
Characteristics of a Stable Ecosystem

High Disturbance
Low Diversity
High Human inputs
Disrupted Eco services

Farm or Ranch

Bacterial
Natural Flow of Energy

Low Disturbance
High Diversity
Low Human Inputs
Highly Functioning Eco services

Fungal

Steady State

David Lamm, NRCS
Soil is a Living Factory

- Management activities improve or degrade soil health
  - Tillage
  - Fertilizer
  - Pesticides
  - Grazing
  - Plant Diversity
  - Cover Crops
Soil Health Evaluation

- Cornell
- Haney
- Solvita
# Crop Budget

[https://extension.umd.edu/grainmarketing/crop-budgets](https://extension.umd.edu/grainmarketing/crop-budgets)

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Quantity</th>
<th>Price</th>
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<td>Wheat</td>
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**Prices**

- Land charging within 20 miles of farm: $66.22
- Land charging over 20 miles of farm: $233.80
- Net income over variable and fixed costs listed above: $401.38
Long Term Soil Fertility and Water Storage Benefits

Cereal Rye-Soybeans
Cereal Rye/crimson clover/brassica-Corn

Soil Fertility Benefit
Water Storage Benefit
Amortized Soil Fertility Benefit
Amortized Water Storage Benefit
Financial Analysis Net Benefits

Cereal Rye-Soybeans
Cereal Rye/crimson clover/brassica-Corn

$100.00
$80.00
$60.00
$40.00
$20.00
$0.00
-$20.00

$/acre

Years
Sediment runoff from conventional-till field

Is the Buffer working?

Gabe Brown - ND
Ray McCormick - IN
Dave Brandt - OH
Brendon Rockey - CO
Ray Styer - NC

6/2007
Ray Styer - NC

- Old tobacco farm
- 70 acres of silage corn
- Rotates with multi-species cover crop cocktails
- No commercial fertilizer since 2000
Dave Brandt - OH

- Corn-Soybean-Wheat
- Using no-till and cover crops since 1970s
- Uses a split-row planter to seed a row of tillage radish and a legume
- More recently incorporated cover crop cocktails
Gabe Brown - ND

- 2000+ acres of cropland
- 4000 acres of range and pasture
- 16 inches of precipitation (compare to 43.2 inches in Denton, MD)
- Reduced inputs (fertilizer, herbicides, etc.) by more than 75%
- No fallow in rotation
- Grazes on cover crops
Ray McCormick - IN

- Corn and soybeans
- No till and cover crops.
- Seeds his cover crops as he is harvesting his crops
  - Uses special seeder attached to his combine that seeds as he is harvesting
Brendon Rockey - CO

- Potato farmer
- Rotates cover crops with potato and companion crops in potato
Conclusions

- Manage More by Disturbing Less
- Diversify with Crop Diversity
- Grow Living Roots throughout the year
- Keep the Soil Covered
Cover Crop Anthem

Questions?

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