



Soils

& Management

Dr. Richard Rosecrance

California State University, Chico

A typical agricultural soil is usually

- 25% 1. 10% air and 90% solids
- 25% ✓ 2. 50% solids and 50% pores
- 25% 3. 25% air and 75% solids
- 25% 4. 10% air, 40% water and 50% solids



Of the following soil types, which would most likely hold the most water at field capacity?

25% 1. Silt

25% 2. Sandy loam

25% ✓ 3. Clay loam

25% 4. Loam



Which of the following is not a chemical property used to evaluate soil quality?

25% 1. pH

25% 2. Organic matter

25% ✓ 3. Enzymes

25% 4. Exchangeable calcium



Topics to Be Covered

Read Chapter 3 Soil & Fertilizer Mgt

1. Online soil survey
2. Soil texture and structure
3. Cation Exchange
4. Organic Matter





UNITED STATES
erosion
Decades of water erosion on tilled fields has degraded soil across the Midwest and Great Plains, although no-till agriculture has recently stemmed losses.



CENTRAL & EASTERN EUROPE
compaction
Soviet-era intensive tillage has left 11% of topsoil across Central and Eastern Europe too densely packed to allow sufficient water and nutrients to reach plant roots.



IRAQ
pollution
During the first Gulf War, 40 million tons of Kuwaiti soil were drenched with oil. Experts fear that soils in Iraq are being damaged by fuel and other chemicals spilled during the current conflict.



KAZAKHSTAN & UZBEKISTAN
pollution, desertification
Shrinkage of the Aral Sea, due to diversion of water from its tributaries, has exposed a seabed laden with fertilizers and pesticides. The tainted dust is picked up by the wind and poisons farmland.



CHINA
desertification
The expansion of deserts due to farming and grazing stokes the country's famous dust storms.



WESTERN EUROPE
sealing
Covering of soils with buildings and roads has put beyond use large swaths of prime soil in European cities.



CHINA
erosion
1.6 billion tons of soil per year wash into the Yellow River from China's Loess Plateau, which has the highest rates of water erosion in the world.



HIMALAYAS
erosion
Overgrazing and deforestation have spurred widespread soil erosion in the lower Himalaya Mountains, where natural rates are already high because of monsoonal rains.



AMAZON
erosion
Slash-and-burn agriculture in the Amazon exposes poor tropical soils that can sustain crops for only a few years before nutrients wash away.



SUB-SAHARAN AFRICA
nutrient depletion
Fields rarely left fallow and the scavenging of vegetation and dung have conspired to mine the soil of nutrients.



AUSTRALIA
salinization
Removal of vegetation has allowed the water table to lift underlying salts, leading to barren landscapes such as this one in Western Australia's wheat belt.

- PHYSICAL DEGRADATION
- ▲ CHEMICAL DEGRADATION

High and very high levels of soil degradation per Global Assessment of Soil Degradation (GLASOD)

- Highly erodible by wind or water
- Few constraints

Climate Constraints

- High temperatures
- Seasonal cold
- Seasonally excess water
- Seasonal dryness
- Continuous cold
- Continuous dryness

Physical Constraints

- High shrink/swell potential
- Minor root restricting layer
- Low structural stability
- Impeded drainage
- Low water holding capacity
- Shallow soils

Chemical Constraints

- Low organic matter
- High anion exchange capacity
- High aluminum
- Calcareous, gypseous condition
- Low nutrient holding capacity
- Low moisture and nutrient status

- High phosphorus, nitrogen, and organic retention
- High organic matter
- Salinity/alkalinity

NOTE: Acid sulfate condition (0.09% of total map area) and steep lands (obscured by erosion risk) are not shown.

Soil and Trouble

WHEN PEOPLE INTENSIVELY TILL FIELDS and clear-cut forests, they can damage or destroy topsoil that took centuries to accumulate. Just how vulnerable soils are depends on underlying conditions. Mismanaged soils in windswept lands can easily turn into desert, for example, and saline soils can become salt-encrusted wastelands.


This map shows the main barriers to productive farming, along with erosion risk, derived from climatic and soil conditions. Overlaid as cross-hatching are regions reported to be highly or very highly degraded according to a global survey of soil experts published in 1990. The hot spots illustrate examples of the worst soil degradation, from the most common physical type—water erosion—to chemical forms, such as that caused by pollution from industrial chemicals and war.

An interactive version of this map appears online at www.sciencemag.org/cgi/content/summary/304/5677/1614.

SOURCES: Adapted from Major Land Resource Constraints map created April 2004 by P. Reich and H. Eversen of USDA/NRCS Soil Survey Division, World Soil Resources, Washington, D.C.; Fines AGU Soil Climate Map and Soil Map of the World, 1996; GLASOD data (L.R. Cochrane et al., 1991) provided by A. Sabatini, IFRI. Data on compaction in Europe from SOVUS/RISC (2000).

Armstrong's footprint on Moon. Is this soil? Why or why not?



Three bright green apples are arranged on a white surface. One apple is in the foreground, slightly to the right, and is the largest. Two other apples are behind it, one to the left and one to the right. The background is a plain white surface. The bottom of the image has a solid green horizontal bar.

What is soil?
What is your ideal soil?

You have 3 minutes to
develop a group consensus
definition.



United States Department of Agriculture
Natural Resources Conservation Service

Web Soil Survey

Online Soil Survey

- Website:

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

- Youtube instruction:

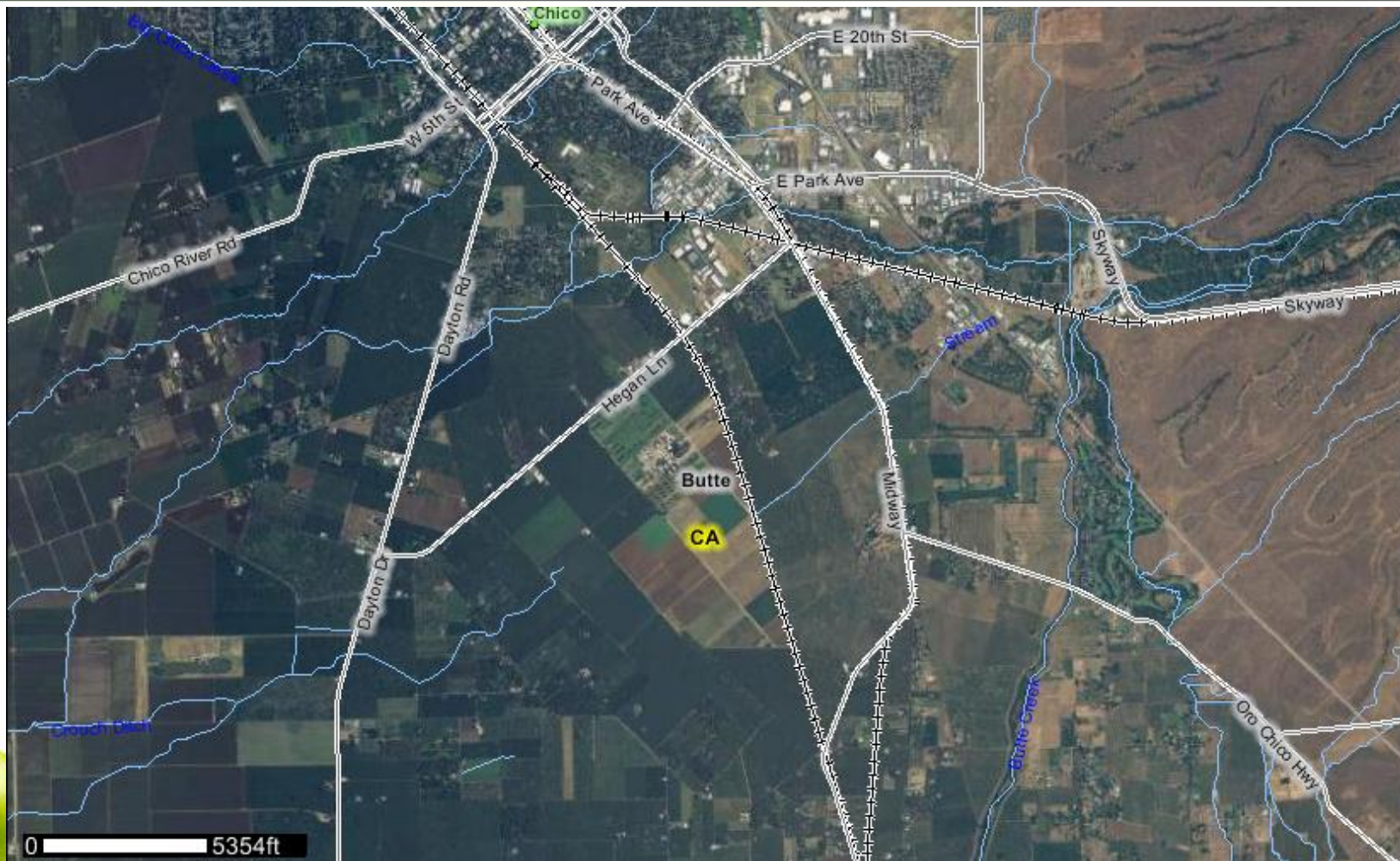
<http://www.youtube.com/watch?v=uBI7w2I9nl8>





United States Department of Agriculture
Natural Resources Conservation Service

Web Soil Survey





United States Department of Agriculture
 Natural Resources Conservation Service

Web Soil Survey

Search

Map Unit Legend

Butte Area, California, Parts of Butte and Plumas Counties (CA612)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
418	ALMENDRA LOAM, 0 TO 1 PERCENT SLOPES	22.4	97.5%
425	VINA FINE SANDY LOAM, 0 TO 1 PERCENT SLOPES	0.6	2.5%
Totals for Area of Interest		23.0	100.0%

Soil Map

Scale (not to scale)

Warning: Soil Map may not be valid at this scale.





United States Department of Agriculture

Natural Resources

Butte Area, California, Parts of Butte and Plumas Counties

418—ALMENDRA LOAM, 0 TO 1 PERCENT SLOPES

Map Unit Setting

Elevation: 110 to 230 feet

Mean annual precipitation: 20 to 26 inches

Mean annual air temperature: 61 to 63 degrees F

Frost-free period: 245 to 255 days

Map Unit Composition

Almendra, loam, and similar soils: 85 percent

Minor components: 15 percent

Description of Almendra, Loam

Setting

Landform: Alluvial fans

Landform position (two-dimensional): Toeslope

Landform position (three-dimensional): Tread

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loamy alluvium derived from igneous, metamorphic and sedimentary rock

Properties and qualities

Slope: 0 to 1 percent

Depth to restrictive feature: More than 80 inches

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat):

Moderately high to high (0.57 to 2.83 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Calcium carbonate, maximum content: 2 percent

Maximum salinity: Nonsaline to very slightly saline (0.0 to 3.0 mmhos/cm)

Available water capacity: High (about 9.5 inches)

Interpretive groups

Land capability classification (irrigated): 1

Land capability (nonirrigated): 3c

Typical profile

0 to 4 inches: Loam

4 to 14 inches: Loam

14 to 29 inches: Loam

29 to 40 inches: Loam

40 to 52 inches: Loam

52 to 74 inches: Very fine sandy loam












74 to 86 inches: Very fine sandy loam

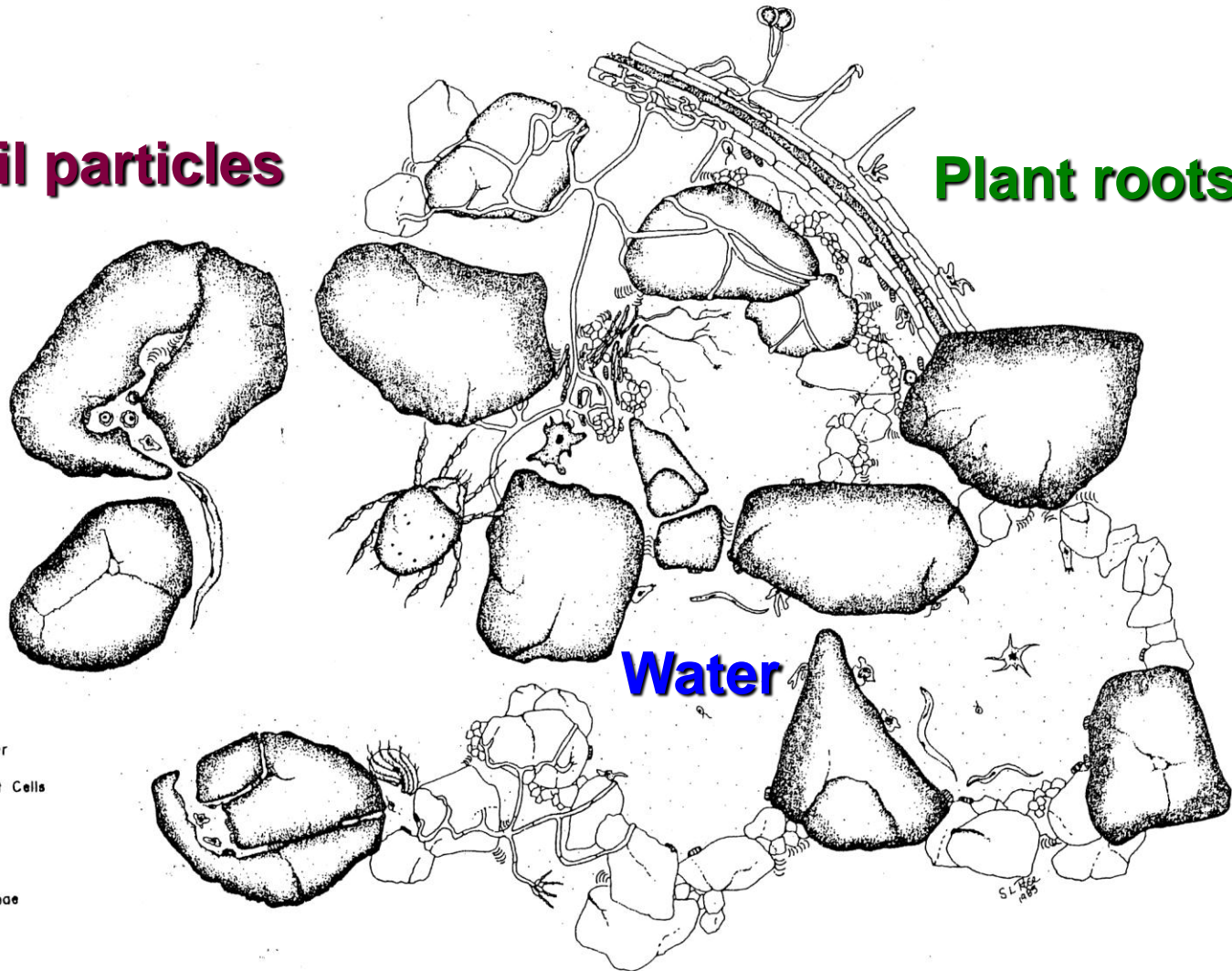


Soil is a habitat

Soil particles

Plant roots

-  Cyst
-  Amoeba
-  Flagellate
-  Bacterial Colonies
-  Nematode
-  Ciliate
-  Clay-Organic Matter Complex
-  Decomposing Plant Cells
-  Water
-  Actinomycete hyphae and spores
-  Fungal hyphae and spores



