Soil Health:

An Ecological Understanding to Soil Function

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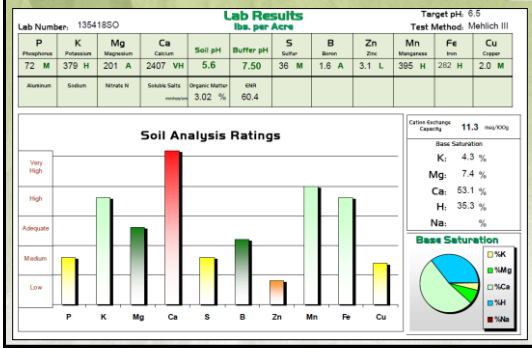
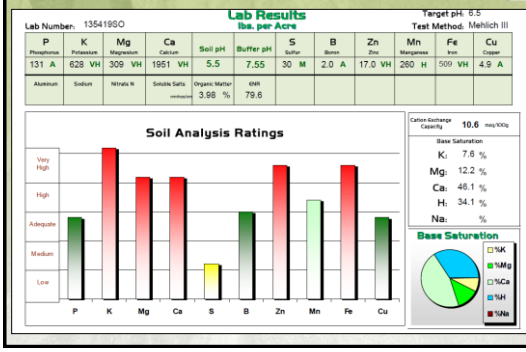
SOIL QUALITY/HEALTH:

The continued capacity of the soil to function as a vital living system that sustains plant, animal, and human health.

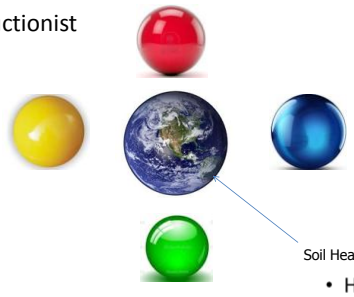
Typical Soil Test





Methods of Thought

- Reductionist



Soil Health

- Holistic

Why a Soil Health push in 2015?

- Because we finally are starting to recognize how the soil is designed to function – biologically / ecologically.
- Economics of energy & labor
- Pressure of environmental regulations
- World population is estimated to be 9 billion by 2050, need 70% more food.
- Between 1982-2007, 14 million acres of prime farmland in the U.S. was lost to development.

Why Should We Care?

Paradigm Shifts

- Paradigm shift #1 Stop treating the symptoms of dysfunctional soil; solve the problem of dysfunctional soil.
- Paradigm shift #2 Restoring soil function can be accomplished without going broke.
  - Apply basic principles of ecology to create quality habitat.
  - There is no waste in Nature.
- Paradigm shift #3 Conservation practices do not restore soil health, understanding soil function restores soil health.

Do not accept a degraded soil!

Soil function can be restored (with proper management) in a dog's lifetime.

Replace "I'll believe it when I see it" with "I'll be able to see it when I believe it can be done."

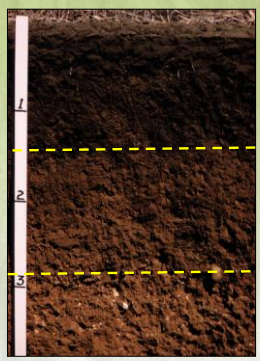
What do you see? Healthy or Not?

What Functions Do You Expect Your Soil to Perform?

- Grow Crops
  - Infiltrate Water
  - Supply Nutrients
    - How does soil perform these functions?

Soil Profile

Physical Characteristics
- Texture
- Structure
- Color
- Define horizon boundaries



A Horizon

B Horizon

C Horizon

Properties of Soil Heath:

Inherent Properties:
Physical properties that usually cannot be changed without much difficulty

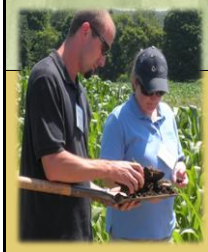
- Soil texture
- Type of clay
- Depth to bedrock
- Drainage class

Dynamic Properties:
Management dependant properties that we do have the ability to change relatively easily

- Organic matter content
- Biological activity
- Aggregate stability
- Infiltration
- Soil fertility
- Soil reaction (pH)

