Soil: Definition and Basic Properties

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Soil Defined: USDA-Natural Resources Conservation Service

- “Soil...is a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following:
  - horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter
  - or the ability to support rooted plants in a natural environment.”
  (Soil Survey Staff, 1999)
Soil Defined: USDA-Natural Resources Conservation Service

- “…a natural body…”
  - Forms naturally in terrestrial ecosystems
  - Not man-made
Soil Defined: USDA-Natural Resources Conservation Service

- “comprised of solids (minerals and organic matter), liquid, and gases...”
Soil Defined: USDA-Natural Resources Conservation Service

- “...occurs on the land surface,...”
- “...occupies space...”
- Has “horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy or matter, or
- Has “the ability to support rooted plants in a natural environment”
Soil Formation (briefly)

- Soil vs. Dirt
- Soil forming factors
  - Parent material, climate, biology, relief and time
- North Carolina has about 400 soil series
- United States has about 20,000 soil series
Soil Defined

- “Nature has endowed the Earth with glorious wonders and vast resources that man may use for his own ends. Regardless of our tastes or our way of living, there are none that present more variations to tax our imagination than the soil, and certainly none so important to our ancestors, to ourselves, and to our children.”

- Dr. Charles E. Kellogg, The Soils That Support Us, 1956
Basic Soil Properties

Soil Science: Edaphology vs. Pedology

- **Edaphology**
  - the study of how soil affects the way humans use the land, especially for growing plants
  - Involves soil fertility

- **Pedology**
  - The study of soil classification, pedogenesis and soil morphology
  - Involves differentiating soil types, to a large extent, based on their morphology—how they look and feel
Soil Master Horizons

- Surface horizons
  - O horizon
  - A horizon
- Subsurface horizon
  - E horizon
- Subsoil horizons
  - B horizon
  - BC horizon
- Substrate (Parent Material)
  - C horizon
  - Cr horizon
  - R horizon

Solum

O (humus or organic)
A (topsoil)
E (eluviated horizon)
B (subsoil) (zone of illuviation)
C (parent material) (saprolite)
R (bedrock)
Soil Depth Classes

<table>
<thead>
<tr>
<th>Soil Depth Classes* (depth to Cr or R layer)</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Very shallow</td>
<td>&lt;25 cm (&lt;10 inches)</td>
</tr>
<tr>
<td>Shallow</td>
<td>25 – 50 cm (10-20 inches)</td>
</tr>
<tr>
<td>Moderately deep</td>
<td>50-90 cm (20-36 inches)</td>
</tr>
<tr>
<td>Deep</td>
<td>90-150 cm (36-60 inches)</td>
</tr>
<tr>
<td>Very deep</td>
<td>&gt;150 cm (&gt;60 inches)</td>
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</tbody>
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*Soil Survey Manual, USDA-NRCS
Craggy series

- Shallow soils found on upland ridges and sides slopes
- Well defined A horizon(s) to a depth of about 10-20 inches (granular structure)
- Usually no B horizon (no translocation of fines)
- Horizon sequence: A - R
Appling series

- Very deep soils on Piedmont uplands
- Well defined A and E horizons (granular structure)
- Well defined B horizon (blocky structure)
- Horizon sequence: A - E - B - C
  - C horizon at >40 inches, and...
  - Extends tens of feet deep
Wake series

- Shallow soils on Piedmont uplands
- Well defined A horizon 0 to about 6 inches (granular structure)
- C horizon from about 6 to 12 inches (massive or rock controlled structure)
- R layer hard granitic bedrock below about 12 inches
- Horizon sequence: A - C - R
Duplin series

- Very deep soils (MWD) on Coastal Plain uplands
- Well defined A horizon 0 to about 8 inches (granular structure)
- E horizon is present, from about 8 to 12 inches
- Bt1 horizon (12-22 inches) is sandy clay with weak blocky structure
- Bt2 and Bt3 horizons are sandy clays with blocky structure and distinct mottling
- Horizon sequence: A - E - B - C
Duckston series

- Very deep (PD) soils found between coastal dunes and on fringes of marshland
- Distinct A₁ horizon with accumulation of organic matter
- A₂ horizon with sandy texture and single grained structure
- Cg horizon suggests extensive inundation or location of permanent water table
- Horizon sequence: O(?) - A - C
Soil Color

