USDA Natural Resources Conservation Service
U.S. DEPARTMENT OF AGRICULTURE

ENVIROTHON

Soils Station

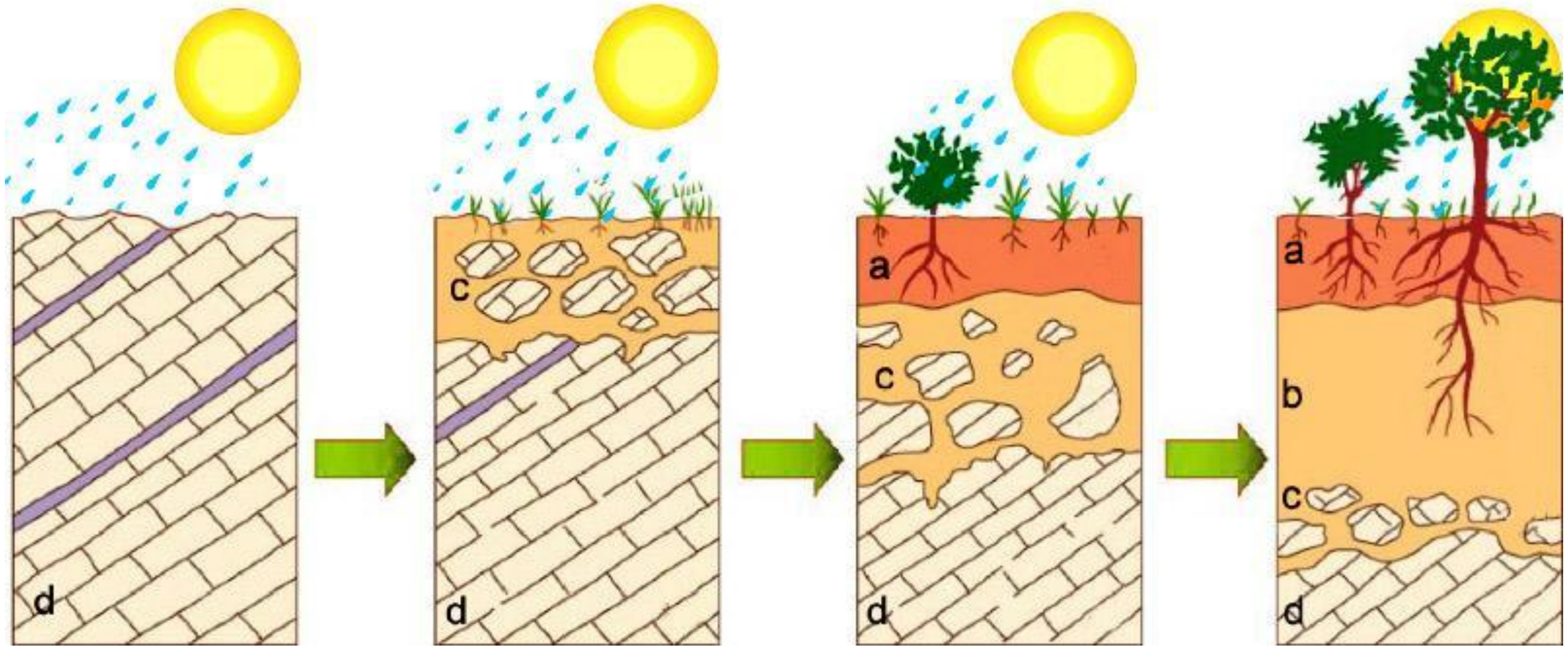
Soil and Plant Science Division | soils.usda.gov
SOIL SCIENCE AND RESOURCE ASSESSMENT

What is soil?

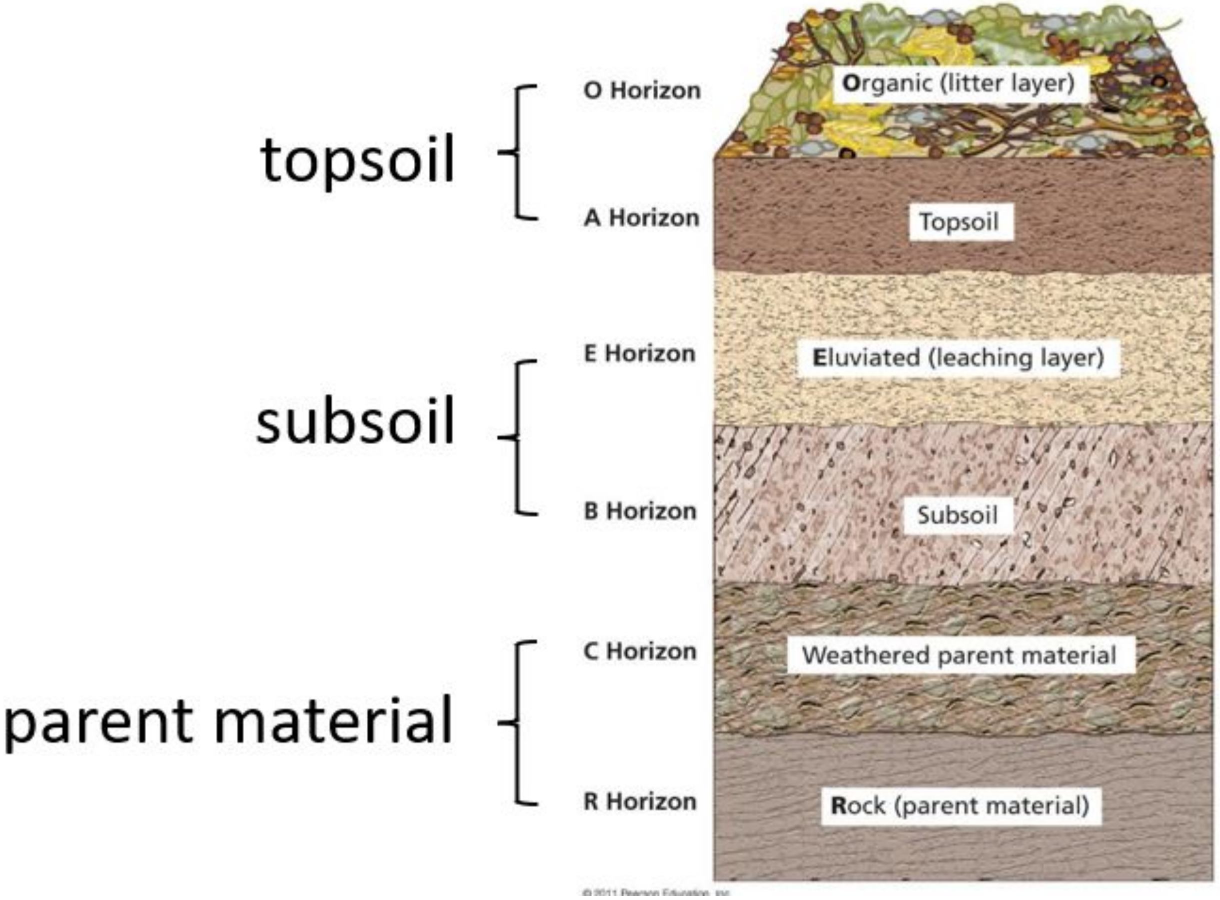
- Natural material that covers the Earth's surface
- Made up of minerals, organic matter, water, and air
- Vital part of the ecosystem, providing a habitat for plants and animals, and storing water

Soil Development

- Process where minerals and rocks break down into soil
- Happens through chemical and physical weathering along with biological activity



As soils age, they form distinct soil horizons and a soil p

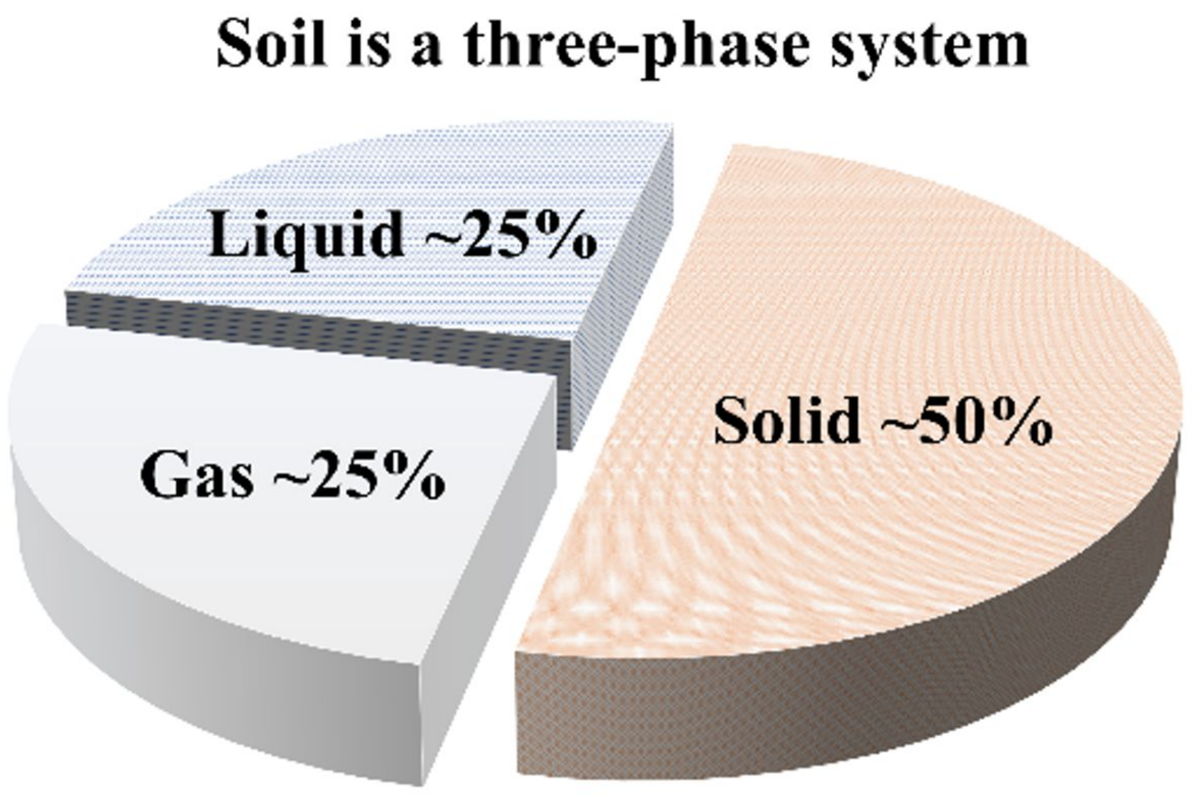


O = organic matter on the soil surface that is in various states of decay.
A = the surface of the mineral soil that is composed of mineral and organic material.
E = (eluviation) the horizon between the surface and subsurface that has some part of it removed and transported to the subsurface
B = (illuviation) the subsurface zone where materials from the horizons above are deposited (illuviated) by the water that continually moves down from the surface.
C = raw parent material
R = bedrock in its unchanged state.

