Soils 101

Erika Crowl | Fundamentals of Nutrient Management
Slides adapted from Andrew Kness and Emileigh Lucas

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EXTENSION

Objectives

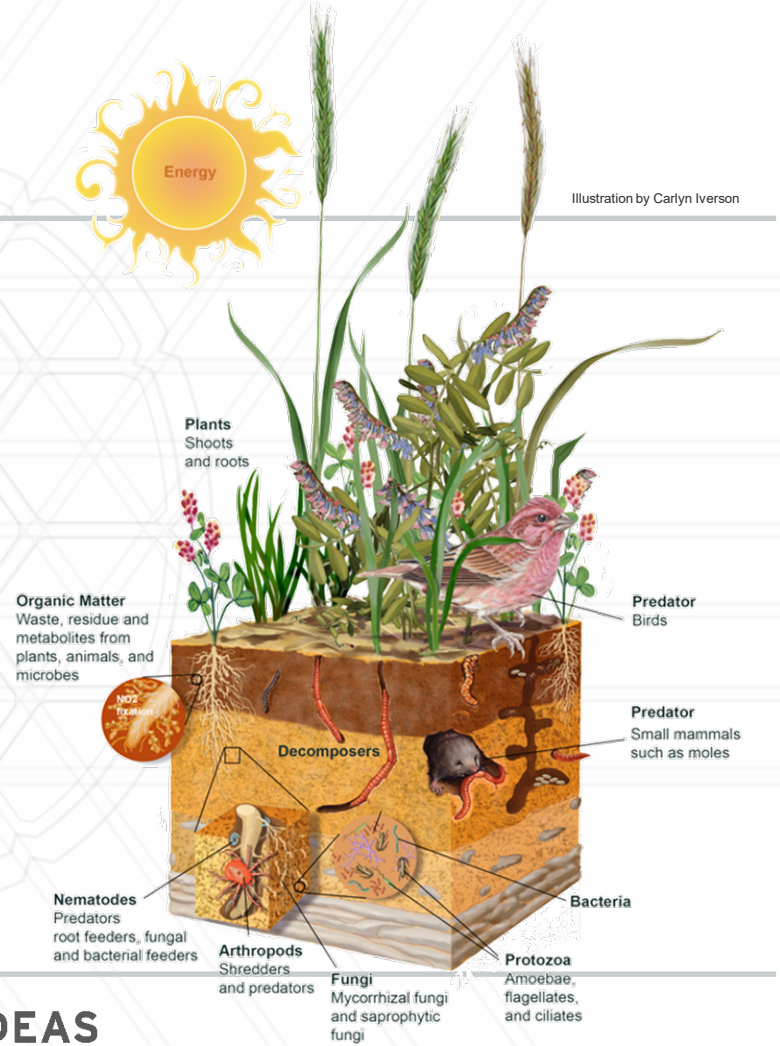
- What is soil and how is it formed?
- Soil physical properties
- Soil chemical properties
- Describe tools for accessing soil survey

What is soil?

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 Taxonomy, 2nd Edition).

What's in soil?

- Minerals
- Water
- Gas
- OM
- Plants
- Animals
- Microbes



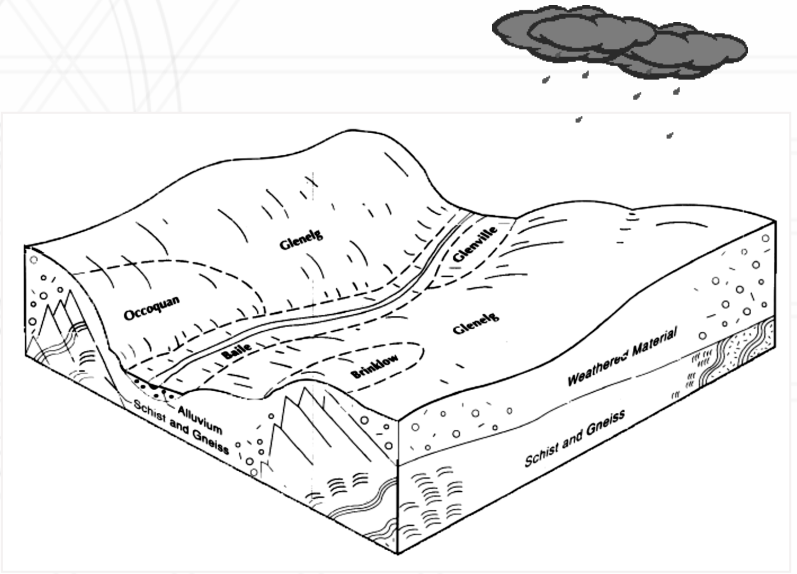
It’s a whole other world!