- Most obvious soil characteristic
- Has little or no effect on behavior and use of soil
- However, provides clues about other soil properties and conditions
Soil Color: Munsell Color Charts

Most Red
- 5R
- 7.5R
- 10R
- 2.5YR
- 5YR
- 7.5YR
- 10YR
- 2.5Y
- 5Y

Most Yellow
Soil Color: Munsell Color Charts

- **Hue**
  - Redness or Yellowness of soil
- **Value**
  - Lightness or darkness of hue
- **Chroma**
  - Intensity or brightness of hue

Example Calls:
- 5YR 5/8 (yellowish-red)
- 10YR 5/8 (yellowish brown)
- 10YR 6/2 (light brownish gray)
Soil Color: Three Factors Influencing Soil Color

- Organic matter content
- Water content
- Presence and oxidation states of iron and manganese oxides
Soil Color and Organic Matter Content

- Organic matter darkens the soil
  - Additions of decaying flora and fauna on the soil surface—A horizon
  - Wet and/or cool soils have thicker dark surfaces

- Spodosols
  - Translocation of organic material forming a dark subsurface horizon
Soil Color and Water Content

- Used to determine Seasonal High Water Table
  - Low chroma colors (values ≥4 and chromas ≤2)
    - AKA: redox depletions, gray mottles or gray matrix
    - SHWT placed where low chroma colors closest to the soil surface

- Used to determine Soil Drainage Class
  - Well-drained: ≥40 inches
  - Moderately well-drained: <40 inches, but upper Bt is depletion free
  - Somewhat poorly-drained: Depletions just below A horizon, but bright matrix
  - Poorly-drained: Depleted matrix below A horizon with ochric surface
  - Very poorly-drained: Depleted matrix below A horizon with umbric surface
Soil Color and Water Content

- Soil color used to determine Seasonal High Water Table/Drainage Class
Soil Color and Fe Oxidation States

- Iron (Fe) primarily responsible for red and yellow soil colors
  - 3rd most common element in soil behind oxygen and silica
  - Silica & oxygen together white to gray
  - Fe oxides “paint” soil particles red and yellow
    - Geothite is yellow
    - Hematite is red

- Oxidized iron: ferric valence state (Fe$^{3+}$)
  - Dry, aerobic, oxidized soil
  - Oxygen primary element for microbial respiration

- Reduced iron: ferrous valence state (Fe$^{2+}$)
  - Saturated, anaerobic reduced soil
  - Fe and other elements used for microbial respiration
Oxidation-Reduction in Soils

- Needs organic matter, active microbes, >5°C temp, Fe oxides, ↓pH
- \( O_2 + 4e^- + 4H^+ \rightarrow 2H_2O \)
- \( 2NO_3^- + 10e^- + 10H^+ \rightarrow N_2 + 6H_2O \)  **Denitrification**
- \( MnO_2 + 2e^- + 4H^+ \rightarrow Mn^{2+} + 2H_2O \)  **Manganese Reduction**
- \( Fe(OH)_3 + e^- + 3H^+ \rightarrow Fe^{2+} + 3H_2O \)  **Iron Reduction**
- \( SO_4^{2-} + 8e^- + 9H^+ \rightarrow HS^- + 4H_2O \)  **Sulphate Reduction**
- \( CO_2 + 8e^- + 8H^+ \rightarrow CH_4 + 2H_2O \)  **Carbon Dioxide Reduction**
Soil Color and Fe Oxidation States

Faceville

Goldsboro

Grady (clayey Rains)
Soil Texture

**Definition**

- Relative proportion of sand, silt and clay
Soil Texture: Fine Earth Fragment

- Relative sizes of sand, silt & clay particles
  - Sand = gritty
  - Silt = smooth, talc-like
  - Clay = sticky, plastic

- Formation
  - Sand & silt = mechanical weathering
  - Clay = chemical weathering

- Surface area
  - Sand & silt = chemically inert
  - Clay = chemically active
Soil Texture—Flow Chart

Soil Texture By Feel Flow Chart

Start

Place approximately two teaspoons of soil in your palm. Add a few drops of water and kneed soil to break down all the aggregates. Soil is at proper consistancy when it feels plastic and moldable, like moist putty.

