

# SOIL SCIENCE: AN INTRODUCTION

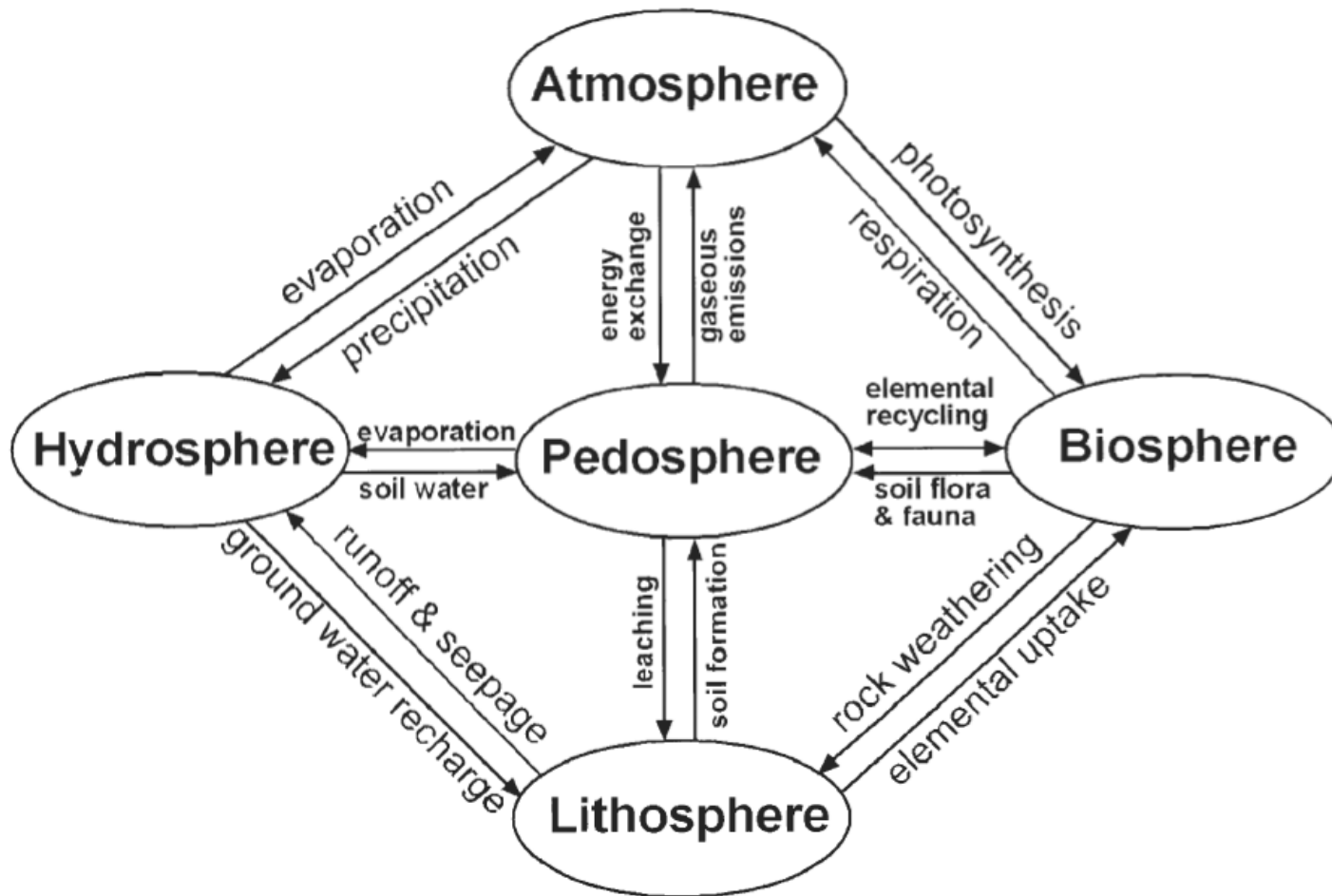
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# What is Soil?

- ④ Brady offers a definition based on the user's perspective:
  - "The unconsolidated material at or near the earth's surface that has properties due to its proximity to the surface"

# Soil Sphere Theory



- ® Pedo: Soil
- ® Bio: Plant
- ® Litho: Rock
- ® Hydro: Water
- ® Atmo: Air

Can you see how all of these are inter-related?

# Definitions



- ④ **Soil Profile:** A vertical section of soil through multiple horizons that extends into the parent material
  - Ex: Ruston series
    - State soil of Louisiana

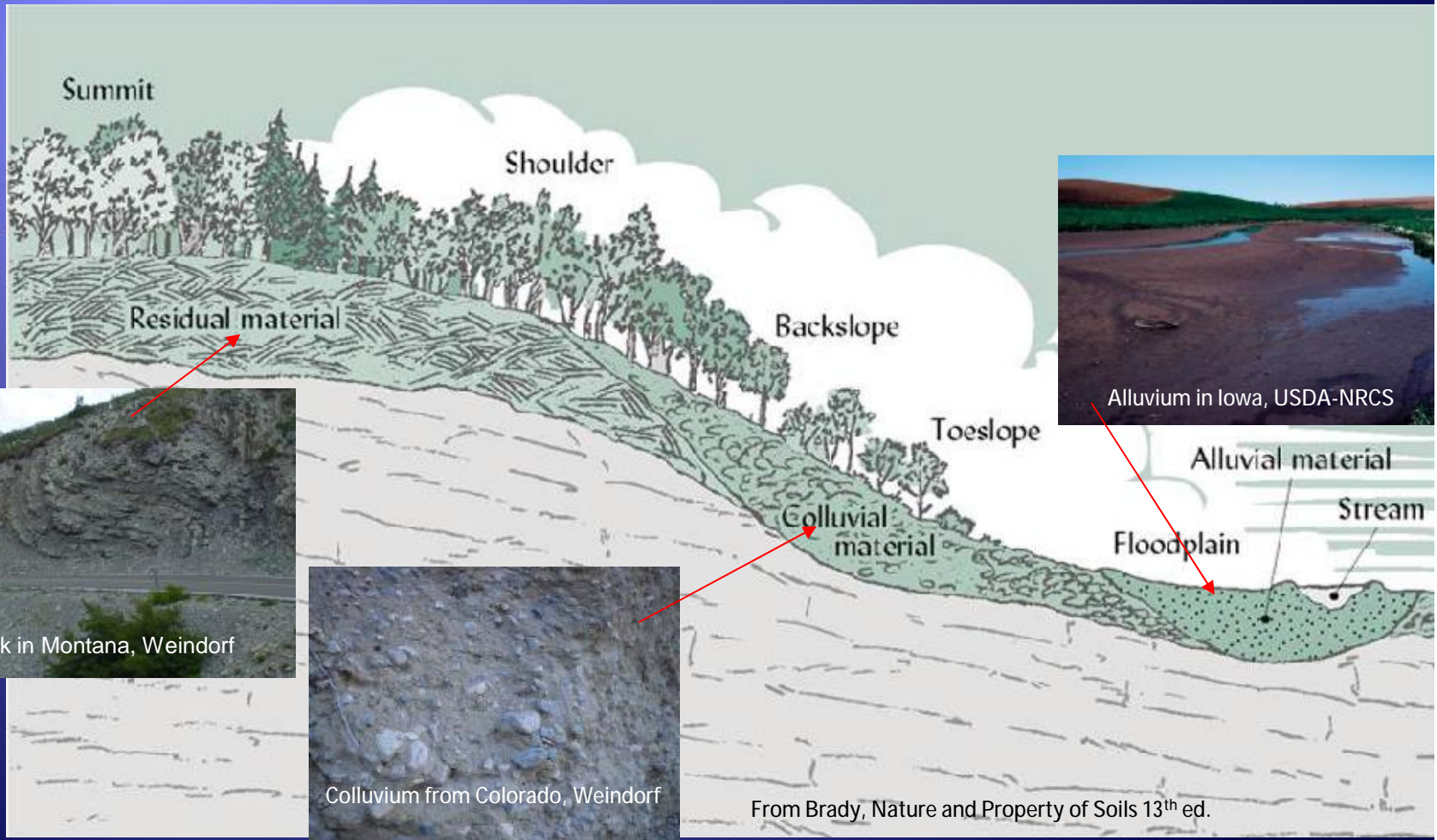
# Parent Material

- ® **Alluvium**: Stream/river deposited
- ® Residuum: Original unweathered material
- ® Lacustrine: Lake deposited
- ® Marine: Ocean deposited
- ® Eolian: Wind deposited