There are more soil microorganisms in a teaspoon of healthy soil than there are people on the earth!

How is soil formed?

Five soil-forming factors:

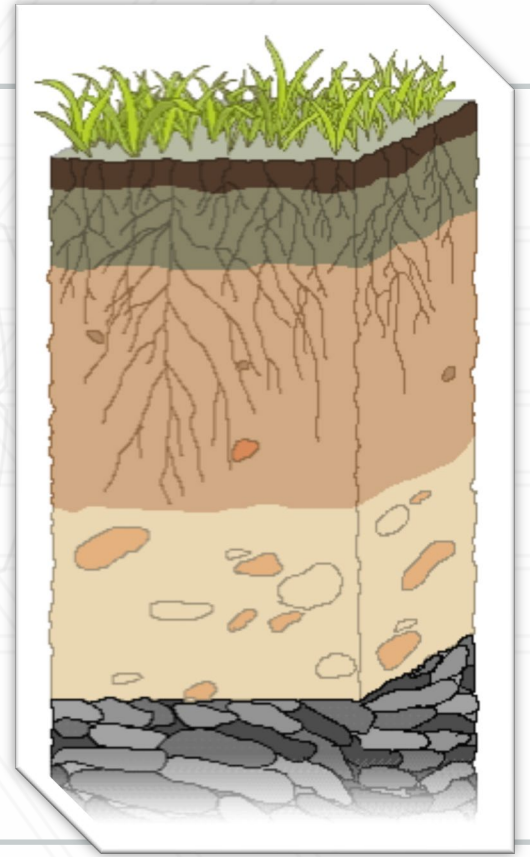
1. Parent material
   a) Rocks and Minerals
2. Climate
3. Landscape position
4. Organisms
5. Time



How is soil formed?

Parent material

- The material in which soils form
- Very few soils form directly from underlying rock



How is soil formed?

Climate

- Precipitation
  - Affects weathering of parent material
- Temperature
  - Increase in temps increases biological activity and chemical reactions
  - Freeze-thaw process weathers parent material

How is soil formed?

Landscape position

- Slope
  - Soils on slopes are subject to erosion
  - Soils at bases of slopes tend to have more topsoil and organic matter
  - Soils at bottom of slopes or formed under little slope will have greater water infiltration
- Slope direction
  - South-facing slopes warm up faster

How is soil formed?

Organisms

- Animals
  - Move and travel over soil
  - Move and travel in soil
- Plants
  - Roots break up soil
  - OM affects soil properties
- Microbes
  - Decompose OM
  - Cycle nutrients
  - Travel through soil

How is soil formed?

Time

- Soil formation takes a lot of time!

How is soil formed?

Four soil-forming processes:

1. **Addition**-material added to soil
2. **Loss**-material lost from soil
3. **Translocation**-material is moved to another part of the soil
4. **Transformation**-materials are changed into another form in the soil

Soil organic matter

Plant, animal, and microbe debris in various stages of decomposition

- **Biomass**-living component
- **Residues** and by-products
- **Humus**-stable end product