The background of the slide is a collage of four microscopic images. Top-left: A brightfield micrograph showing several chains of small, yellowish, spherical bacteria. Top-right: A scanning electron micrograph (SEM) showing numerous rod-shaped bacteria, some appearing to be in a cluster. Bottom-left: A brightfield micrograph showing a network of thin, brown, fibrous structures, likely fungal hyphae or soil organic matter. Bottom-right: A scanning electron micrograph (SEM) showing a large, complex, multi-layered structure, possibly a fungal fruiting body or a large bacterial colony.

Soil is alive...

For example, in 1g of soil:

- >100,000,000 bacterial cells
- >11,000 species of bacteria

Also fungi and larger animals

ASM MicrobeLibrary.org©Chloris

ASM MicrobeLibrary.org©Smith

Part I: Definitions

- **Soil:**
- An ecological system consisting of inorganic minerals, decomposing organic matter, living organisms and growing plants

- **Soil health or soil quality:**
A general term that describes the ability of a soil to function



Definitions: soil functions

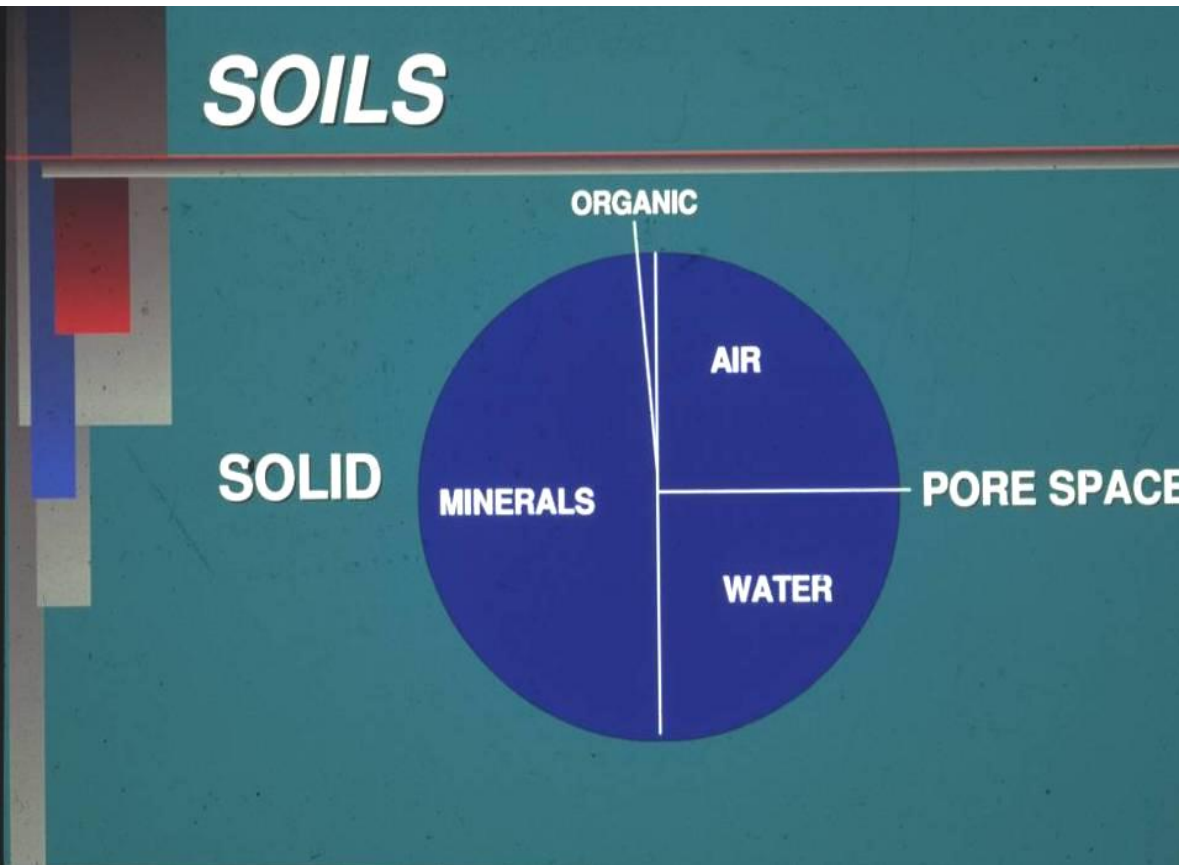
- **Sustain plant and animal productivity**
- **Regulate water flow through the environment**
- **Buffer environmental changes in air quality, water quality and global climate**
- **Support human health and habitation**



The Ideal Soil is Rare!



What is soil composed of?



- Solid particles (sand, silt, clay)
- Soil pores (air, water)
- Soil organisms (OM)
- Chemistry (nutrients)



Soil Texture vs. Structure, what's the difference?