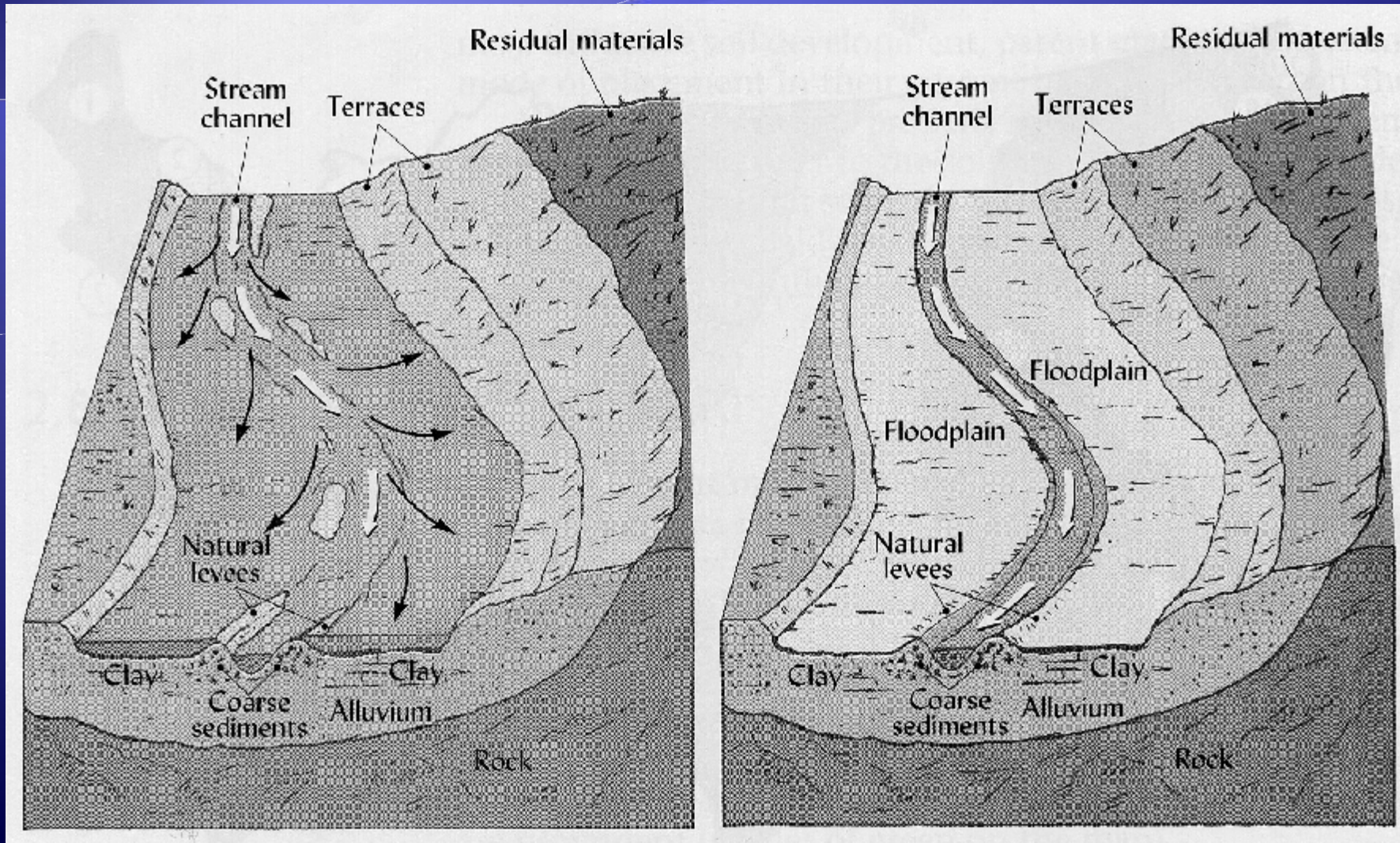


Columbia River floodplain alluvium, Oregon

# Parent Material

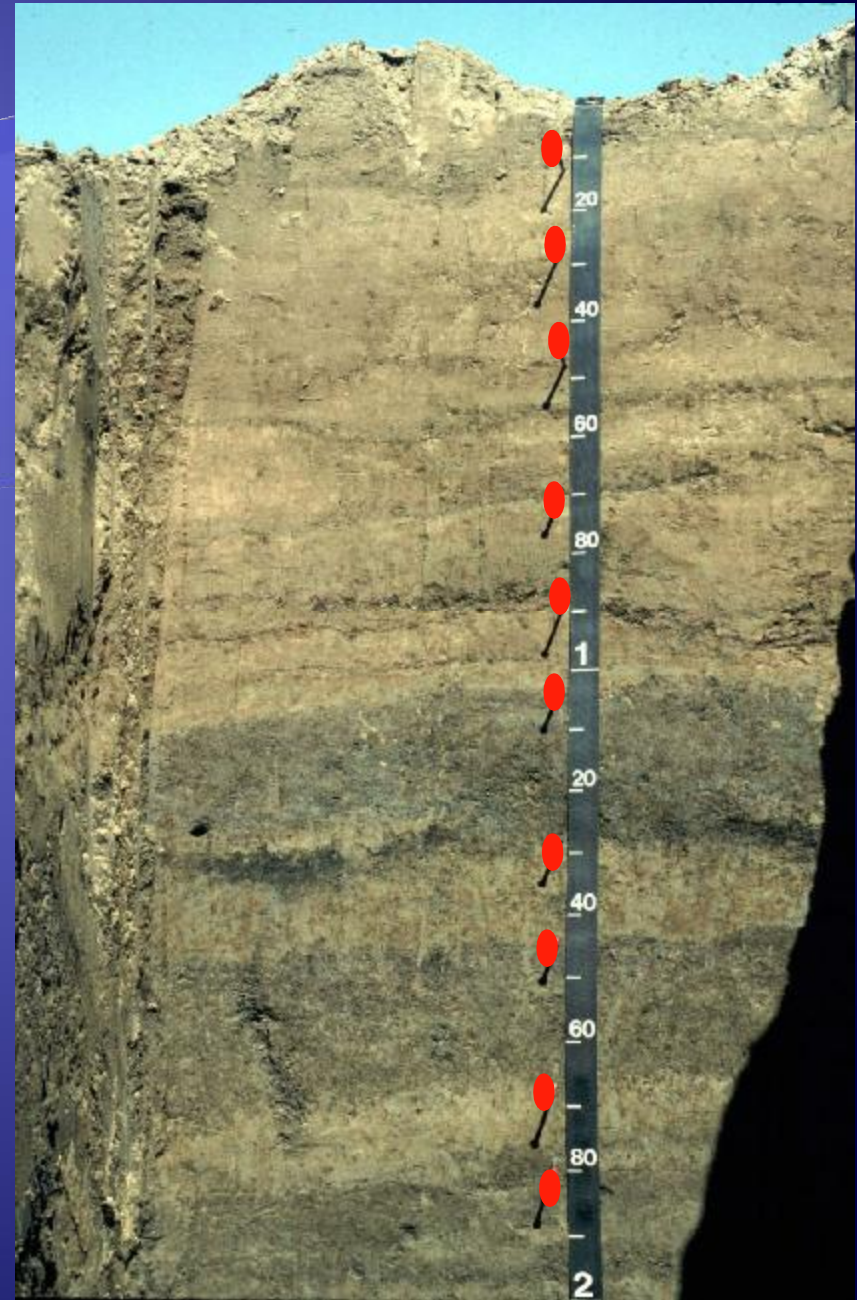


# Alluvial Formation



# Alluvial Soil

- ④ Multiple flooding events
- ④ Dark layers – Previous surfaces
  - Rich in organic matter
  
- ④ Bruin Silt Loam - Tensas





# Soil Horizons

- ④ Defined: A layer of soil or soil material approximately parallel to the land surface and differing from adjacent genetically related layers in physical, chemical, and biological properties or characteristics such as color, structure, texture, consistency, kinds and number of organisms present, degree of acidity or alkalinity, etc.
  - 6 major master horizons (O, A, E, B, C, R)
  - Numerous subordinates (lower case letters)
    - Further describe master horizon attributes

# Soil Horizons

- ④ A – Surface (can be darker in color than below)
  - Ap – Soil has been mechanically disturbed
- ④ B – Typically higher in clay content in older soils
  - Bt – clays have moved down from surface
  - Bw – color changes slightly



