Basic Soil Properties
Three Categories of Soil Properties

- **Physical**: texture (proportions of sand, silt and clay), structure, bulk density, moisture, infiltration, porosity
- **Chemical**: nutrient content, salinity, pH, organic matter, mineral content (parent material)
- **Biological**: activity of microbes (bacteria, fungi), biomass, biodiversity, biological activity
Major Soil Components

- Water: 25%
- Minerals: 45%
- Air: 25%
- Organic Matter: 5%
Soil Descriptors

• **Texture:** Relative proportion of sand, silt, and clay in the soil
• **Structure:** Forms the soil takes as particles clump together
• **Peds:** Structural units of soil
• **Bulk Density:** A soil’s weight per volume
• **Horizon:** Layer of soil with somewhat uniform color, texture, and structure
• **Profile:** Vertical soil section showing layers of development
Soil Texture

• Relative proportions of sand, silt, and clay in the soil
• These proportions affect how soil feels to the touch, thus the term “texture”
• Sand are the largest particles
  *feel “gritty”*
• Silt are medium sized
  *feel soft, silky or “floury”*
• Clay are the smallest sized particles
  *feel “sticky”*
Sand

- Gritty feel
- Particles can be seen with the naked eye
- Hand sampling: No residue left on hand
Silt

- Dry: Powdery smooth feel, flour-like
- Wet: Creamy slick, slippery feel
- No sticky or plastic feel
- Particles can be seen with a hand lens or microscope
- Hand sampling: Coats hand, able to brush off
Clay

- Wet: Sticky, plastic feel
- Dry: Hard feel
- Particles can be seen with an electron microscope
- Hand Sampling:
  - Sticks to fingers

About.com & http://thedirtduke.blogspot.com/
Soil Texture Classification

• The proportions of different sized mineral particles in the soil or the relative amount of sand, silt, and clay present in the soil expressed as percentages

• There are 12 textural class categories
Soil & Water: Basic Soil Properties

Agronomy 105
Soil Texture By Feel Flow Chart

Start

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

Yes

Does the soil remain in a ball when squeezed?

No

Is the soil too dry?

Yes

Add dry soil to soak up water

No

Is the soil too wet?

Yes

Is the soil too wet?

No

Sand

Yes

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?

No

Loamy Sand

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

- **Does soil make a weak ribbon < 1” long before it breaks?**
  - Yes: Sandy Loam
  - No: Sandy Clay Loam

- **Does soil make a medium ribbon 1-2” long before it breaks?**
  - Yes: Sandy Clay
  - No: Clay

- **Does soil make a strong ribbon > 2” long before it breaks?**
  - Yes: Sandy Clay
  - No: Silty Clay Loam

- **Does soil feel very gritty?**
  - Yes: Sandy Loam, Sandy Clay
  - No: Loam

- **Neither gritty nor smooth?**
  - Yes: Loam, Clay
  - No: Silty Loam, Silty Clay

- **Does soil feel very smooth?**
  - Yes: Loam, Clay
  - No: Silty Loam, Silty Clay
Determining Soil Texture in a Lab

*Hydrometer measures Relative Density of Liquids*
Particle Size Analysis

• Which soil particle would you expect to settle first:
  – Clay?
  – Silt?
  – Sand?
Soil Texture and Surface Area

• As particle size decreases, surface area increases
  – For the same volume, clay has about 10,000 times as much surface area as sand

• Surface area has a big effect on:
  – Water holding capacity
  – Chemical reactions
  – Soil cohesion
  – Ability to support microorganisms

• A loam is a mixture of sand, silt and clay
Soil texture and Plant Available Water

[Diagram showing the relationship between soil texture and plant available water, with labels for field capacity, wilting point, available water, and unavailable water.]
Well-Drained Soils

• Change temperature more quickly—warm up quicker in spring
• Colors tend more brown, red, or orange
• Good plant growth (unless drought)
Poorly-Drained Soils

- Change temperature more slowly—warm up slower in spring, thus cooler
- Colors tend to be more gray
- Slow decomposition of organic matter
- Poor plant growth (unless drought)
- Visible surface soil water
<table>
<thead>
<tr>
<th>Property/Behavior</th>
<th>Sand</th>
<th>Silt</th>
<th>Clay</th>
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<tbody>
<tr>
<td>Water holding</td>
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<td>High</td>
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<td>Aeration</td>
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<td>Poor</td>
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<td>Compact-ability</td>
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<tr>
<td>Pollutant leaching</td>
<td>High</td>
<td>Med</td>
<td>Low</td>
</tr>
</tbody>
</table>
• If you could choose the soil texture on your perfect farm, what would that be?
• Why did you choose that?
Soil Structure Defined

• The combination or arrangement of primary soil particles (sands, silts, clays) into secondary units, called peds. Soil structures are distinguished according to size and shape.
Soil Aggregates

• Secondary units or granules held together by organic substances, iron oxides, clays, carbonates, etc.

