The Real Dirt On Woods

Exploring the Dynamic World of Forest Soils
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Three Topics of Discussion

- Introduction to Basic Soil Science with emphasis on Forest Soils
- Soils and Forest Productivity
- Soils and Forest Management
Functions of Forest Soils

- Support that holds tree upright
- Provides the mineral nutrients
- Provides water
- Provides air
CYCLES

- The Hydrologic, Carbon and Nitrogen cycles comprise sequences of events that are key to making the Earth capable of sustaining life.

- Soils play an important part in each of these cycles.
Factors That Influence Soil Formation

- Climate
- Parent material
- Topographic relief
- Organisms
- Time
SOIL

- Component definition: Mixture of mineral matter, organic matter, water, and air.

- Example:
Soil Forming Processes

- Translocations
- Transformations
- Additions
- Losses
Key Soil Properties

- Horizons
- Color
- Organic matter
- Texture
- Structure
- Permeability
- Available Water Capacity
Major Horizon Designations

- **Surface Organic Layer**: O horizon
- **Surface Mineral Layer**: A Horizon
- **Subsoil**: B Horizon
- **Underlying Material**: C Horizon
- **Bedrock**: R Horizon
A horizon

B horizon

C horizon
Significance of Soil Color

- Tells a story of the history of each soil

- Can be an indication of the degree of weathering. Color changes from weathering are mostly associated with the formation of iron oxides. (parent material and age)

- Indicator of the amount and distribution of organic matter.

- Indicator of the degree of aeration or reduction.

- Light colors can be an indicator of leaching.
# Major Forms of Iron and Effect on Soil Color

<table>
<thead>
<tr>
<th>Form</th>
<th>Chemical Formula</th>
<th>Color</th>
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</thead>
<tbody>
<tr>
<td>Ferrous oxide</td>
<td>FeO</td>
<td>Gray</td>
</tr>
<tr>
<td>Ferric oxide (Hematite)</td>
<td>Fe$_2$O$_3$</td>
<td>Red</td>
</tr>
<tr>
<td>Hydrated ferric oxide (Limonite)</td>
<td>2Fe$_2$O$_3$ · 3H$_2$O</td>
<td>Yellow</td>
</tr>
</tbody>
</table>
Aspects of Soil Color

- Hue
- Value
- Chroma

10R 5/8
Soil Color

Munsell Soil Color Book

The Munsell notation system is used for recording color.
Hue

Red

0  2.5R  5R  7.5R  10R

Yellow-Red

0  2.5YR  5YR  7.5YR  10YR

Yellow

0  2.5Y  5Y  7.5Y  10Y
The Lightness or Darkness of Color

- 10/0 - Pure White
- 5/0 - Gray
- 0/0 - Pure Black
Chroma

“Neutral” Color

Increasing strength of color

Increasing grayness

“Pure” Color
Using Soil Color as a Wetness Indicator

- Soils that have seasonal high water tables or long periods of saturation commonly develop particular color patterns.

- These color patterns can help to identify soils that are seasonally wet when examined during the dry periods of the year.

- Color patterns caused by wetness are called “redoximorphic features”.

Soil Drainage Sequence

Increasing wetness duration
Redox concentrations – reddish brown

Redox depletions – grayish colors
Gleyed Matrix – iron is in a reduced form, causing the grayish to blue hues. Usually the result of prolonged saturation.
Thick, black surface horizon over gray subsoil is an indicator of soil wetness.
Soil Texture

- Soil texture is an expression of the proportion of sand, silt, and clay.

- It is probably the most important of all soil physical properties.

- It affects the ability of the soil to hold water and plant nutrients.

