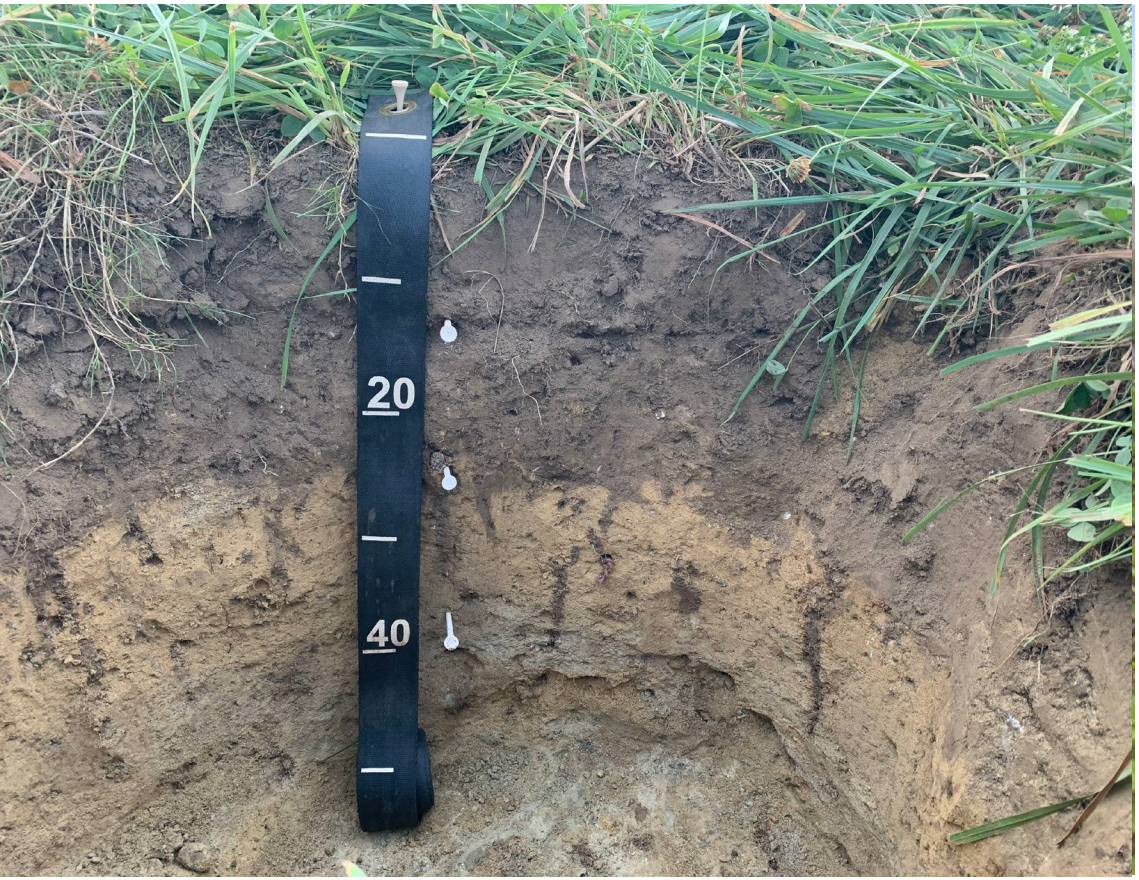
USDA

United States Department of Agriculture



Natural Resources Conservation Service

Basic Soil Properties and Characteristics

August 25, 2020 | Debbie Surabian (CT/RI-NRCS SSS) & Jacob Isleib (CT-NRCS RSS)

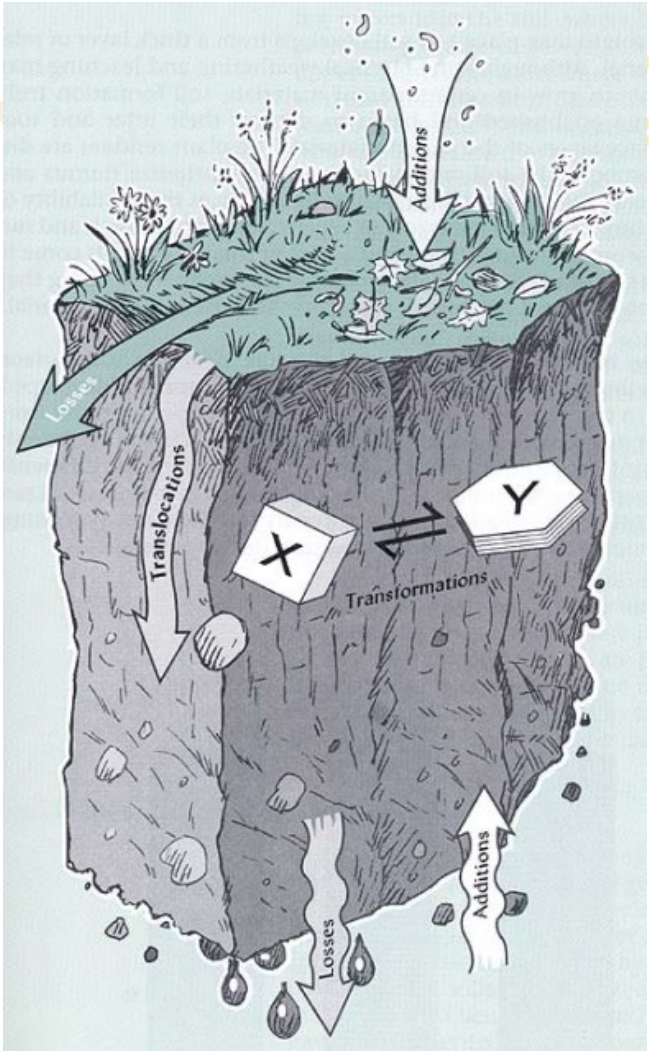
Natural Resources Conservation Service

nrcs.usda.gov/

Definition of Soil

Soil … is a natural body that occurs on the land surface … and is characterized by [either] **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.



Definition of Soil

The upper limit of soil is the boundary between soil and air, shallow water (subaqueous soils), live plants, or plant materials that have not begun to decompose. The lower boundary of soil is arbitrarily set at 200 cm.

Average "natural" Soil Composition

Soil is a mixture of

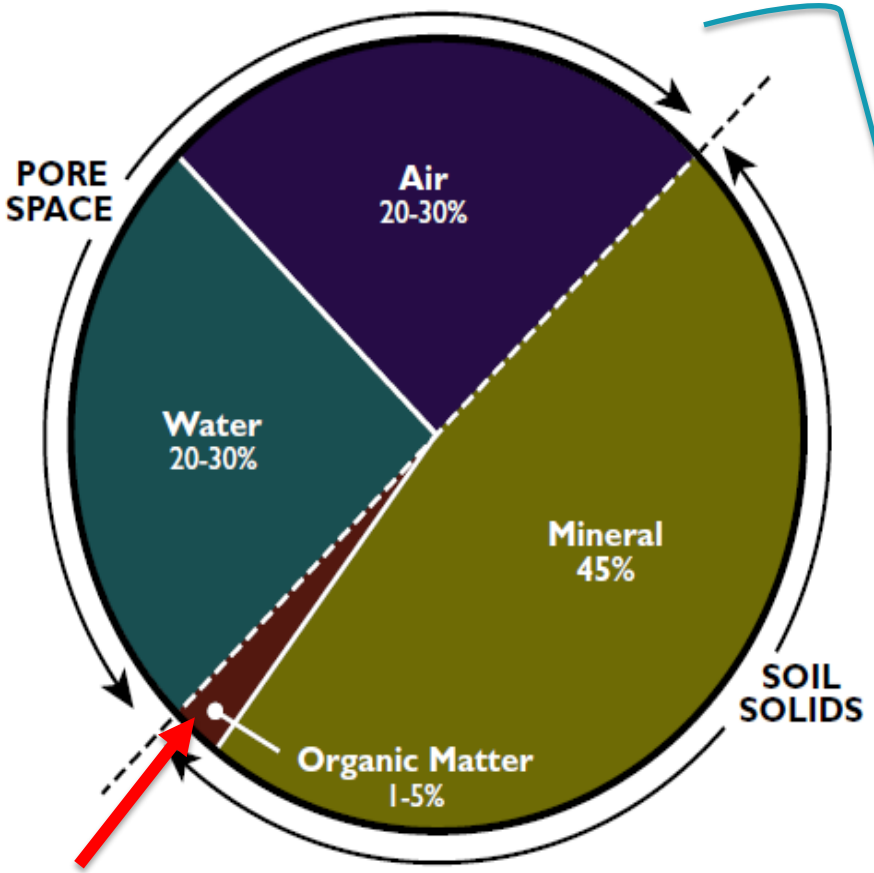
mineral material

air/gases

organic material

water

which forms on the land surface.