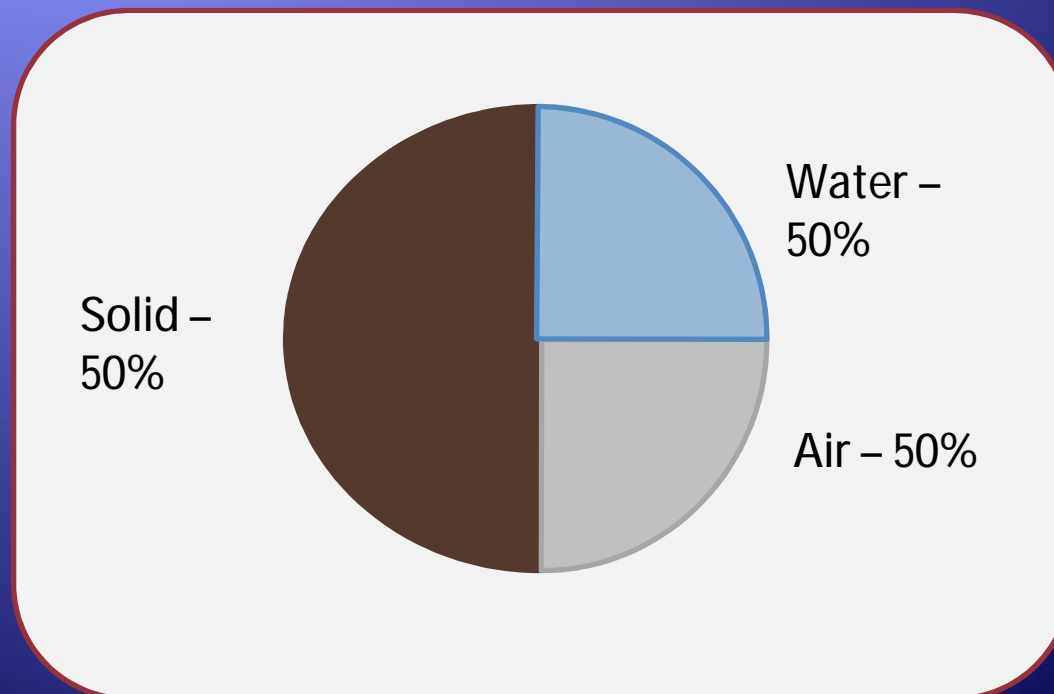
# SOIL PHYSICAL PROPERTIES

# Soil Phases

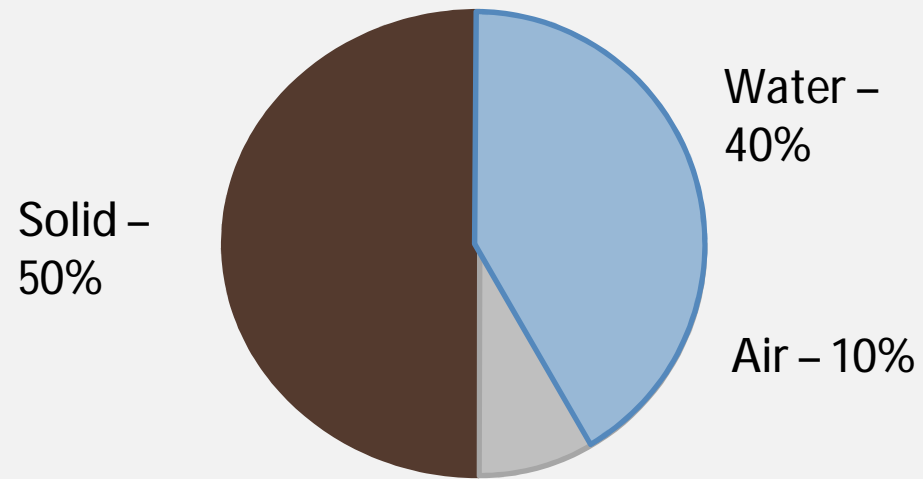
- ④ Soil is comprised of three phases:
  - Solid (Soil matrix)
  - Liquid (Soil solution)
  - Gas (Soil atmosphere)
- ④ Most of us think of soil as a solid substance, but in fact solids account for only 50% of a typical profile

# Idealized Soil Phases

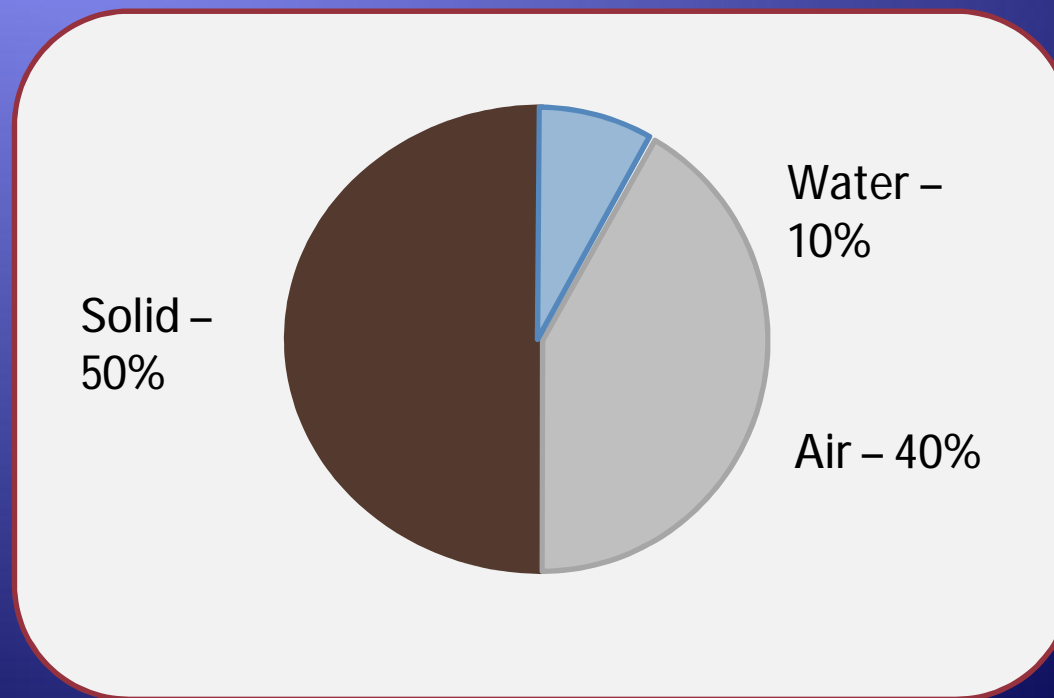
- ① Soil solution and soil atmosphere constantly flux based on infiltration, evaporation, plant respiration, etc. to account for the other 50%



# Phases Following Heavy Rain



# Phases After Prolonged Drought



# Solid Phase

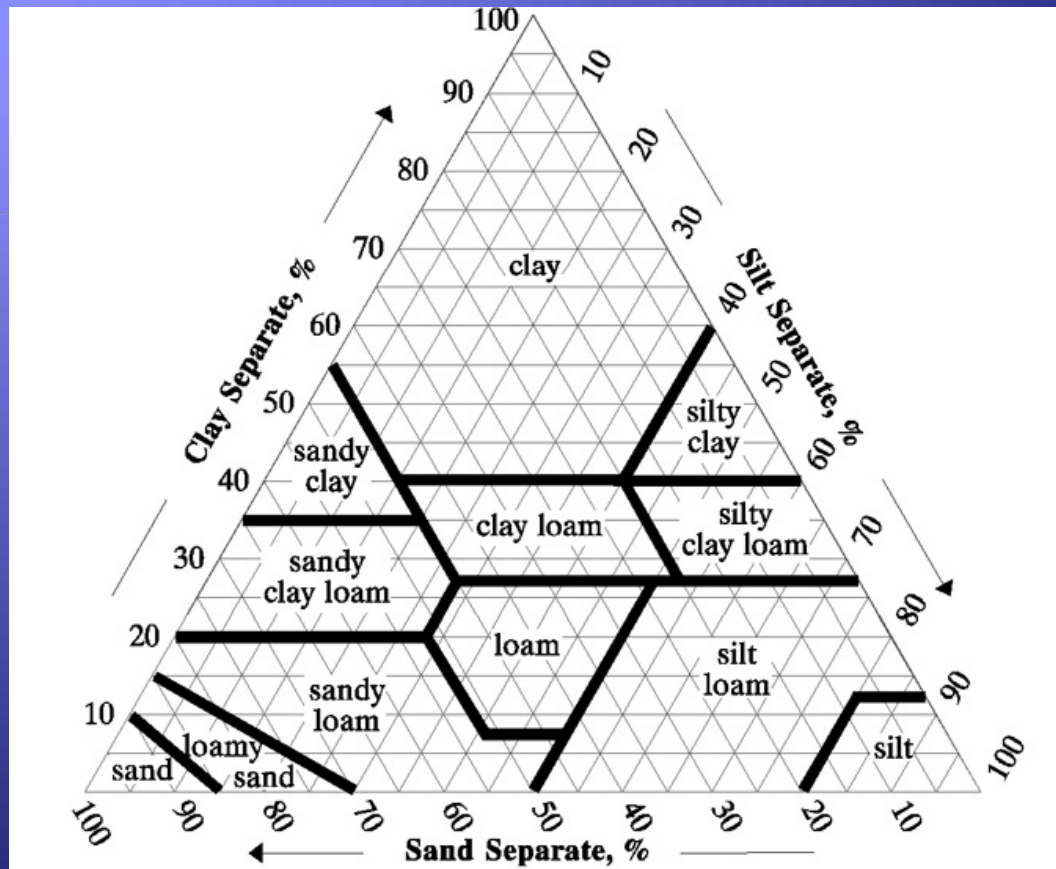
- ④ The solid phase is dominantly mineral soil (99%) with approximately 1% organic matter from plants and animals found in the upper-most mineral horizons
  - O horizons may contain significantly more organic matter, but are not considered mineral soil
  - Marsh Soils can be high in organic material



