Soil and Water Conservation CCA Study Session

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OKLAHOMA STATE UNIVERSITY EXTENSION

Overview of CCA materials for Soil and Water Conservation

- Soil Management:
  - Soil Properties
  - Erosion
  - Residue Management
  - Restrictive Soil Layers
  - Air Quality
  - Site Evaluation
- Water Management:
  - Water and Solute Movement
  - Soil-Plant/water relations
  - Irrigation and Drainage
  - Water Quality

Basic Soil Properties

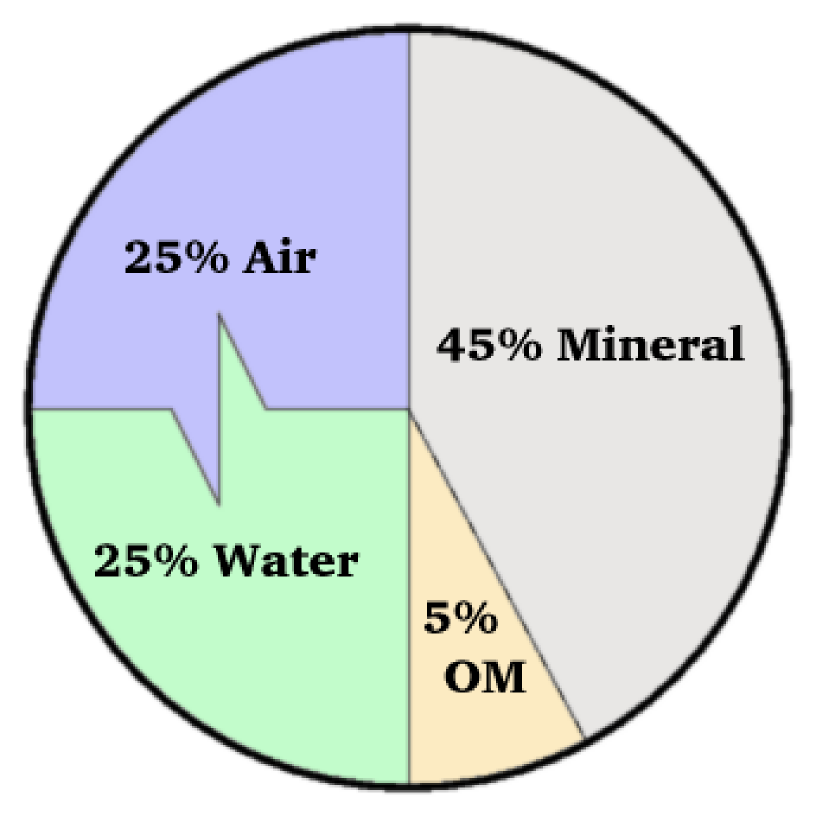
- Chapter 1 of Soil Fertility Handbook
  - Formation
  - Soil Components
  - Soil profiles
  - Texture
  - Structure
- Cation Exchange Capacity

Soil Forming Factors

- Parent material,
- Climate,
- Living organisms,
- Topography,
- Time.

