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# Soils, Soil Health, and the Watershed

October 28, 2022

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USDA-NRCS

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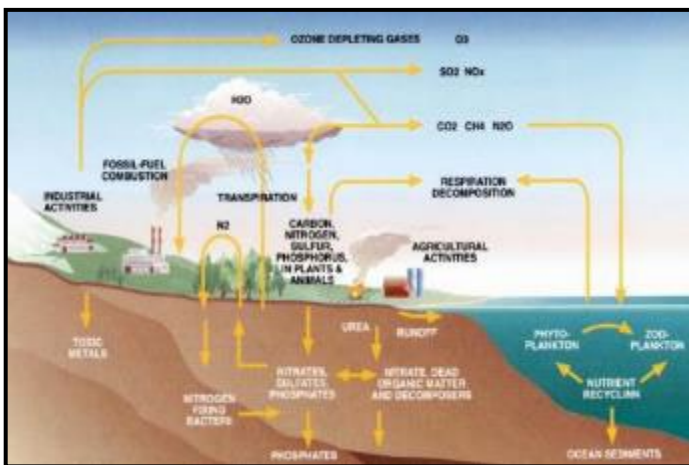
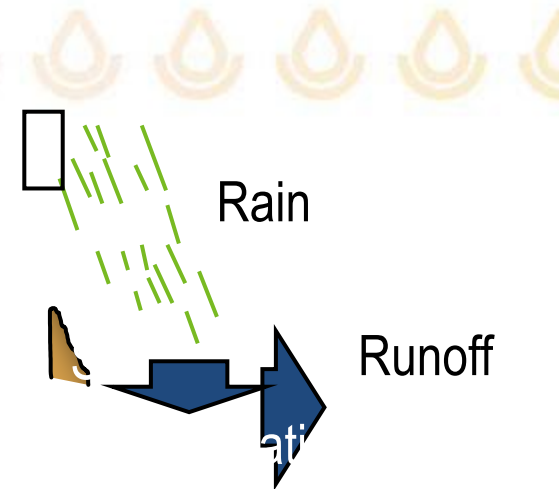
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# Soil. Huh? What is it good for?