of OM decomposition

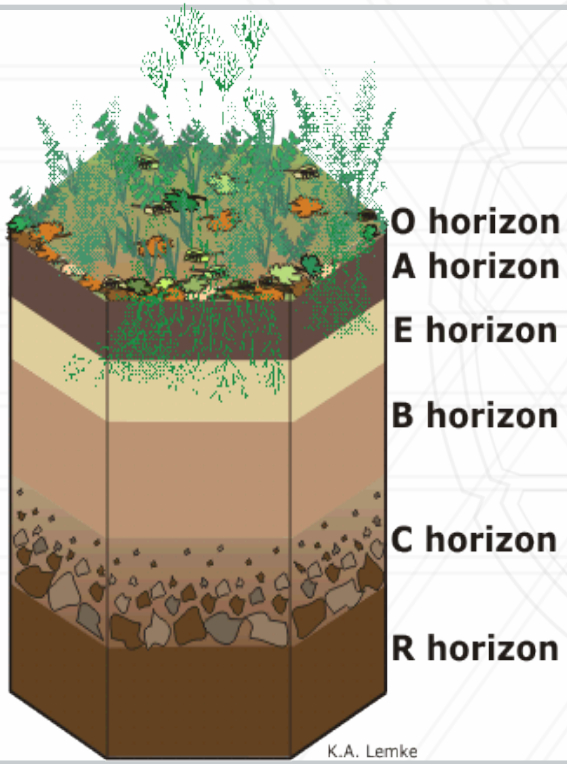
Photo: NC State Extension

Soil organic matter

SOM only comprises 2-5% of soil by weight, but has a **huge** impact on soil properties

- Higher water-holding capacity
- Increased water infiltration
- Higher CEC and greater ability to hold nutrients
- Improves soil structure

Soil profile



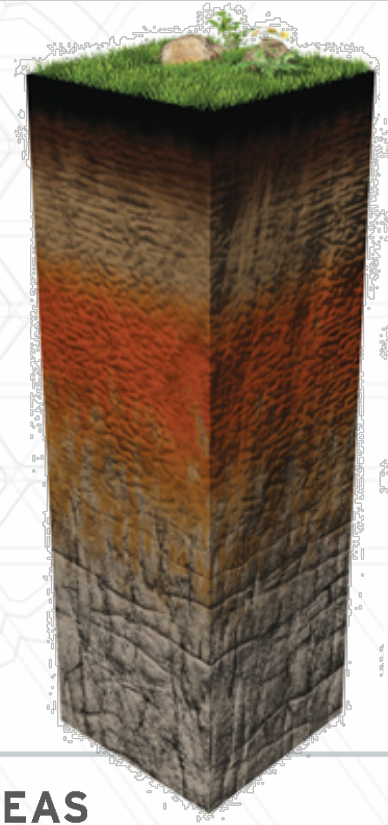
Soil Horizons

- O: Organic Horizon
- A: Mineral and organic components mixed
- E: Eluviated horizon – loss of clays, Fe, Al
- B: Illuvial accumulation of clays, Fe, Al, OM
- C: unconsolidated bedrock
- R: hard bedrock

Soil profile

Photo: NRCS

Photo: NRCS



Soil properties

- Physical properties
- Chemical properties

Soil properties

Physical properties

- Texture
- Structure
- Porosity
- Bulk density
- Water-holding capacity

Soil properties

SOM **does not** affect texture.
Management practices have no effect on texture.

Texture

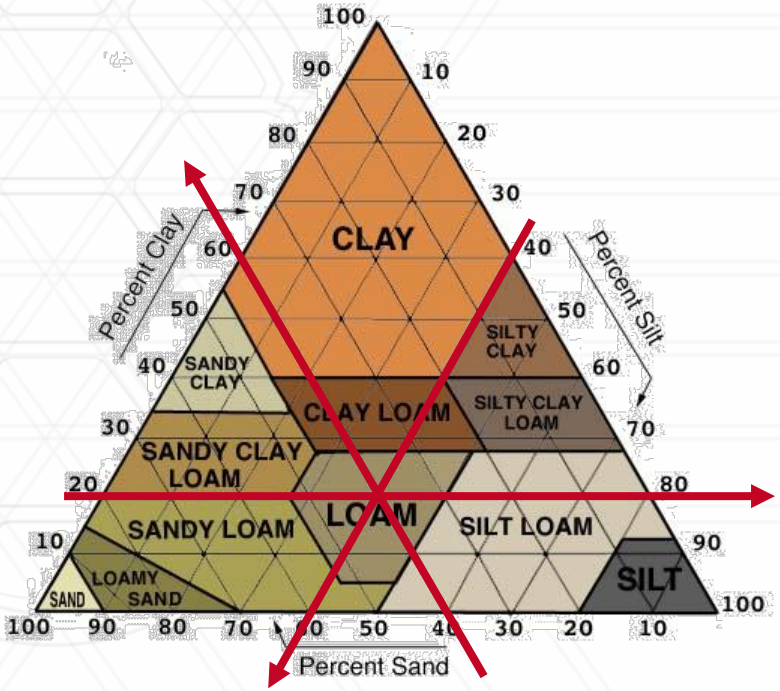
- Soil texture refers to the proportion of the soil “separates” that make up the mineral component of soil
  - % sand, silt, and clay