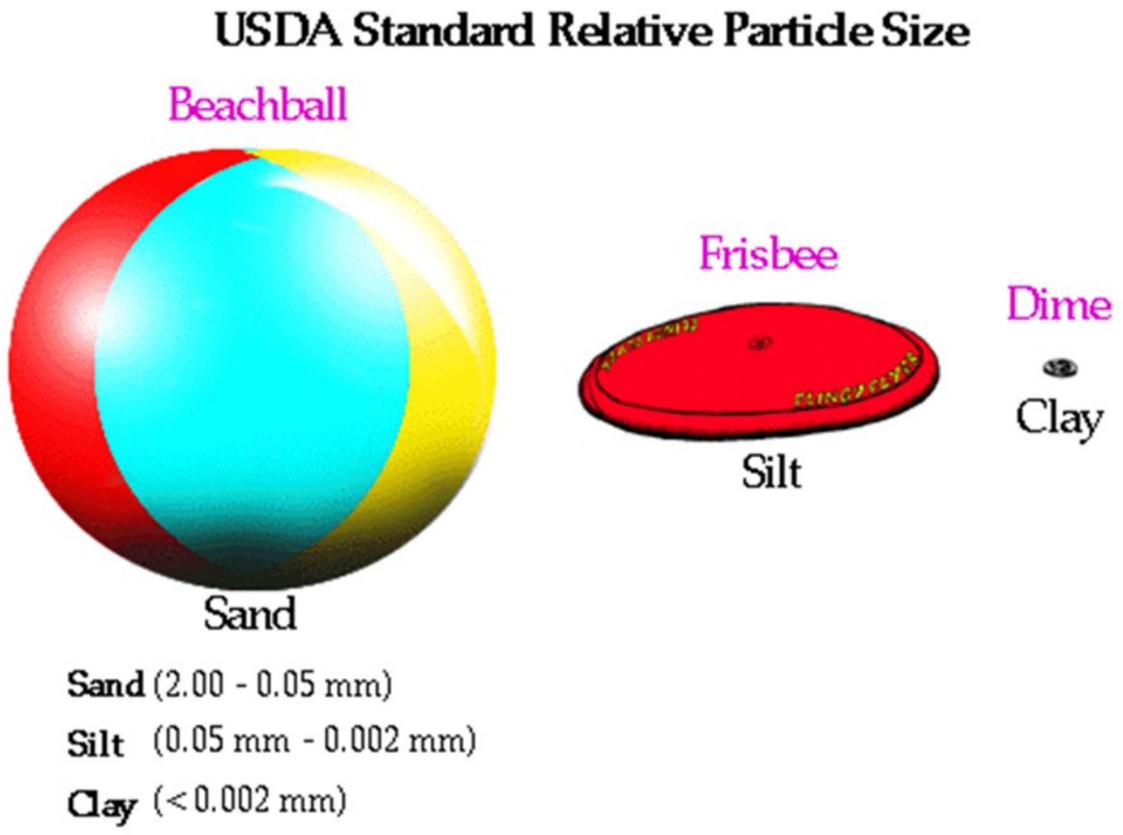
Soil Phases

- Soils are made up three major components

- 1) The solid phase- made of mineral particles and organic matter- structure nutrients and support for plant growth.
- 2) The Liquid Phase made up of soil water
- 3) Gas Phase made up soil air such as oxygen, CO2
- These proportions are not fixed



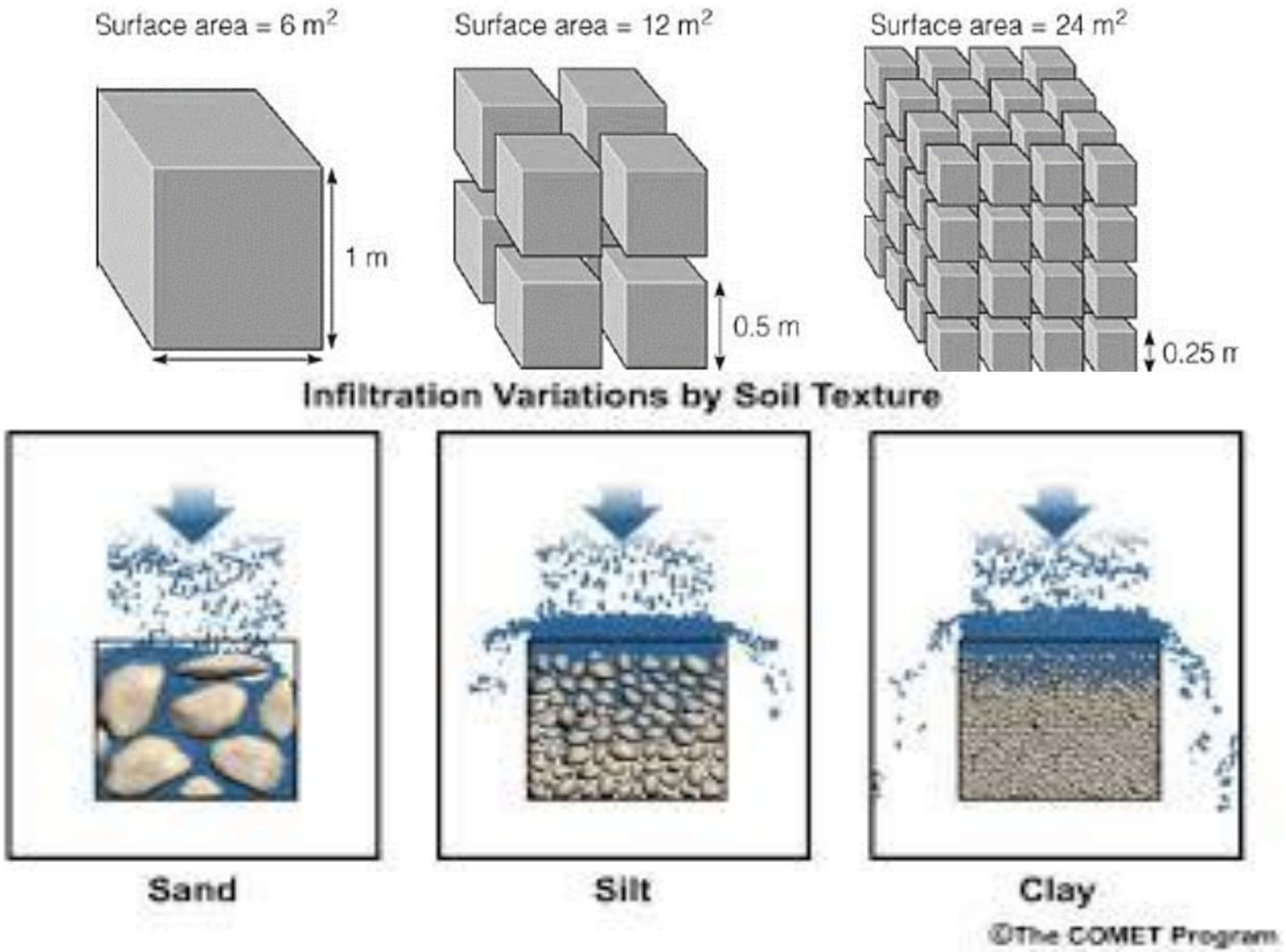
Particle Sizes



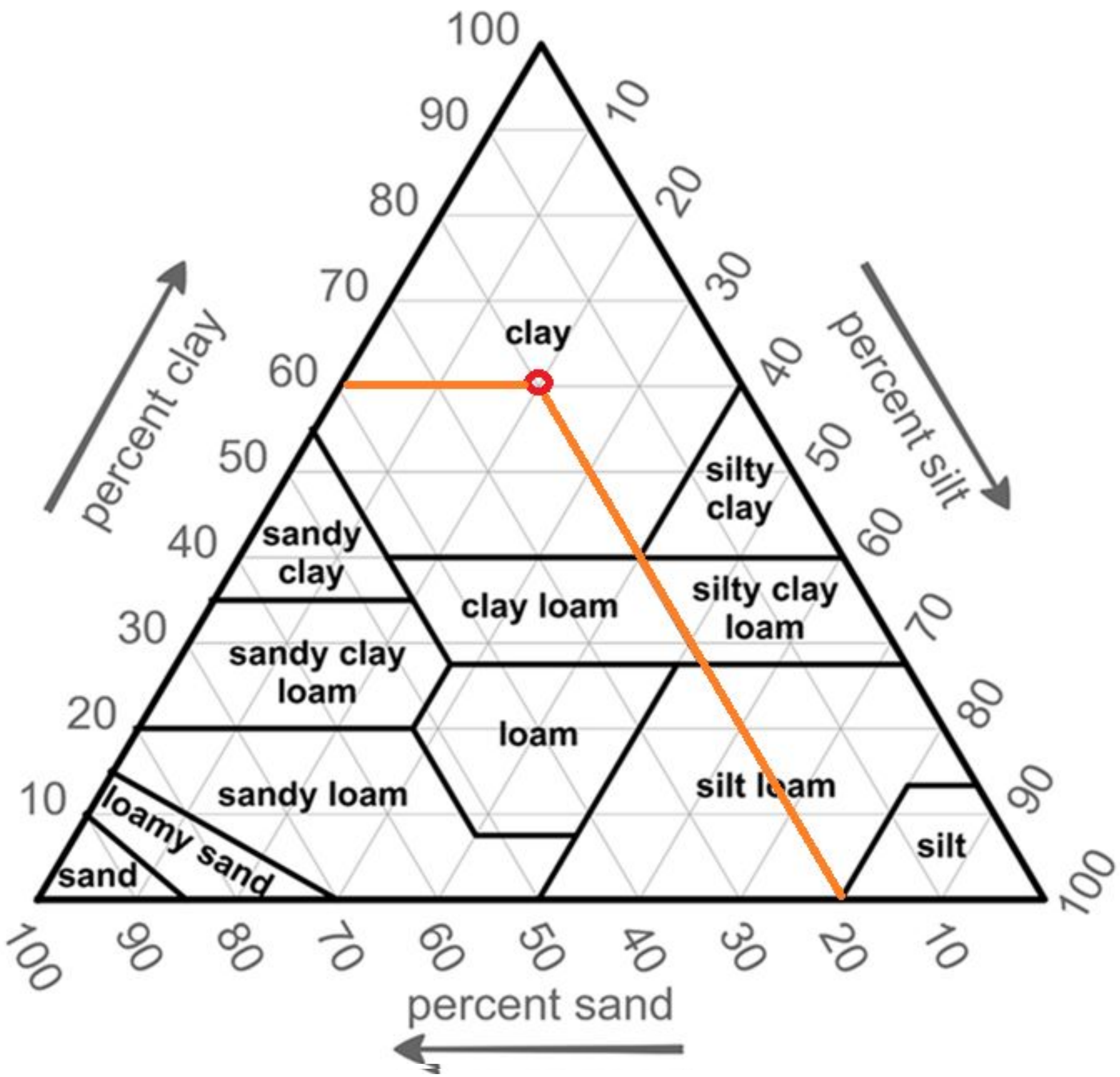
- 1) Course Fragments (greater than 2 mm):
- boulders, stones, cobbles gravels
- 2) Fine Particles (less then 2mm):
  - •Sand 2-0.05mm
  - •Silt 0.05-mm-0.002mm
  - •Clay less than .002mm
- Does not Include Organic Matter

Surface Area & Drainage

- Clay particles are more cohesive (sticky) but have less connected pore space that inhibits drainage
- Sandy soils have more drainage because of their large connected pores
- Silty soils are more erosive