1 - 5% organic matter

(in mineral soils; wet soils may be dominantly or entirely organic)

Mineral Soil Material

Decreasing in size

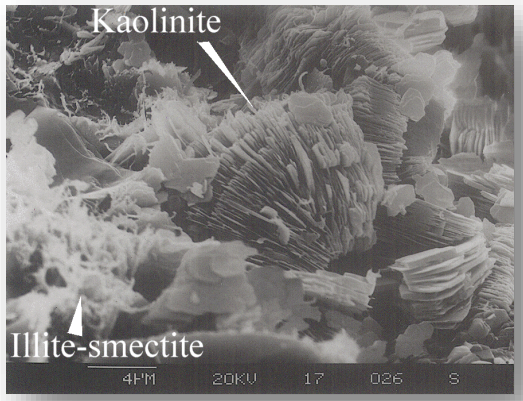
Sand - 2 to 0.05 mm

Silt - 0.05 to 0.002 mm

Clay - less than 0.002 mm

Too small to see individual particles with the naked eye – but we can hand texture

Sand-sized particles

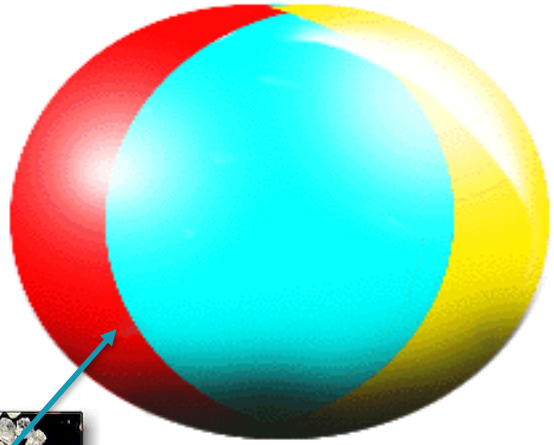


Clay-sized particles, ESM imagery

Relative Sizes of Mineral Soil Particles

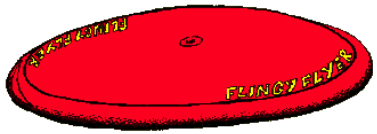
If we magnified our mineral soil particles..

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)

Keep soil particle size in mind, later on we'll discuss Soil Texture…..

Coarse fragments

Decreasing in size

Boulders -greater than 24”

Stones - 10 to 24 inches

Cobbles - 3 to 10 inches

Gravel - 2 mm to 3 inches

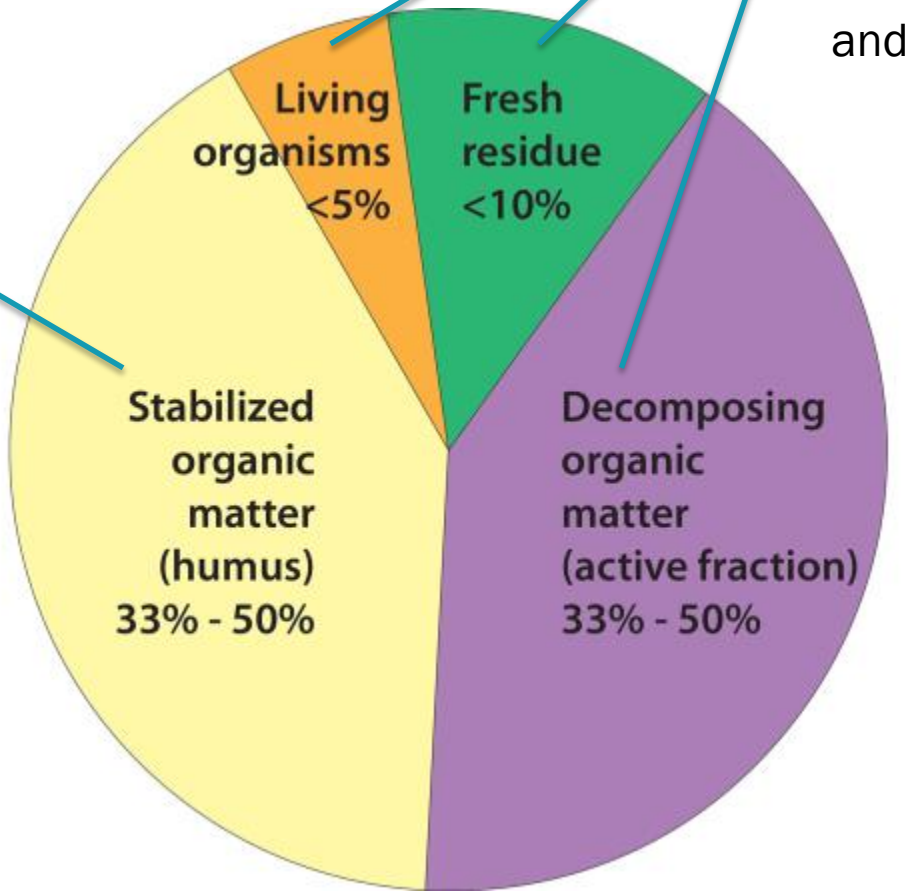
Photo from www.gov.nl.ca

Soil Organic Matter (SOM)

plant or animal tissue in various stages of decomposition

The Active Fraction
Used by living plants, animals, and microbes for food

Most cycling of Nitrogen and Carbon happens here



The Stable Fraction
Large, complex compounds that few microbes can degrade (humus)

Carbon and Nitrogen in a very stable from and released slowly by microbial digestion

What is soil?

taken from slide by Joel Gruver

Beneficial impacts of SOM

Physical

- aggregation / improves soil structure
- improves infiltration
- improves water holding capacity
- lowers bulk density

Chemical

- increases CEC i.e., nutrient holding
- acts as a pH buffer
- ties up metals/contaminants

Biological

- supplies energy for soil organisms, incre populations and activities
- source and sink for nutrients

Image by CCSI, 2014

Benefits of SOM and other Soil Health principles will be covered in a Soil Health module later in the training

What is soil?

Mineral Soils

Composed primarily of weathered mineral material - sand, silt, and clay, with varying amounts of soil organic matter

Organic soils

Composed primarily of decomposed organic material (*Peat, Muck)* formed in very wet environments (swamps, bogs, tidal marsh)

Typically not managed for agriculture, but exceptions exist (cranberry bogs, “black dirt” areas in Orange Co, New York)

**Not to be confused with Organic Farming systems*

Soil performs critical functions

Our food comes directly or indirectly from plants anchored in and nourished by soil.

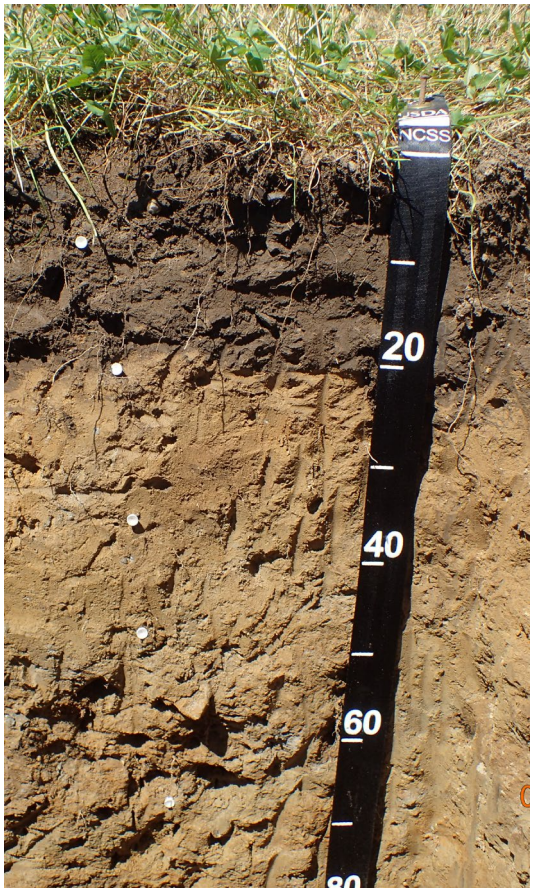
Water we drink and use everyday has been **filtered** by soil.

Soils process and **recycle nutrients**, including carbon, so that living things can use them over and over again.

Soils serve as the **foundation** for the construction of roads, dams and buildings.

Soils provide **habitat** for organisms.

-Soil Science Society of America



Natural Resources Conservation Service

nrcs.usda.gov/

Non-soil areas

- **Urban land**
  aka impervious surfaces
- **Water**
  **subaqueous soils*
  Napatree, Anguilla
- **Beaches**
- **Rock outcrop**
- **Dumps**
  **NYC mapping*
  Freshkills, Greatkills

These <u>are</u> represented in Soil Surveys as ***Miscellaneous areas***

Soil Formation

How do soils form?

