Soils and their Sustainable Management

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What is Soil?

• the living skin of the Earth (Ian Pepper, soil microbiologist)
• crucible of terrestrial life (Daniel Hillel, soil physicist)
• the pedosphere
  • the interface between the lithosphere, hydrosphere and atmosphere (ecologists)
• a medium for plant growth
• phenomena of nature (natural bodies)
What are Soils?

- reactive, dynamic, three-phase ecosystems composed of solids, liquids and gases

- Topsoil several days after rainfall or irrigation

- Minerals: 48%
- Air: 25%
- Water: 25%
- Organic Matter: 2%
FIGURE 3-8 The soil triangle is redrawn to show fine-, medium-, and coarse-textured soils. An exception is very fine sandy loam, which is considered medium textured.
<table>
<thead>
<tr>
<th>Property</th>
<th>Fine Texture</th>
<th>Medium Texture</th>
<th>Coarse Texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available Water Capacity</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Nutrient Holding Capacity (CEC)</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Infiltration &amp; Percolation</td>
<td>Slow</td>
<td>Medium</td>
<td>Fast</td>
</tr>
<tr>
<td>Crusting</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Compaction</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
</tbody>
</table>
Harsh Reality!

• textural groupings set the stage for many physical properties
  – parent material
  – time

• management can ameliorate extremes to a certain extent
The Other Soil Solid Material: Organic Matter

- Humus: 75%
- Biomass: 10%
- Residues & By-Products: 15%
The Soil Food Web

Source: USDA

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

Plants
Shoots and roots

Organic Matter
Waste, residue and metabolites from plants, animals and microbes.

Nematodes
Root-feeders

Arthropods
Shredders

Fungi
Mycorrhizal fungi
Saprophytic fungi

Nematodes
Fungal- and bacterial-feeders

Protozoa
Amoebae, flagellates, and ciliates

Bacteria

Arthropods
Predators

Nematodes
Predators

Arthropods
Predators

Birds

Animals
Biomass: What It Does

• participates in nutrient cycling
  – comminute (shred or fragment) plant and animal residues, using what they can utilize and leaving behind what they cannot

• mineralization
  – conversion of organic form of an element to an inorganic form
  – protein to amino acid to ammonium
Biomass: What It Does (cont.)

• creation of biopores
  – larger organisms move through soil creating channels or pores
  • channels promote water infiltration and create a healthy balance between large and medium pores
  – disseminate spores and microbes
Resources about Soil Organisms

TED Talk – How Bacteria “Talk”
http://www.ted.com/talks/bonnie_bassler_on_how_bacteria_communicate.html

Soil Biology Primer
Residues and By-products: What They Are

• **dead stuff**
  – crop residues, dead roots and bodies of soil creatures

• **by-products**
  – materials that plant roots and soil creatures release or exude into the soil
Residues and By-products: What They Do

• fuel and nutrients for soil organisms
  – energy and nutrient source for most of the soil creatures

• formation and maintenance of soil aggregates (structure or architecture)
  – sticky and gummy by-products of residue decomposition hold soil particles together in clumps or aggregates
Humus

- relatively stable end product of residue decomposition
- composes the majority of organic matter
- resists further decomposition (1% per year)
- it is not a good nutrient or energy source for soil creatures
Humus: What It Does

• very small in particle size & high surface area

• charged sites at many locations on the surface

• effective at holding water and nutrients
Mantra

Soil is a living factory of macroscopic and microscopic workers who need food to eat and places to do their work. USDA-NRCS
So, what about the pore space...
Different Pores Perform Different Functions

- macropores (large pores)
  - drain quickly after rain or irrigation
  - allow rapid infiltration of rainfall and replenishment of oxygen in the root zone

- mesopores (medium-sized pores)
  - “storage pores”
  - hold water in a form most plants can use

- micropores (very small pores)
  - water is held too tightly to be use to most plants
Soil Aeration – the interplay between water and air
Pore space

- Residues & by-products
  - Micro
  - Meso
  - Macro
  - Biomass

- Organic solids
  - Humus

- Inorganic solids
  - Clay layer minerals
  - Oxides
  - Clay

- Soil
- Solution
- Sand
- Silt
- Air

Organic solids

Inorganic solids

Pore space
Characteristics of a Sustainably Managed Soil

- fertile but not excessive in nutrient status
- holds adequate water for plant growth
- allows rainfall or irrigation to infiltrate yet provides adequate aeration
- has good tilth
- has surface protection
- contains adequate beneficials/minimal pathogens
What is a fertile soil?