Texture – The percent sand, silt, & clay, based on the soil triangle

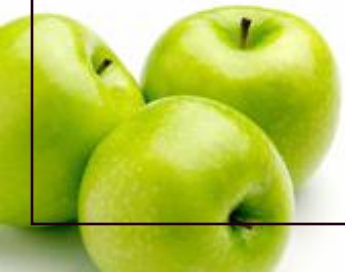
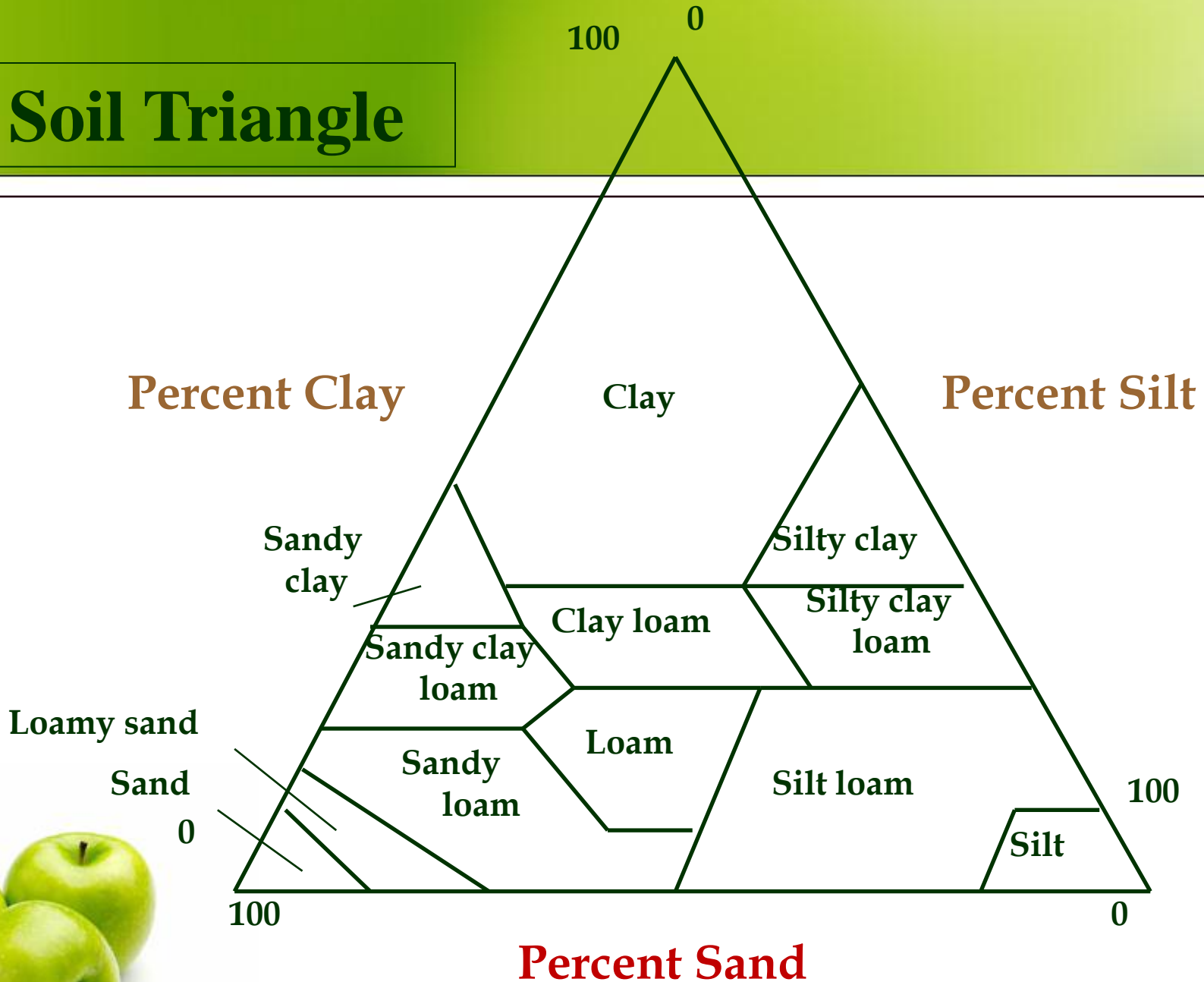
e.g., sandy loam, clay loam

Structure – The arrangement of primary particles into secondary units (aggregates)

Affected by compaction



Soil Triangle



What is the textural class name for a soil that contains 22% sand and 18% clay?