Unique types of soils form under unique sets of

Soil Forming Factors

$$s = f(cl, o, r, p, t)$$

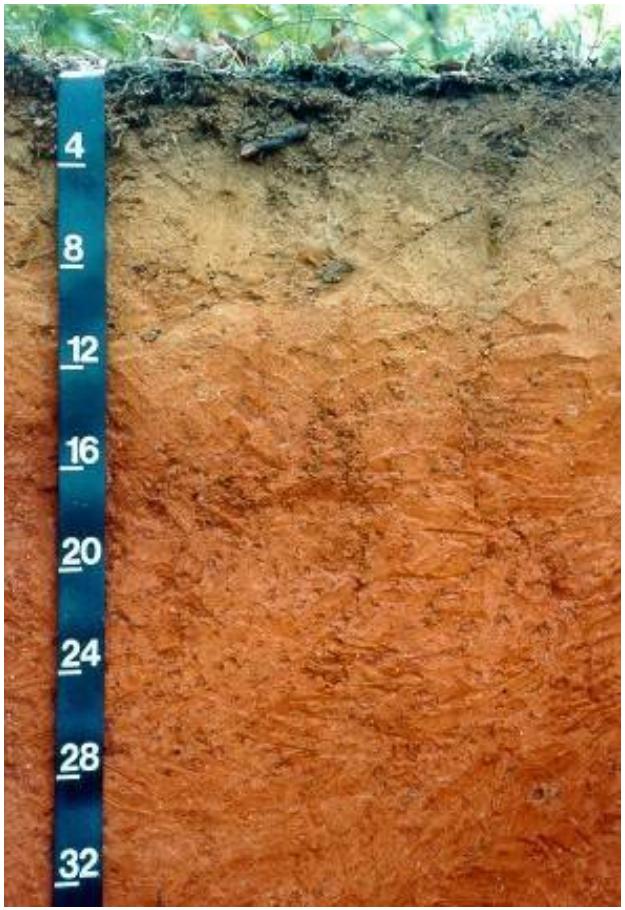
(H. Jenny, 1941 book “Factors of Soil Formation”)

ion

5 Soil Forming Factors: *CLORPT!*

Climate
(temp and precip)

Relief
(topography, landscape position)



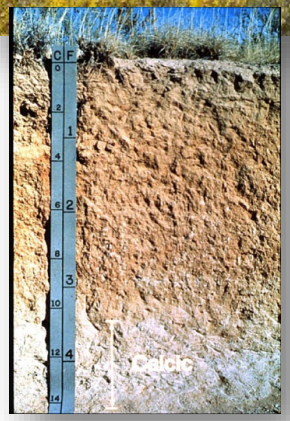
Organisms
(biota, plants, humans)

Parent Material
(geology)

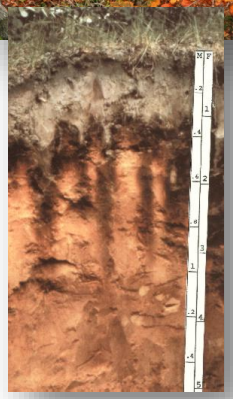
Interacting together over a period of **Time**

Soil Forming Factors

Climate – Soils develop faster in warm, moist climates and slower in cold or arid ones.

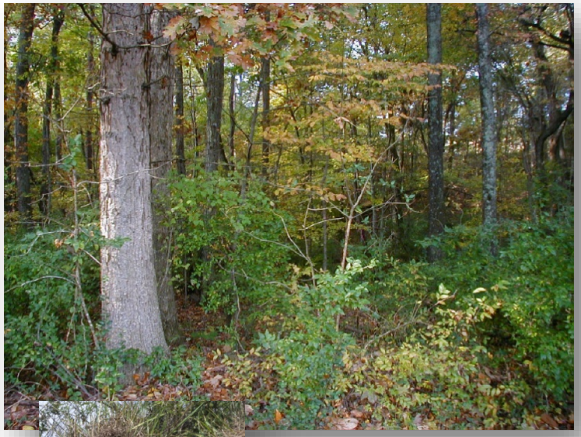


Hot, Dry
(Arid)
Eg. Southwest



Cool, Wet

Eg. New England



Warm, Wet
(Humid)
Eg. Southeast

Natural Resources Conservation Service

nrcs.usda.gov/

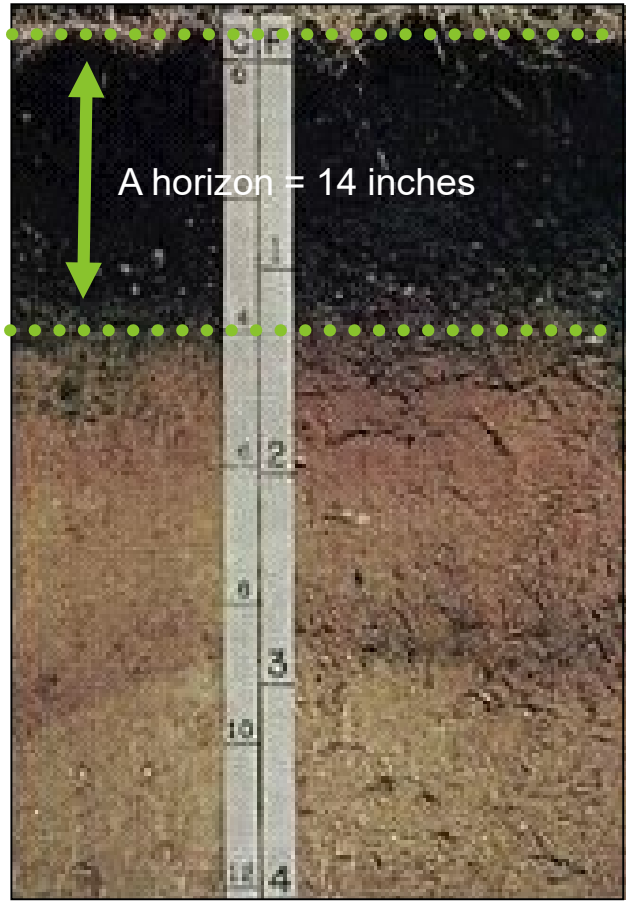
Soil Forming Factors

Organisms – Break down organic matter, increase soil porosity, affect soil chemistry, move soil

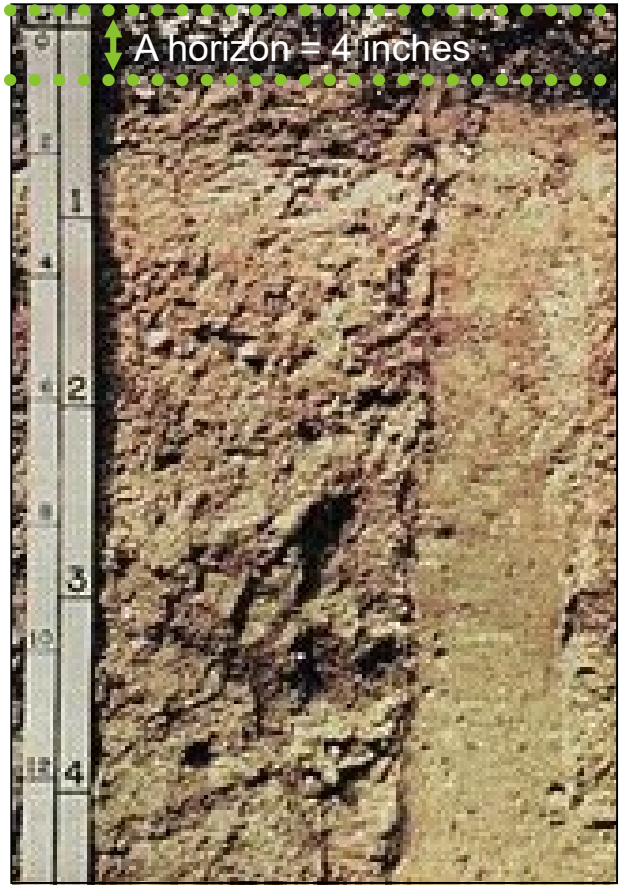
Photo Credit: USDA NRCS

Organisms (includes humans)