**Sustaining plant and animal life below and above the surface**

**Regulating and partitioning water and solute flow**



**Filtering, buffering, degrading, immobilizing, and detoxifying**

**Storing and cycling nutrients**



**Providing support to structures**



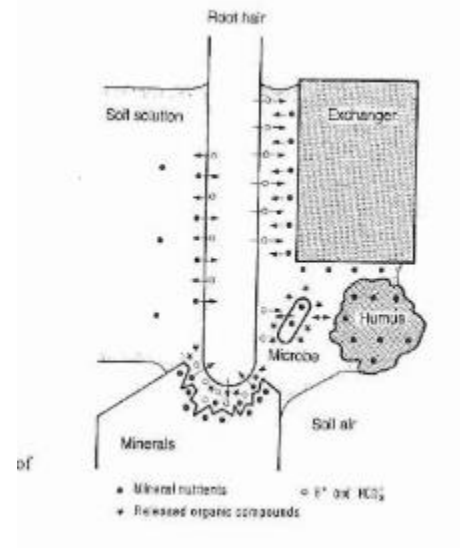


# Five Factors of Soil Formation

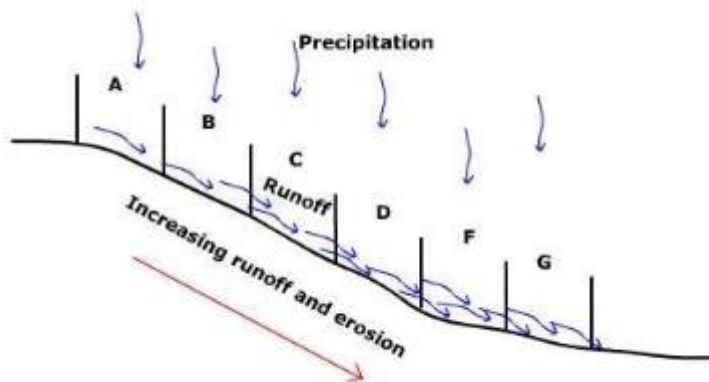