• one that provides an adequate supply of all nutrients throughout the entire growing season

• test soil to determine if soil is too acidic and major nutrients are in inadequate supply
  – lime first, then add other nutrients when needed
soil acidity: the adverse condition in the soil solution in humid regions
## Soil Tests and Their Interpretation

<table>
<thead>
<tr>
<th>Soil Test Category</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>very low, low</td>
<td>nutrient will limiting plant growth</td>
</tr>
<tr>
<td>medium</td>
<td>nutrient may not be limiting; addition of nutrient advisable</td>
</tr>
<tr>
<td>sufficient, optimum or high</td>
<td>nutrient supply is OK; no more is needed</td>
</tr>
<tr>
<td>high, very high or excessive</td>
<td>nutrient supply is more than adequate; no more is needed</td>
</tr>
</tbody>
</table>
Soil test results
Protect the Soil Surface – Why?

• minimizes erosion
• protects soil aggregates
• conserves moisture
• moderates soil temperature
Protect the Soil Surface – How?

• protect soil from direct impact of rainfall
  – encourage a complete crop canopy
  – mulch

• plant a cool season cover crop

• minimize bare soil all seasons of the year!
May - Aug  |  Sept - Nov  |  Dec - Apr

E  |  P  |  E + T

Ground water  |  Precipitation  |  Surface runoff
E  |  T  |  P
Evaporation  |  Transpiration  |  Percolation
Compaction

• bulk density high enough or pore space low enough to negatively impact plant growth

• bulk density >1.6 grams per cubic centimeter or pore space <40% will restrict root growth

• information on either is difficult to obtain
Many subsoils in Maryland’s Piedmont are high in bulk density and low in porosity
Soil Tilth

• a soil property that assesses the suitability of soil to support plant growth

• a physical condition of a soil that relates to its ease of tillage, the impedance of seedling emergence and root penetration
Practically speaking, what does good tilth look like?

• compaction is absent in the entire root zone
• soil does not crust after a rain
• soil is firm when dry and friable (crumbly) when moist
• drains well after rainfall
Tips for Maintaining Good Tilth

• add organic matter
  – food for most soil creatures (heterotrophs)
  – amendments
  – cover crops**
    • warm and cool season choices

• use mulch
  – moderates temperature and moisture content
  – protects soil from crusting and erosion

• minimize extreme tillage
  – rototilling
Are you managing your fields sustainably?

• Are the major macronutrients in the optimal range based on soil test?
• Is it friable and crumbly when moist?
• Is root growth restricted in the subsoil?
• Does water pond after significant rainfall?
• Do rills form during rainfall?
Who Needs a Plan?

Any agricultural operation or farm that

• tills, crops, pastures animals, or produces an agricultural product, and

• has a gross annual income of $2500 or more or 8 animal units (1 animal unit = 1000 lbs. of live weight).
What is a Nutrient Management Plan?

• a written, site-specific plan

• specifies the amount, placement, and timing of all nutrient applications (manure, fertilizer, or other nutrient sources)
What Information Must Be Provided?

• soil tests for each field and pasture
• manure or compost analysis
• type and number of animals
• amount and type of bedding
• days or hours per day on pasture vs. confinement
What Information Will I Be Asked to Provide? (cont.)

• farm map
  – FSA office
  – hand drawn is acceptable

• tax account ID numbers
  – from tax bill or assessment
Duration of Plans

• Most plans are updated annually; however, plans can be written to cover a three-year period under some conditions.

• Soil tests & nutrient source are the limiting factors
  – a soil test is considered current for 3 years
  – organic nutrient sources are tested each year
Where Can I Get a Nutrient Management Plan?

• Certified Nutrient Management Consultants
  – private-sector consultants
  – public-sector consultants (University of Maryland Extension advisors)

• Certified Farmer Operators
  – UME Baltimore series (March & early April)
Questions? Comments?

INTERNATIONAL YEAR OF SOILS 2015

USDA-NRCS SOIL HEALTH INFOGRAPHIC SERIES #001

science of healthy soil

healthy soil is
made of about 45% minerals,
25% water,
5% organic matter, 25% air

Source: The Nature & Properties of Soils page 17
(Nyle Brady, Ray R. Weil)

USDA United States Department of Agriculture

Want more soil secrets?
Check out www.nrcs.usda.gov

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