Mineral class	Size of particle	Feel of particle
Sand	0.05 – 2 mm	Gritty
Silt	0.002 – 0.05 mm	Flour, talcum powder
Clay	< 0.002 mm	Sticky when wet

Soil properties

Textural triangle

What's the texture of a soil that's:
40% sand,
40% silt,
and 20% clay?



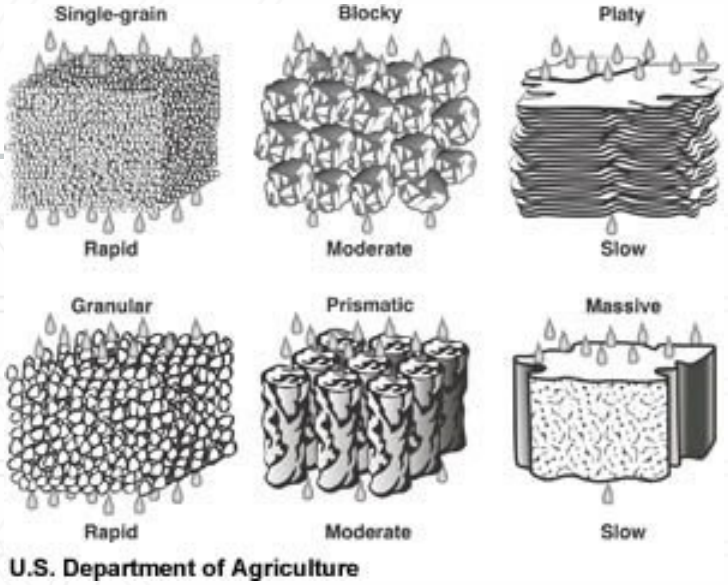
Effect of Soil Texture on Soil Properties

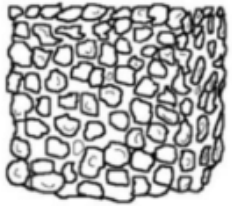
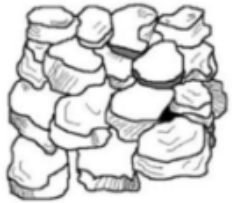
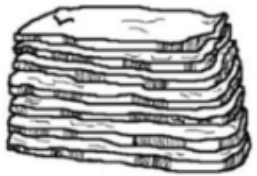
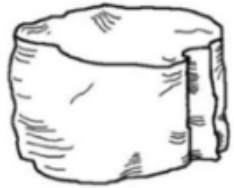
	coarse textured	medium textured	fine textured
water-holding capacity	low	moderate	high
nutrient retention capacity	low	moderate	high
leaching potential	high	moderate	low
susceptibility to erosion	low	high	moderate

Soil properties

Structure

- How soil separates are aggregated together to form **peds**
- Soil structure determines pore space



SINGLE GRAIN	GRANULAR	BLOCKY
		
Composed of largely non-reactive sand size particles of roughly uniform size distribution.	Predominantly the result of biological forces including: earthworms, insects, fungal hyphae, and fine roots.	Developed through cycles of shrink-swell. Size defined by boundaries in homogeneous matrix (i.e. root patterning). Most common to soils with rapid drying.
PRISMATIC	**PLATY**	**MASSIVE**
		
Uniform shrinkage after extended periods of saturation. Most common in uniformly textured soils, enriched with sodium, that slowly dry.	Generally occur through unidirectional compressional forces. Most commonly produced in surface soils compressed by heavy equipment.	Common in fine textured sediments that are slowly sorted and cemented (argillinc), manufactuired (clay barriers), or compressed (fragipan).