Climate

Organisms

Time



Topography



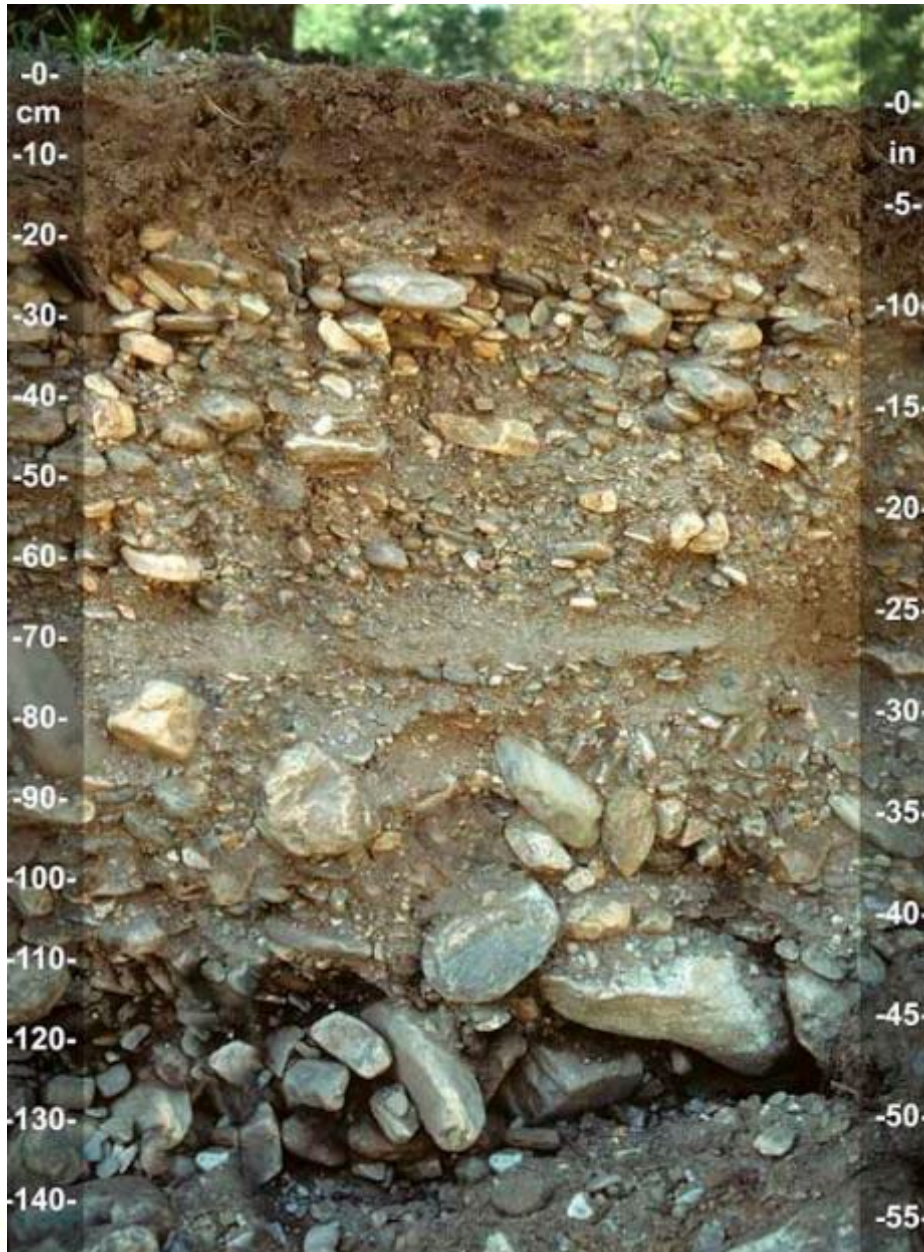
Parent material

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# Five Factors in Action



Parent Material?  
Time?  
Topography?

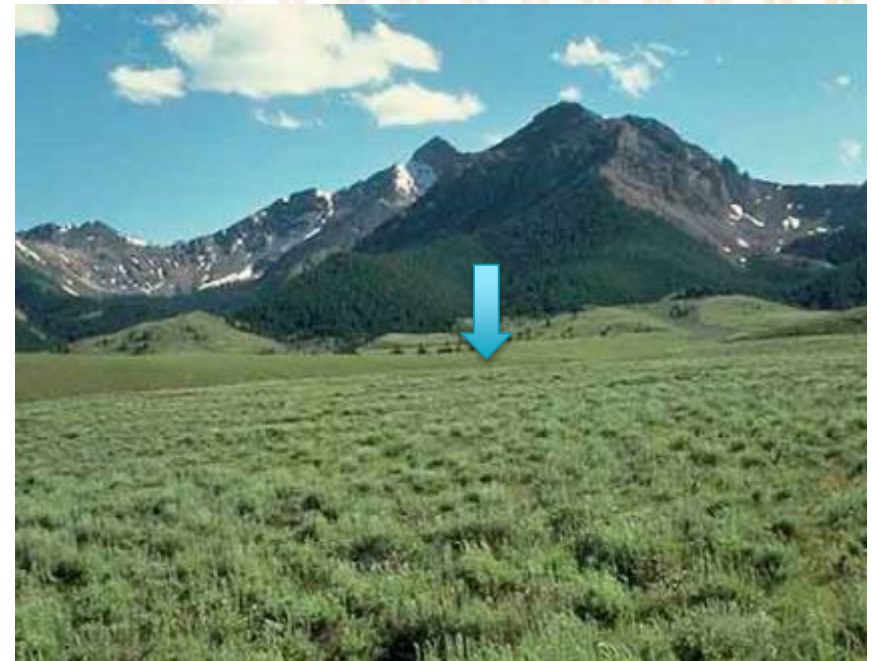
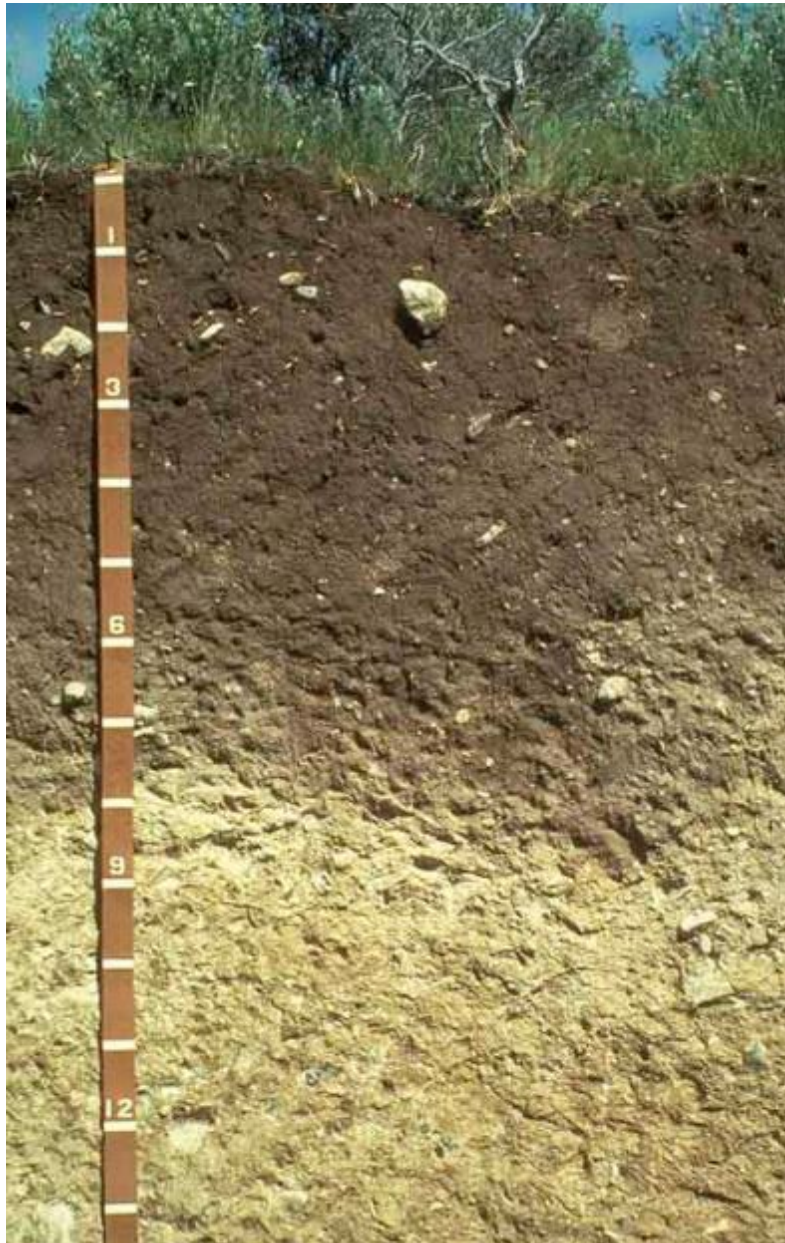
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# Five Factors in Action