- It affects the movement of air and water through the soil.
Relative Sizes of Soil Particles

Sand (0.05-2.00 mm)

Silt (0.002-0.05 mm)

Clay (<0.002 mm)
Relative Sizes of Particles

- **beach ball**: Sand (feels gritty) (2.00 - 0.05 mm)
- **frisbee**: Silt (feels floury) (0.05 - 0.002 mm)
- **dime**: Clay (feels sticky) (< 0.002 mm)
USDA Soil Texture Triangle
In this example there is
15% clay
15% sand
70% silt

USDA texture = silt loam
Texture

Flowchart

Start:
Place approximately 25 g soil in palm. Add water dropwise and knead the soil to break down all aggregates. Soil is at the proper consistency when plastic and moldable, like moist putty.

Does soil remain in a ball when squeezed?
- Yes: Is soil too dry?
- No: Is soil too wet?
- No: Add dry soil to soil to soak up water

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

Does soil form a ribbon?
- Yes: Does soil make a weak ribbon less than 1 inch long before breaking?
- No: LOAMY SAND

Does soil make a weak ribbon less than 1 inch long before breaking?
- Yes: Excessively wet a small pinch of soil in palm and rub with forefinger
- No: Sandy Loam

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

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

Sandy Clay Loam:
- Does soil feel very smooth?
- Yes: Sandy Clay Loam
- No: Sandy Clay

Sandy Clay:
- Does soil feel very smooth?
- Yes: Sandy Clay Loam
- No: Sandy Clay

Silty Clay Loam:
- Does soil feel very smooth?
- Yes: Silty Clay Loam
- No: Silty Clay

Silty Clay:
- Does soil feel very smooth?
- Yes: Silty Clay Loam
- No: Silty Clay

Silty Clay Loam:
- Does soil feel very rough?
- Yes: Silty Clay Loam
- No: Silty Clay

Silt Loam:
- Does soil feel very smooth?
- Yes: Silty Clay Loam
- No: Silty Clay

Silt Clay Loam:
- Does soil feel very smooth?
- Yes: Silty Clay Loam
- No: Silty Clay

Neither grittiness nor smoothness predominates:
- Yes: Loam
- No: Clay

Clay Loam:
- Does soil feel very smooth?
- Yes: Clay Loam
- No: Clay

Clay:
- Does soil feel very smooth?
- Yes: Clay Loam
- No: Clay
Soil Structure

- The combination or arrangement of primary soil particles into secondary units or *peds*.

- **Peds** are natural soil aggregates, in contrast to clods or fragments that are formed by tillage or other human activities.
Factors that Affect Soil Structure

- Kind of clay
- Amount of organic matter
- Freezing and thawing
- Wetting and drying
- Action of burrowing organisms
- Growth of root systems of plants
Examples of Soil Structure

<table>
<thead>
<tr>
<th>Granular</th>
<th>Blocky</th>
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<tbody>
<tr>
<td>(Subangular)</td>
<td>(Angular)</td>
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</table>

<table>
<thead>
<tr>
<th>Platy</th>
<th>Prismatic</th>
<th>Columnar</th>
</tr>
</thead>
</table>

| Wedge             |                    |          |
Granular Structure

- Most common in A horizons high in organic matter content
- Microorganisms excrete lignin ("glue") from humus to bind particles together
- Commonly influenced by soil management
Angular blocky soil structure
Blocky (ABK or SBK)

- common in B horizons, particularly in humid regions
  - ABK (angular)
    - more common in soils higher in smectite
  - SBK (less angular)
    - more common in soils higher in kaolinite

- up to a point, the more shrinking and swelling, the more angular the structure (PJT theory)
Prismatic (PR)

- most common in clayey subsoils
- height of ped is greater than width of ped; angular tops
Columnar (COL)

- similar to prismatic except has rounded tops
- found in soils high in Na (sodium)
Platy (PL)

- width is wider than height
- commonly found in compacted soil horizons
  - natural compaction
    - fragipans
    - dense basal till
  - artificial compaction
    - plow plans
Structureless

single grain (SG)  massive (MA)
Saturated Hydraulic Conductivity

$K_{sat}$

- Is the amount of water that would move vertically through a unit area of saturated soil in unit time under unit hydraulic gradient

- Estimated property, though it can be measured in the field
Saturated hydraulic conductivity

- Replaces use of permeability in soil survey to measure movement of water through the soil

- The soil properties that affect saturated hydraulic conductivity are distribution, continuity, size, and shape of pores, which are not readily observable or measureable
Saturated hydraulic conductivity

- Texture, structure, pore size, density, organic matter, and mineralogy are observable properties related to pore geometry and are used to estimate $K_{sat}$.