Images courtesy of the U.S. Department of Agriculture

Soil properties

Structure

- SOM plays a **big** role in soil structure
- Management practices can greatly affect soil structure

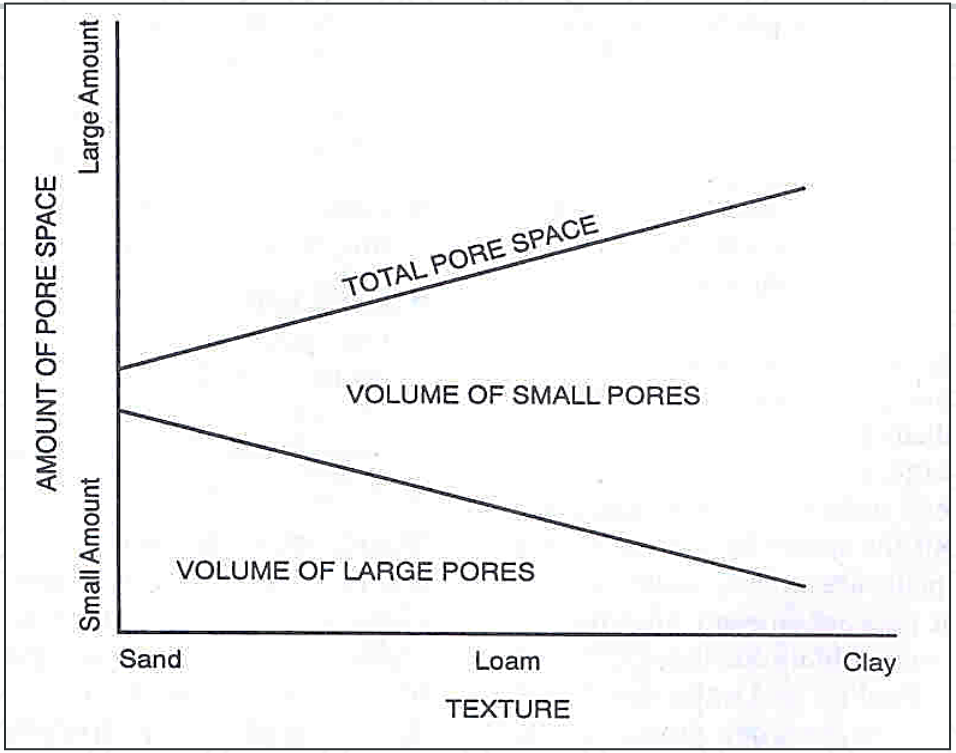
Photo: soilplanttech.com

Soil properties

Porosity

- Space in between peds and particles
  - May be occupied by air or water

Soil properties



Soil properties

Formula for porosity

% PORE SPACE = 100 - % SOLID SPACE

OR

% PORE SPACE = 100 - (BD/PD X 100)

Soil properties

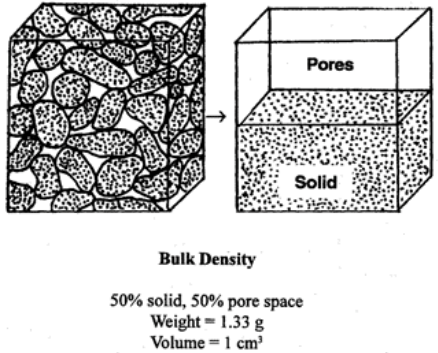
Bulk and Particle Density

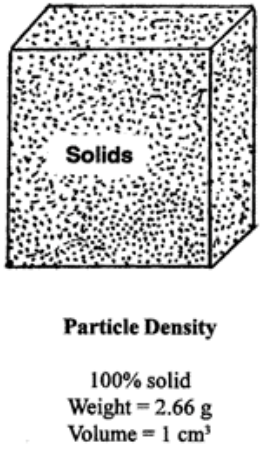
- Two kinds of Density
  - Bulk density is the weight of soil in a given volume
  - Particle density is the weight of soil solids only

Soil properties

Bulk Density

- Affected by porosity
  - More porous soil = lower bulk density
  - Compacted soils will have a bulk density >1.6g/cm^3





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Soil Properties

If a soil ped has a volume of 124 cm^3 and a dry weight of 138 grams, what is its bulk density?