2%

1. sandy clay loam

2. clay

0% ✓

3. silt loam

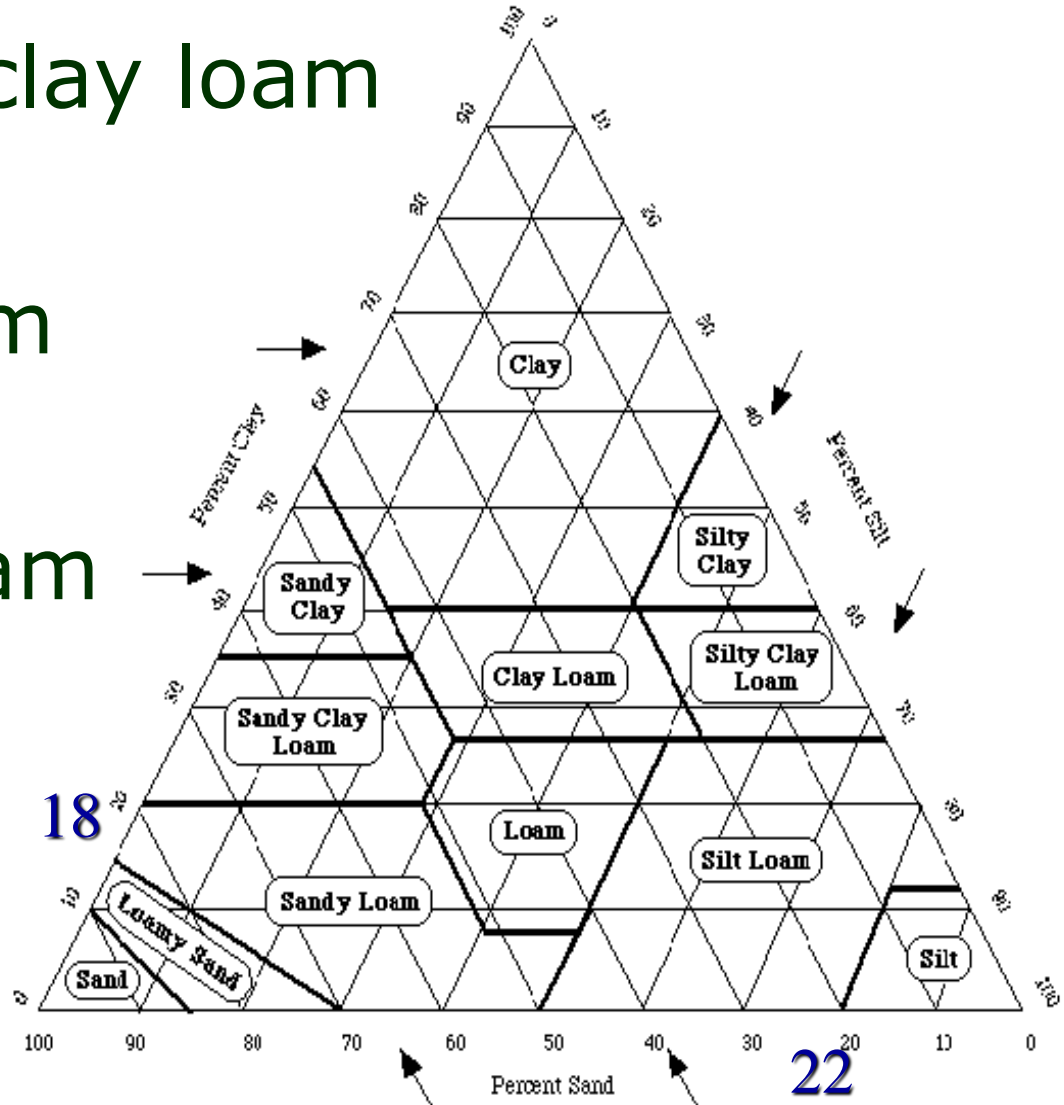
95%

4. loam

5. clay loam

2%

0%





Sandy



Clayey

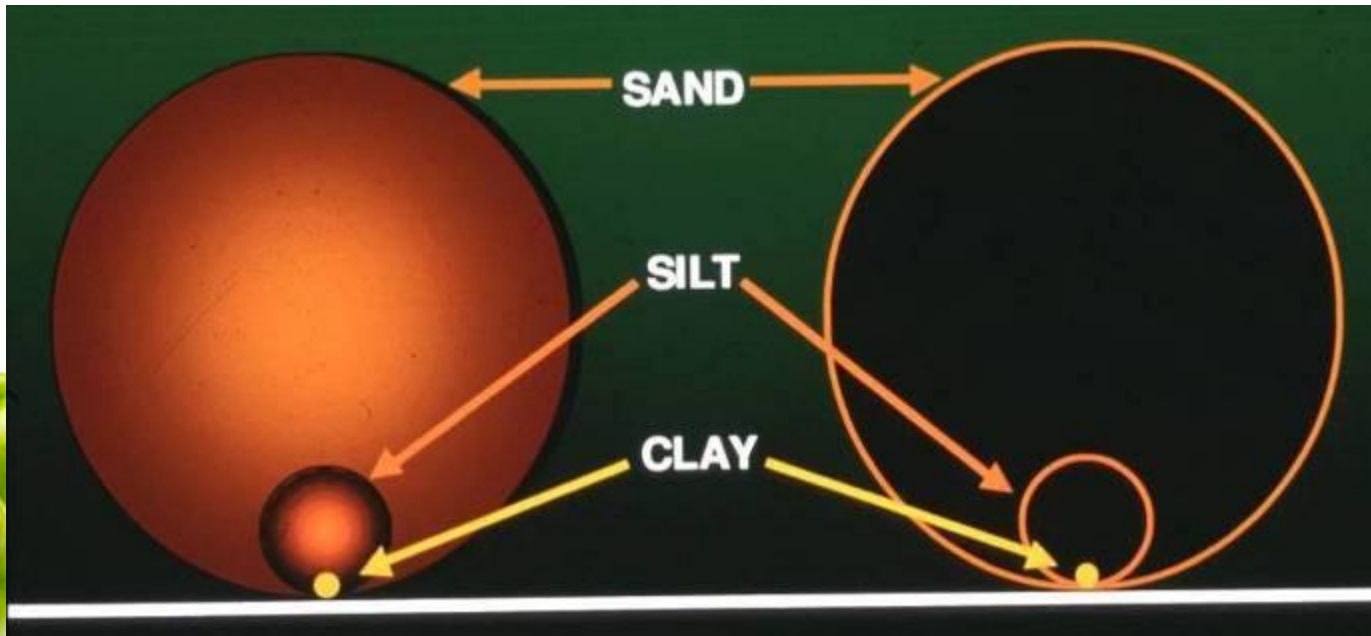


Soil Particle Sizes

Sand 2.00 to 0.05 mm

Silt 0.05 to 0.002 mm

Clay 0.002 to <0.0002 mm



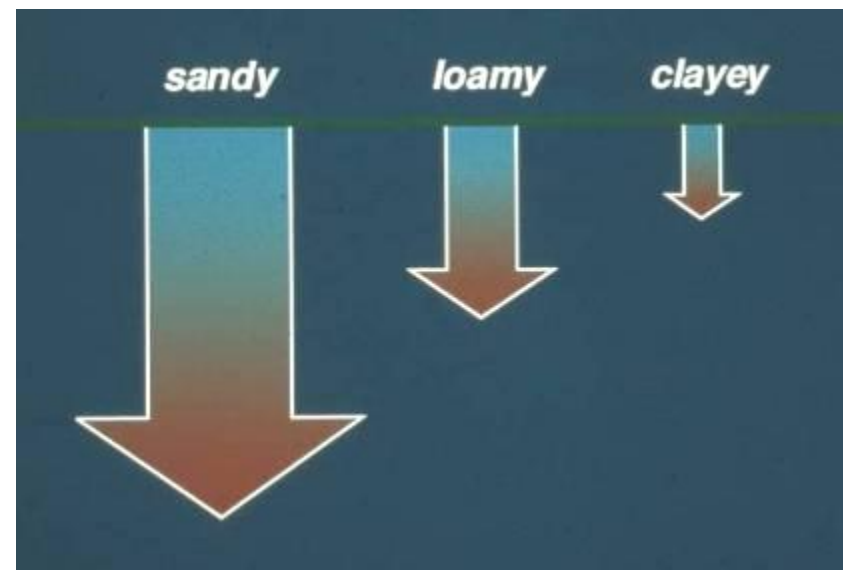
Soil Texture Affects Soil Moisture



Water Holding Capacity

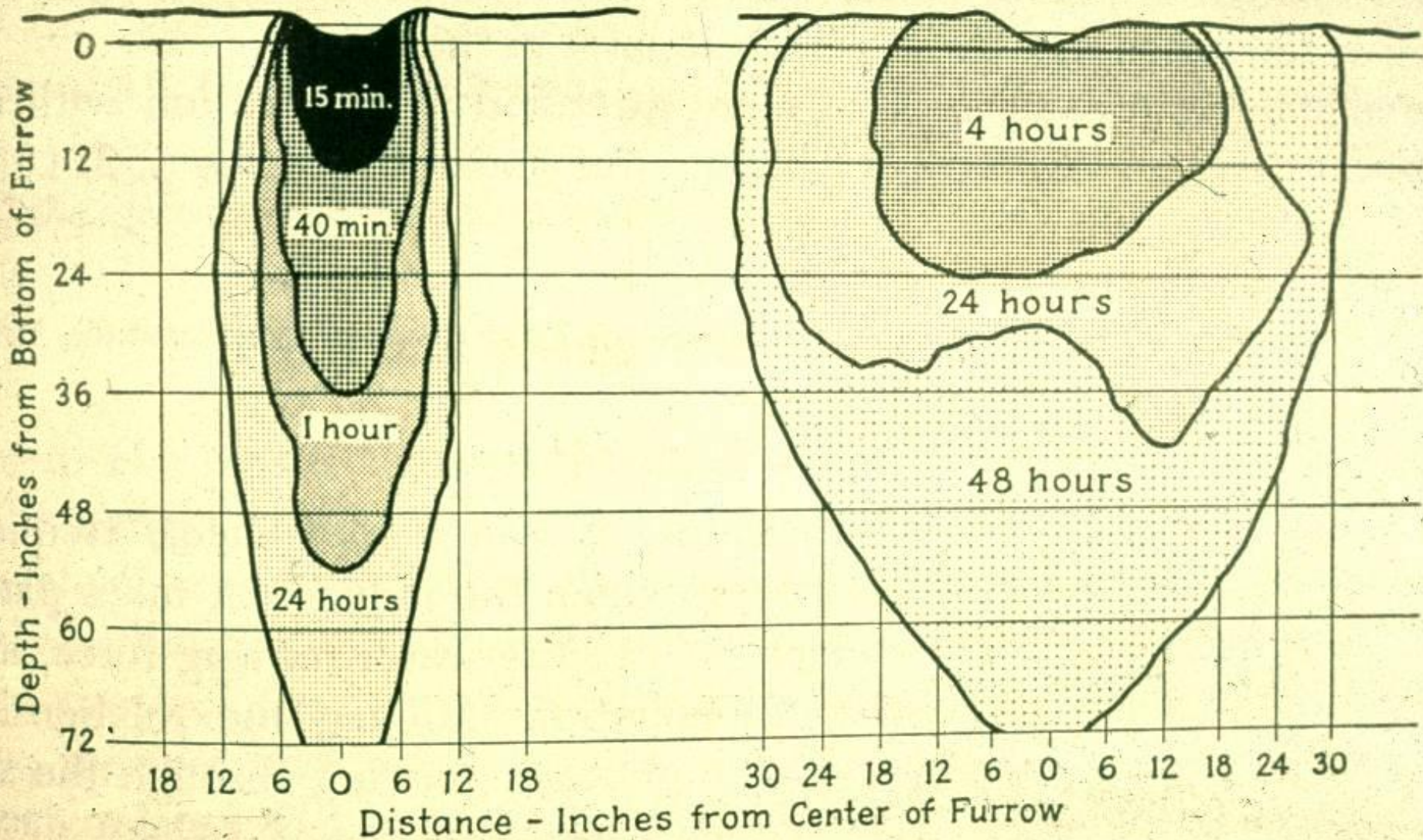


Permeability



SANDY LOAM

CLAY LOAM



Properties Influenced by Soil Texture

	<u>Sand</u>	<u>Loam</u>	<u>Clay</u>
Aeration	excellent	good	poor
Water holding	low	moderate	high
Available	7%	16%	11%
Permeability	high	moderate	low
Nutrient holding capacity	limited	moderate to high	high



What is Soil Cation Exchange Capacity?



Which of the following statements are true concerning soil CEC?

100%



1. High CEC soils can adsorb more exchangeable cations, and can store more plant nutrients than soils with a low CEC
2. Higher CECs are found in soil low in organic matter than soils high in organic matter.
3. High CEC soils do not retain nutrients
4. Higher CECs are found in sandy soils than clay soils