Climate?  
Organisms?  
Topography?  
Time?



# Five Factors Influence Soil Properties

## Morphology (appearance)

**Color**

**Structure**

**Roots & Pores**

**Special features**

**(Fe reduction/oxidation)**

## Quantitative Properties

**SOM Content**

**CEC, pH**

**Texture**

**Depth to Restriction**

**Depth to Water Table**

**Flooding and Ponding**

**Rock Fragments**

**Landform position**

**Slope and Aspect**

Soil morphology and properties influence land use capabilities, ecosystem dynamics (carbon, water, nutrient cycling), and how soils are differentiated for mapping purposes.



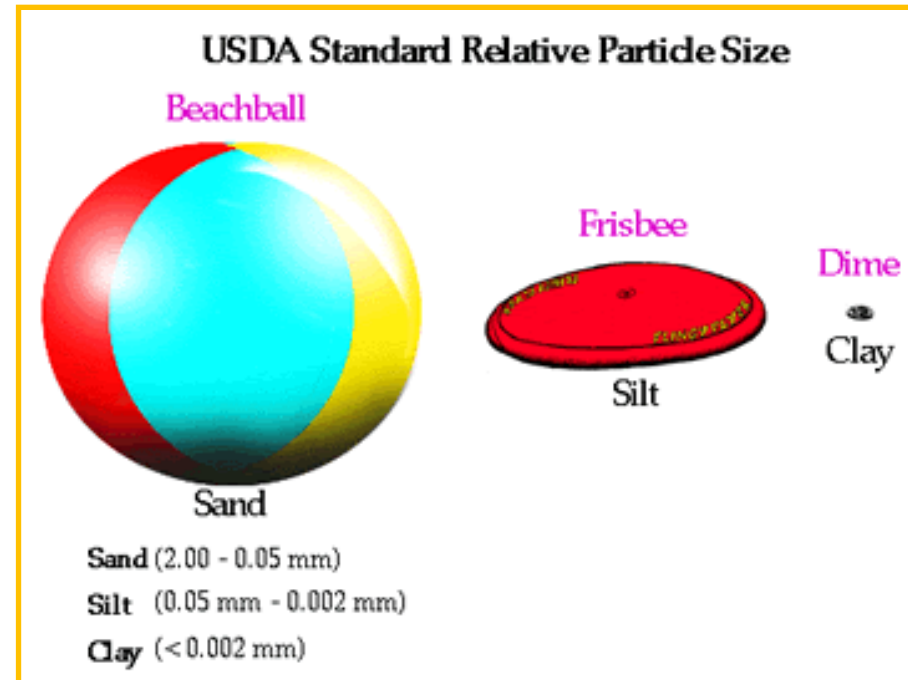
# Soil Texture

## The ratio of sand, silt, and clay in a soil

- Sand: 2 - 0.05 mm
- Silt: 0.05 - 0.002 mm
- Clay: < 0.002 mm

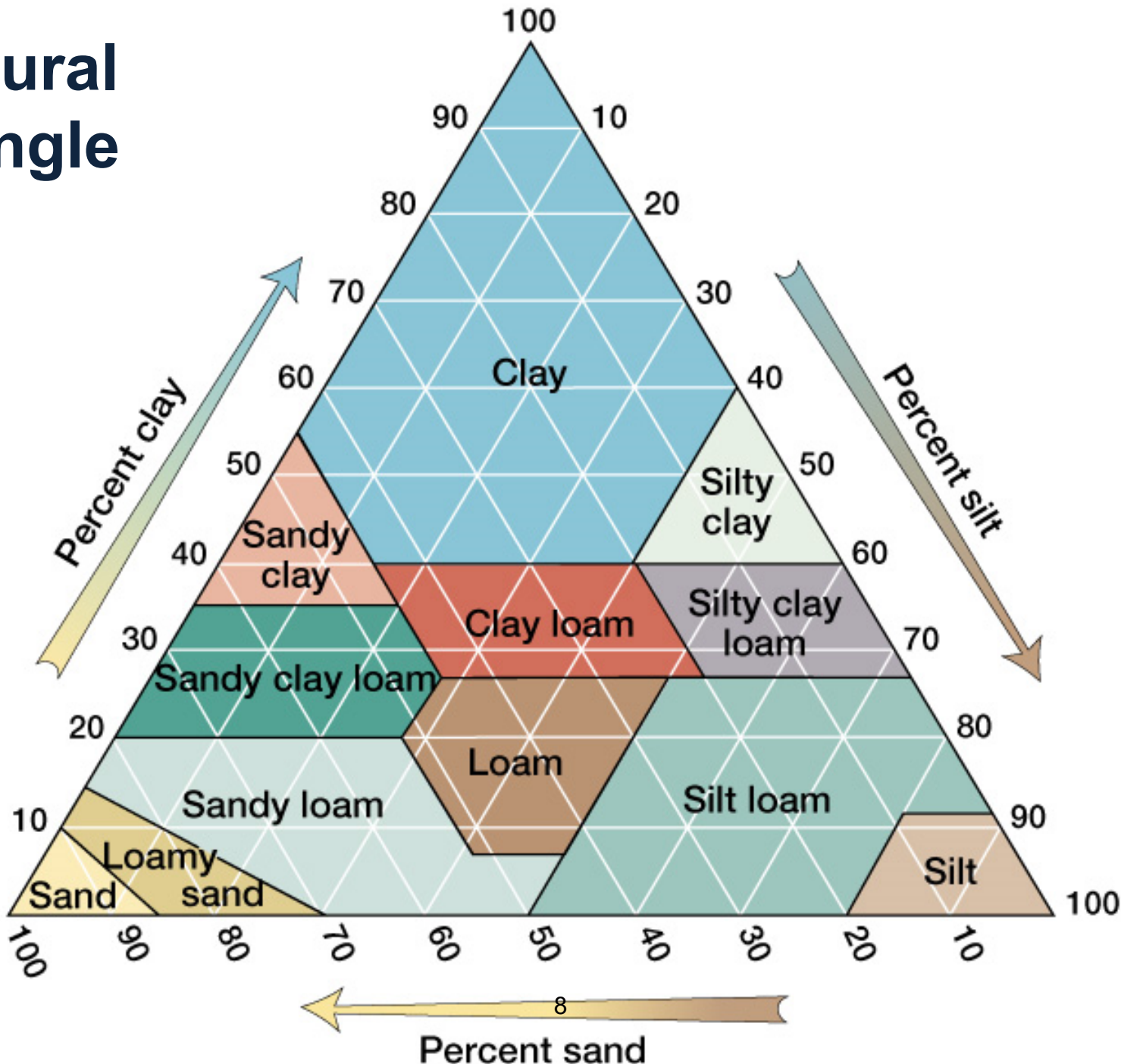
## Particle size affects:

- Water holding capacity
- Water movement
- Nutrient holding
- Other biological and chemical processes





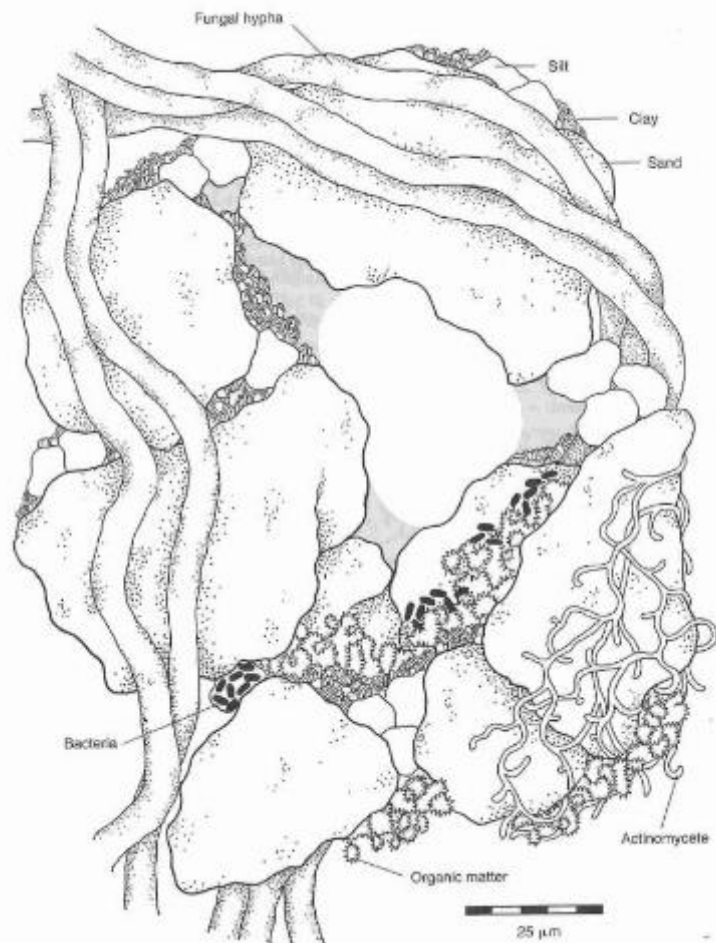
# Textural Triangle





# Soil Aggregates - Structure

- Size and shape individual sand, silt, and clay particles aggregate together.
- Aggregates form into structural units, held together by organic materials and clays through the action of roots, micro and macro fauna.
- Strong well-developed structure promotes aeration, permeability, and drainage, and is an indicator of good soil health.