# Particle Size

- ④ Soil particles are divided into three main size categories:
  - Sand
  - Silt
  - Clay
- ④ Combinations of these three sizes of particles yield one of twelve recognized soil textures
- ④ Represented on the USDA textural triangle

# USDA Textural Triangle



# Smectite (Gumbo Soils/Blackland Clay)

- ④ Smectitic soils are fertile

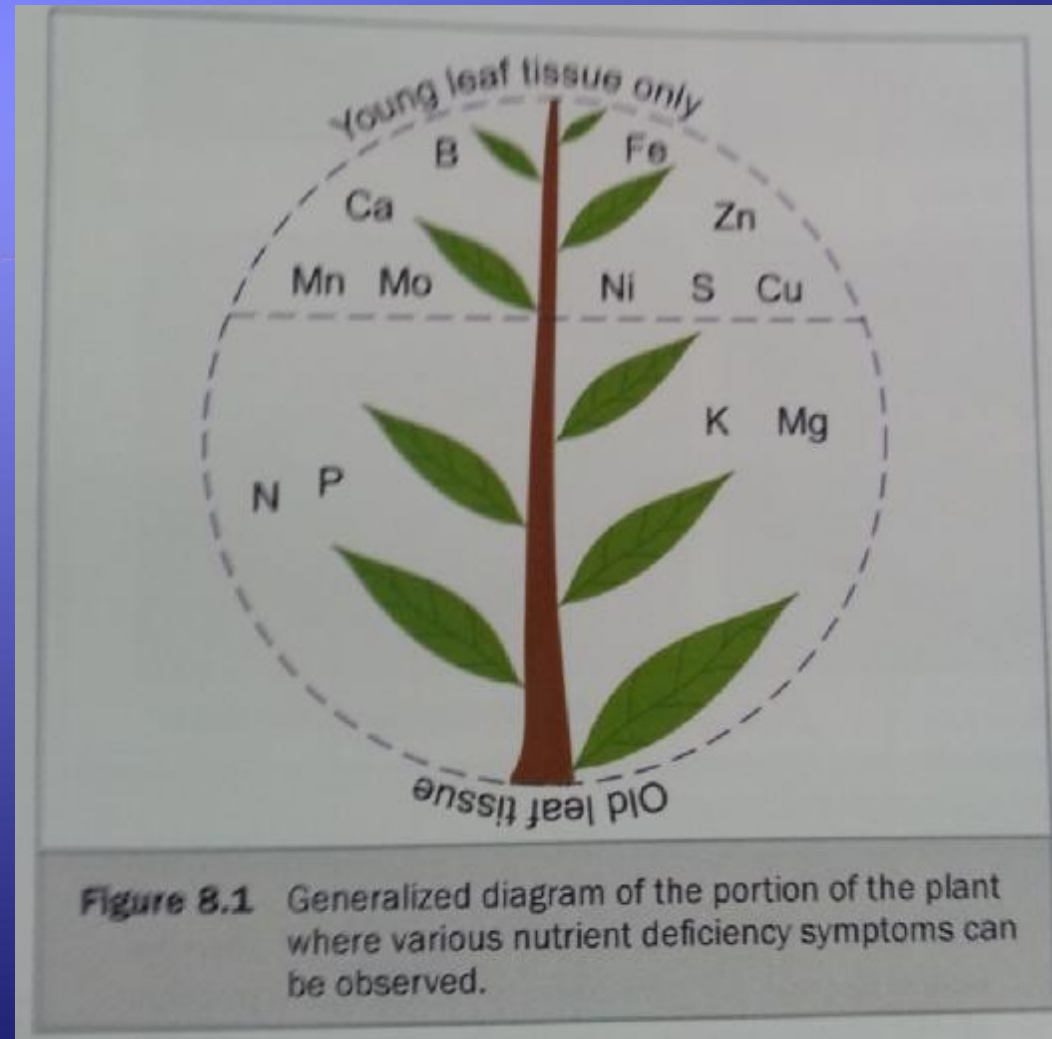
- Hard to work
- High degree of shrinking and swelling



Root pruning of cotton caused by extensive cracking.

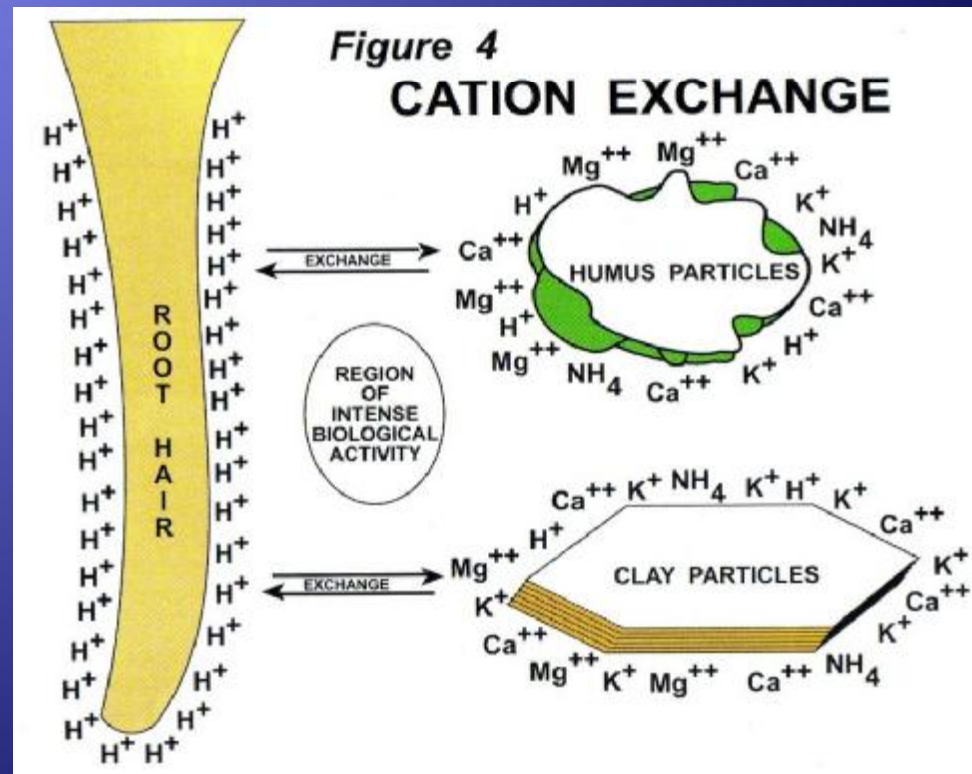
# Liquid Phase

- ① **Soil solution** is dominantly water, but the water contains nutrients that are essential to plant growth