Land Use/ Land Cover affects soil properties



Prairie



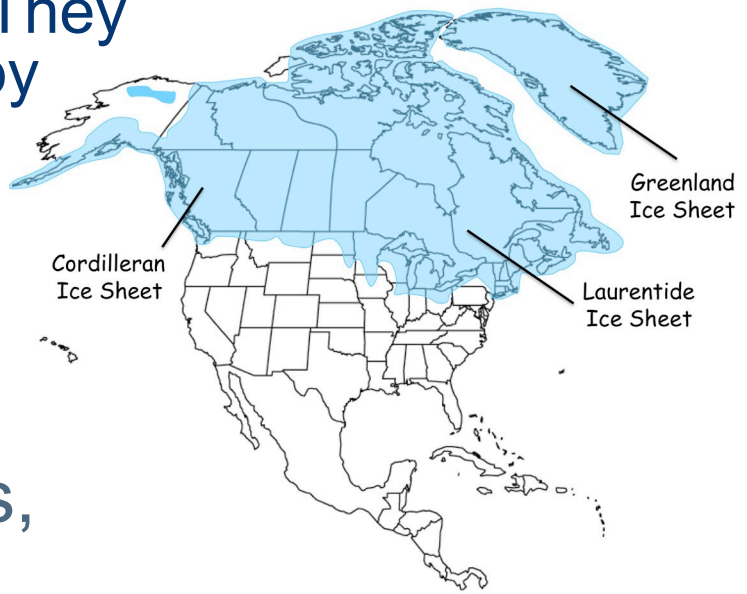
Forest

Natural Resources Conservation Service

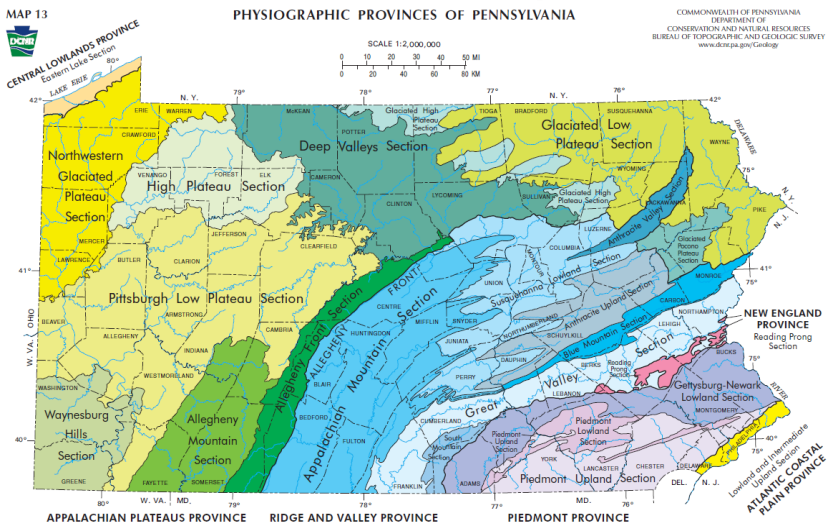
nrcs.usda.gov/

Parent Material

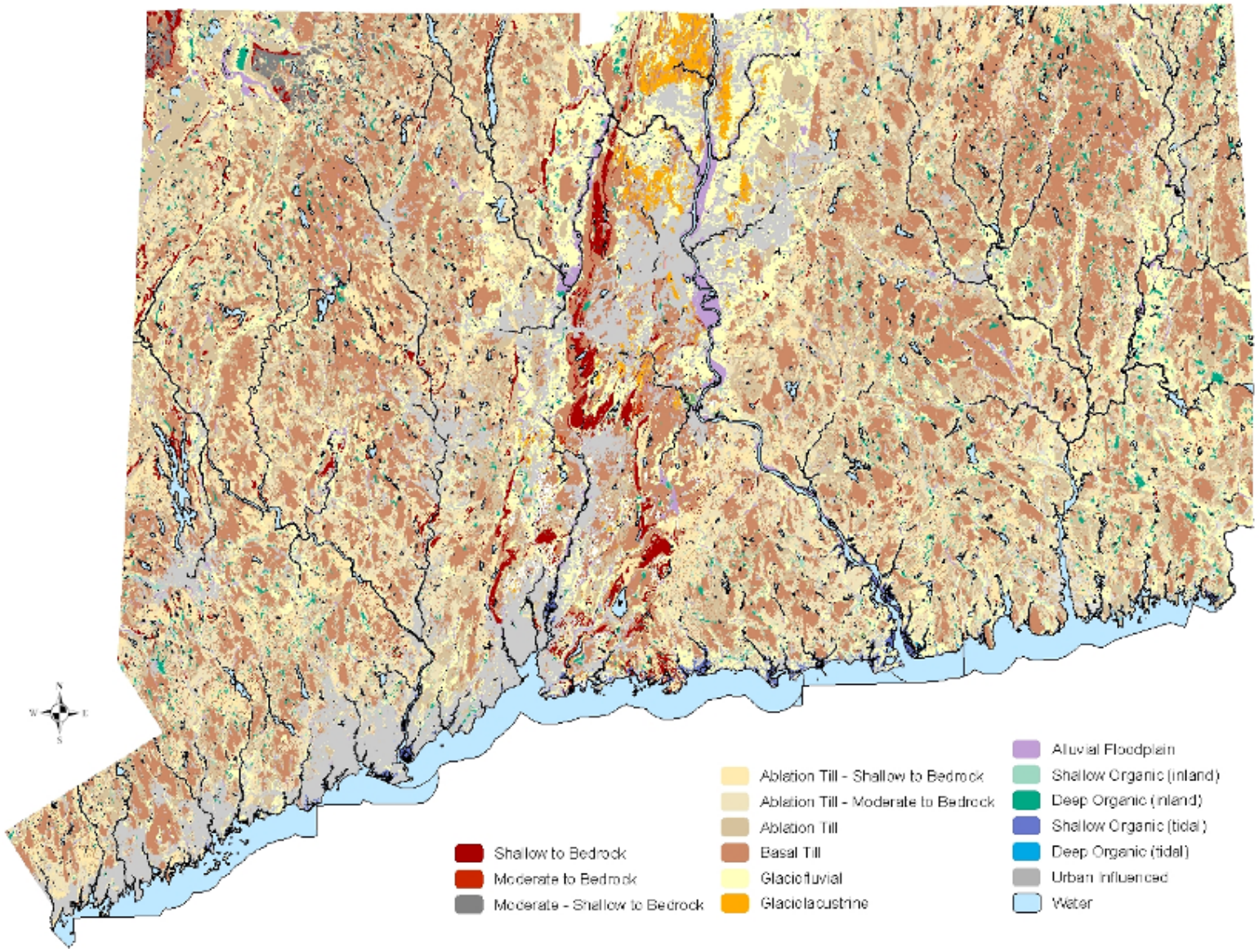
Soils inherit traits from parent material. They may be formed in place or transported by flooding rivers, glacial deposition, mass wasting, or blowing winds.



- Residuum
- Colluvium
- Glacial (till, meltwater deposits, glacial lakebeds)
- Alluvium (floodplain)
- Organic materials (swamp, tidal marsh)
- *and more…*

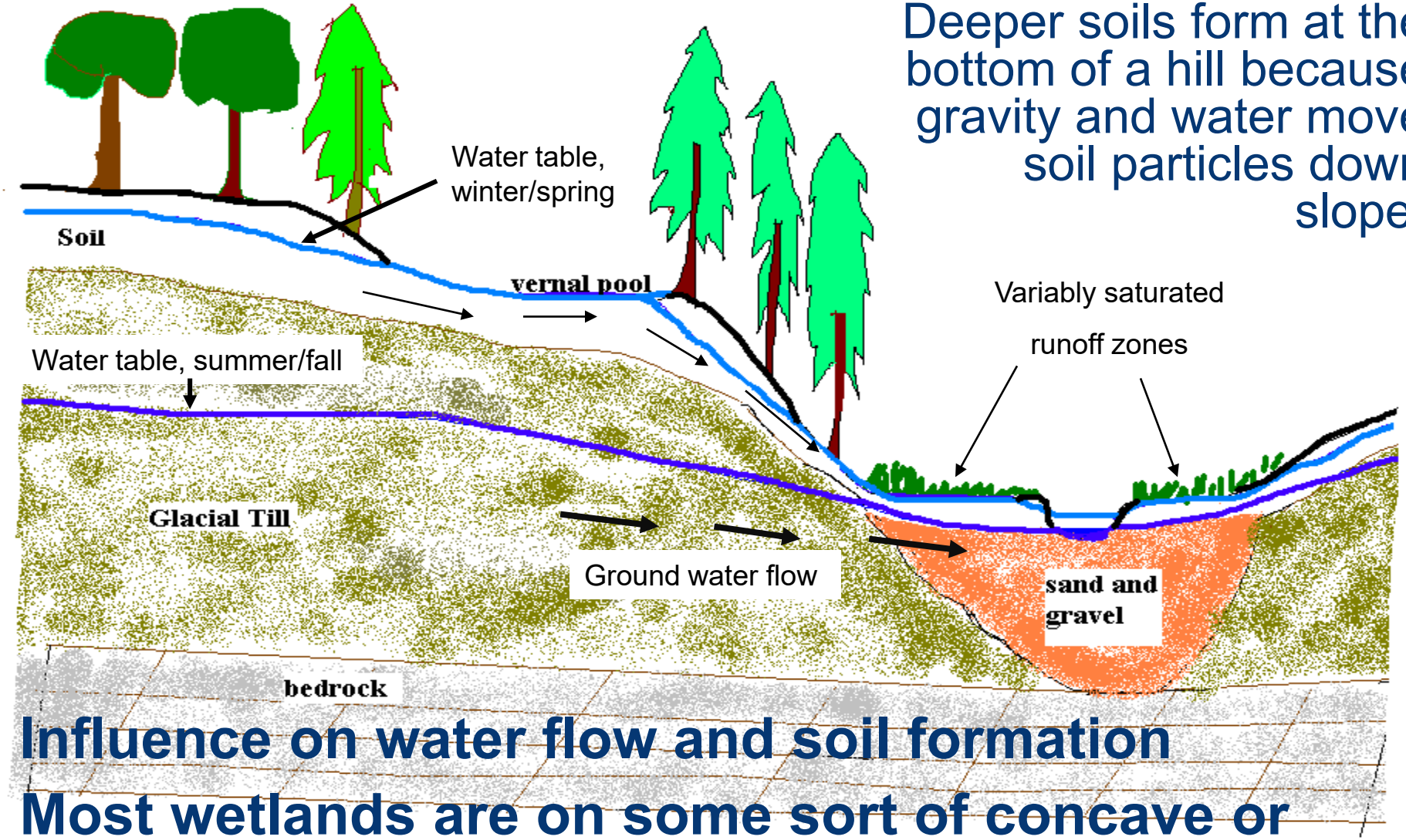


Soil Parent Material maps



Relief (Landscape Position)

Deeper soils form at the bottom of a hill because gravity and water move soil particles down slope.