## Soil color can be an indicator of:

- Organic Matter Content
- Mineralogy
- Iron Oxidation and Reduction (Water Table)
- Translocation and Deposition of Materials

## Soil Color is Notated Using the Munsell Soil Color System

Hue (Page)

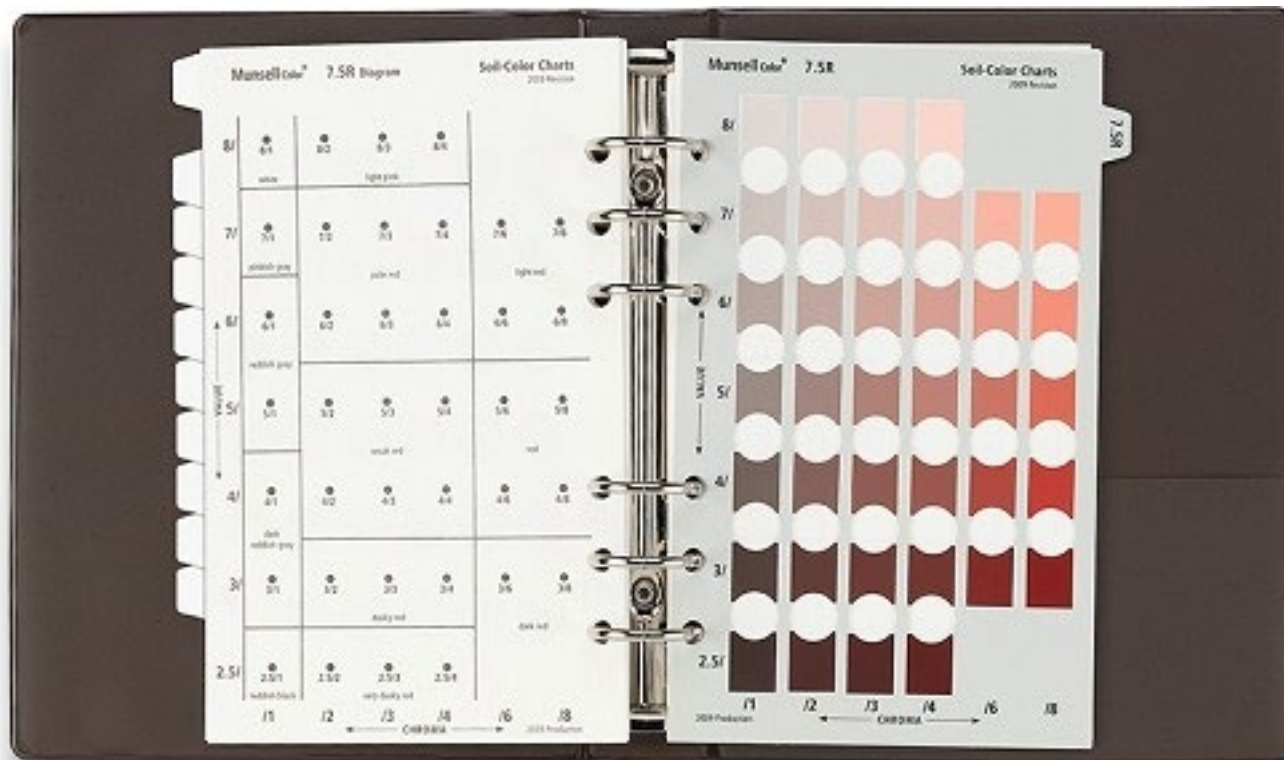
Ex: 10YR

Value (Y axis)

Ranges 2-8

Chroma (X axis)

Ranges 1-8





# Soil Organic Matter

**Why is soil organic matter so important?**

**A small percentage of have a large effect!**

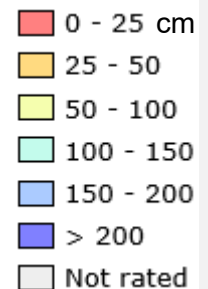
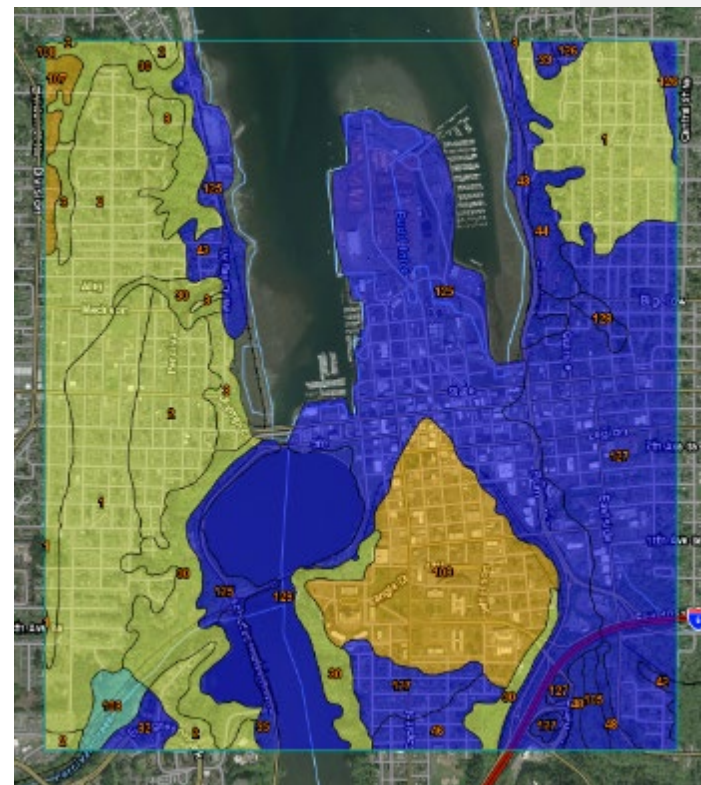
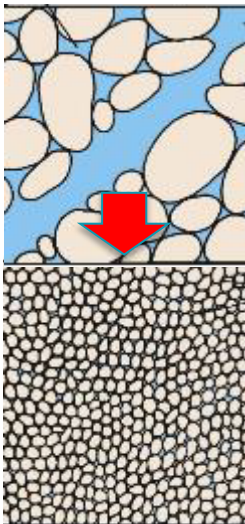
**Organic Matter:**

- **Contributes to soil structure**
- **Increases soil aeration**
- **Increases soil water-holding capacity**
- **Increases CEC (cation exchange capacity)**
- **Source of nutrients**
- **Lowers bulk density (compaction)**
- **Habitat for the soil food web**



# Impermeable layers (Soil Depth)

- Adjacent soil layers with highly variable textures can impede drainage
- Restrictive features such as bedrock or dense glacial till can also impact drainage.