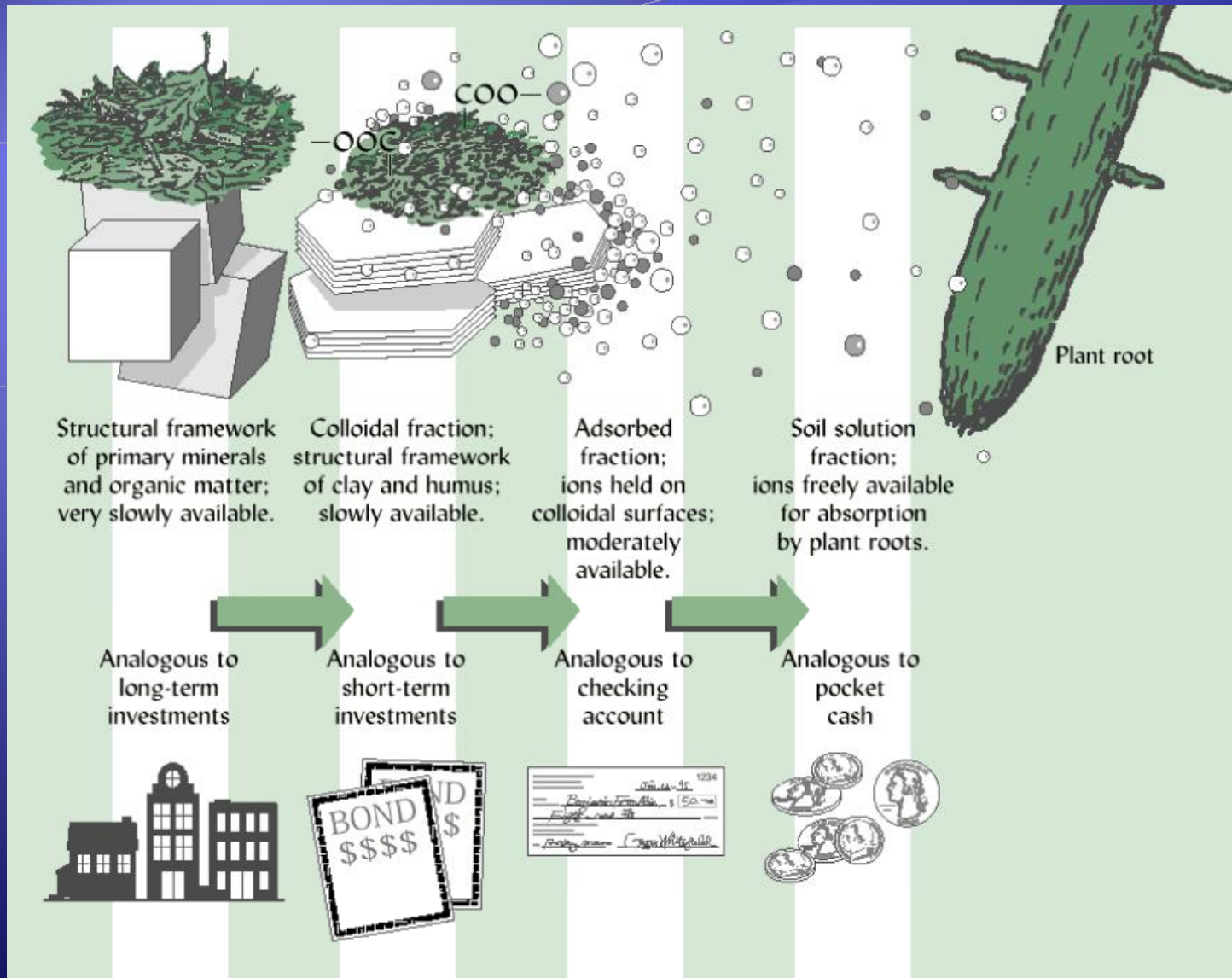


# Nutrient Supply

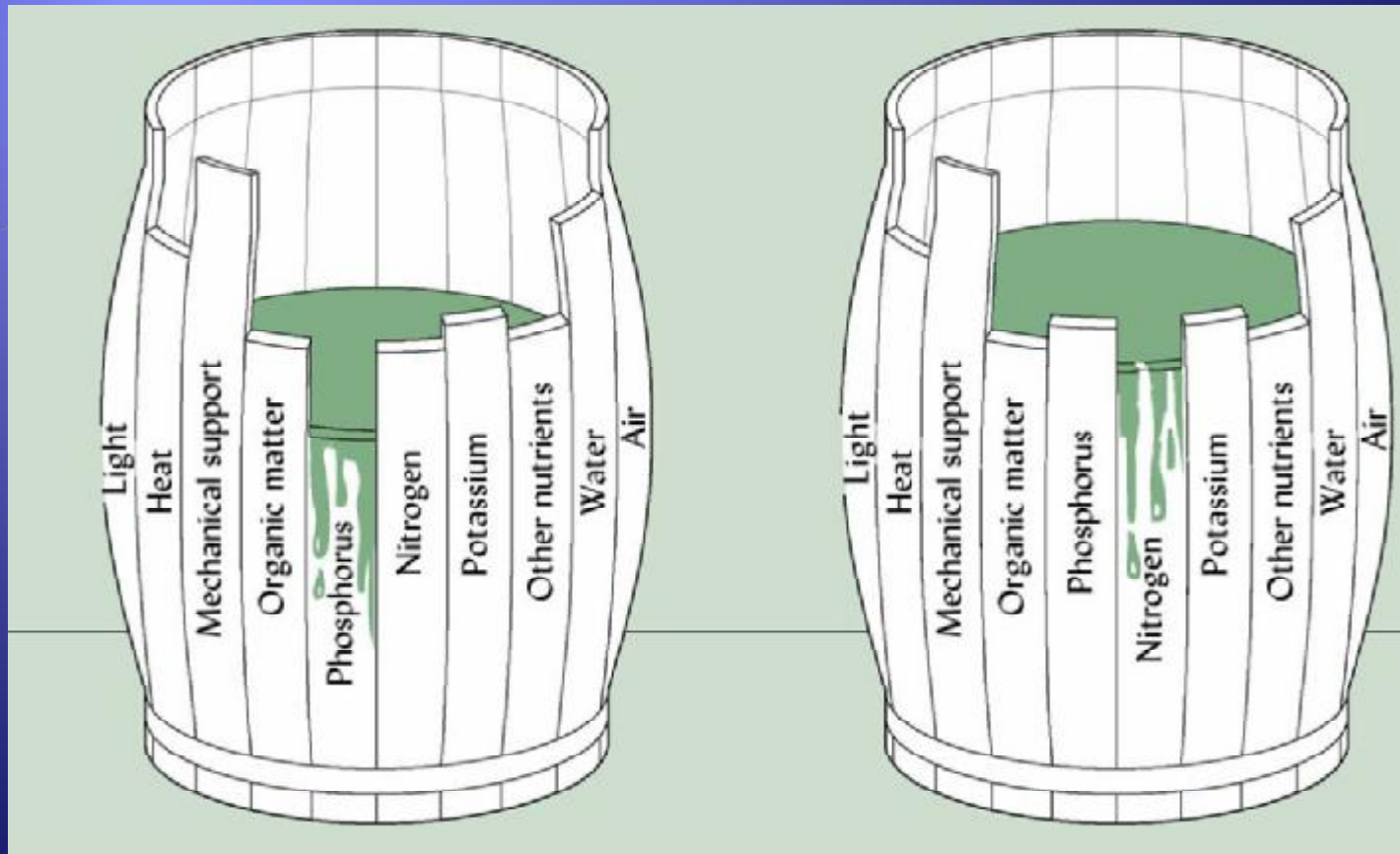
- ① Original Source
  - Living Organisms
  - Minerals
- ① As organic matter and minerals break down, the soil solution carries them to soil particles or roots via mass flow
- ① The principle storage points for plant nutrients:
  - Organic material
  - Certain clays



# Nutrient Supply



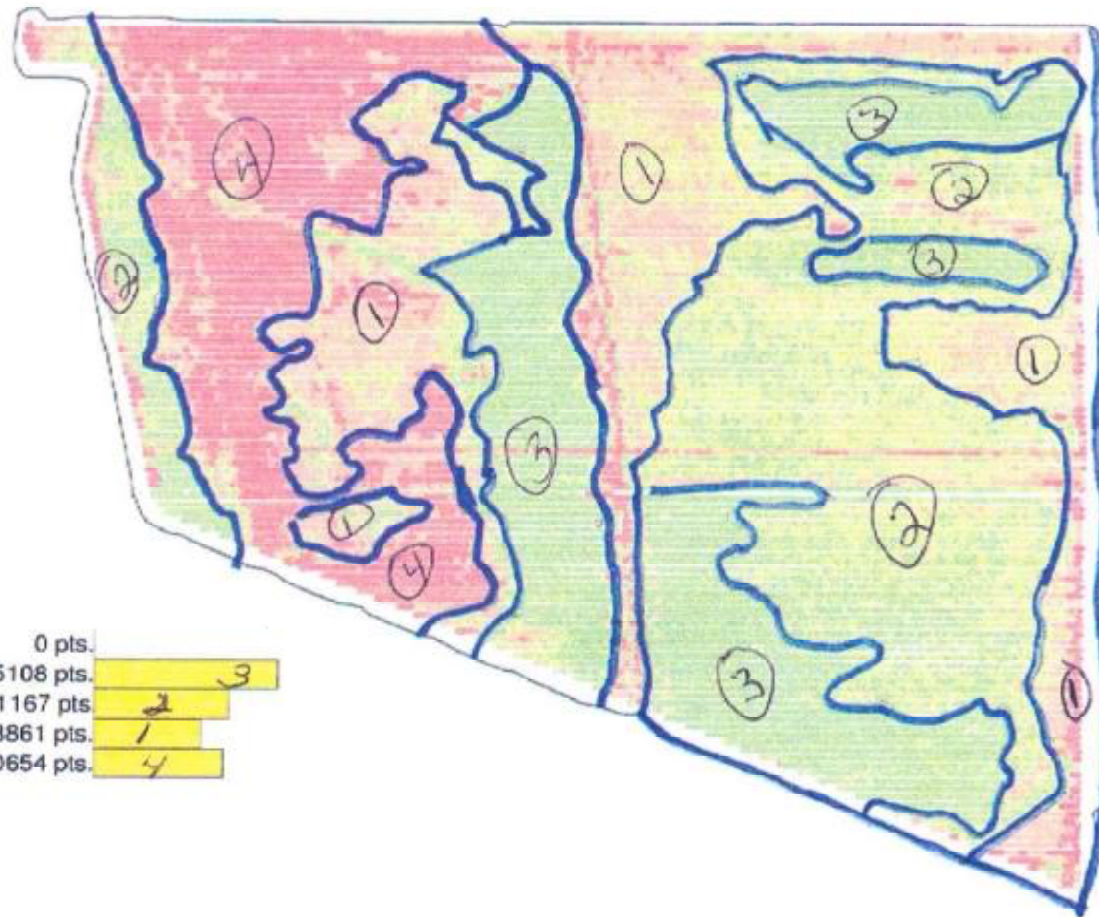
# Nutrient Supply – Law of the minimum



Brady and Weil, 1999

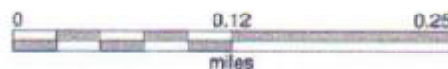
# Law of the minimum

Elevator - 2011 Corn: Harvesting  
Dry Yield



Above 274.9 bu/ac	0 pts.	
200.0 - 274.9 bu/ac	15108 pts.	3
175.0 - 199.9 bu/ac	11167 pts.	2
125.0 - 174.9 bu/ac	8861 pts.	1
0.0 - 124.9 bu/ac	10654 pts.	4