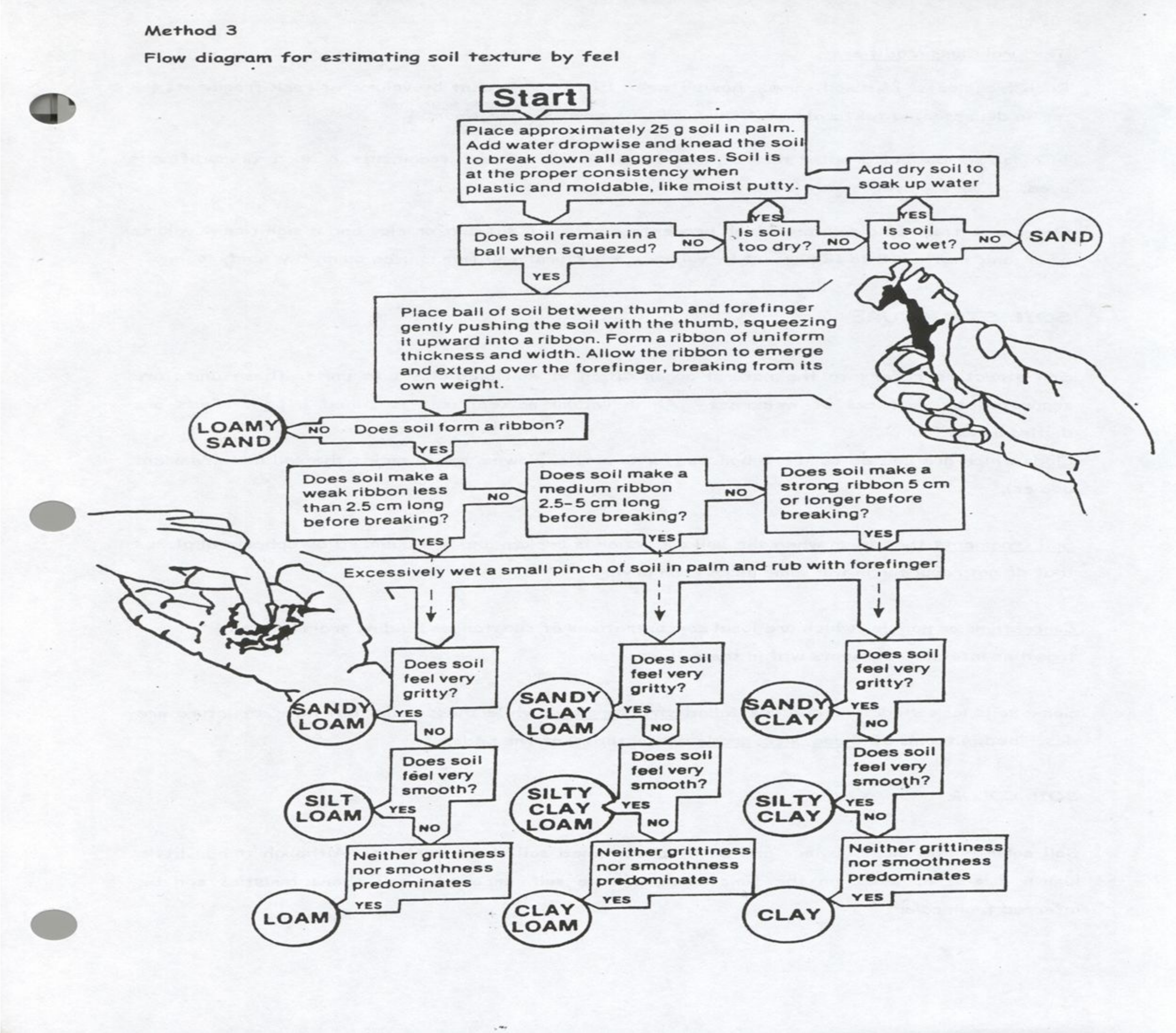
Soil Textural Triangle



- Loam textures have a balanced combination of all three fine particle sizes (sand, silt and clay)
- This brings together the ideal conditions for drainage, structure and nutrient holding capacity for growing many types of crops

Texture by Feel

- Method used in the field to determine soil textures

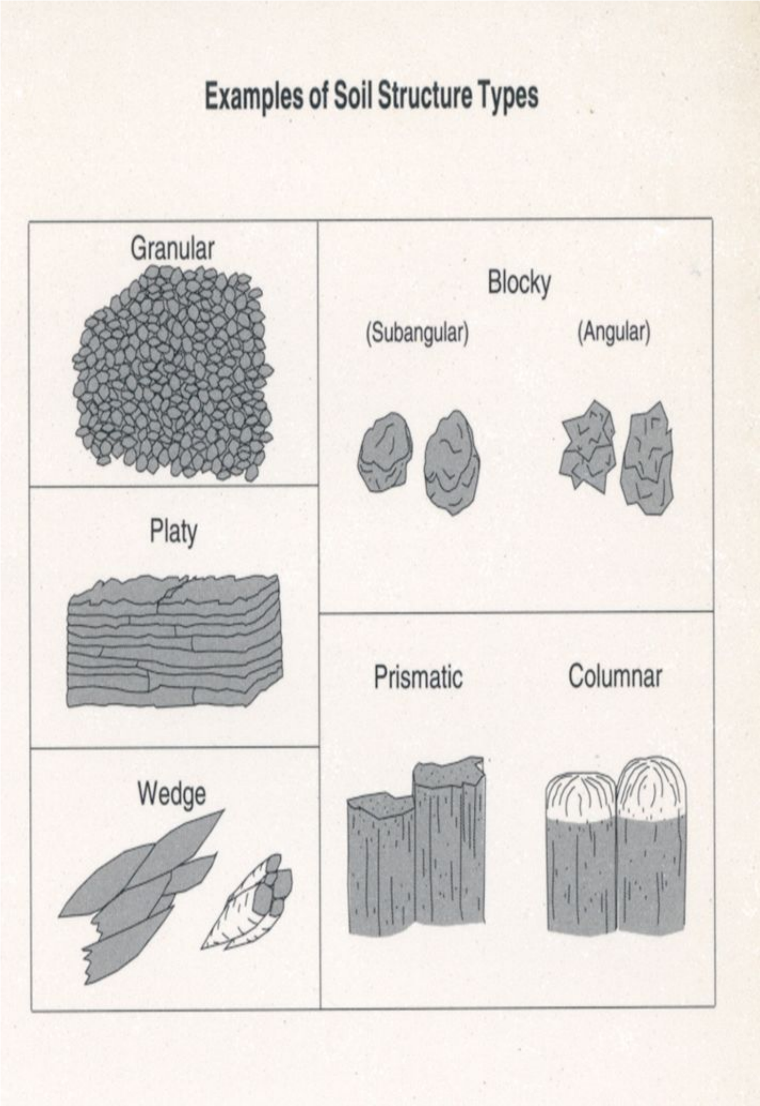


Soil Structure

- Soil structure is the natural organization of soil particles into units called peds.
- Structure is measured by looking at the shape, size and grade of the peds
- Size: (smallest to largest) very fine, fine, medium, course, very course
- Grade: Structureless, Weak, Moderate, Strong

Soil Structure Types

- Granular- crumb size units; often associated with A horizons that contain organic material
- Blocky and sub-angular blocky- block like with more rounded or sharper edges and faces; often associated with B horizons
- Platy- thin flat horizontal plate like aggregates often associated with compaction
- Massive- No structural units; material is a coherent mass
- Single grain- No structural units; loose sand

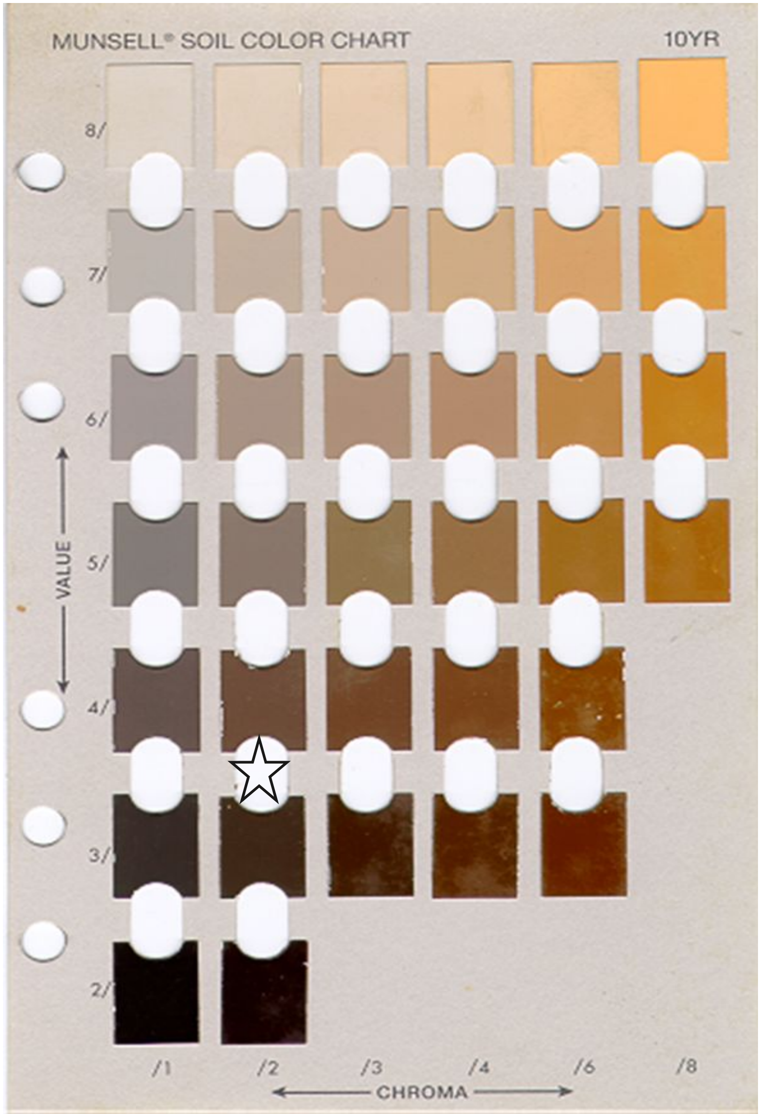


Soil Color

- Color can tell us about
- nutrients and elements available,
- the type of parent material,
- redox potential,
- the amount of organic matter,
- Helps with defining soil horizons

Munsell Soil Color Book

- Hue: Dominant spectral color. Value found in the top right-hand corner of each page.
- Value: The degree of light/dark of a color in relation to a neutral gray scale. Values along the left-hand side of each page.
- Chroma: Strength of hue. Values along the bottom of each page.



What is the color chip for the star: 10YR 3/ 2

Questions?