Indicators of Soil Health:

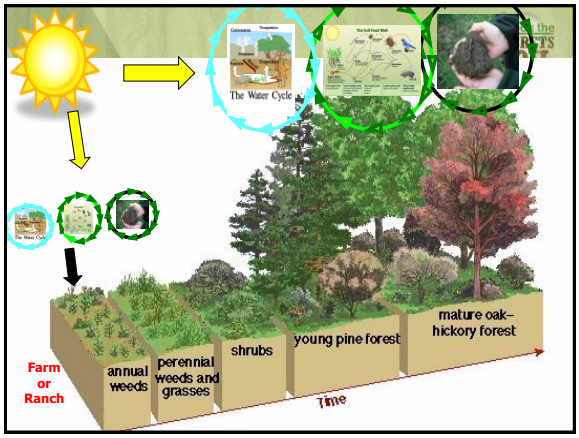
Physical indicators commonly used to assess agronomic soil quality include:



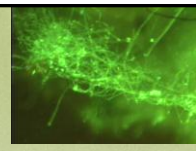
- Aggregate stability
- Available water holding capacity
- Bulk density
- Infiltration
- Slaking
- Soil crusts
- Soil structure and macropores

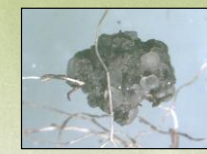
Soil is a Living Factory

- Macroscopic and microscopic organisms
  - Food
  - Water
  - Shelter
  - Habitat
  - Powered by sunlight
- Management activities improve or degrade soil health
  - Tillage
  - Fertilizer
  - Pesticides
  - Grazing
  - Plant Diversity



Glue-makers

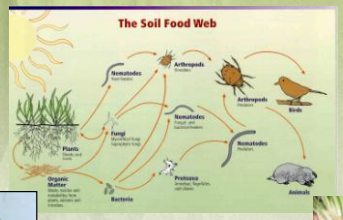




- It's all about the Food
- Bacteria – stick it to me.
  - microaggregation
- Fungi – seal the pipes.
  - Macroaggregation
- Aggregates are habitat
- Microbes must be well fed to make good aggregates.

Create Quality Microbial Habitat

Every Farmer has Livestock



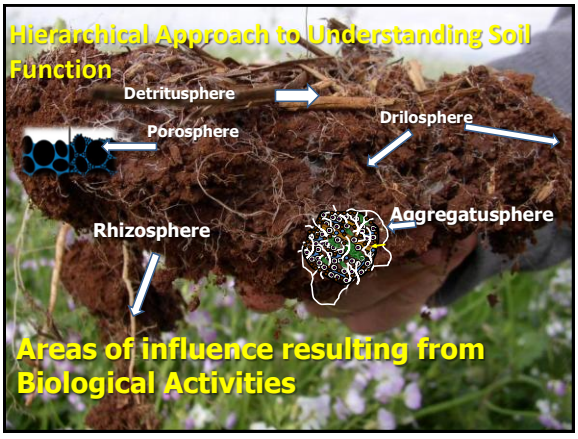
What the Soil Foodweb Does

- Plant nutrient immobilization / mineralization
- Creates stable soil aggregates
  - Water infiltration / retention
  - Habitat for soil foodweb
  - Root movement
  - Nematode, microarthropod movement
  - Air movement

What is the most limiting element in the soil for agricultural production?

Where does the Carbon contained in the soil come from?

Hierarchical Approach to Understanding Soil Function



Rhizosphere…where roots meet soil

Zone of concentrated biological activity adjacent to the root…

- Bacteria
- Fungi
- Protozoa
- Nematodes
- Microarthropods
- Earthworms

Managing for Soil Health

Principles of Managing for Soil Health

- Minimize Disturbance of the soil
- Maximize Diversity of plants in rotation
- Keep Living Roots in the soil as much as possible
- Keep the soil covered with plants and plant residues
- Create the most favorable habitat possible for the soil food web

Caution!

- Do not make implementation of tools a goal.
- If your goal is improving soil health; then no-tillage, crop rotation, cover crops, etc. can be excellent tools.
- The devil is in the details, you must become a student of the tools without losing sight of the **goal** of building soil health.