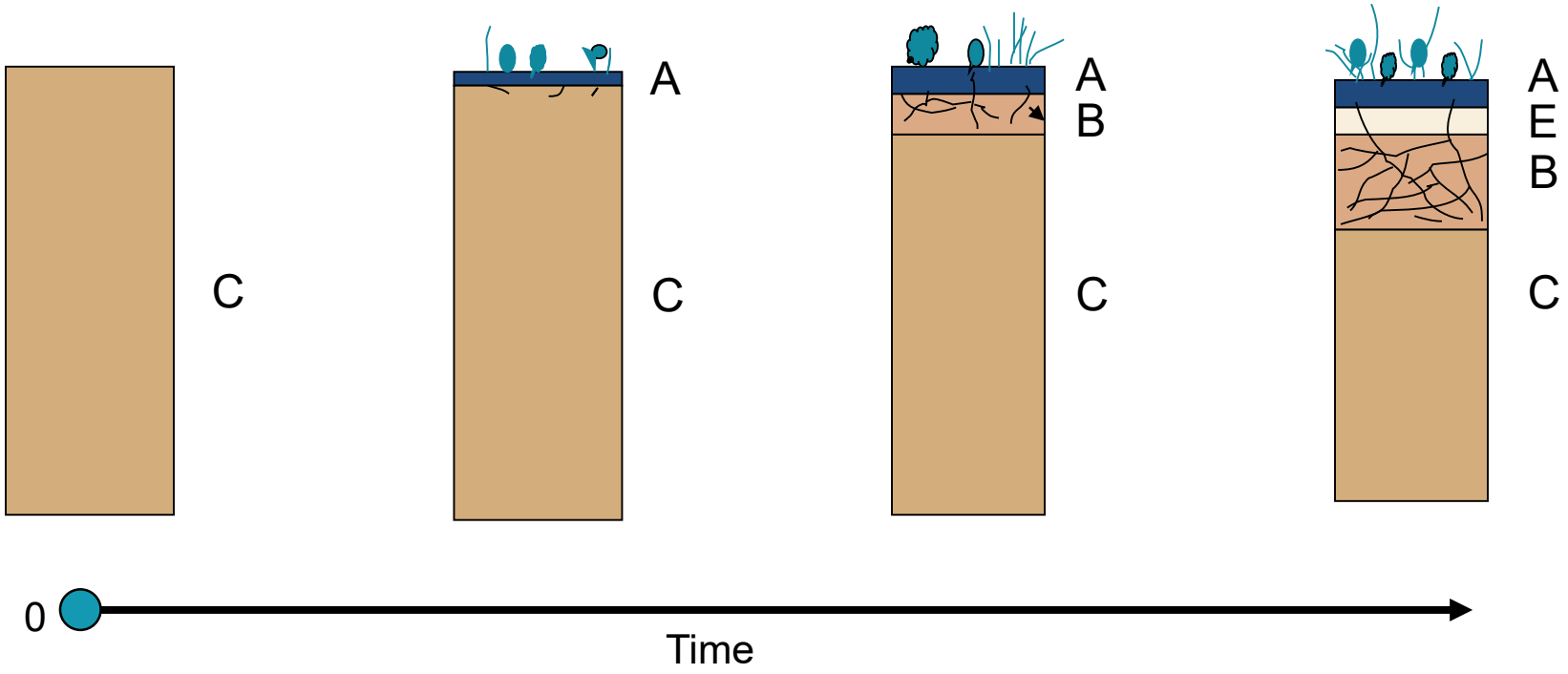


Influence on water flow and soil formation

Most wetlands are on some sort of concave or broad, flat surface

Time

All the factors work together over time. Major geologic events (e.g., glaciation) can *reset* the clock



Soil development as a function of time

(parent material, topography, climate and biota being held equal)

Soil Properties and Characteristics

- Horizonation
- Color
- Redox Features
- Texture
- Structure
- Consistence
- pH and Nutrient Supply
- Soil water holding capacity
- Organic matter content
- Saturated hydraulic conductivity

Soil Texture

Sand

2 to 0.05 mm

Particles visible without a magnifying glass

Feels coarse and gritty

Silt

0.05 to 0.002 mm

Not typically visible by the unaided eye

Feels smooth and floury

Clay

< 0.002 mm

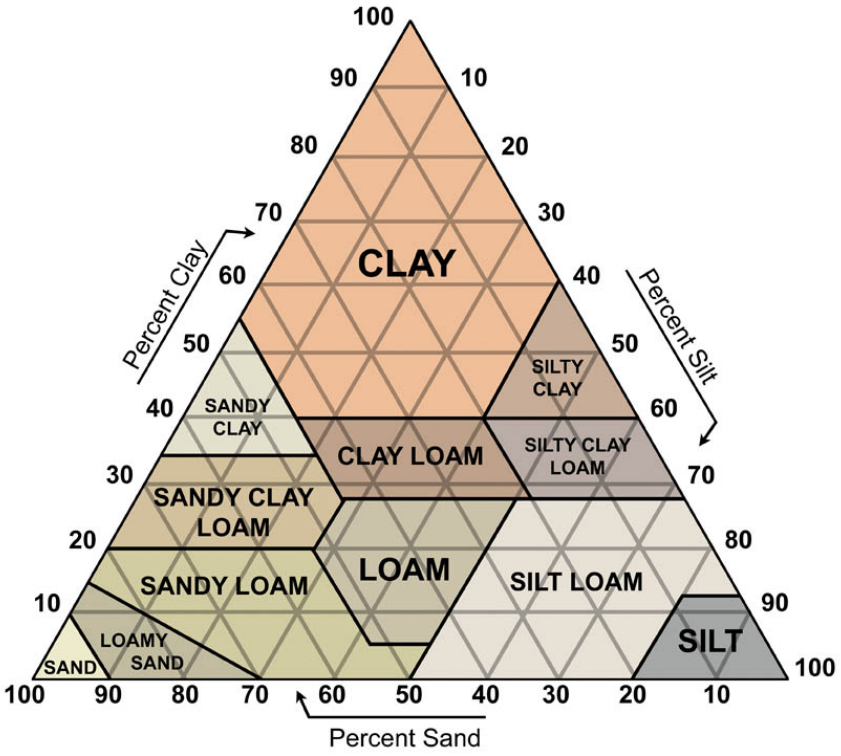
Seen only with an electron microscope

Feels stiff and sticky

Photos by Jim Baker, Virginia Tech

Texture Classification Systems

USDA Soil Texture Classification



Used in OSDs, Soil Surveys, Soil Testing

Unified Soil Classification System (USCS)

COARSE-GRAINED SOILS
(more than 50% of material is larger than No. 200 sieve size.)

GRAVELS More than 50% of coarse fraction larger than No. 4 sieve size	Clean Gravels (Less than 5% fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
		GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
	Gravels with fines (More than 12% fines)	GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
SANDS 50% or more of coarse fraction smaller than No. 4 sieve size	Clean Sands (Less than 5% fines)	SW	Well-graded sands, gravelly sands, little or no fines
		SP	Poorly graded sands, gravelly sands, little or no fines
	Sands with fines (More than 12% fines)	SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures

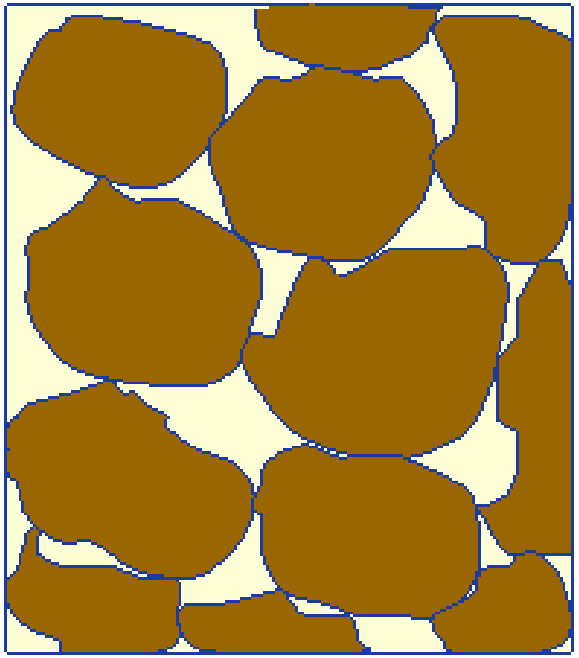
Common in engineering design criteria, Practice Standards for structures