Factors of Soil Formation

CLimate

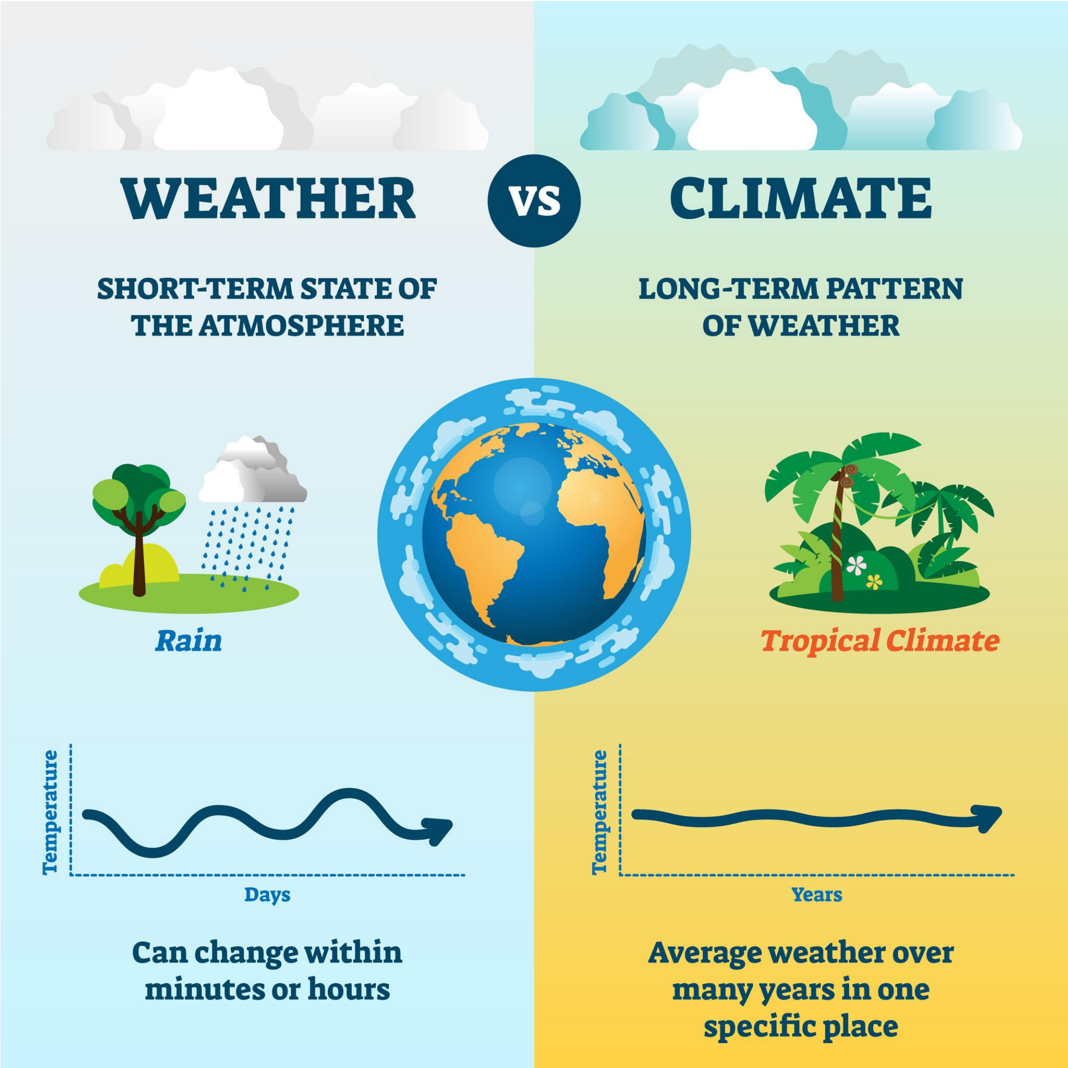
Organisms

Relief

Parent Material

Time

Climate


WEATHER
VS
CLIMATE
SHORT-TERM STATE OF THE ATMOSPHERE
LONG-TERM PATTERN OF WEATHER
Rain
Tropical Climate
Temperature
Days
Temperature
Years
Can change within minutes or hours
Average weather over many years in one specific place

Climate Drivers of Soil Development

- Temperature and moisture are main climatic controls on soil development
- Warm and moist conditions typically most conducive to soil development
- Extreme ends of spectrum inhibit development (hot and dry, cold and wet)

Vermont’s Climate

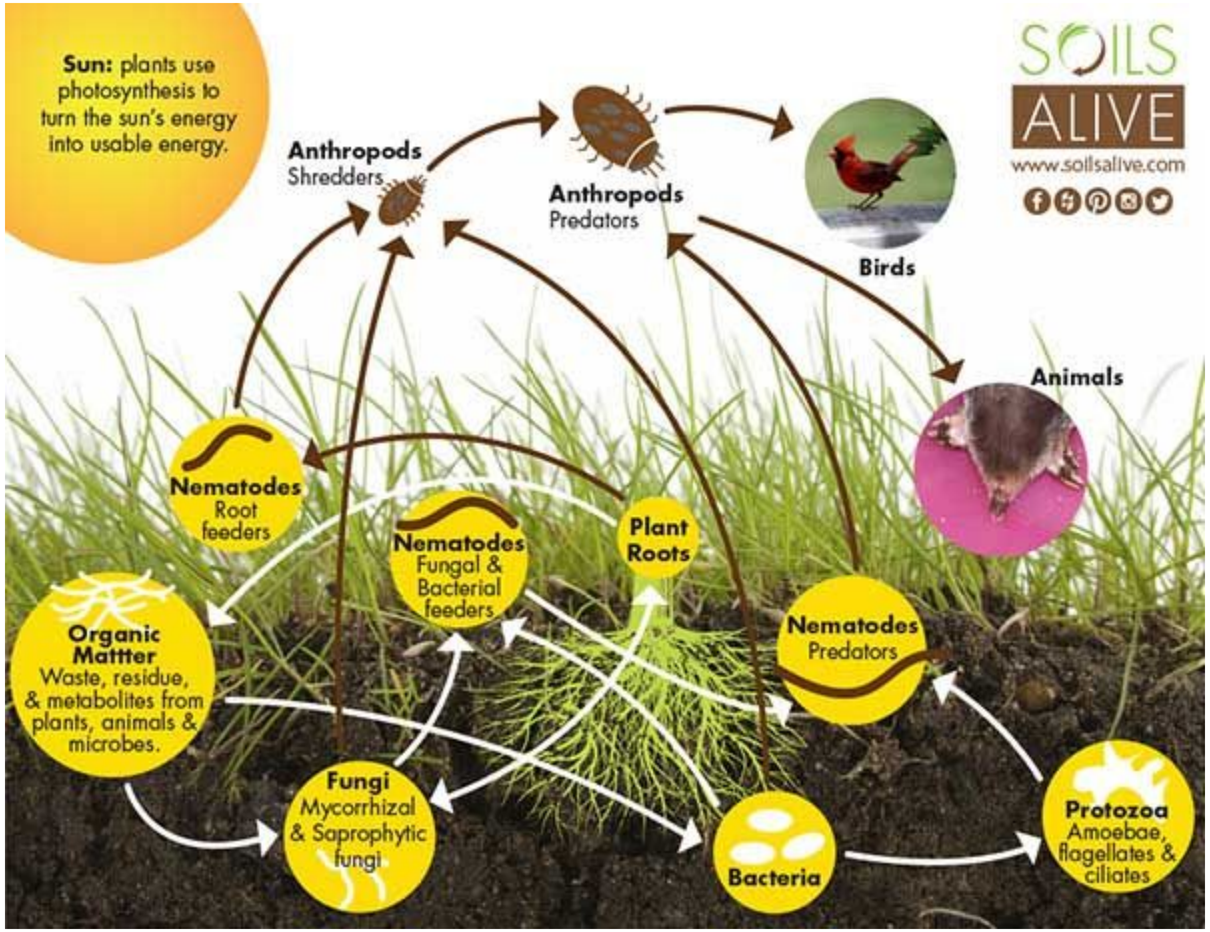
Today

Continental

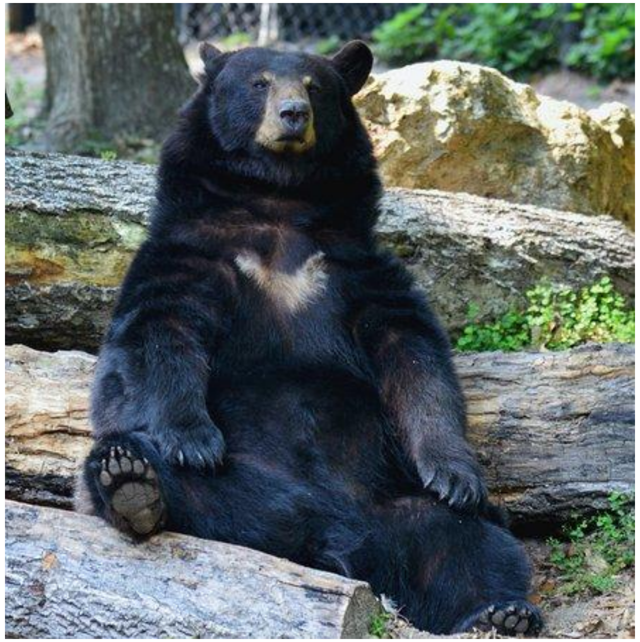
~10,000 years ago

Glacial

Organisms


Sun: plants use photosynthesis to turn the sun's energy into usable energy.
SOILS ALIVE
www.soilsalive.com
Anthropods Shredders
Anthropods Predators
Birds
Animals
Nematodes Root feeders
Nematodes Fungal & Bacterial feeders
Plant Roots
Nematodes Predators
Organic Matter Waste, residue, & metabolites from plants, animals & microbes.
Fungi Mycorrhizal & Saprophytic fungi
Bacteria
Protozoa Amoebae, flagellates & ciliates

Vermont Organisms



Relief (aka Topography)