ZONE  
1  
2  
3  
4





# Factors affect nutrient availability

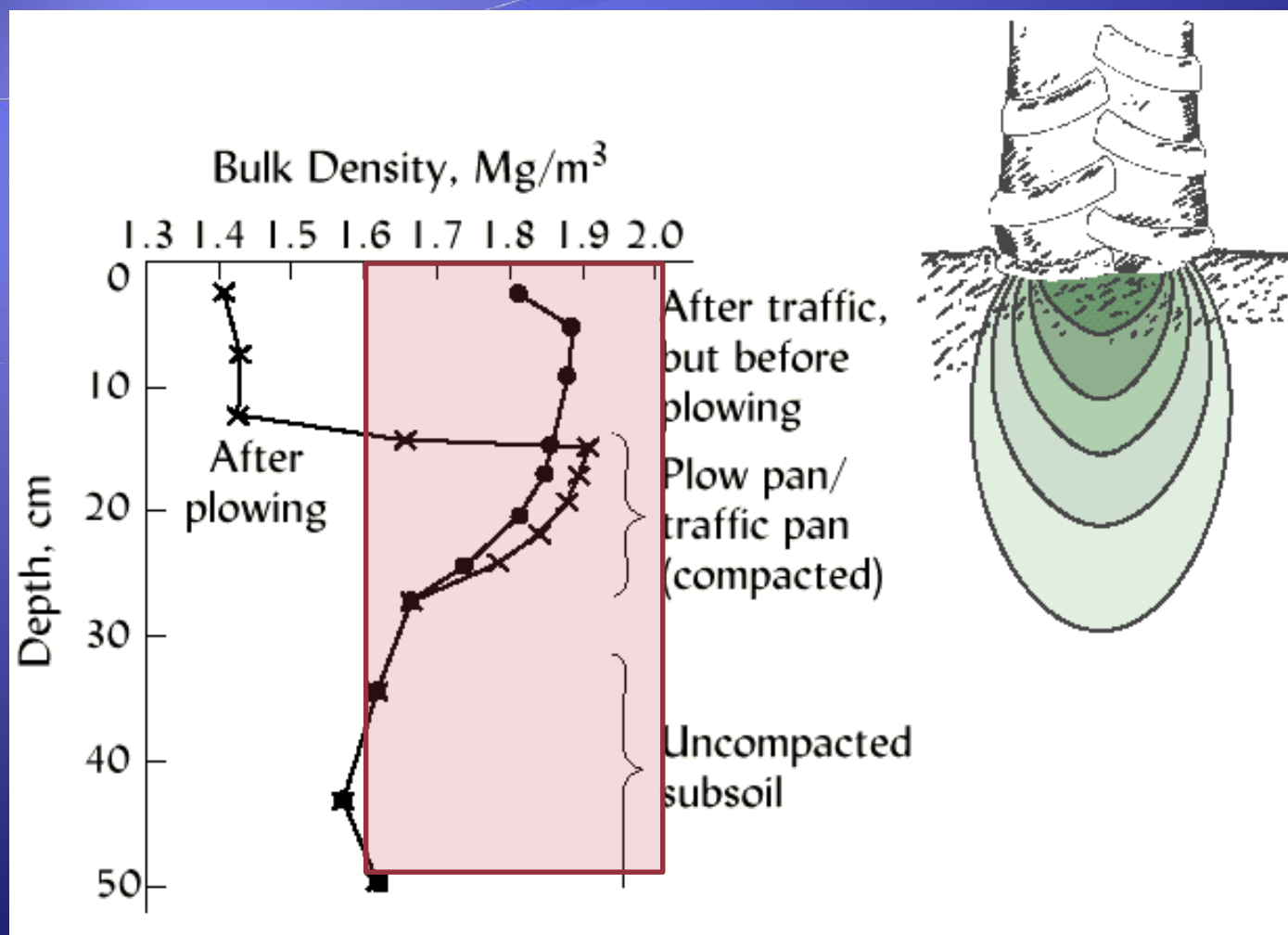
- ④ Soil Compaction
- ④ Cold Temperatures
- ④ Low Soil Moisture

Reduces



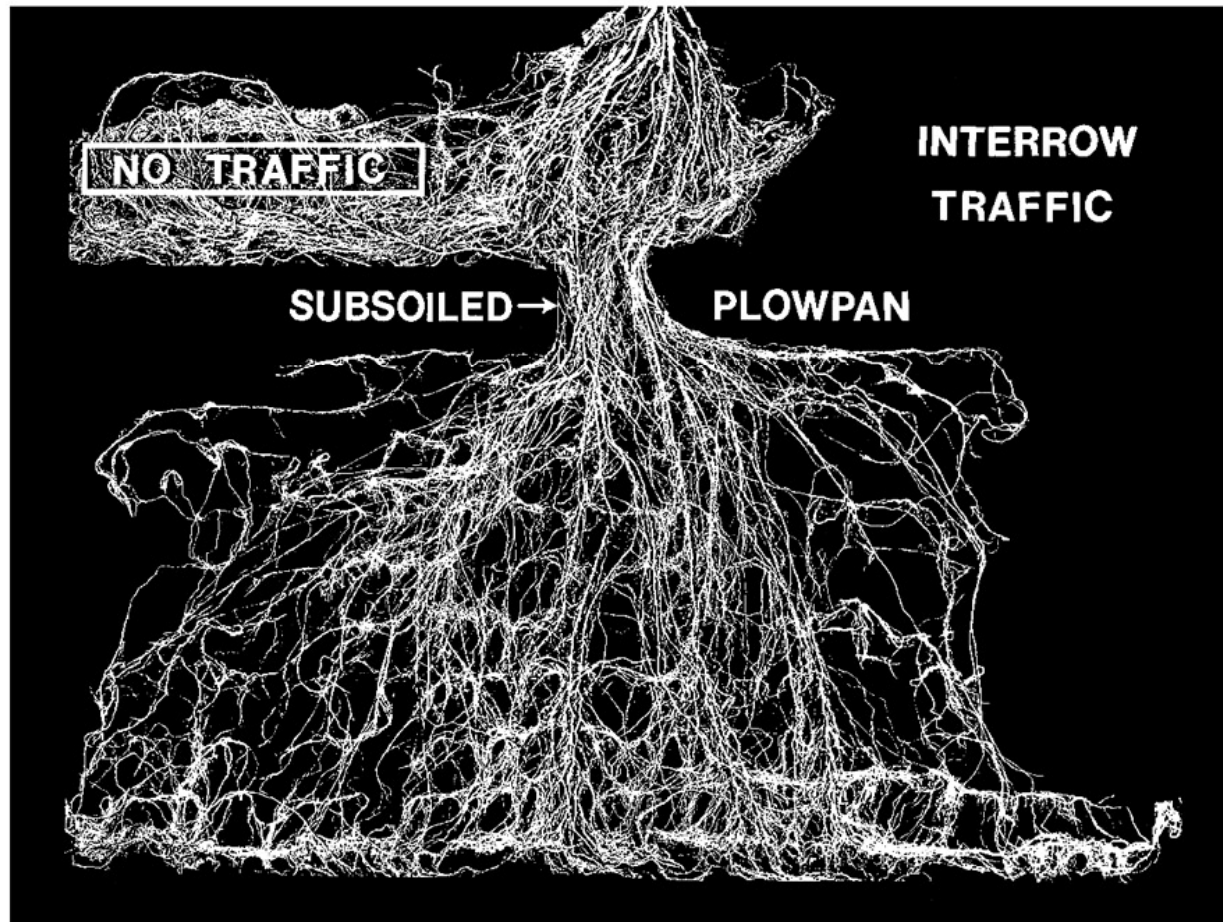
- ④ Mass Flow
- ④ Diffusion
- ④ Root Interception

# Compaction



Brady and Weil, 1999

# Roots seeking loosened soil



Brady and Weil, 1999

# Soil Structure

- ④ Aggregate
  - Individual soil particles come together
- ④ Formation is due to three key forces
  - Physical: Shrinking/swelling, wetting/drying
  - Chemical: Clays sticking together
  - Biological: Roots, organics "glues"
- ④ Soil Structure is a function of soil development