- In making estimates, the soil characteristic that exerts the greatest control for many soils is texture.
Guide for estimating saturated hydraulic conductivity (Ksat) from soil texture.

National Soil Survey Handbook – Exhibit 618-9
Ksat Classes Used in Web Soil Survey

- micrometers per second
  - Very low: 0.00 - 0.01
  - Low: 0.01 - 0.1
  - Moderately low: 0.1 - 1.0
  - Moderately high: 1 – 10
  - High: 10 – 100
  - Very high: 100 - 705
Available Water Capacity

- Amount of water that a soil can store that is available for use by plants

- Affected by:
  - Texture
  - Organic matter
  - Rock fragments
  - Bulk density
Estimating AWC

- No one method will work for the entire country because of variables found in the soil.
- Some variables are properties unique to a region that will affect the ability of the soil to hold water:
  - Ash in Northwest; multiply by factor of 1.1 or 1.2
- Also affected by rock fragments.
- What to do? Trust the data provided in your soil survey information for your area.
## Estimated Available Water Capacity Chart (AWC)

<table>
<thead>
<tr>
<th>Texture Class</th>
<th>AWC (cm water/cm of soil)</th>
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<tr>
<td></td>
<td>Low</td>
<td>RV</td>
<td>High</td>
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<tr>
<td>Sand</td>
<td>0.02</td>
<td>0.04</td>
<td>0.06</td>
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<tr>
<td>Loamy sand</td>
<td>0.06</td>
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<td>Sandy loam</td>
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<tr>
<td>Loam</td>
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<td>0.18</td>
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<tr>
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<td>Clay loam</td>
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<tr>
<td>Silty clay loam</td>
<td>0.18</td>
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<td>0.22</td>
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<td>Sandy clay</td>
<td>0.14</td>
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<tr>
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Soils and Forest Productivity

Let’s now tie what we know about soils to the productivity of a forest site.

One way to measure Forest Productivity is to look at what is called Site-Index.
Site-Index is the average height that the dominant or dominant and co-dominant portion of the even-aged forest stand will have at a specific age. Usually 50 years in the eastern United States.
A tree that is 50 years old and has a height of 70 feet would have a SI of 70.

Same species and age tree at a different site is only 40 feet in height the SI is 40.

Which site is more productive?
Figure 1. Site index curves for loblolly pine at index age 50 years in the Coastal Plain of Virginia, North Carolina, and South Carolina. (These curves are based on stem analysis of 40 dominant trees in the middle and lower Coastal Plain.)
<table>
<thead>
<tr>
<th>Soil name and map symbol</th>
<th>Ordination symbol*</th>
<th>Commonly grown trees</th>
<th>Site index</th>
<th>Cubic feet per acre</th>
<th>Board feet per acre</th>
<th>Cords per acre</th>
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See footnotes at end of table.
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<tr>
<th>Soil name and map symbol</th>
<th>Erosion hazard*</th>
<th>Seeding mortality*</th>
<th>Plant competition*</th>
<th>Haul roads and skid roads**</th>
<th>Log landings**</th>
<th>Operability of equipment in logging areas**</th>
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Summary

- Soils are an important component of the forest ecosystem.
- Soils influence the productivity of the forest site.
- Soils influence how the forest should be managed to maintain productivity.
- Soils are an integral component of many of natures cycles, in particular the water, the carbon and the nitrogen cycles.
SO DON’T TREAT YOUR SOILS LIKE DIRT
QUESTIONS?