Natural Resources Conservation Service

nrcs.usda.gov/

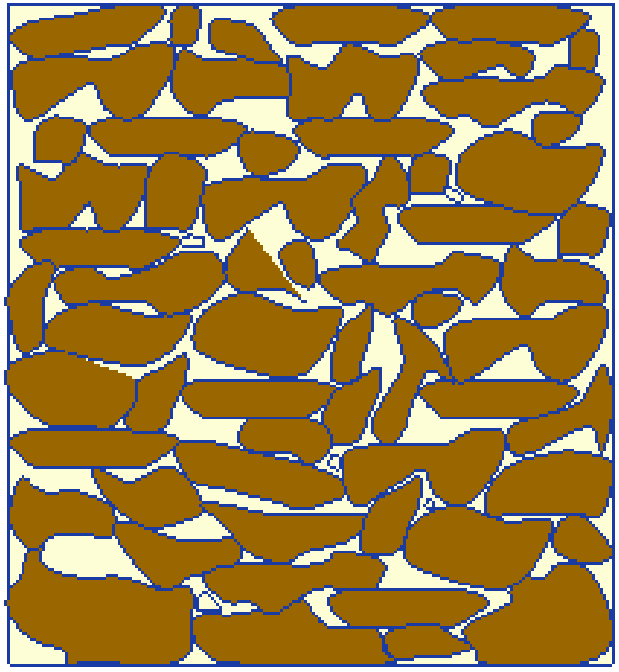
Texture and Pore Space

Coarse Textured Soil



Less pore space,
more *macro* pores

Fine Textured Soil

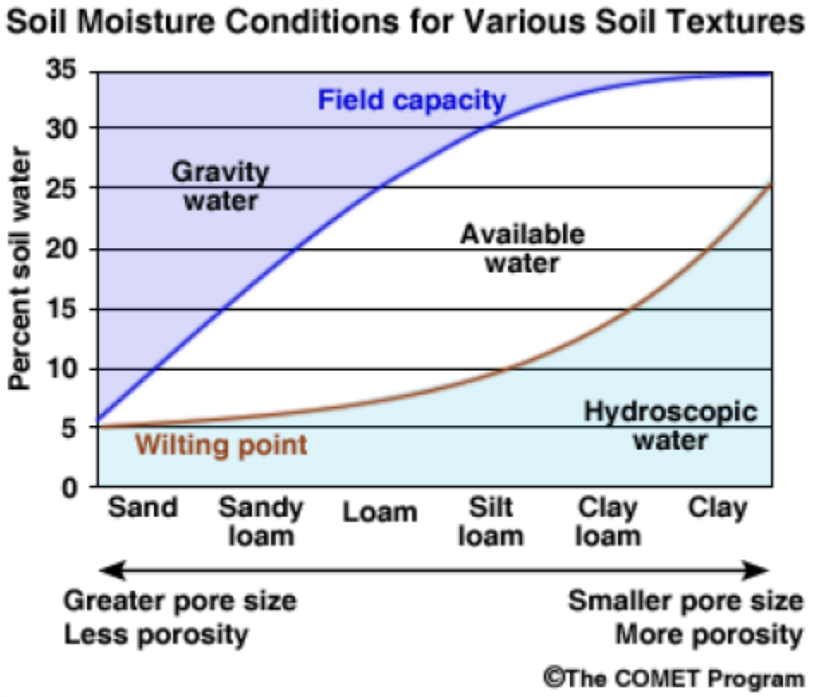


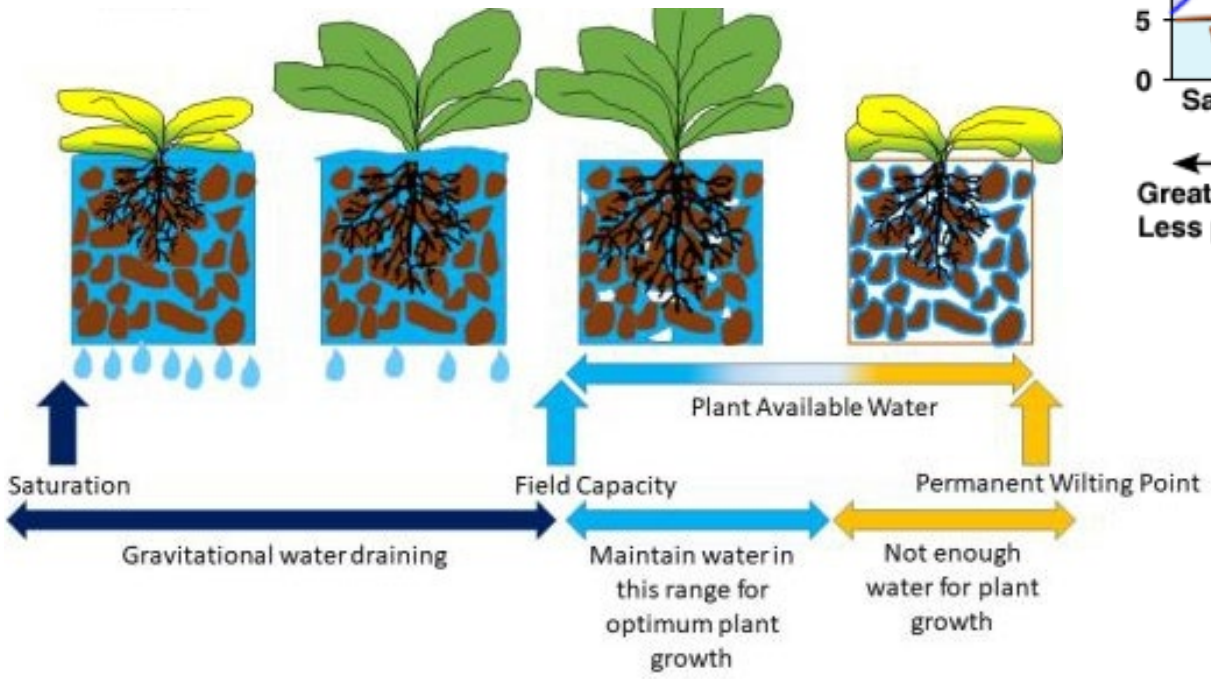
More total pore space,
smaller pore size

Available Water Capacity

Different soil types have different available water capacity (AWC)

Soil texture, organic matter content, and rock fragment content all affect AWC





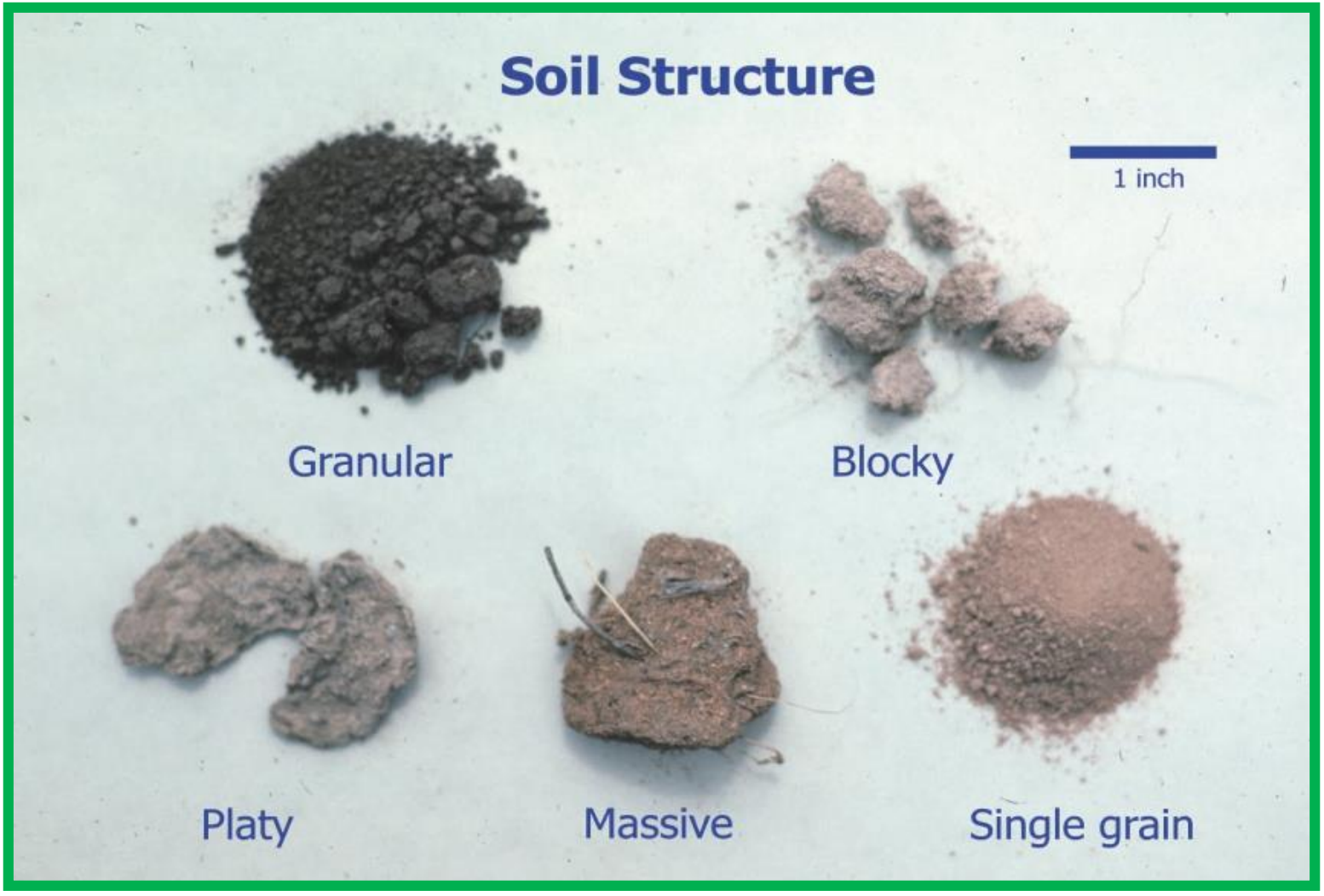
Images from University of Minnesota Extension

Natural Resources Conservation Service

nrcs.usda.gov/

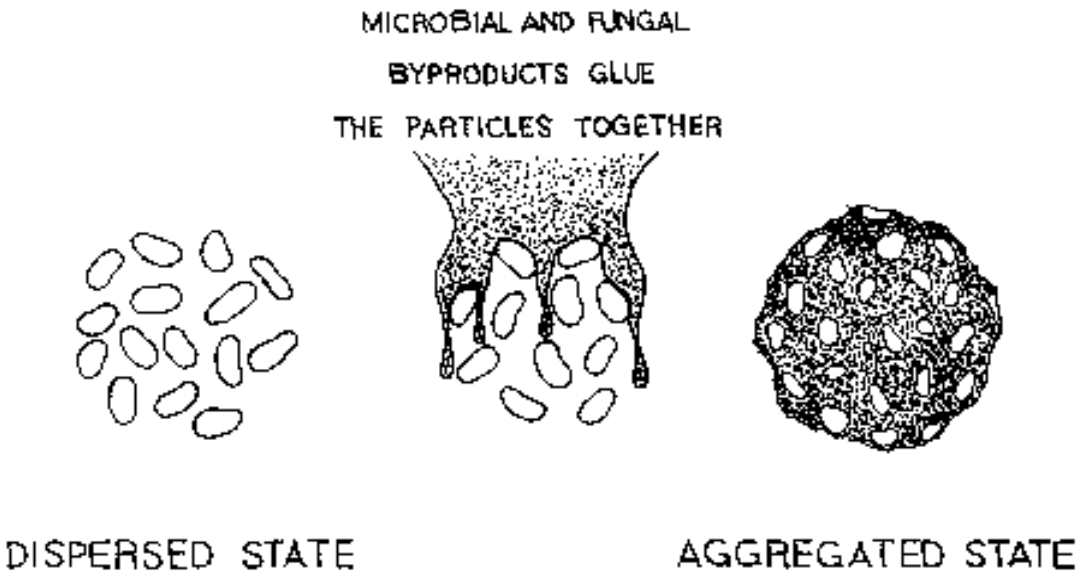
Soil Structure

Soil structure is the aggregation of soil particles into small units, called *peds*.