Parent Material

- Origin of soil material

Residuum

Colluvium

Alluvium

Parent Material

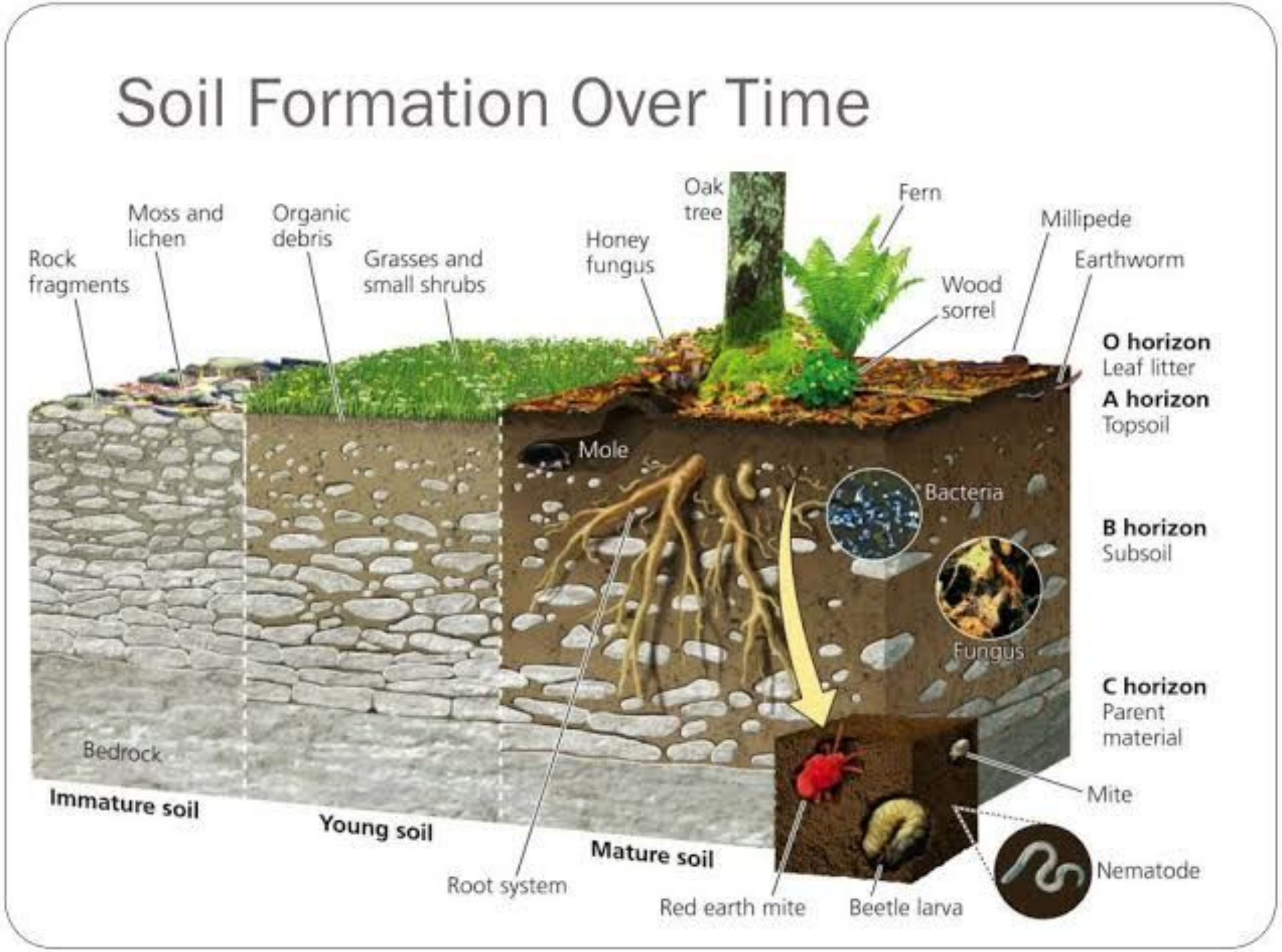
- Can affect soil chemistry, texture, structure, fragments
- Examples:
- Soil weathered from limestone residuum will inherit the calcium carbonate found in the original rock, meaning it will have a basic pH
- Soil developed from an old lake-bed will be finer textured since most sediment suspended in the slow-moving water reaching a lake are finer grains

Vermont Parent Materials

Till

Glaciolacustrine Deposits

Time


Soil Formation Over Time
Rock fragments
Moss and lichen
Organic debris
Grasses and small shrubs
Honey fungus
Oak tree
Fern
Wood sorrel
Millipede
Earthworm
O horizon
Leaf litter
A horizon
Topsoil
Mole
Bacteria
B horizon
Subsoil
Fungus
C horizon
Parent material
Bedrock
Immature soil
Young soil
Mature soil
Root system
Red earth mite
Beetle larva
Mite
Nematode

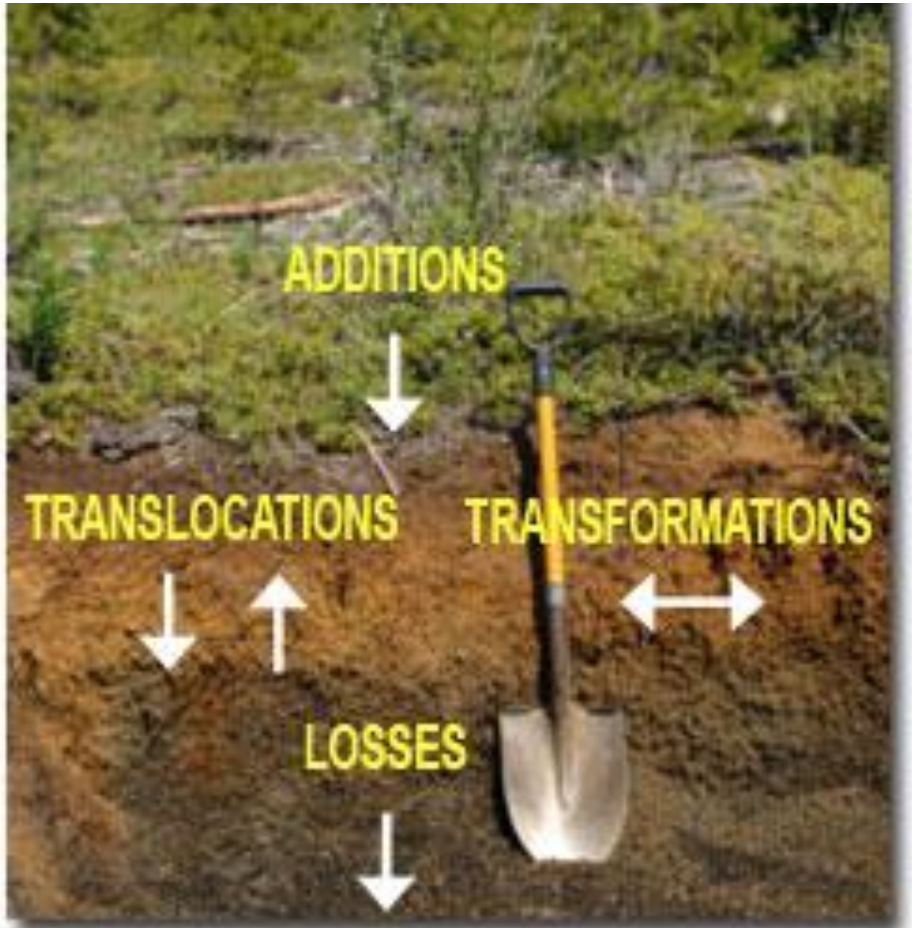
How does Parent Material become Soil?

Additions

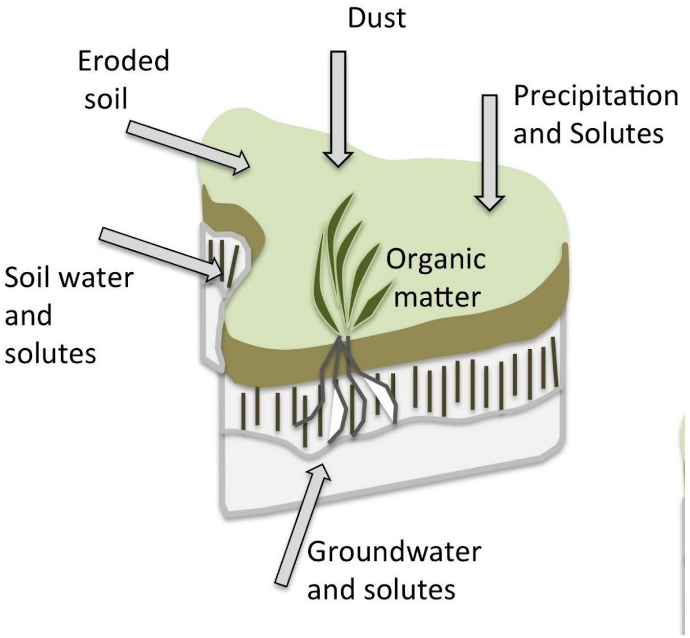
Losses

Transformations

Translocations

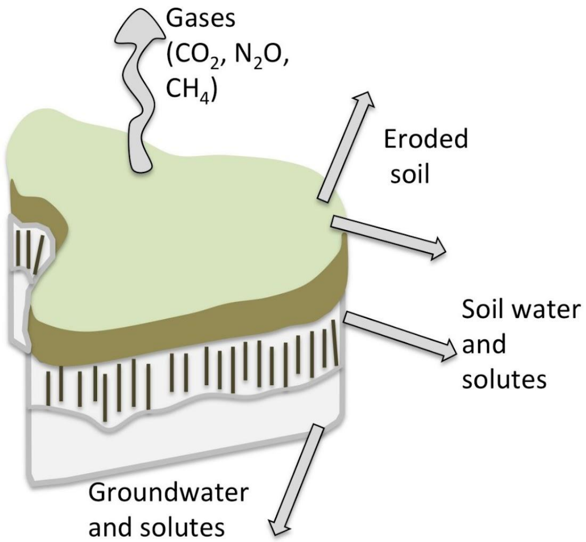


Additions



- Plant material
- Eroded Soil
- Solutes from rain or ground water

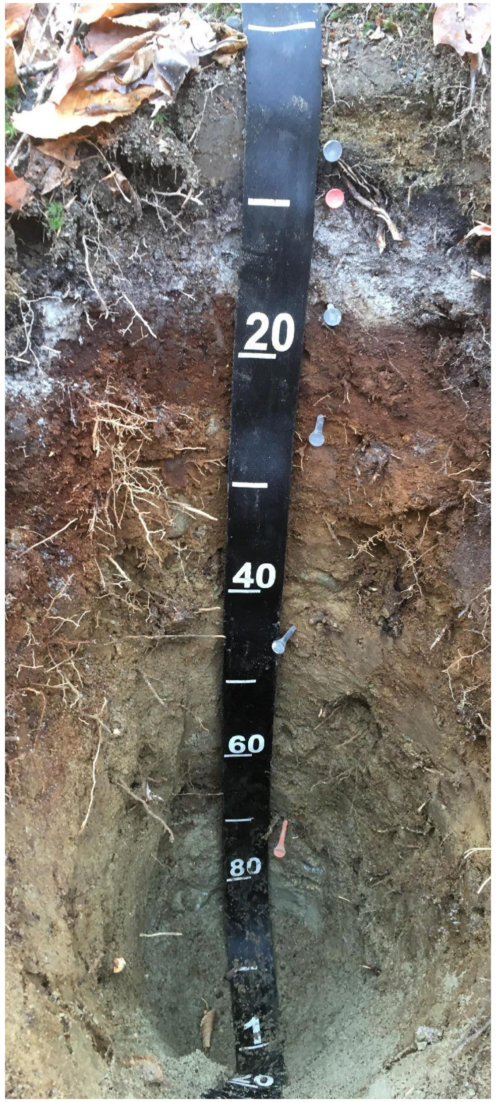
Losses



- Erosion
- Gas exchange
- Loss of nutrients to ground water

Translocations

- Movement of materials within the soil profile
- Types of translocations
  - Organic matter
  - Clay
  - Salts



Transformations

- Materials are transformed by chemical or biological reactions
- Examples of transformations
  - Organic materials decay
  - Rocks and minerals weathering
  - Nutrient cycling
  - Reduction and Oxidation reactions

Redox Features

- Type of transformation of Iron compounds when soil is very wet
- **O**xidation **i**s **L**oss of electrons
- **R**eduction **i**s **G**ain of electrons
- **OILRIG**