BD = 138 grams/124 cm^3

- 1.11 grams/ cm^3

Soil properties

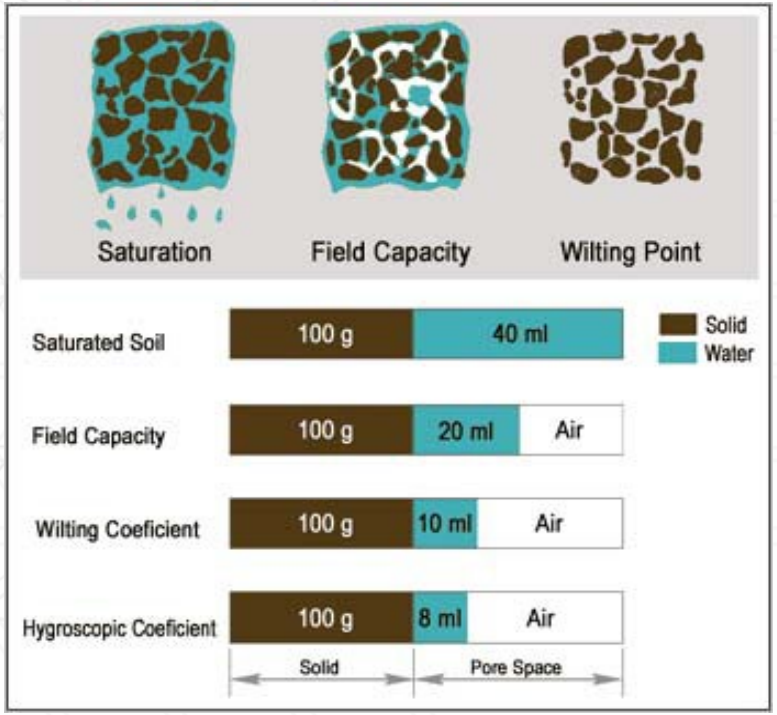
Water-holding capacity

- Affected by:
  - Porosity
    - More micropores = more water-holding capacity
  - Soil texture
    - More clay = more water-holding capacity
  - Soil organic matter
    - More SOM = more water-holding capacity