What promotes good surface structure or aggregate stability?

- Plant Roots
- Organic Matter
- Soil Biota

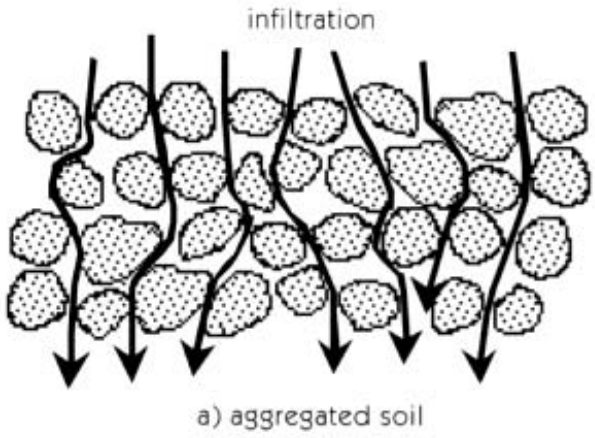


Soil structure can be **improved** or **degraded** depending on management.

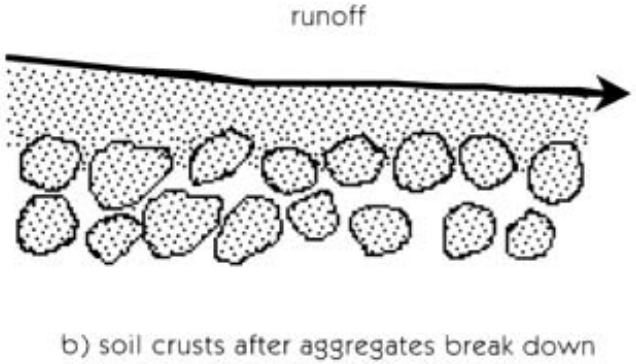
Good Structure Lacking?

You may have….

- Erosion - runoff
- Crusting
- Compaction - ponding
- Poor infiltration



a) aggregated soil



b) soil crusts after aggregates break down

Natural Resources Conservation Service

nrcs.usda.gov/

Soil Color

Soil color can inform:

- degree of weathering
- amount and distribution of organic matter
- Seasonal high-water table; redox features
- Soil mineralogy - different minerals have different hues

Strongest coloring agents in soil:

Organic carbon = BLACK, darkening effect

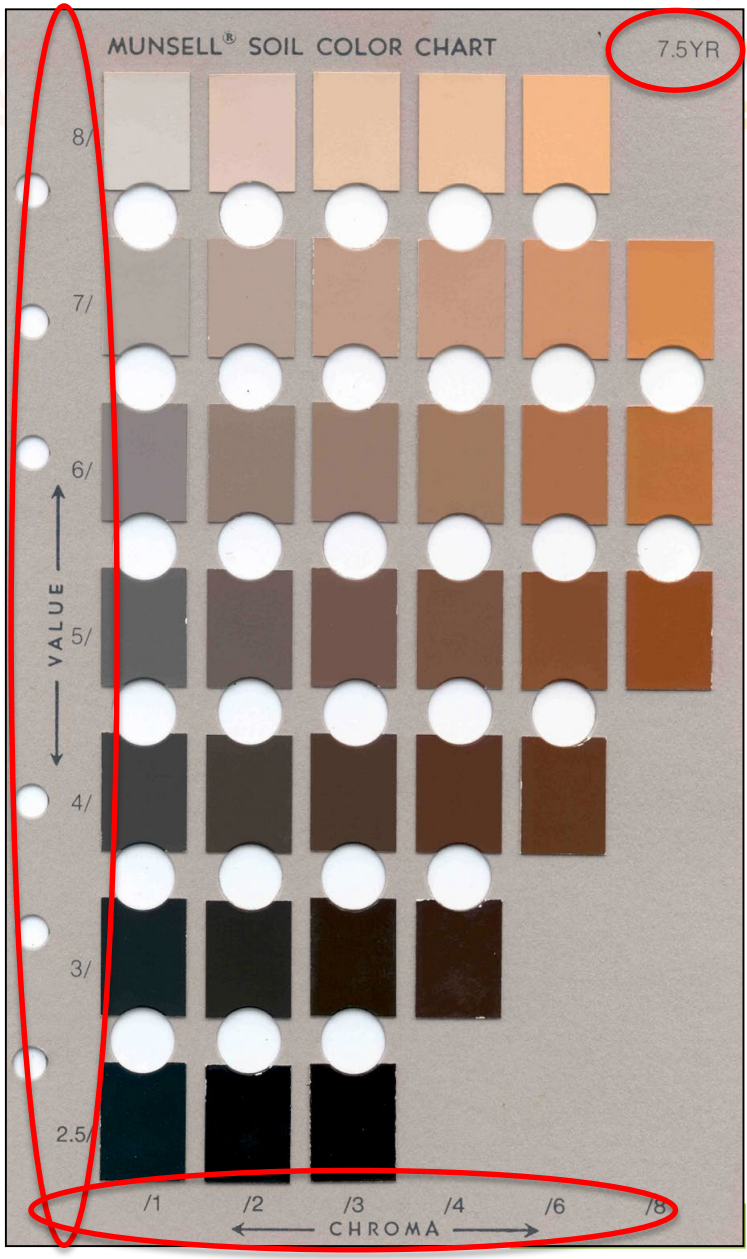
Iron (Fe) oxides = Reds, Oranges, Yellows (like Rust)

Photo Credit:
Soil Science Society of America

Soil Color Description

Munsell®

Hue, Value, Chroma



Soil Color as indicator of soil wetness

Well Drained

Poorly Drained

Moderately Well Drained

Natural Resources Conservation Service

nrcs.usda.gov/

Drainage Class

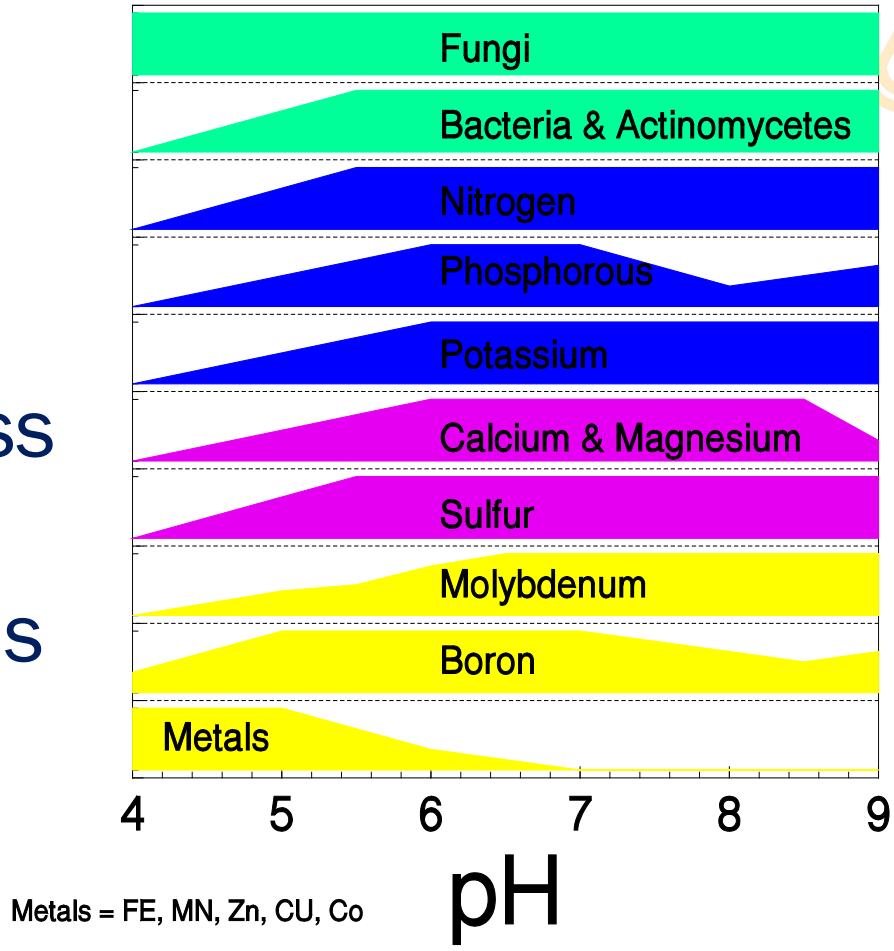
Soil interpretation – the frequency and duration of wetness under which the soil formed

Depth to SHWT interpreted by presence of **redox features**, gray mottles (chroma <2 redoximorphic features)

Soil pH

Influences:

- Nutrient availability
- Plant growth and biomass yield
- Availability of toxic metals
- Soil biological, chemical, and physical processes



Metals = FE, MN, Zn, CU, Co

A pH of 6.0 to 6.8 is ideal for most crops because it coincides with optimum solubility of the most important plant nutrients.