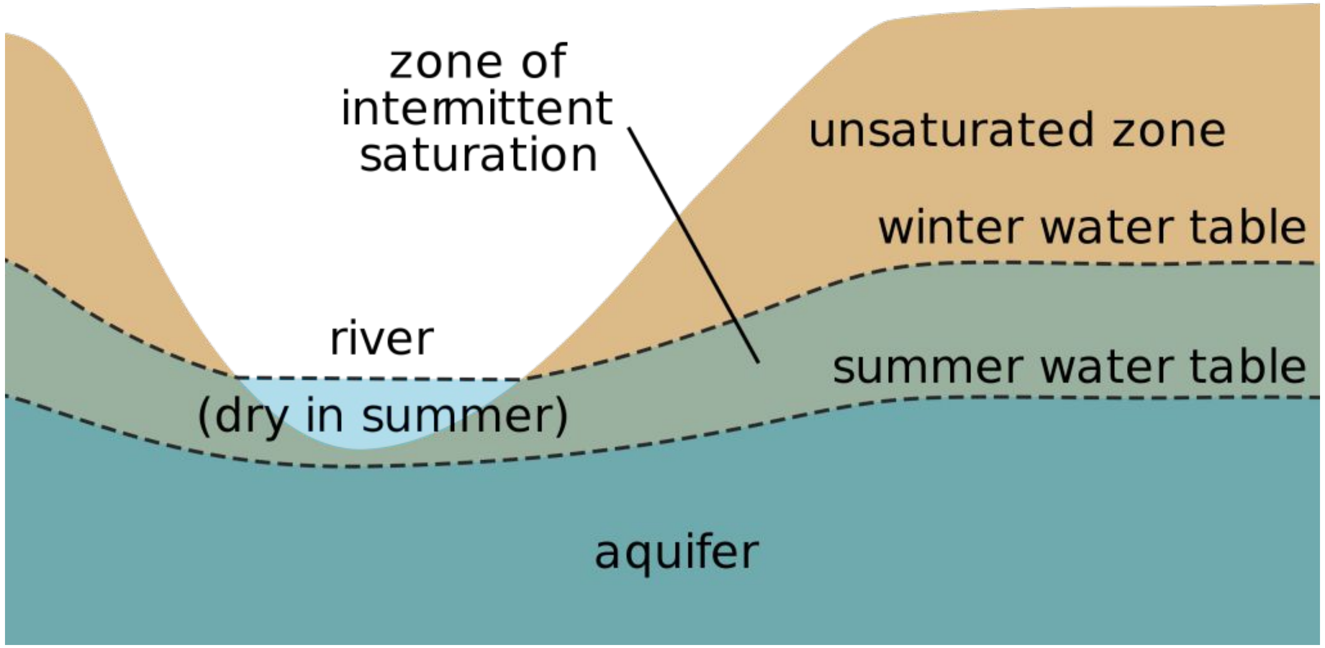
$$Fe^{3+} + e^{-} \rightleftarrows Fe^{2+}$$

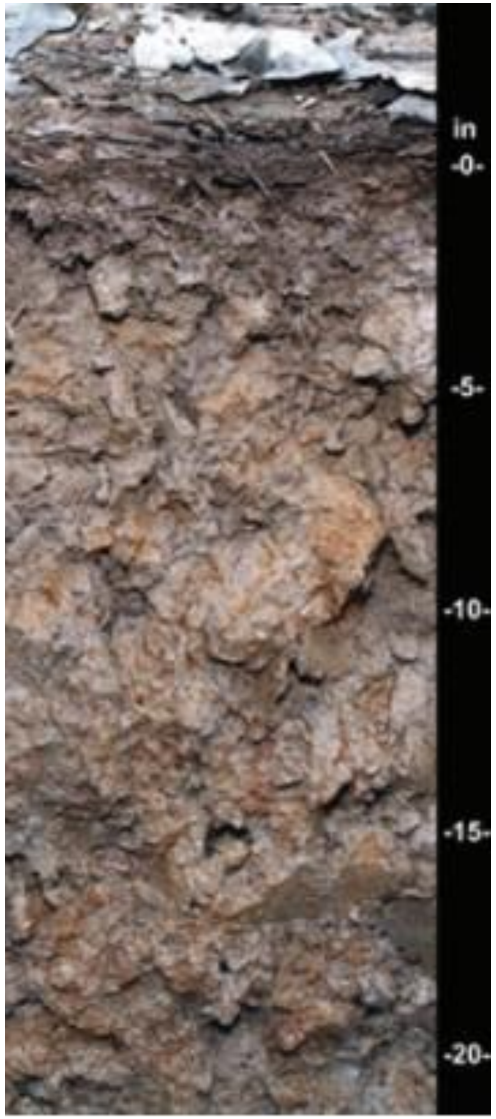
Redox and water table

- Spring snowmelt = high ground water
- Redox indicates seasonally-high water table

Importance

- House site and septic tank placement
- Wetland delineation

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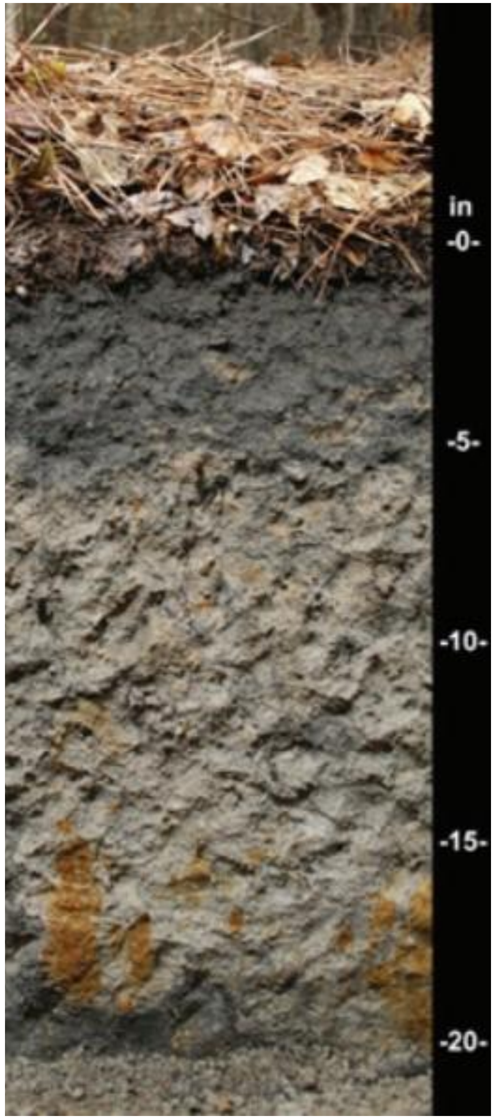
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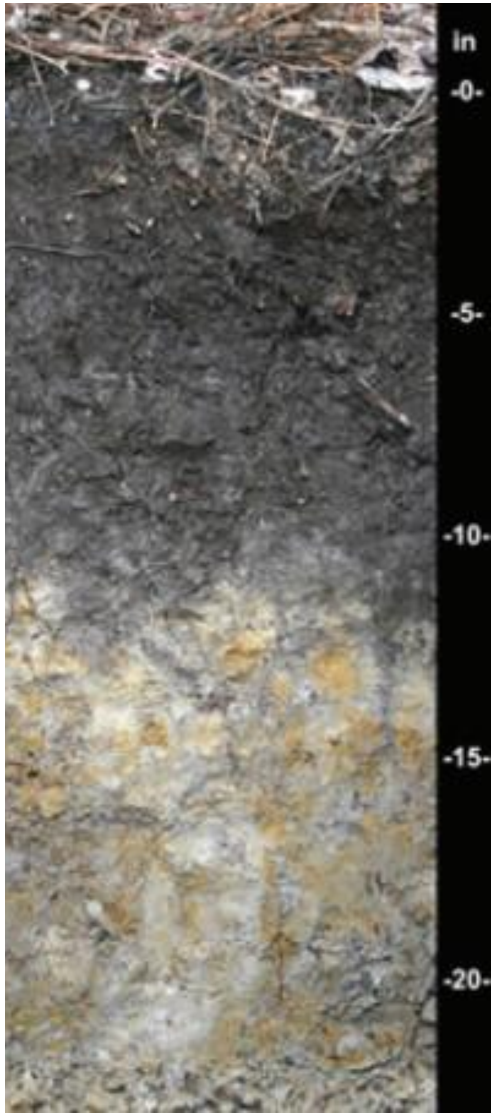
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Hydric Soils

- Soils that are saturated, flooded, ponded long enough during the growing season to develop anerobic (oxygen depleted) conditions that support the growth of wetland vegetation

Hydric Soils

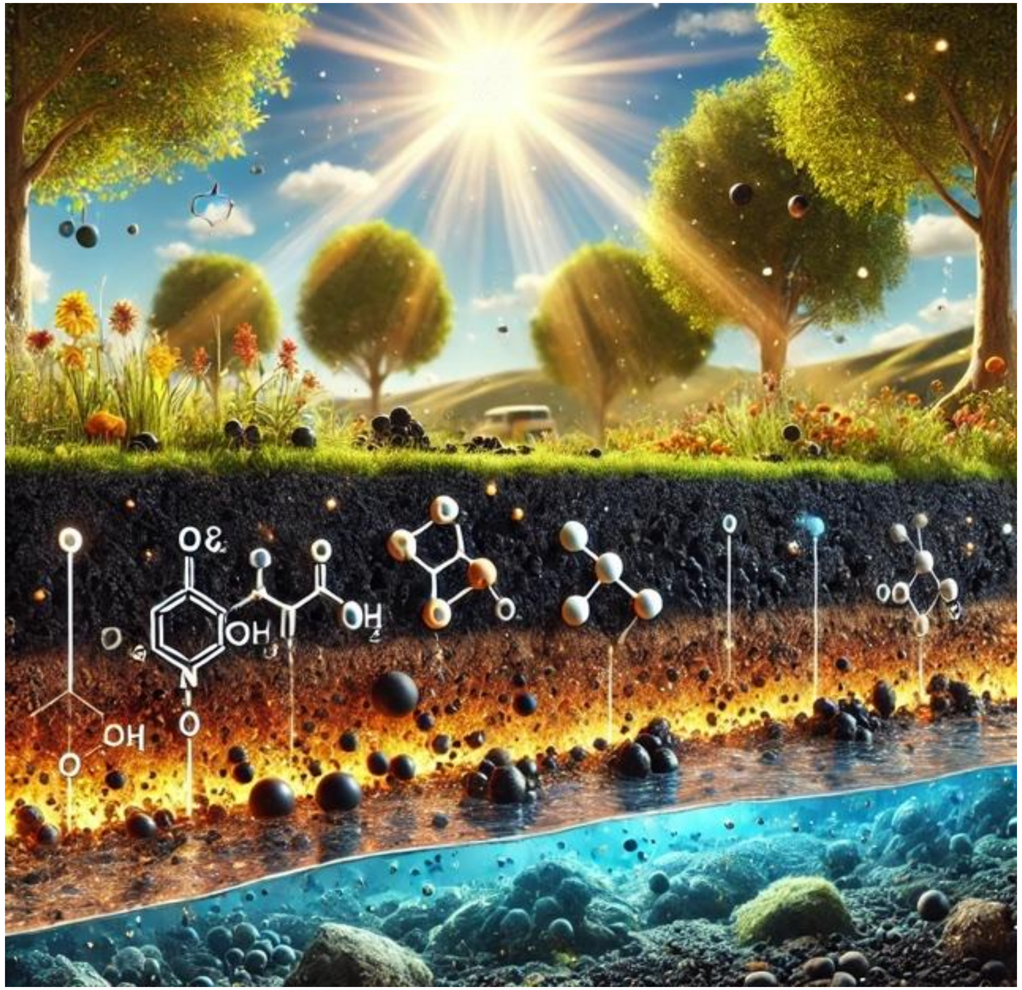
- We look for:
- Gray colors
- Accumulation of Organic matter on surface layers
- Redoximorphic features

- These soils are important because they are essential for wetland delineation
- Provide habitat for wetland species
- Influence water filtration and nutrient cycling

Questions?