# Soil Structure

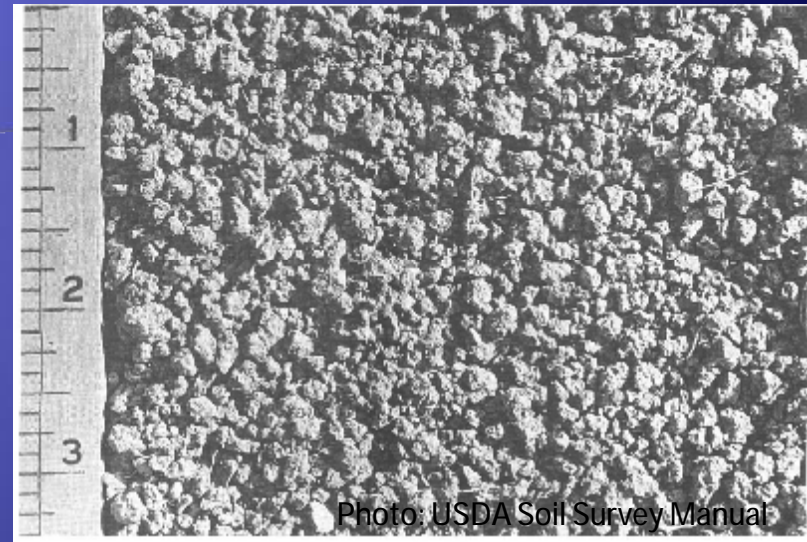
Why do we want to see structure in the soil?

- Ⓡ Provides drainage
- Ⓡ Provides a path for roots
  
- Ⓡ Six major types of structural units
- Ⓡ Two types of structureless conditions

# Soil Structure

## ® Granular or crumb:

- Typically found the A or B horizons
- Usually weakly to moderately developed



# Soil Structure

## ® Columnar:

- Usually found in the B horizons of arid or semi-arid regions
- Rounded tops
- Good indicator of high levels of sodium ( $\text{Na}^+$ )



# Soil Structure

## ® Prismatic:

- Similar to columnar structure
- Flat tops
- Not associated with sodicity



Photo: Weindorf



# Soil Structure

## ® Subangular Blocky:

- Smaller blocks with somewhat rounded edges
- Common in the B and A master horizons



Photo: Weindorf

# Soil Structure

## ® Angular Blocky:

- Smaller blocks with sharp edges
- Common in the B and A master horizons
- Typically associated with higher levels of clay



Photo: Weindorf

# Soil Structure

## ® Platy:

- Small plate-like aggregates of soil
- Typically found in A or E master horizons



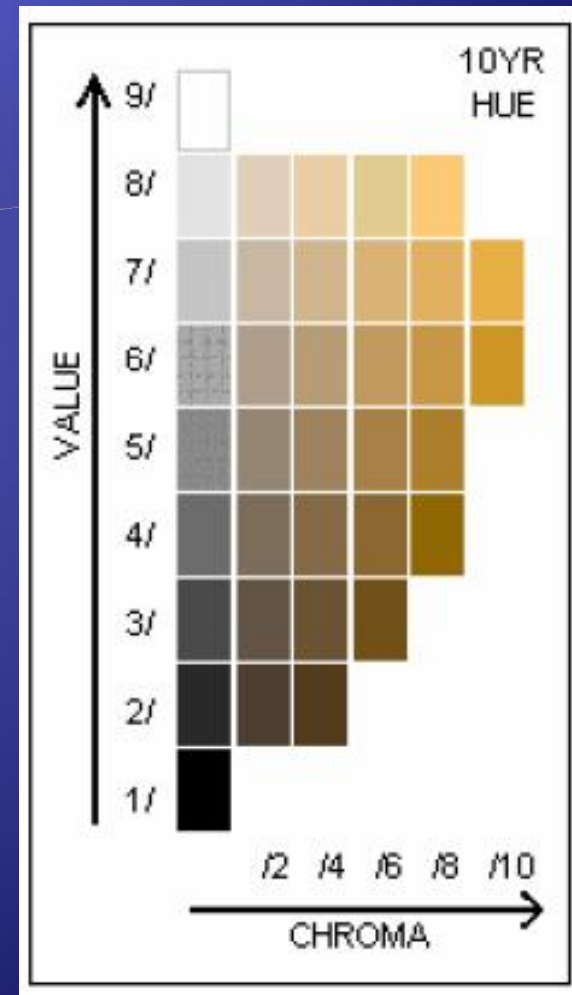
Photo: Weindorf

# Soil Structure

- ② Two structureless conditions exist:
  - **Massive**: No repeating pattern to the angles of breakage
  - **Single Grain**: Sands or loamy sands that do not show any discernable particle aggregation
    - Each grain of sand is acting independently of the others, yielding no structure

# Soil Color

- ⑩ Munsell notation of color precisely defines soils color using three parameters
  - Hue
  - Value
  - Chroma
- ⑩ Can give an indication of soil drainage/permeability, amount of organic material, etc.

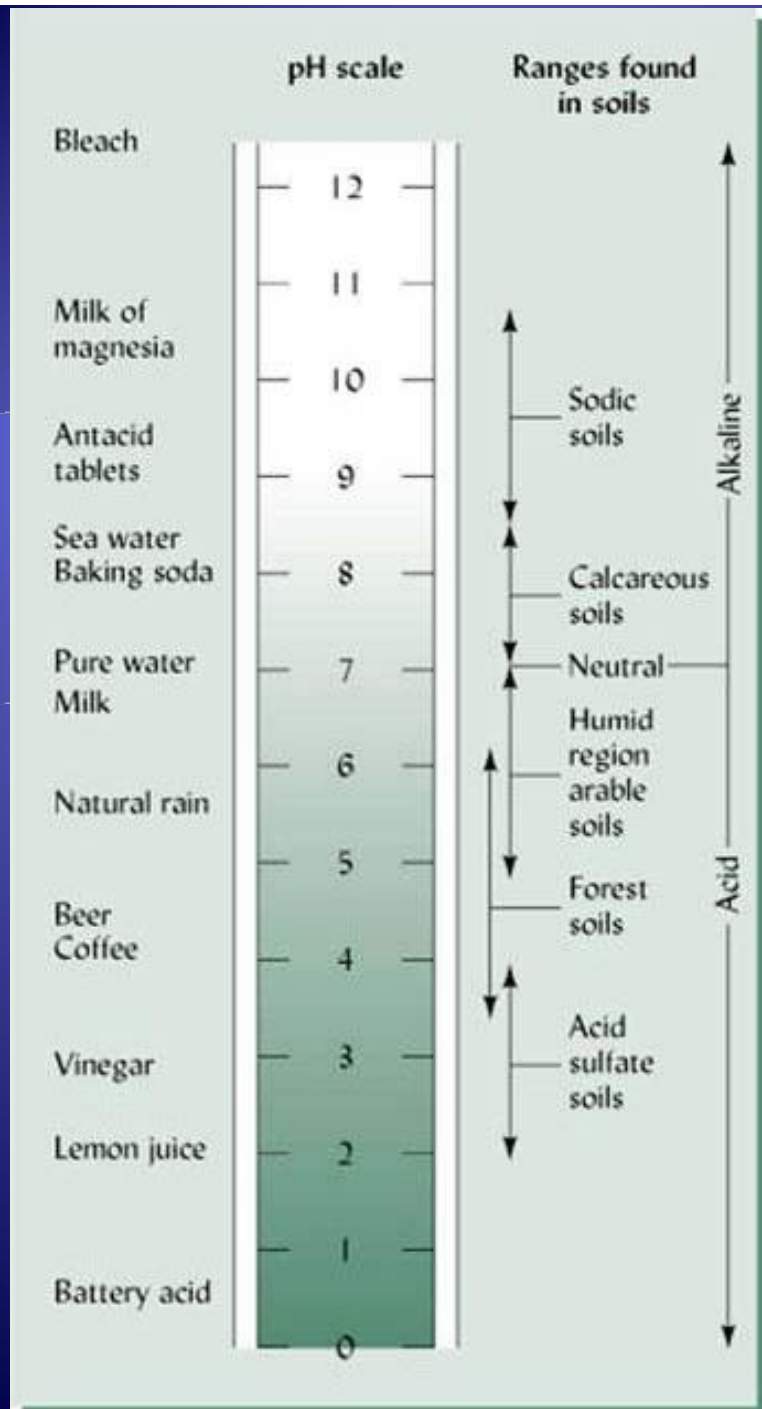




# SOIL CHEMICAL PROPERTIES

# pH Defined

- ④ By definition, pH is defined as the negative logarithm of the hydrogen ion concentration
- ④ This same statement holds true for the reaction of soils



# Soil Reaction

- Under normal conditions, the lowest and highest observed pH in soil is about 1.5 and 12, respectively
- The typical range in pH is from approximately 4.0 to 9.5