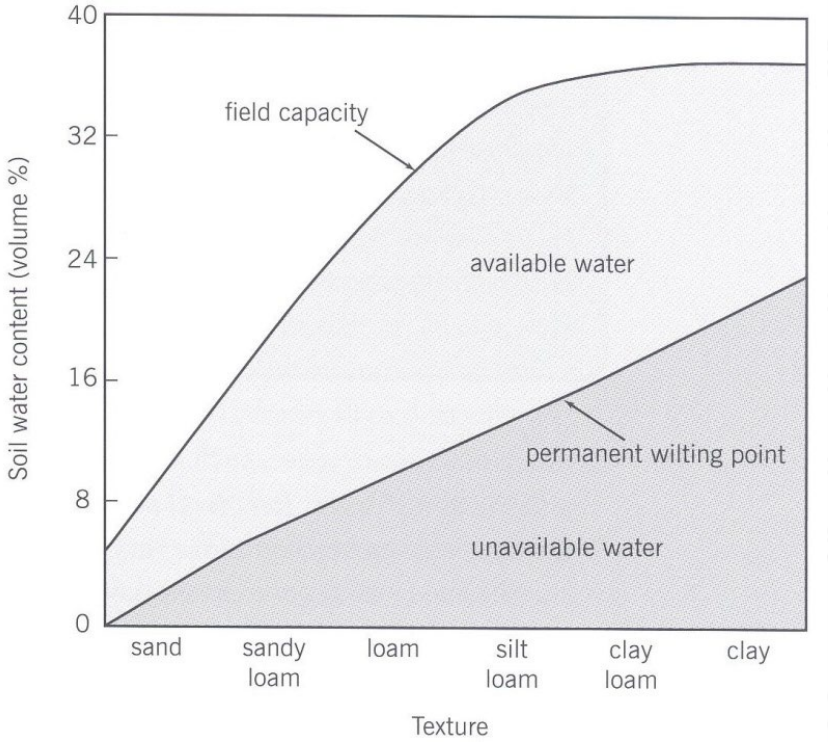
Soil properties

Water-holding capacity

- Saturated
- Field capacity
- Permanent wilting point



Soil properties



Soil Drainage

- The rate and extent of water removal during the growing season.
- Indicated by soil color patterns and color variations.

Soil properties

Chemical properties

- pH
- Cation exchange capacity (CEC)
- Anion exchange capacity (AEC)

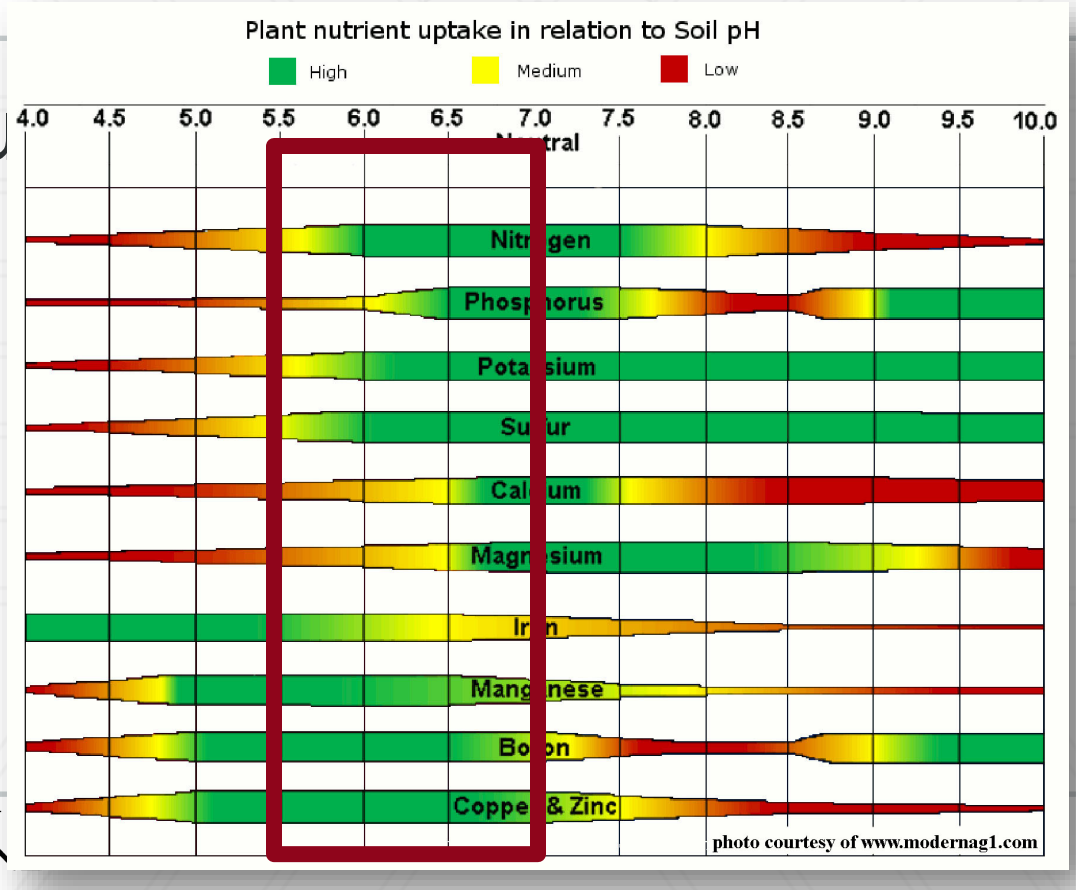
Soil properties

pH

- Soil pH is a measure of the acidity and alkalinity in soils
- pH between 5.5-7.0 required for most plants
- pH affects the **availability** of nutrients in the soil
  - pH also affects the availability of toxic metals in the soil