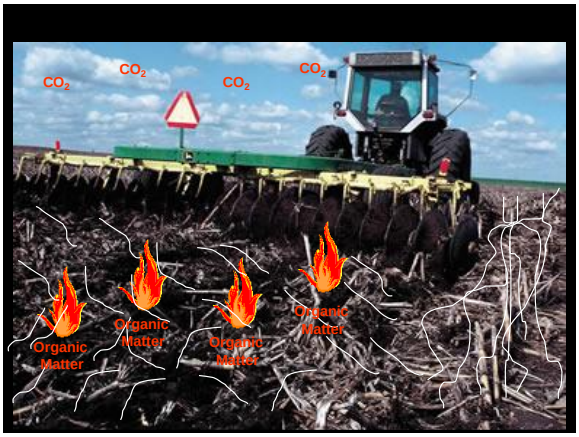
Soil Health Toolbox

- (No) Tillage
- Crop Rotation Diversity
- Cover Crops
- Degree of Fertilizer use
- Degree of Pesticide use
- Livestock

Which of these tools could positively affect soil health on your farm?

Reduce/Eliminate Tillage of the Soil

- Tillage is physical soil disturbance
  - Destroys aggregates
  - Exposes organic matter to decomposition
  - Facilitates compaction
  - Damages soil fungi
  - Reduces habitat for all members of SFW
  - Disrupts soil pore continuity
  - Promotes salinity at the soil surface



Chemical Soil Disturbance from Fertilizer

- Excessive nitrogen or phosphorus fertilizer…
  - Short-circuits the rhizosphere
  - Depresses activity of natural N fixers
  - Stimulates bacterial decomposition of SOM
  - N at risk for leaching or denitrification
  - Synthetic fertilizers are salts (salinity)

Chemical Soil Disturbance from Pesticide use

- Impact of pesticides on non-target organisms not well understood.
- Pesticides simplify, not diversify SFW
- Crop rotation restrictions
- Cover crop diversity restrictions

Use Diversity of Plants to add diversity to Soil Organisms

- Plants interact with particular microbes
  - Trade sugar from roots for nutrients
- Microbes convert plant material to OM
- Requires a diversity of plant carbohydrates to support the variety of microbes
- Lack of plant diversity will drive system to favor some microbes more than others

Plant Diversity through crop rotation / cover crops

- Crop diversity = Soil Food Web diversity
- Diversity
  - Balanced/Diverse diet to Soil Food Web
  - Help Reduce pest pressure
  - Help Increase soil nutrient cycling
  - Reduces risk
  - Spreads workload

Crop Rotation / Cover Crops

- Increased influence of living roots
  - Feeds Soil Food Web
  - Increase soil aggregation and porosity to increase available water holding capacity
  - Use any excess water to address salinity
  - Stimulate SFW into increased activity
  - Integrate grazing
  - Nitrogen fixation/recovery

Simplified Crop Classification

- Plant morphology
  - Broad leaf
  - Grasses
- Plant growth habits
  - Cool season
  - Warm season

Keep the soil covered

- Leave crop residues in place after harvest
- Cover crops
- Perennials in rotation
- Balance cover with decomposition

Livestock

- Add and distribute biology to soil
- Cycle residues, reduce C:N ratios
- Put plant residues in contact with soil
- Opportunity for increased income
- Increase intensity & reduce duration to improve soil health on rangeland

Benefits of Managing for Soil Health

- Improved Nutrient Cycling
  - NDSU 50#/ac N credit for long term no-till
  - Fungi increase P and water supply to plants
- Improved soil aggregation
  - Increased water movement and storage
  - Better root growth into more soil
  - Better habitat for the Soil Food Web
- Fewer weeds and diseases
  - A balanced Food Web helps suppress pests
  - Less soil disturbance plants fewer weed seeds

How do we know if soil health is improving?

- Soil aggregate stability increases
- Water infiltration increases
- Organic matter increases
- Crop response
- Reduced input costs
- Soil Food Web analysis

Contact Information

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Questions / Discussion