Depth to restrictive layer -- Olympia

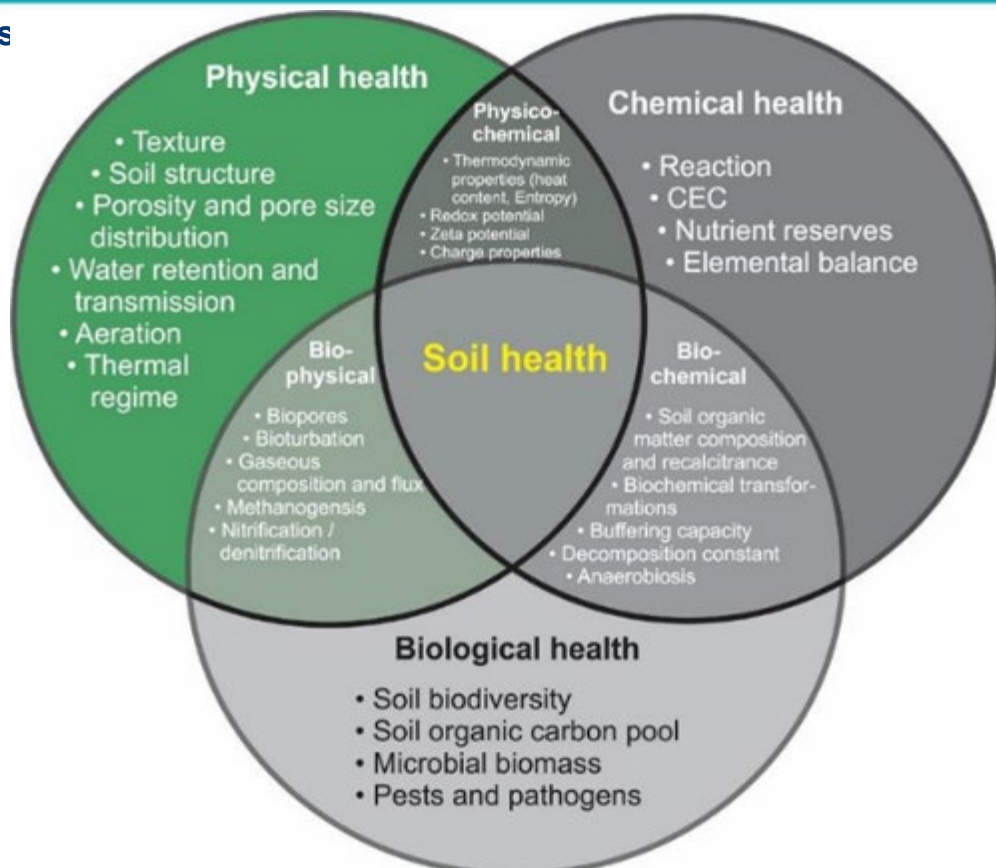




- Redoximorphic Features = Evidence of water table presence during growing season
- Grey = Iron Depletions; forming under saturated conditions
- Red = Oxidized Iron concentrations; forming in un-saturated conditions
- Depth to redox features should be noted when making management decisions
- High water table and/or standing surface water can be detrimental to agricultural operations
  - Water occupies all pore space = no air
  - Mold growth
  - Effects microbial activity
- Soil Drainage Class is determined by depth to redox features:
  - 0 - 25cm = poorly drained (PD)
  - 25 - 50cm = somewhat PD
  - 50 - 100cm = mod well drained
  - No redox within 100cm = well drained



- **Soil Health Definition:** Capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.
- Is the soil able to independently function for its intended purpose?
- Is the soil supporting other healthy earth systems?
- Evaluation of collective (physical, chemical, biological) soil properties in conjunction with the effects of land use and management practices
- **Indicators of soil health:**
  - Bulk density (aeration, porosity, permeability)
  - Organic Matter Content (water holding capacity, increased CEC, microbial fuel)
  - Microbial activity (nutrient cycling, pest control)
  - Soil Structure and Aggregate Stability (erosion resistance, aeration, porosity)
  - Earthworms





## Erosion: 3 Part Process

### 1: Dislodgement:

- Rain drop impact
- High winds
- Physical disturbance
- Other?



### 2: Transportation (sheet, rill, gully formation)



### 3: Deposition (sedimentation)





## PRONE TO EROSION

- **Areas without vegetation:** Surface cover reduces raindrop impact and living roots hold soil in place.
- **Areas with steep topography and shallow bedrock** at greater risk.
- **Disturbed areas** (recent fires, clear cuts, plowed fields) are at greater risk.



## EROSION CONSEQUENCES

- Channelized flows remove moisture from site
- Road and trail washouts
- Mud flows, debris slides, mass movements
- Eroded sediment is detrimental to water quality, wetlands, riparian wildlife and habitat
  - Sedimentation often non-point source erosion
- Removes nutrients and organic matter from the site.
  - Eutrophication





# Managing Erosion

## Prevention is best strategy!

### Preventing Sediment Dislodgement:

- Maintain vegetative cover →
- Maintain soil cover: (stubble, mulch, crop residue) →
- Minimize disturbance (tillage, equipment operation)
- Be mindful of slope, aspect, and season when disturbance is necessary (tillage, forestry and grazing operation)



### Preventing Sediment Transport

- Goal is to hold soil in place and slow surface flow
- Maximize living roots
- Maximize soil organic matter (improves structure)
- Maintain vegetative cover - cover crops! →
- Contour tillage and farming
- Spread and/or leave slash (forestry operations)