• Aggregate Stability - Ability of soil aggregates to resist disintegration when forces associated with tillage and water or wind erosion are applied. (NRCS, 2008)
  – Wet – resistance to raindrop impact and water erosion.
  – Dry – uses size distribution of dry aggregates as an indicator of resistance to abrasion and wind.
Soil Aggregates

• Aggregate Stability is an indicator of:
  – OM content
  – Biological activity
  – Nutrient cycling
  “soil quality”

• Important for many physical properties:
  – Infiltration and water movement
  – Root penetration and growth
  – Resistance to erosive forces of wind and water
Common Types of Soil Structure

- **Granular**
- **Blocky**
- **Prismatic**
- **Columnar**
- **Platy**
Without Structure

Single Grained

Massive
Simple Soil Structure Test

Simple clod test: Healthy soil, at left, holds together in water, while poor soil falls apart.
Bulk Density

• Bulk Density = weight/volume
• Calculated dry
• Indicator of soil compaction
• Most soils have bulk densities between 1 and 2
• By comparison, water has a bulk density of 1 g/cm³ (at about 40 degrees F)

For example, 2 cm³ of a soil weighs 3 grams

 Bulk density = 1.5 grams/cm³
Measuring Bulk Density
Compacted Soils Can Restrict Root Growth

http://extension.missouri.edu/explore/images/g01630art01.jpg
Wet Soils More Prone to Compaction

http://extension.missouri.edu/explore/images/g01630art01.jpg
Sometimes Field Work Can’t Wait for Soils to Dry
How to Evaluate Soil Moisture
(to help determine suitability for field operations)

1. Determine texture of soil.
2. Squeeze small handful of soil firmly.
3. Observe the condition of the ball and your hand.
4. Attempt to form a ribbon of the soil between your thumb and forefinger.
5. Observe what happens.
6. Compare your observations with what is expected of various soil types.

Source: http://www.wy.nrcs.usda.gov/technical/soilmoisture/soilmoisture.html
Appearance at Various Moisture Conditions

Sandy clay loam, loam, and silt loam:
Available Water Capacity 1.5-2.1 inches/foot:

25-50 percent available: Slightly moist, forms a weak ball with rough surfaces, no water staining on fingers, few aggregated soil grains break away.

50-75 percent available: Moist, forms a ball, very light staining on fingers, darkened color, pliable, forms a weak ribbon between the thumb and forefinger.

75-100 percent available: Wet, forms a ball with well-defined finger marks, light to heavy soil/water coating on fingers, ribbons between thumb and forefinger.

100 percent available (no picture): Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking, medium to heavy soil/water coating on fingers.

Source: http://www.wy.nrcs.usda.gov/technical/soilmoisture/soilmoisture.html
Soil Horizons

A Horizon “Topsoil”
Greatest biological activity, high amounts of organic matter

B Horizon “Subsoil”
Concentration of silicate clays, humus, etc, and/or the development of structure

C Horizon
parent material
A Horizon

- Maximum biological activity
- Leaching
- Greatest amount of organic matter
- Generally highest in N and P
- Often granular or crumb structure
B Horizon

- Accumulation of clays and iron or aluminum oxides
- Less organic matter and less biological activity than A Horizon
- Common soil structure in B horizons includes subangular blocky, columnar, platy
Sources of Color

- Organic matter (humus)-decomposed plant matter
  - % organic matter can be determined by using the Munsell chart
- Iron oxides
  - Oxidized iron (Fe$^{+++}$) reds, browns, tans, and yellows
  - Reduced iron (Fe$^{++}$) grays

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<th>3-5% OM</th>
<th>&gt;5% OM</th>
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<tr>
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<td>&lt; 3% OM</td>
<td></td>
</tr>
</tbody>
</table>
Clarion-Nicollet-Webster Series

Summit

Shoulder

Backslope

Footslope

Clarion

Nicollet

Webster

Glencoe
Soil Color/Organic Matter

Google Maps; near Nappanee, IN
Near Plains, GA
Mato Grosso, Brazil