0%

0%



0%

Cation Exchange Capacity

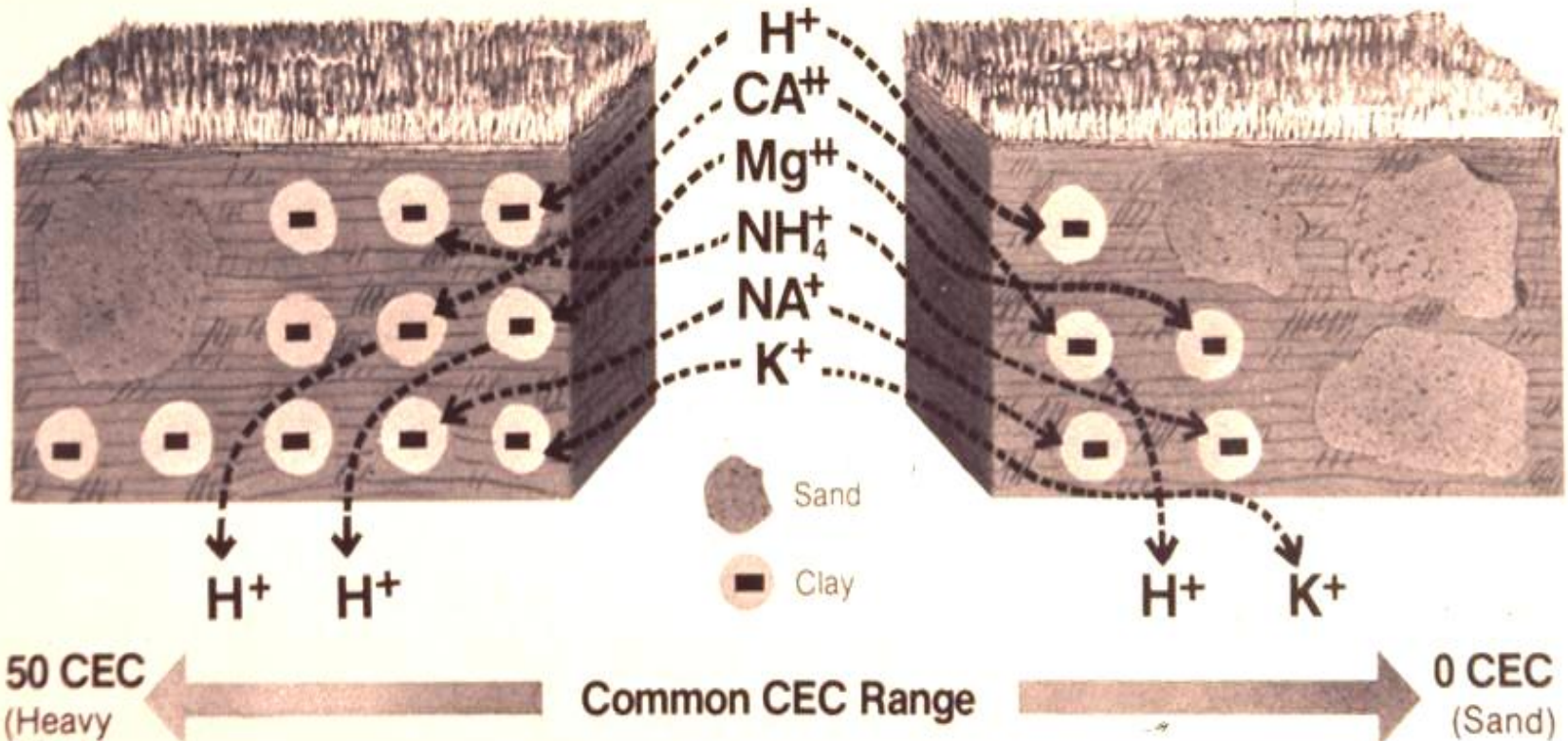
A SCHEMATIC LOOK AT CATION EXCHANGE

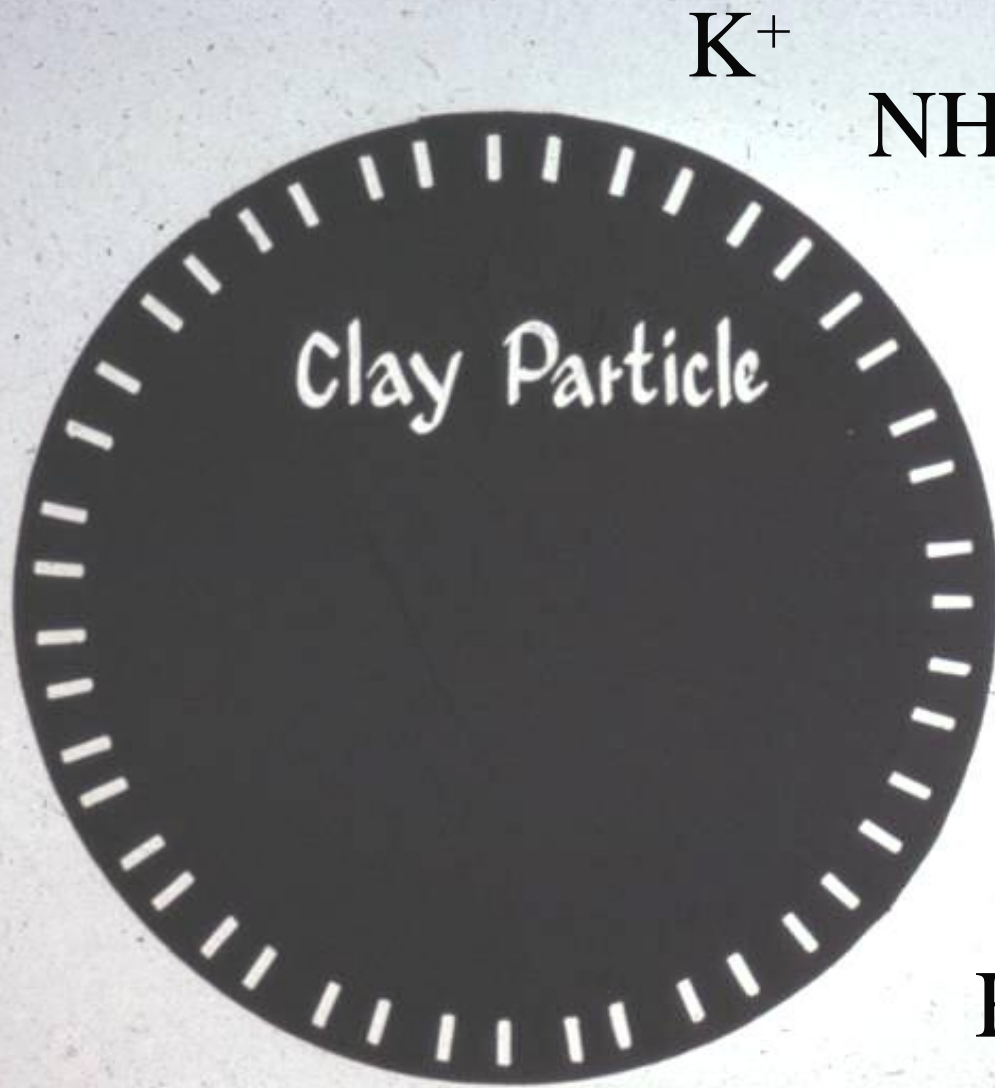
CEC 25

MORE CLAY, MORE POSITIONS
TO HOLD CATIONS

CEC 5

LOW CLAY CONTENT,
FEWER POSITIONS TO HOLD CATIONS





Clay Particle

Soil Structure

Structure - the arrangement of soil particles into aggregates

Various types: blocky, platy, prismatic

Good structure: holds water (micropore space) and has air space (macropore space).

Poor structure lacks adequate macropore space.



Soil structure & texture can be highly variable across small areas

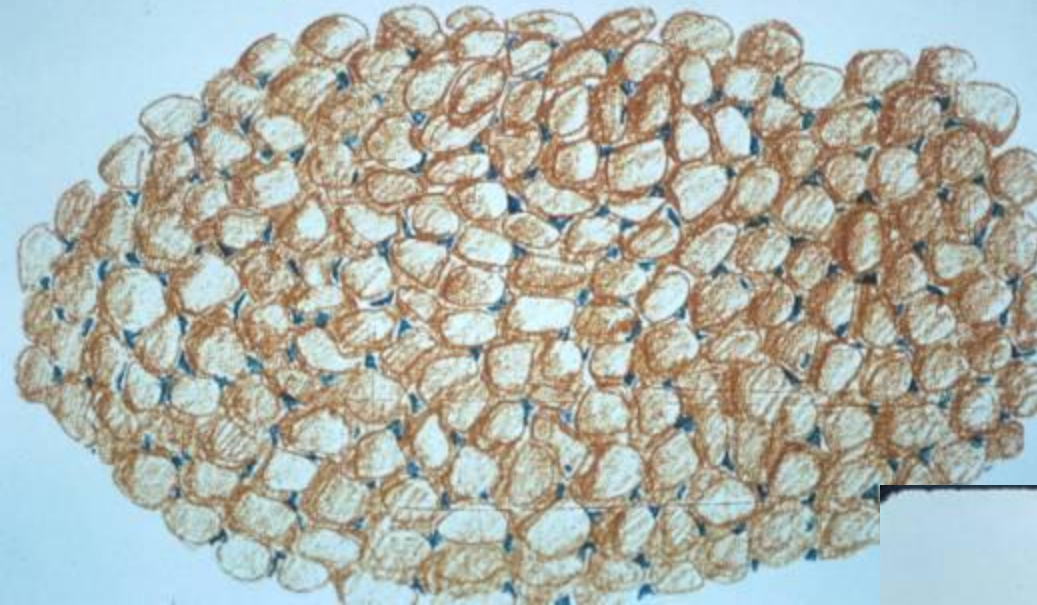


Planters and medians can have very poor soil structure



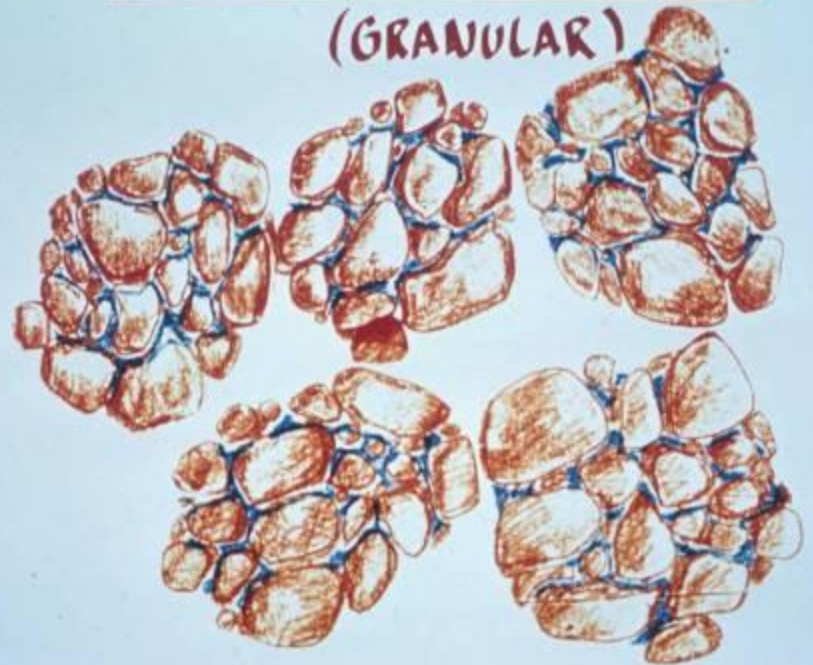
POOR SOIL STRUCTURE

(MASSIVE - COMPACT)