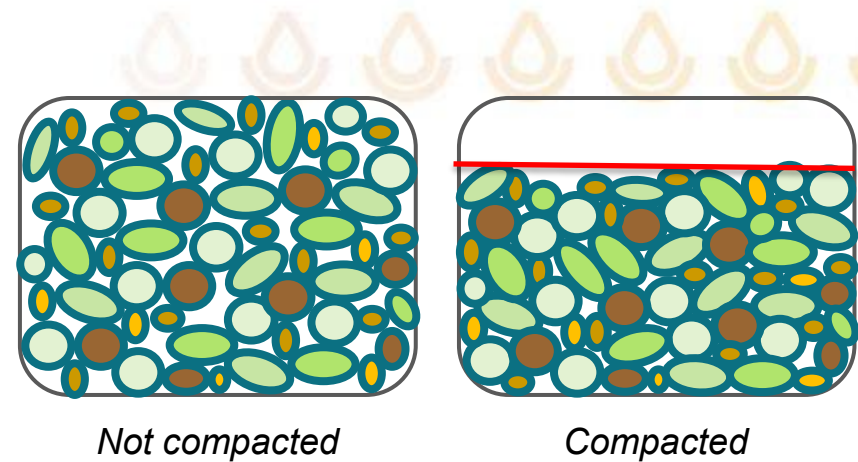


### Preventing (managing) Sediment Deposition

- Best to avoid getting to this point
- Buffer strips along slope base →
- Riparian area buffers and planning



- Increased bulk density often caused by heavy machinery, high density grazing.
- “Hard Pan”, “Plow Pan”
- Impacts to soil aeration, root/gas exchange, water infiltration and permeability, and seedling growth
- Duration and severity influenced by soil texture, moisture, climate, and vegetation
- Channelized runoff can lead to erosion





# Managing Compaction

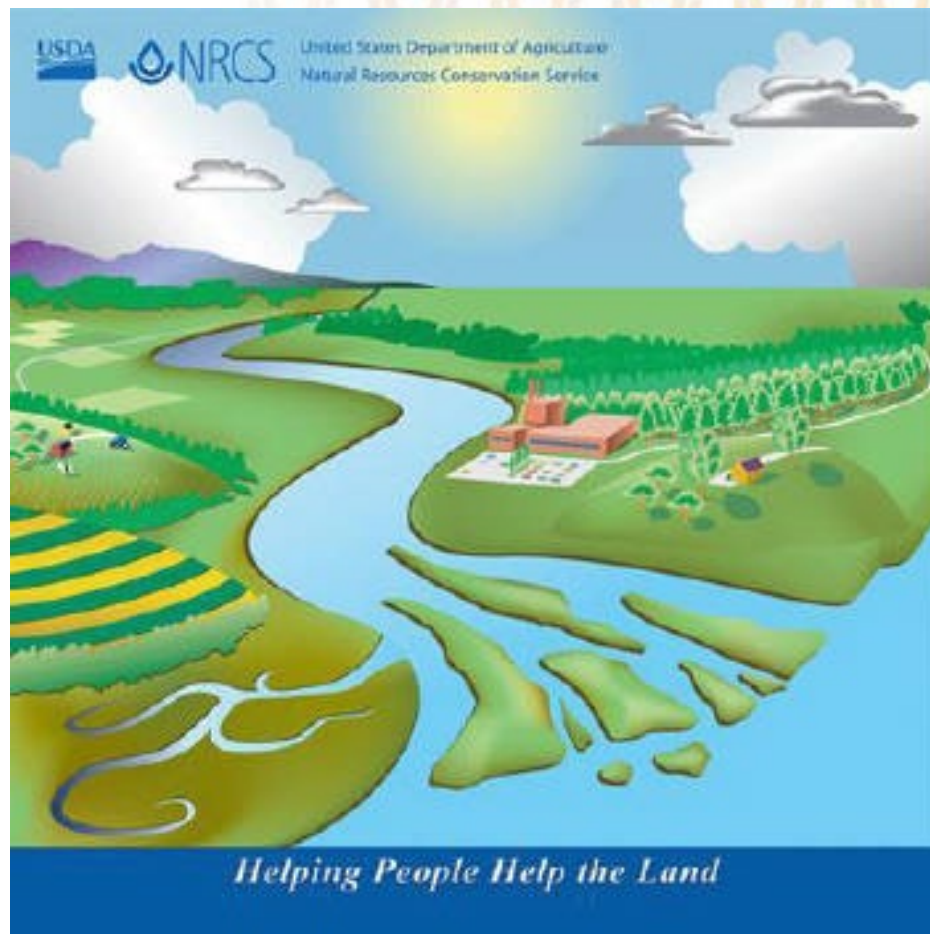
**Again, Prevention is the best strategy!**

- **Avoid operating equipment on wet soils.**
- **Use smaller equipment, low-pressure tires or tracked equipment.**
- **Designate high impact areas and minimize passes.**
- **Pasture Management.**
- **Forestry operations: Operate on slash or mats, using equipment with long reach**
- **Agricultural operations: Promote living roots and organic matter inputs.**
  - **Strong soil structure resists compaction**
  - **Cover crops**
  - **Mulching and mulch tillage**
  - **No-till farming**



# Soils and the Watershed

- **Healthy soils and management systems that promote soil health correlate to watershed health**
- **Agriculture and Forestry-related erosion and runoff are most prevalent types of non-point source pollution**



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- **Result of erosion.**
- **Sediment Pollution: Loose sand, silt, clay, and organic particles suspended or settled in a waterbody.**
- **EPA lists sediment as most common pollutant in rivers and streams.**
- **Environmental effects on watershed:**
  - Turbidity prevents animals from navigating and finding food
  - Reduced sunlight penetration inhibits vegetation growth
  - Degradation or loss of aquatic habitat
  - Degradation of salmon spawning habitat
  - Interferes with fish respiration and digestion processes
  - Sediment often contains pesticides and fertilizers
- **Economic effects on the watershed:**
  - Fills storm drains and catch basins; increasing flooding potential
  - Increases cost of water treatment
  - Impact on commercial and recreational fisheries