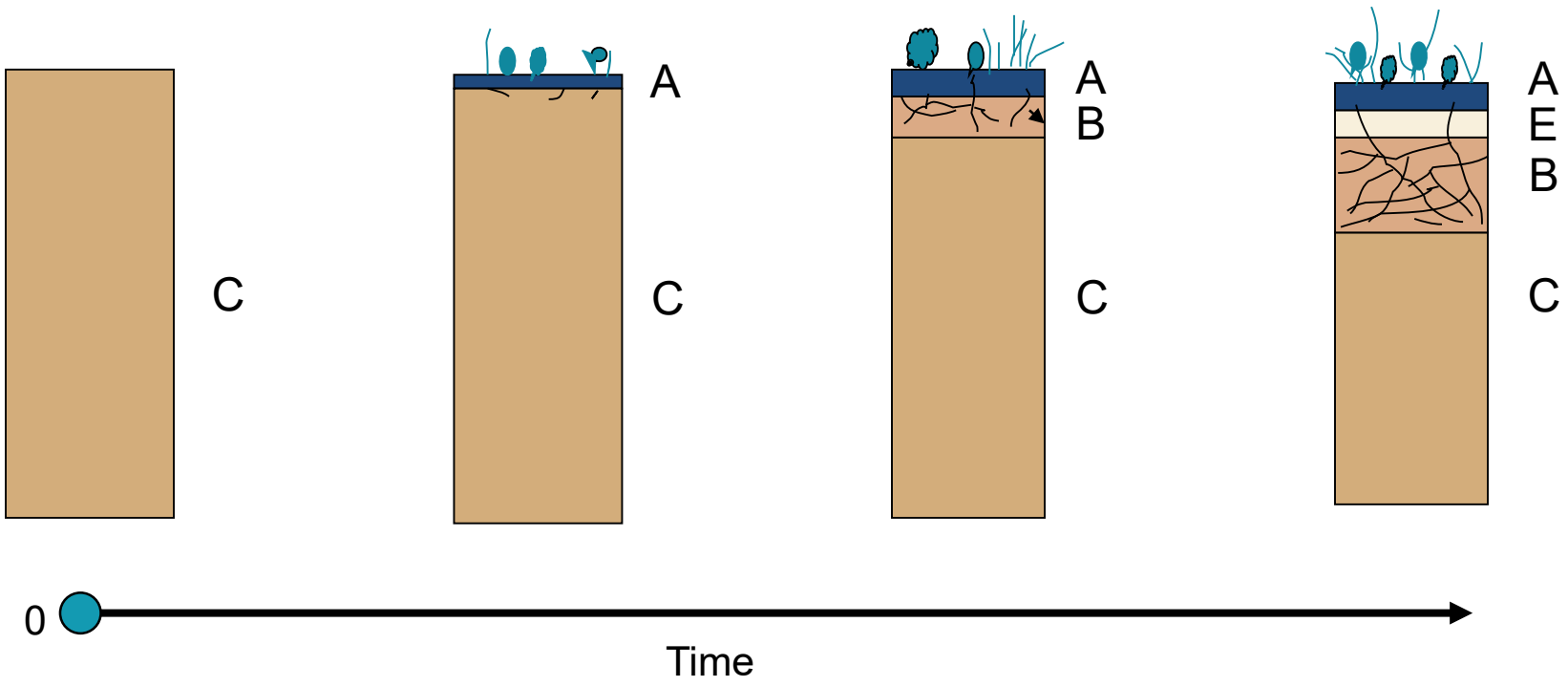
Soil Restrictions

Water and root-limiting layers:

- Bedrock contact
- Dense till materials
- Fragipan

Depth Class	Depth
Very deep	> 60”
Deep	40 - 60”
Moderately Deep	20 - 40”
Shallow	10 - 20”
Very Shallow	0 - 10”

Soil Horizons



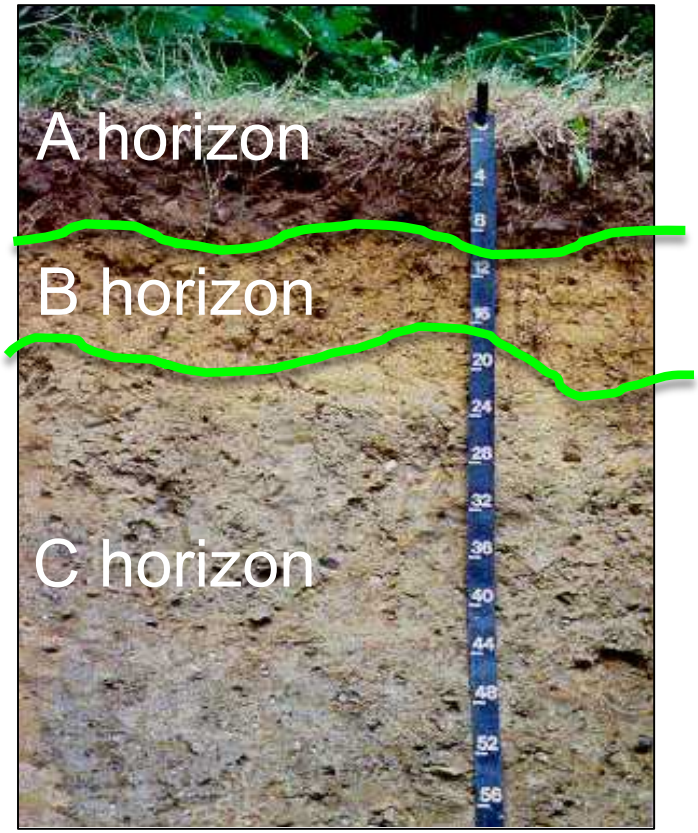
Soil change over time often can be visualized by horizon development

Older soils typically have more horizon development

Horizons are differentiated by changes in:

- Soil Color
- Soil Texture
- Roots
- Soil Structure
- Rock fragment content
- Redoximorphic features
- Restrictive features
- Consistence

There is no set number of horizons a soil profile can have.



Horizon Nomenclature

O - Dominated by organic matter

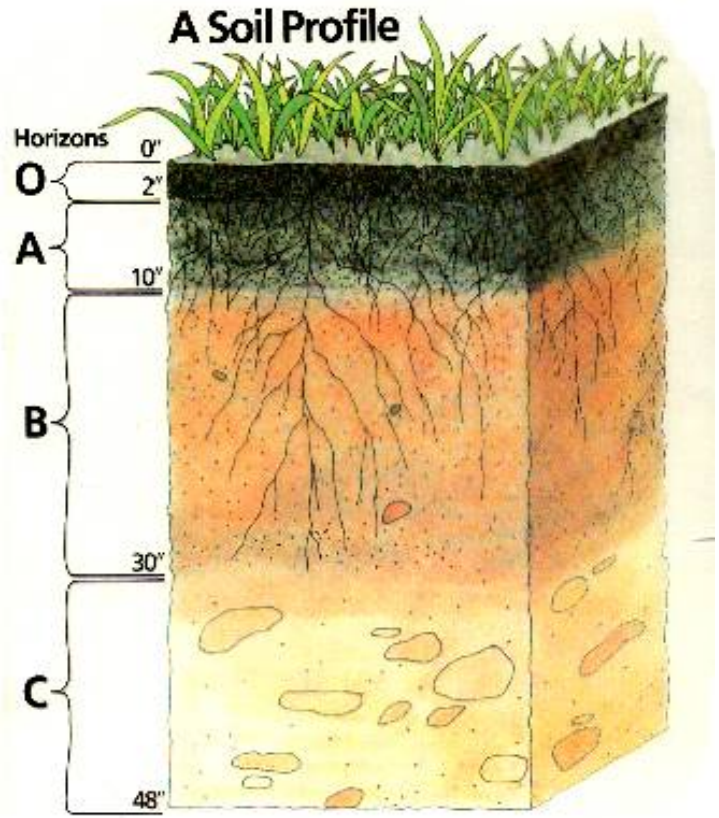
A - Mineral layer with some accumulation of organic matter

E- Loss of clay, iron, and aluminum. Paler in color

B - Concentration of clay, iron, and aluminum. Development of structure

C - no evidence of soil forming process no structure but can have redox features

R - Bedrock



Natural Resources Conservation Service

nrcs.usda.gov/

Basic Soil Properties and Characteristics Module Summary

Take home concepts:

- Different soil types represent different soil properties resulting from soil formation and management
- Different soils are better suited for different land uses and land covers. Good conservation planning can involve matching these.
- Learn more about soils on the USDA NRCS soils website https://www.nrcs.usda.gov/wps/portal/nrcs/site/soils/home/
- Work with your NRCS SSS/RSS to learn more about the soils in your area. Become familiar with the soil survey.