Understanding Soil Chemical Characteristics

- pH
- Soil Carbon
- Cation Exchange Capacity
- Nutrients (NPK)
- Environmental and land use impacts



Soil pH

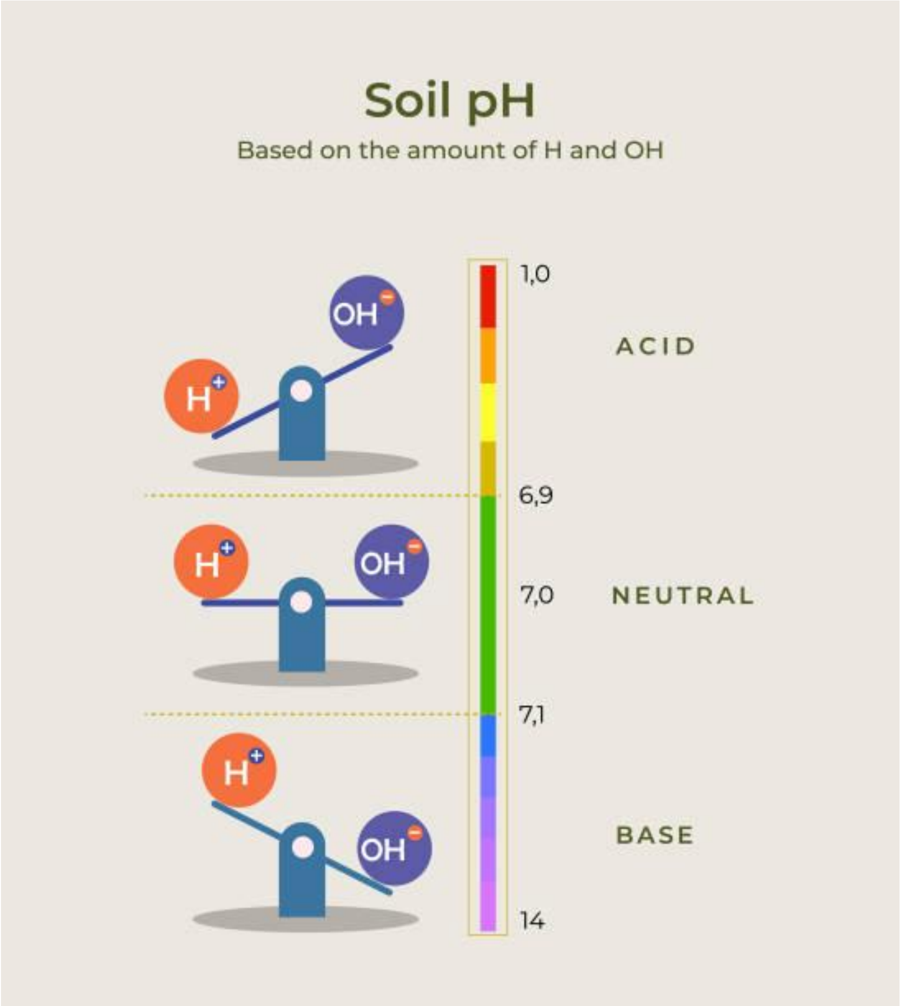
pH = power of hydrogen

Measure of the concentration of hydrogen ions (H^+) in a solution

- 0 to <7: Acidic (high concentration of H^+ ions).
- 7: Neutral (equal concentrations of H^+ and OH^- ions)
- >7 to 14: Basic (low concentration of H^+ ions, high concentration of hydroxide ions, OH^-).

pH is measured on a logarithmic which means each unit change in pH represents a ***tenfold change*** in H^+ concentration.

Ex. a solution with pH 5 is 10 times more acidic than one with pH 6.

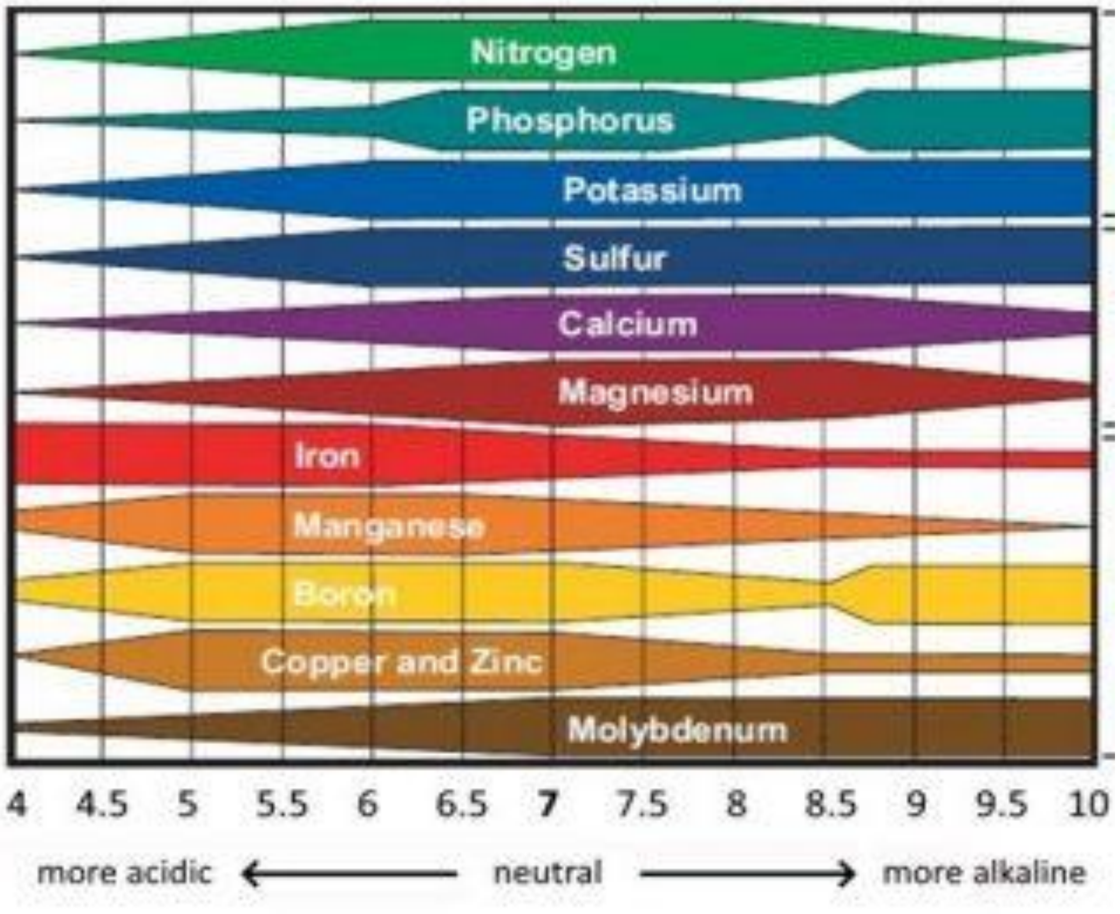


pH and Soil Nutrients

pH affects what nutrients are available to plants

- Concentration of H^+ ions can change the form of nutrient ions
- H^+ ions take up exchange sites on soil particles

Plant Nutrient Availability According to Soil pH

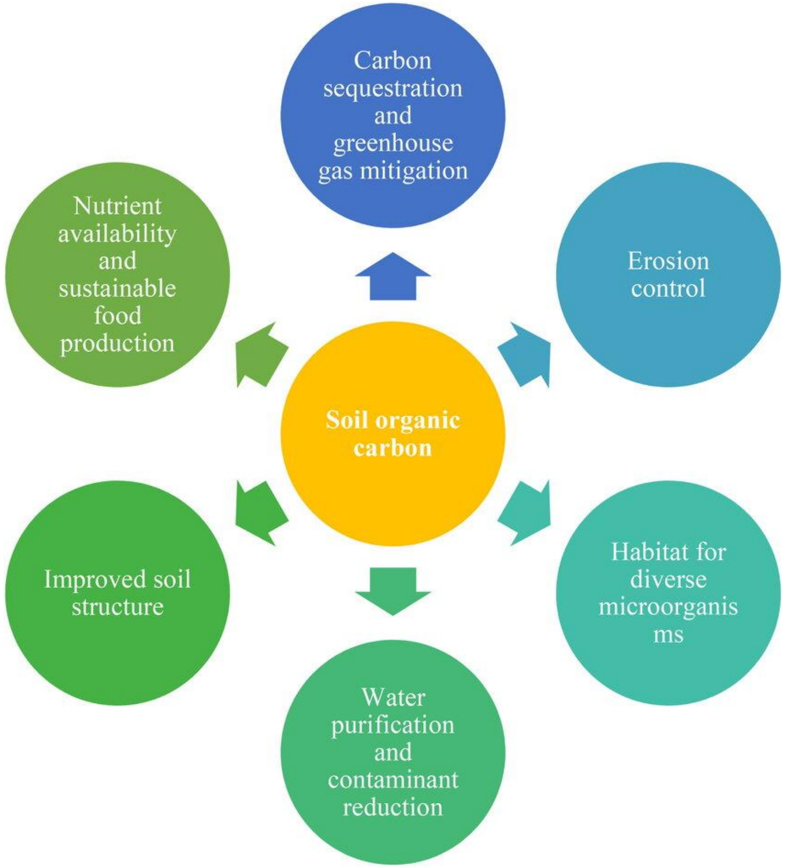


Soil Carbon

Soil Organic Carbon (SOC):
• Derived from decomposed plant and microbial material.
• Critical for soil structure (aggregation), retention and cycling
Soil Inorganic Carbon (SIC):
• Found in forms like calcium carbonate in arid soils.

Importance:
• Soil Health: Improves aggregation, water retention, and nutrient supply.
• Climate Regulation: SOC acts as a major carbon sink, mitigating climate change.