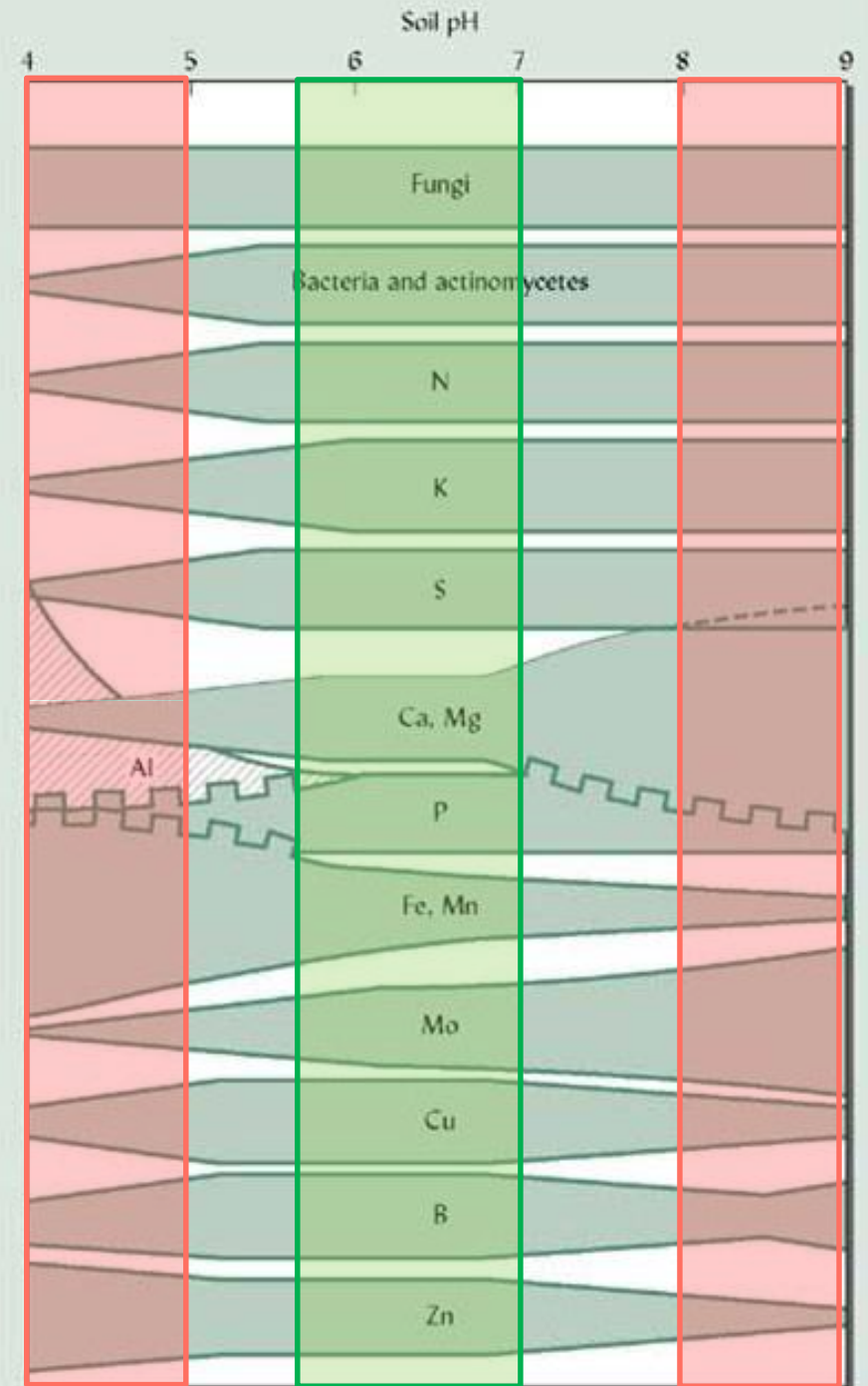


# Field Description Terminology

Ultra Acid	<3.5
Extremely Acid	3.5-4.4
Very Strongly Acid	4.5-5.0
Strongly Acid	5.1-5.5
Moderately Acid	5.6-6.0
Slightly Acid	6.1-6.5
Neutral	6.6-7.3
Slightly Alkaline	7.4-7.8
Moderately Alkaline	7.9-8.4
Strongly Alkaline	8.5-9.0
Very Strongly Alkaline	>9.0

# Nutrients and Soil pH

- ① Availability of most macronutrients is limited by acidic conditions
- ① Availability of most micronutrients is limited by alkaline conditions
- ① pH 5.5-7.0 generally considered optimal for overall availability of both



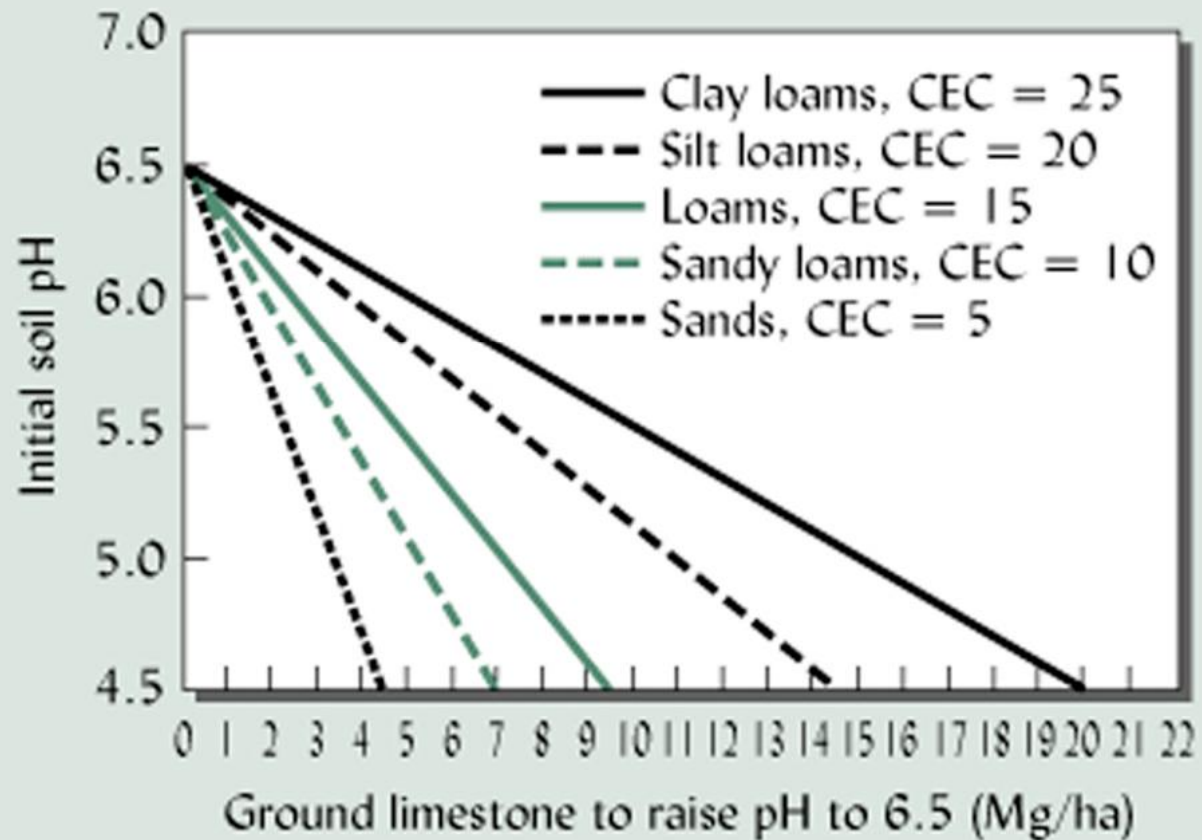
# Modifying pH

- ® Buffering Capacity
  - ® High CEC = High Buffering

- ® Acidic Soil
  - Lime

- ® Basic Soil
  - Sulfur

# Lime Requirement by texture



# Cation Exchange Capacity (CEC)

- Ⓢ The sum of exchangeable cations which attach and detach from soil particle in soil solution
  - Ca
  - K
  - Na
  - Mg
  - Fe
  - Al
- Ⓢ Gives an indication of soil fertility
  - 0 = very low; 100 = high

# Cation Exchange Capacity

Soil Texture	CEC Range (meq/100g)
Sand (low OM)	3-5
Sand (High OM)	10-20
Loam	10-15
Silt Loam	15-25
Clay and clay loam	20-50
Organic soils	50-100

"The nation that destroys its soil,  
destroys itself." *Franklin D. Roosevelt*

# Useful Soils Websites

® Soil Science Society of America

- [www.soils.org](http://www.soils.org)

® NRCS- Soils

- <http://soils.usda.gov/>

® NRCS- Geospatial Gateway

- <http://datagateway.nrcs.usda.gov/>

® Web Soil Survey

- <http://websoilsurvey.nrcs.usda.gov/app/>