Soil properties

pH & nu



Soil properties

Adjusting soil pH

- Most soils are naturally acidic and will become more acidic over time
- Limestone is added to soil to adjust soil pH up to a more acceptable range
  - Calcitic limestone ($CaCO_3$)
    - Also a source of calcium
  - Dolomitic limestone ($MgCO_3$)
    - Also a source of magnesium

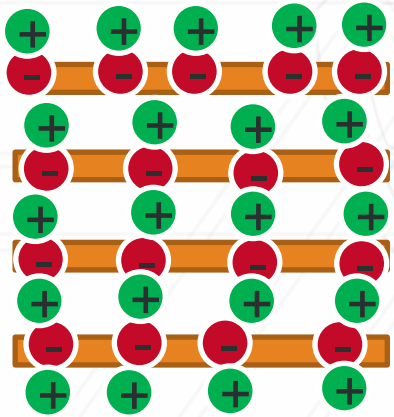
Soil properties

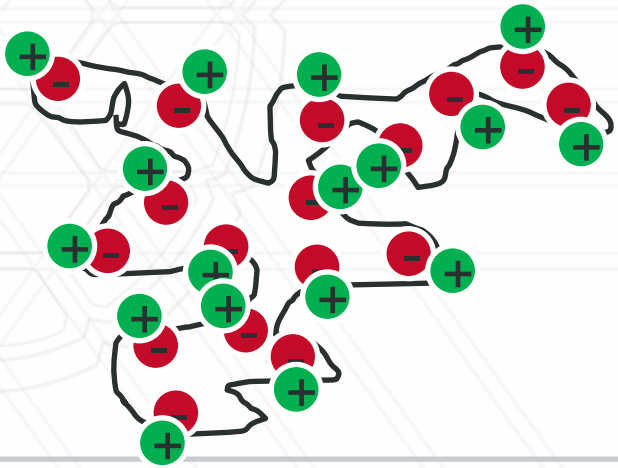
Cation exchange capa

- The ability of soil to
  positively charged ic

Cations

- Calcium (Ca^{2+})
- Magnesium (Mg^{2+})
- Potassium (K^{+})
- Sodium (Na^{+})
- Ammonium (NH_4^{+})
- Aluminum (Al^{3+})
- Hydrogen (H^{+})





Effect of CEC on soil properties

Low CEC (1-10meq/100g)

- High sand and low clay content
- Low OM content
- Low water- holding capacity
- Low soil pH
- Low productivity
- Easy to change pH

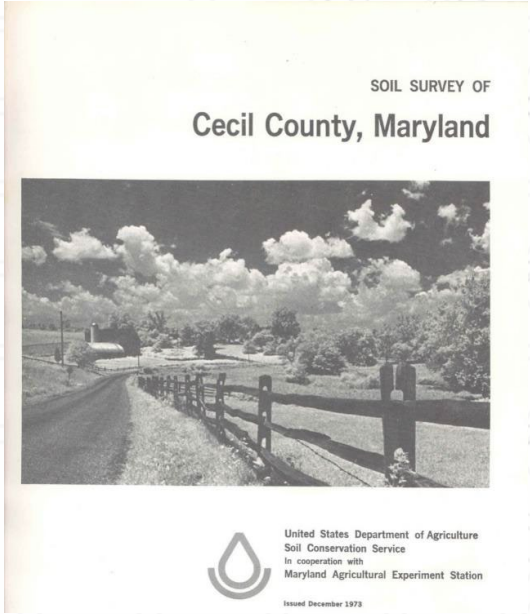
Effect of CEC on soil properties

High CEC (11-50 meq/100g)

- Low sand and higher clay content
- Moderate to high OM content
- High water- holding capacity
- Less nutrient losses to leaching than low CEC soils
- Harder to change pH

Soil Survey

From this….



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Soil Survey

- Basic soil properties
  - HSG
  - Permeability
  - K – erodibility
- Applied soil use
  - vegetative productivity
  - water management
  - land management

Thousands of bits of info!

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