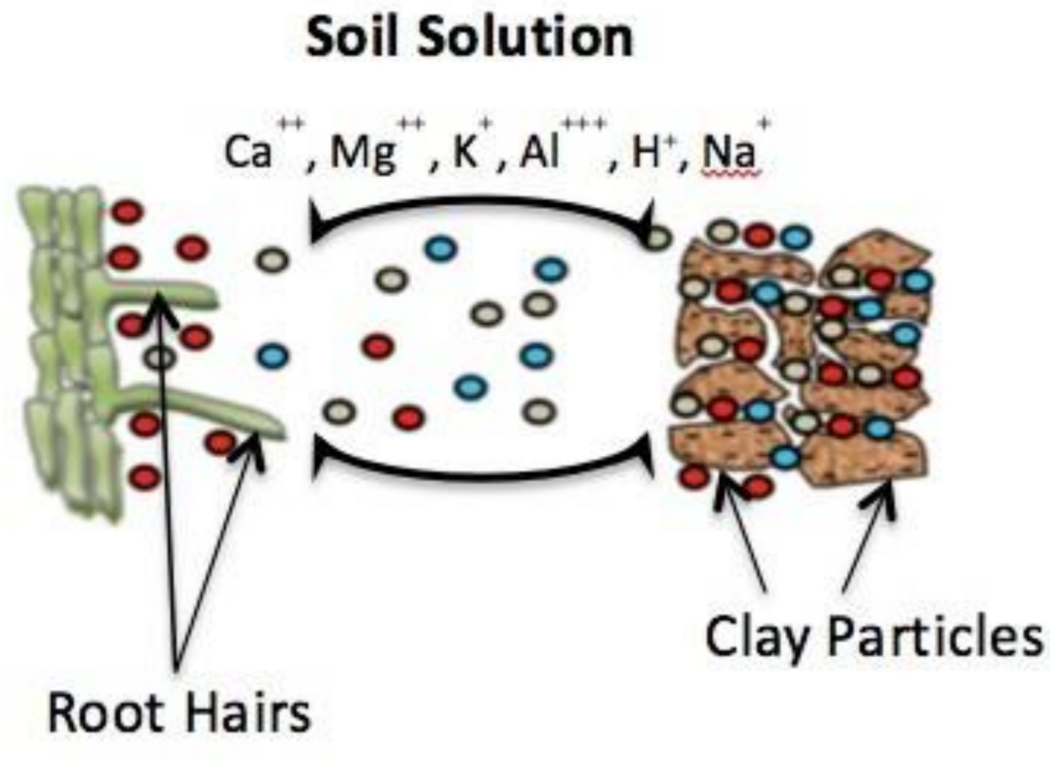
Increasing SOC:
• Incorporate cover crops, reduce tillage, add biochar or compost, and practice crop rotation



Cation Exchange Capacity (CEC)

CEC is the soil's ability to hold and exchange positively charged ions

- Cations – positively charged ions
- Soil and organic matter particles are negatively charged
- Exchange between organic matter, clay and plant roots



Cation Exchange Capacity

- **Importance:**
  • High CEC soils (e.g., clay, organic matter) retain nutrients, reduce leaching, and buffer against pH changes.
  • Low CEC soils (e.g., sandy soils) are prone to nutrient loss and require frequent amendments.

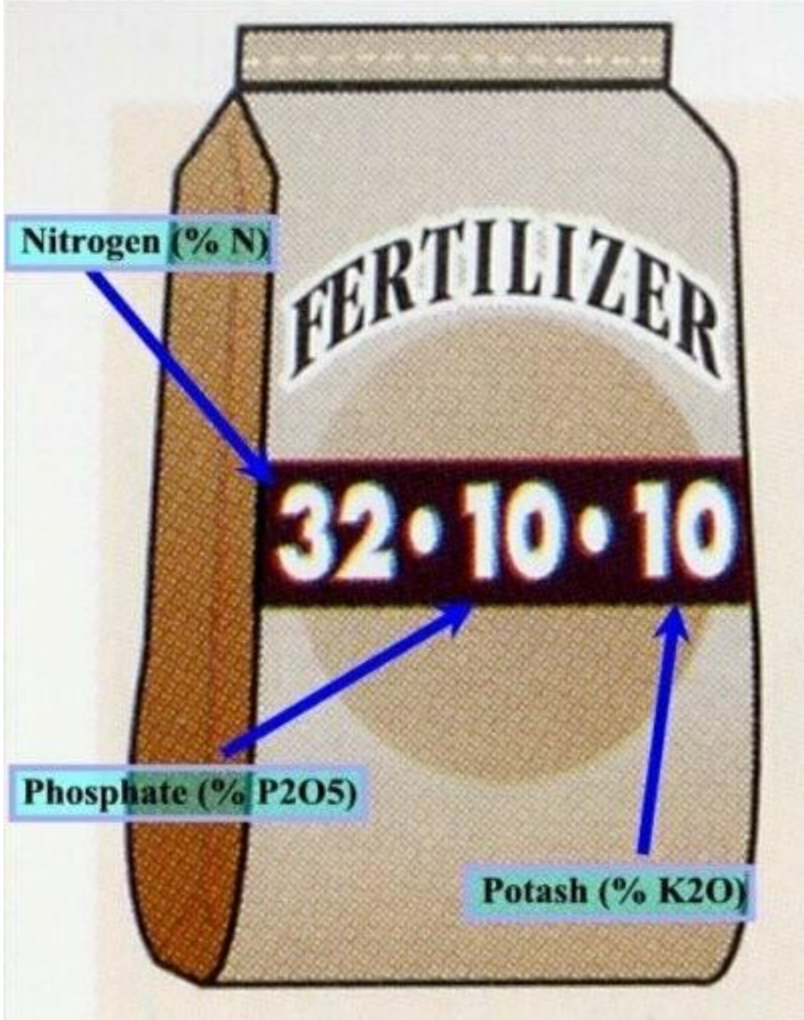
- **Factors Affecting CEC:**
  • Texture, mineral composition, and organic matter content.

Three Primary Nutrients (NPK)

Nitrogen (N):
• Promotes vegetative growth and chlorophyll production.
• Sources: Organic matter decomposition, fertilizers.

Phosphorus (P):
• Vital for root development, flowering, and energy transfer (ATP).
• Sources: Bone meal, rock phosphate.

Potassium (K):
• Enhances disease resistance, water regulation, and enzyme activity.
• Sources: Potash, compost.



Environmental Problems with Excess Nutrients

Nutrient Leaching:
• Excess nitrogen (as nitrate) and phosphorus can leach into groundwater, contaminating drinking water sources.
Eutrophication:
• Nutrient runoff into water bodies causes algal blooms, depletes oxygen, and results in fish kills.
Soil Degradation:
• Over-fertilization leads to soil acidification and salinization, impacting productivity.
Solutions:
• Implement conservation practices like buffer strips, cover crops, nutrient management plans, and precision fertilization.

Ecological Function of Soil

- Soil is the basis for everything!
  - Soil microbes help cycle nutrients, breaking down organic matter and releasing essential nutrients back into the ecosystem
  - Act as a reservoir, absorbing and storing rainwater, releasing it to plants, and can help mitigate flooding
  - Store significant amounts of carbon and help to regulate the global carbon cycle
  - Provide a home for many macro- and micro-fauna such as worms, bacteria, fungi, insects, etc.
  - Soil pores allow for the exchange of gasses such as O_2 and CO_2 between the atmosphere and living plant roots
  - Healthy soil structure with vegetation cover helps prevent soil erosion by wind and water
  - Filter pollutants from water as it passes through, helping to clean water sources

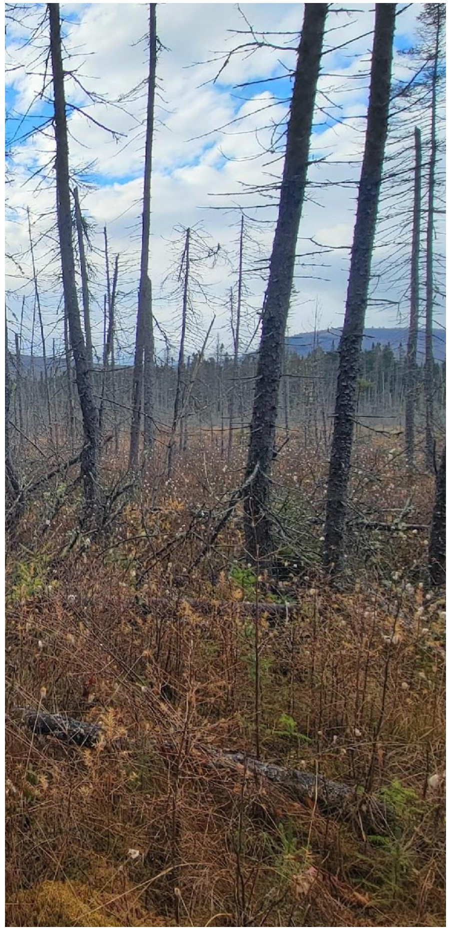
Relating Soils to the Current Issue

Roots and Resiliency: Fostering Forest Stewardship in a Canopy of Change

- Soils provide the foundation for forests to grow
  - Supply nutrients, water, and medium for plants
  - Different soils can result in different forest types
- Forests help to stabilize and create new soil through decomposition, providing food for soil organisms and storing organic and inorganic carbon
- Plant cover can help reduce soil erosion, add organic matter, improve soil structure and water holding capacity, increase nutrient content…. the list goes on and on!

Relating Soils to the Current Issue

Roots and Resiliency: Fostering Forest Stewardship in a Canopy of Change

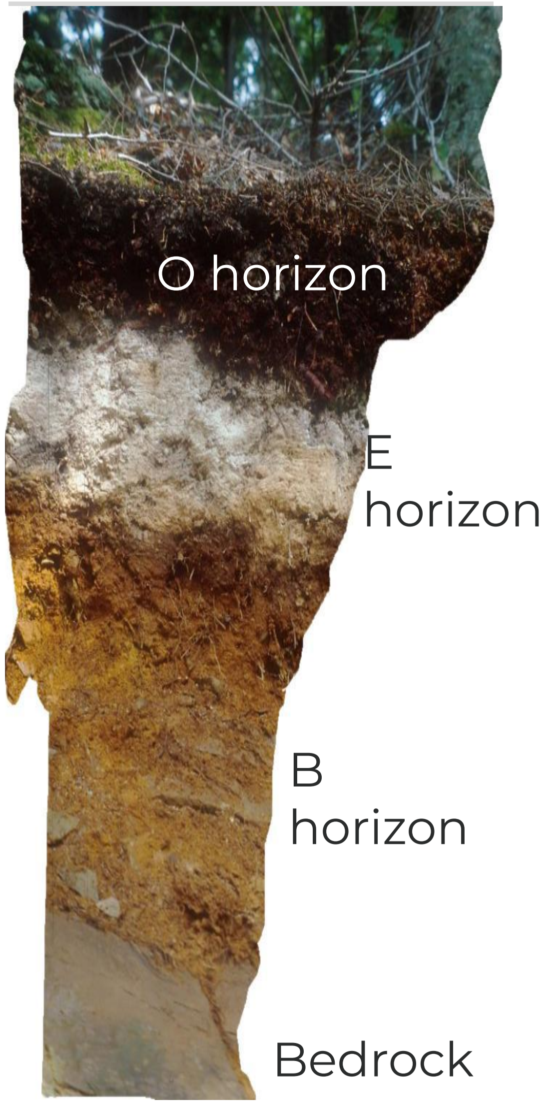


What does it have to do with me?

- By learning about different forestry practices, we can identify where vulnerabilities may lie and learn to better protect the foundation of forests.... the soil
  - Many forest management plans already take the soil into account
    - Avoid commercial clear cuts that can lead to increased soil erosion and rather choose to use different harvesting methods that help maintain soil and forest integrity
    - In wetter areas, harvest in the winter when the ground is frozen to minimize damage to the soil
    - Establish trees and shrubs in the understory prior to harvest to maintain soil surface cover
    - Establishing windbreaks / buffer zones between cleared areas and sensitive areas to reduce the amount of sediment, organic matter, pesticides, and other pollutants

State Soil of Vermont - Tunbridge

- Loamy textured
- Acidic reaction (pH ~5)
- Well drained soil
- Glacial till parent material (Wisconsin-age)
- Non-calcareous bedrock (schist, gneiss, phyllite, granite)
- Between 20 to 40 inches deep
- Found on sloping, hilly, and mountainous terrain
- Supports sugar maple, yellow birch, American beech, eastern hemlock, white birch, white pine, red spruce, and red maple



Why do I care?

This series supports the vast forestry industry in Vermont, including maple syrup production (highest in the country partially due to forest supported by these soils). Many other uses include recreation (skiing, biking, hiking) and agriculture (pasture/ hayfields)

Questions?

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- Check out our YouTube channel @nrcssoilandplantscience

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