Does the soil remain in a ball when squeezed?

Yes

Is the soil too dry?

No

Is the soil too wet?

No

Yes

Add dry soil to soak up water

No

Sand

Loamy Sand

Place ball of soil between thumb and forefinger, gently pushing the soil with your thumb, squeezing it upward into a ribbon. Form a ribbon of uniform thickness and width. Allow the ribbon to emerge and extend over forefinger, breaking from its own weight. Does the soil form a ribbon?

Yes

No

Does soil make a weak ribbon < 1" long before it breaks?

Does soil make a medium ribbon 1/2" long before it breaks?

Does soil make a strong ribbon > 2" long before it breaks?

Yes

No

Excessively wet a small pinch of soil in your palm and rub it with your forefinger.

Does soil feel very gritty?

Yes

Sandy Loam

Sandy Clay Loam

Sandy Clay

No

Neither gritty nor smooth?

Leaves

Neither gritty nor smooth?

No

Loam

Clay

Silt Loam

Silty Clay

Silty Clay
Clay Types and Charge

- 1:1 clays vs. 2:1 clays
- Stability vs. Shrink-Swell
- Sources of charge
  - pH dependent surface charge
  - Isomorphs substitution
pH dependent charge

pH-dependent charge

Low pH  Neutral pH  High pH
Clay structure & charge
Humus exchange sites

Large complex organic humus molecule consisting of chains and rings of mainly carbon and hydrogen atoms.

- Carboxyl group
- Phenolic hydroxyl group
- Alcoholic hydroxyl group
Images of Clay
Soil Structure—Types of Soil Structure

- Relates to the arrangement of sand, silt, clay and organic particles in soils.
- These particles become aggregated together due to various forces and at different scales to form distinctive structural units called **peds**.
Soil Structure—Granular (Crumb)
Soil Structure—Angular & Subangular Blocky

Angular Blocky

Subangular Blocky
Soil Structure--Platy
Soil Structure—Prismatic and Columnar

Prismatic

Columnar
Soil Structure—Massive (Structureless)

Massive (M)

Single Grain (SG)
Soil Structure—Grade and Size Class

- **Grade**
  - How well structure is expressed.

- **Grades**
  - Weak (1)
    - Peds barely observable in-situ or in hand.
  - Moderate (2)
    - Peds well-formed in-situ or in hand.
  - Strong (3)
    - Peds distinct in-situ and separate cleanly when disturbed.

- **Size Class**

- **Granular**
  - Very Fine (<1 mm)—vf
  - Fine (1 to <2 mm)—f
  - Medium (2 to <5 mm)—m
  - Coarse 5 to <10 mm)—co
  - Very Coarse (≥10 mm)—vco

- **Blocky**
  - Very Fine (<5 mm)
  - Fine (5 to <10 mm)
  - Medium (10 to <20 mm)
  - Coarse 20 to <50 mm)
  - Very Coarse (≥50 mm)

Example Calls: “1mgr” or “3msbk”
Soil Consistence

Definition—the resistance of soil to deformation or rupture under an applied stress.

- Moist Soil (Friability)
  - Loose (l)—single grain structure
  - V. Friable (vfr)—very slight force
  - Friable (fr)—slight force
  - Firm (fi)—moderate force
  - V. Firm (vfi)—strong force
Wet Consistence

- **Wet Soil (Stickiness, Plasticity)**
  - **Stickiness**
    - Non-Sticky—Little adherence to fingers
    - Slightly Sticky—Adheres, little stretch
    - Mod. Sticky—Adheres, some stretch
    - V. Sticky—Adheres firmly, stretches
  - **Plasticity**
    - Non-Plastic—can’t form 6 mm rod
    - Slightly Plastic—6 mm forms, 4 mm not
    - Moderately Plastic—4 mm yes, 2 mm no
    - Very Plastic—2 mm forms and supports weight
Basic Soil Properties Summary

- Provide a basis for classifying soil
  - Soil properties occur within a range of characteristics for a particular soil series
  - Not all are morphologically deduced. Lab data needed for some distinctions.

- Provide a basis for interpreting soils for various uses