- **Nutrient Pollution: Contamination by excessive inputs of nutrients**
  - Nitrogen and Phosphorous
- **Eroded sediment and runoff from agriculture operations are primary contributors**
- **Eutrophication: Abnormally rapid growth of algae, phytoplankton, or cyanobacteria due to excessive richness of nutrients in water.**
- **Environmental effects on watershed:**
  - Depletion of oxygen in water
  - Reduced sunlight penetration inhibits vegetation growth
  - Die-off of fish, shellfish, and amphibians due to hypoxia and/or eutrophication-produced toxins
  - Interferes with fish respiration and digestion processes
- **Human and Economic effects on the watershed:**
  - Unsafe fish and shellfish
  - Illness due to toxin exposure
  - Increases cost of water treatment
  - Impact on commercial and recreational fisheries
  - Impact to tourism and recreational use of effected areas



Source: fs.usda.gov



Source: usda.nifa.gov





# Managing for Soil and Watershed Health

- Soil health will contribute to healthy watersheds
- Common detriments to soil and watershed health can be prevented and managed
- Soil erosion and compaction management is key for soil and watershed health.
- Complete soil health management systems also emphasize soil microbial and fungal communities, nutrient cycling, and biodiversity.



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# Soil Health Management Systems

## What is it?

## What does it do?

## How does it help?

### Conservation Crop Rotation

Growing a diverse number of crops in a planned sequence to increase soil organic matter and biodiversity in the soil.



- Increases nutrient cycling
- Manages plant pests (weeds, insects, and diseases)
- Reduces sheet, rill and wind erosion
- Holds soil moisture
- Adds diversity so soil microbes can thrive

- Improves nutrient use efficiency
- Decreases use of pesticides
- Improves water quality
- Conserves water
- Improves plant production

### Cover Crop

An un-harvested crop grown as part of planned rotation to provide conservation benefits to the soil.



- Increases soil organic matter
- Prevents soil erosion
- Conserves soil moisture
- Increases nutrient cycling
- Provides nitrogen for plant use
- Suppresses weeds
- Reduces compaction

- Improves crop production
- Improves water quality
- Conserves water
- Improves nutrient use efficiency
- Decreases use of pesticides
- Improves water efficiency to crops

### No Till

A way of growing crops without disturbing the soil through tillage.



- Improves water holding capacity of soil
- Increases organic matter
- Reduces soil erosion
- Reduces energy use
- Decreases compaction

- Improves water efficiency
- Conserves water
- Improves crop production
- Improves water quality
- Saves renewable resources
- Improves air quality
- Increases productivity

### Mulch Tillage

Using tillage methods where the soil surface is disturbed but maintains a high level of crop residue on the surface.



- Reduces soil erosion from wind and rain
- Increases soil moisture for plants
- Reduces energy use
- Increases soil organic matter

- Improves water quality
- Conserves water
- Saves renewable resources
- Improves air quality
- Improves crop production



## What is it?

## What does it do?

## How does it help?

### Mulching

Applying plant residues or other suitable materials to the soil surface to compensate for loss of residue due to excessive tillage.



- Reduces erosion from wind and rain
- Moderates soil temperatures
- Increases soil organic matter
- Controls weeds
- Conserves soil moisture
- Reduces dust

- Improves water quality
- Improves plant productivity
- Increases crop production
- Reduces pesticide usage
- Conserves water
- Improves air quality

### Nutrient Management

Managing soil nutrients to meet crop needs while minimizing the impact on the environment and the soil.



- Increases plant nutrient uptake
- Improves the physical, chemical and biological properties of the soil
- Budgets, supplies, and conserves nutrients for plant production
- Reduces odors and nitrogen emissions

- Improves water quality
- Improves plant production
- Improves air quality

### Pest Management

Managing pests by following an ecological approach that promotes the growth of healthy plants with strong defenses, while increasing stress on pests and enhancing the habitat for beneficial organisms.



- Reduces pesticide risks to water quality
- Reduces threat of chemicals entering the air
- Decreases pesticide risk to pollinators and other beneficial organisms
- Increases soil organic matter

- Improves water quality
- Improves air quality
- Increases plant pollination
- Increases plant productivity



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- **Successful soil management requires informed decisions.**
- **Look at the landscape. Find a representative point. Dig a hole.**
  - What do you see?
  - Soil color, texture, structure?
  - Soil health indicators?
  - Management issues?
- **Get a soil test**
  - Lab analysis
  - Soil chemical properties
- **Web Soil Survey**
  - Free!
  - Compare soil mapping to your observations





# Web Soil Survey

<http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm>

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## Web Soil Survey

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- National Soil Characterization Data
- Soil Health
- Soil Geography

The simple yet powerful way to access and use soil data.

**START WSS**

Welcome to Web Soil Survey (WSS)

Web Soil Survey (WSS) provides soil data and information produced by the National Cooperative Soil Survey. It is operated by the USDA Natural Resources Conservation Service (NRCS) and provides access to the largest natural resource information system in the world. NRCS has soil maps and data available online for more than 95 percent of the nation's counties and anticipates having 100 percent in the near future. The site is updated and maintained online as the single authoritative source of soil survey information.

Soil surveys can be used for general farm, local, and wider area planning. Onsite investigation is needed in some cases, such as soil quality assessments and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center at the following link:

I Want To...

- Start Web Soil Survey (WSS)
- Know Web Soil Survey Requirements
- Know Web Soil Survey operation hours
- Find what areas of the U.S. have soil data
- Find information by topic
- Know how to hyperlink from other documents to Web Soil Survey
- Know the SSURGO data structure

Announcements/Events

- Web Soil Survey 3.3 has been released!

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# Questions?



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