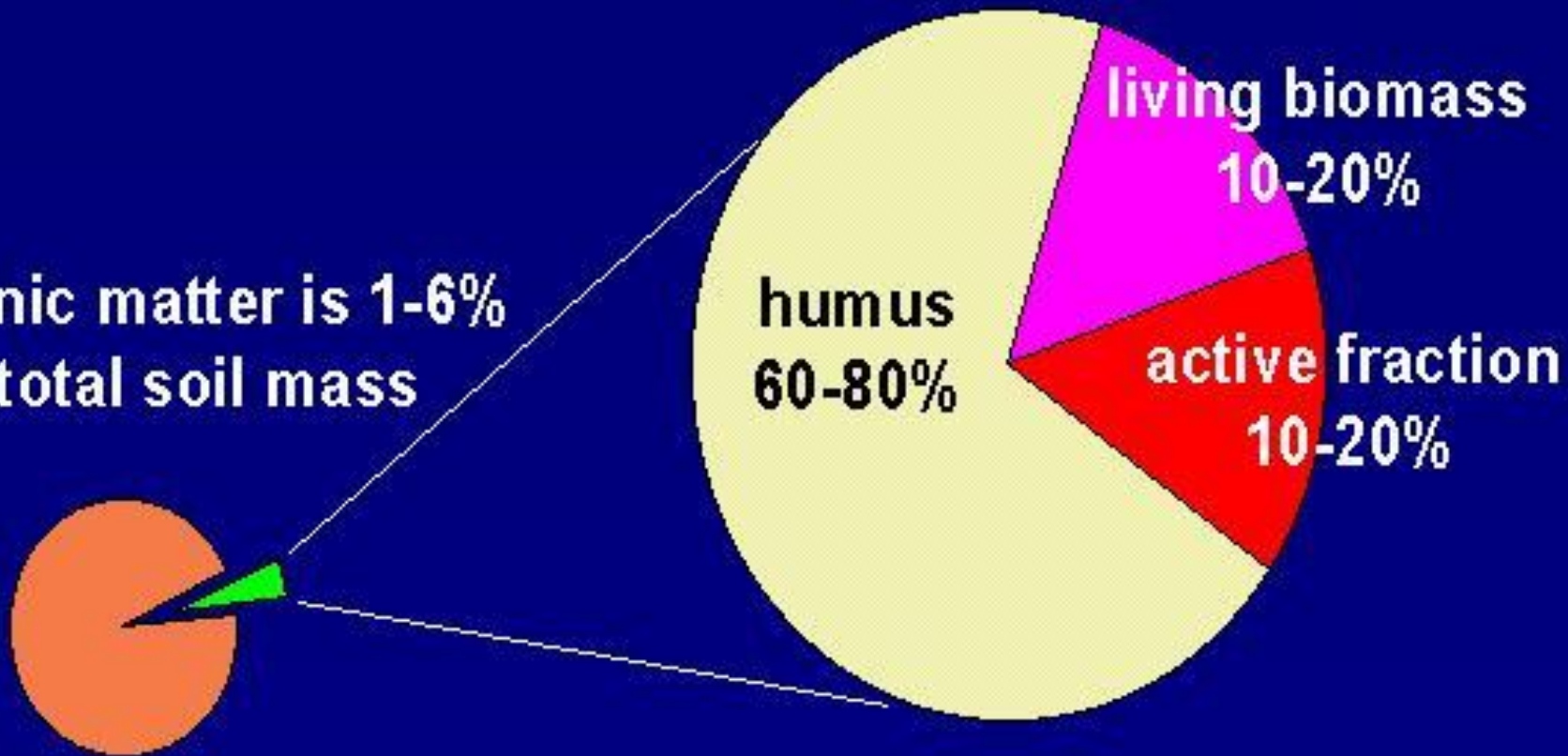
GOOD SOIL STRUCTURE

(GRANULAR)



Soil organic matter (SOM)

Organic matter is 1-6%
of total soil mass



Role of soil organic matter

Two major components:

- **Effects of the organic matter itself**
soil structure, chelation of micronutrients,
pH buffering capacity
- **Effects of decomposition of organic residues**
aggregation, nutrient release, biological
activity, disease suppression



Soil Structure:

Water holding capacity

- Organic particles can hold more water than mineral particles



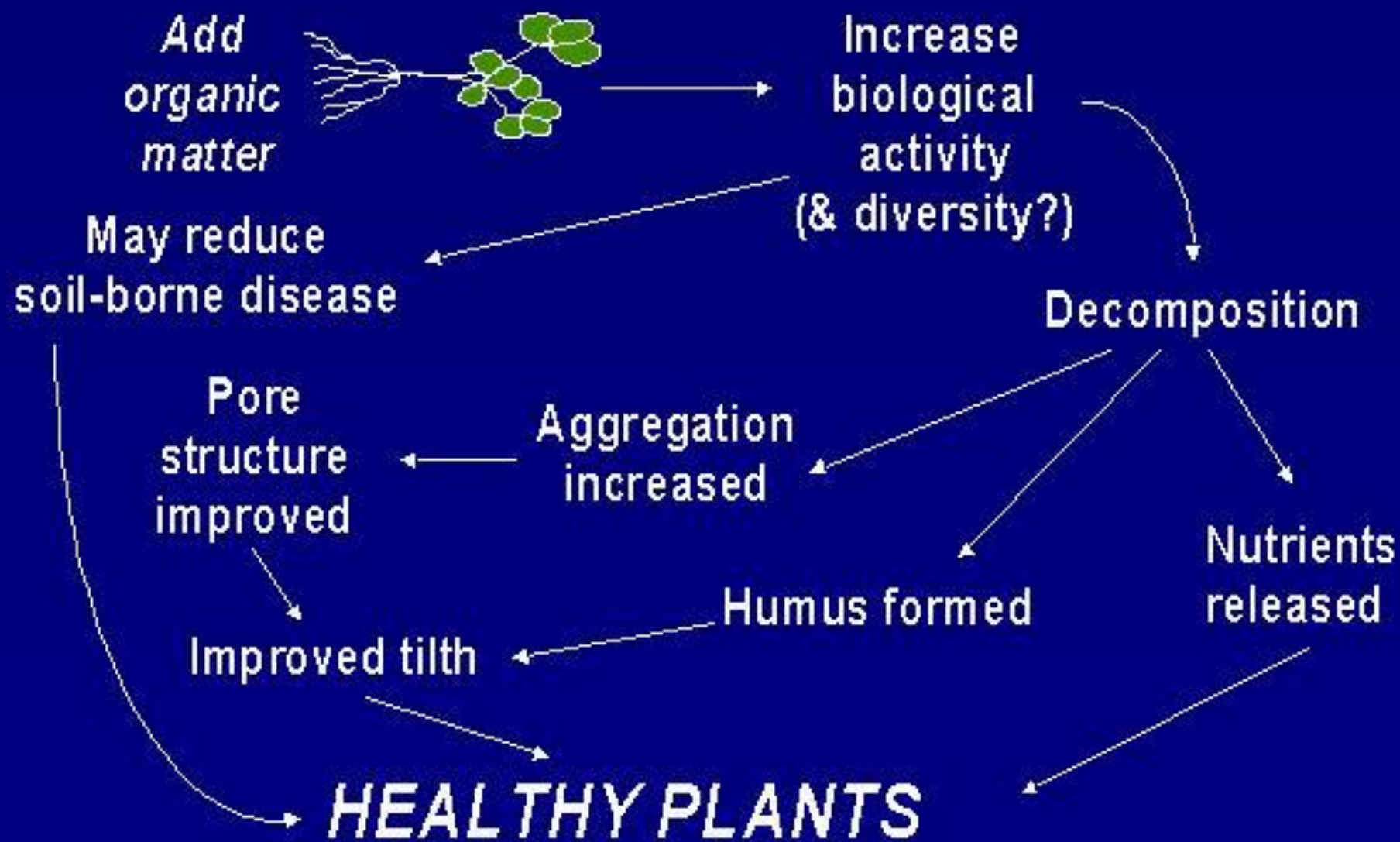


Nutrient reservoir:

Cation exchange capacity



Effects of OM additions





How Can we increase SOM?



Cover Crops