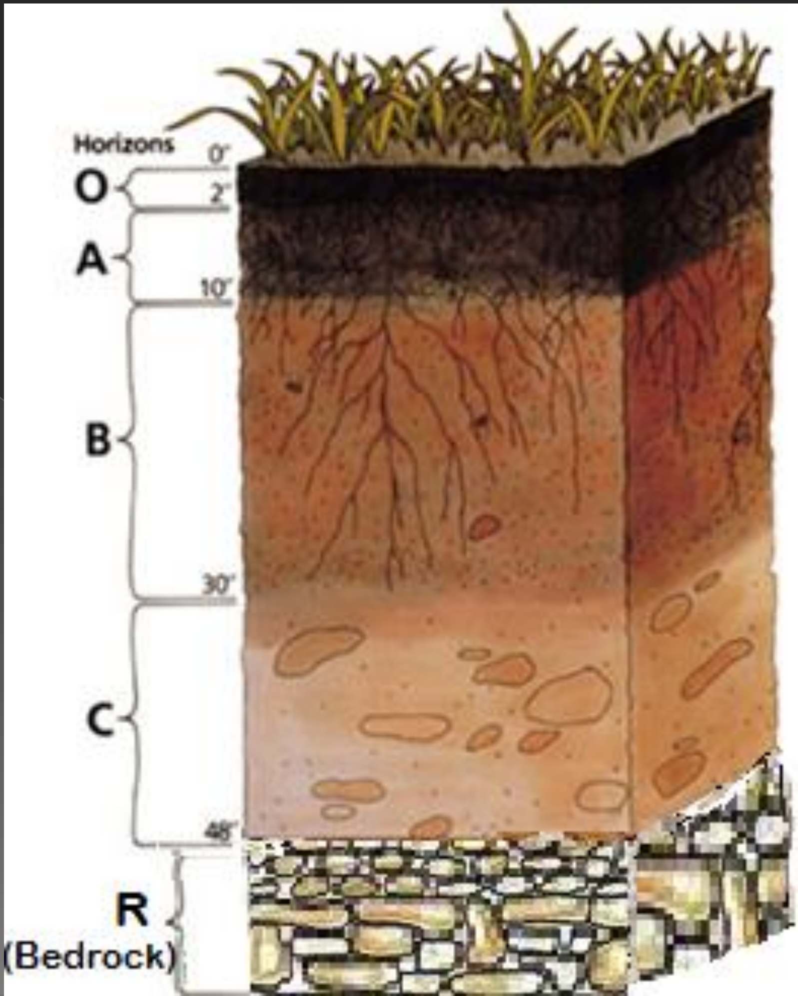
Soil Components

- Mineral (Sand, Silt, and Clay)
- Air
- Water
- Organic Matter



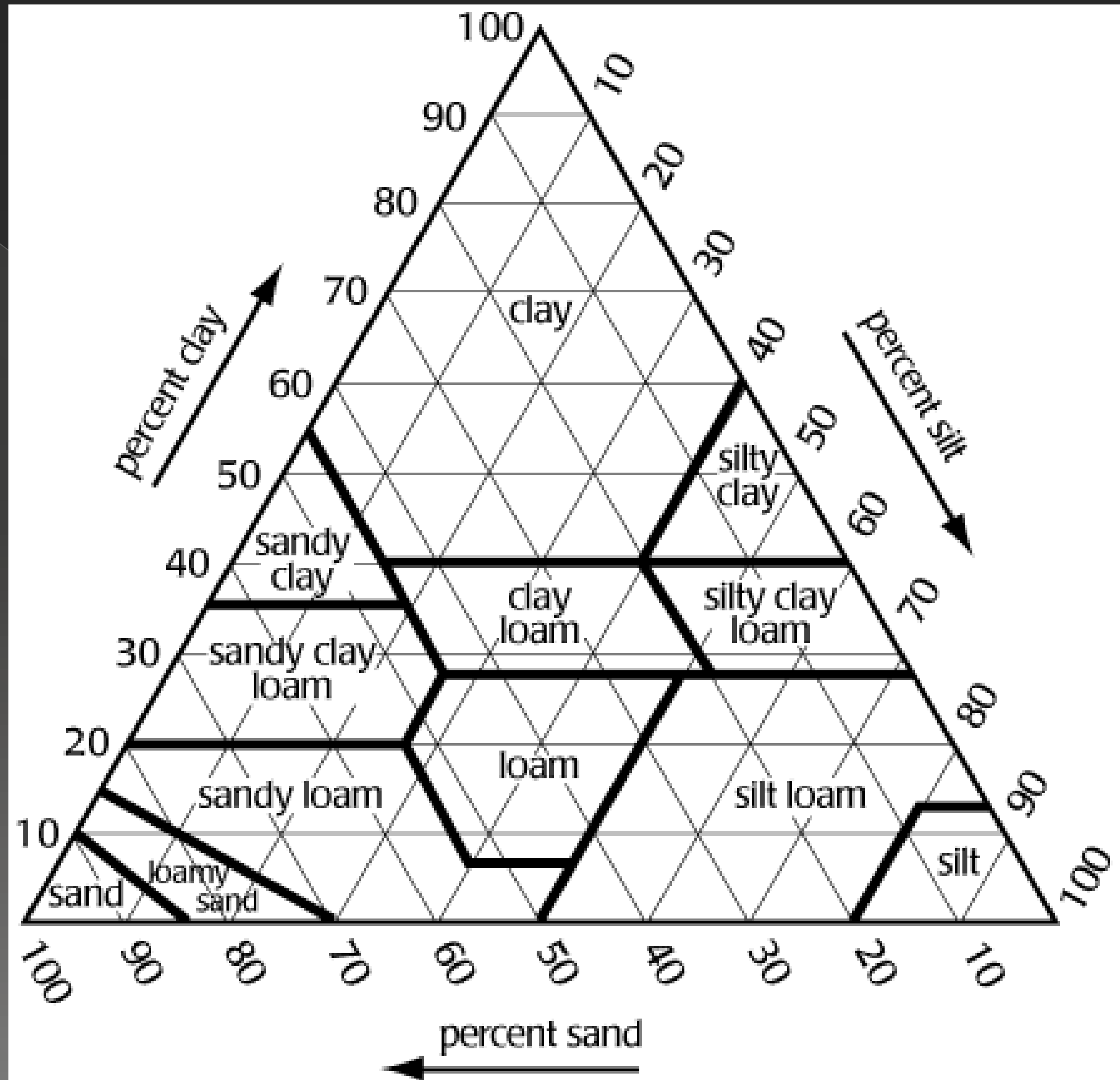
Soil Profile Horizons

- O=organic layer
- A=Topsoil
  - Elevated organic matter
  - Granular structure
- B=Subsoil
  - Elevated clay
  - Blocky structure
- C=unconsolidated parent material
- R=Rock



Soil Texture

- Sand
  - 2.0-0.05 mm
- Silt
  - 0.05-0.002mm
- Clay
  - <0.002mm



Soil Characteristic Influenced by Texture

- Reactive surface area:
  - Nutrient holding capacity
  - Water holding capacity
  - Organic matter content

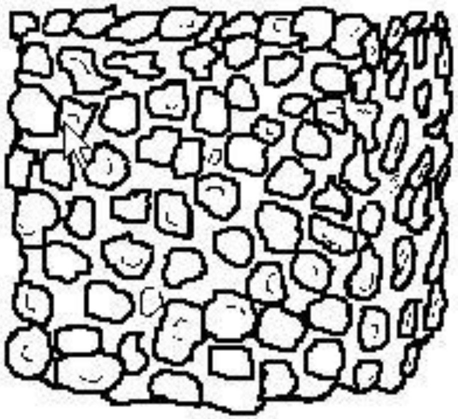
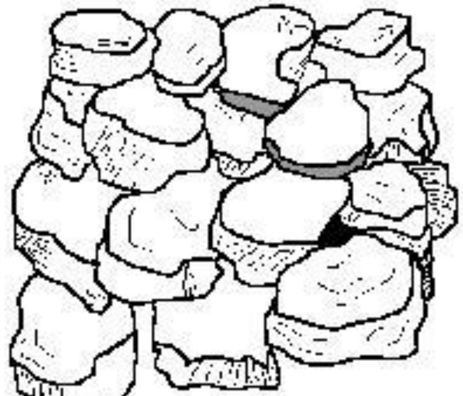
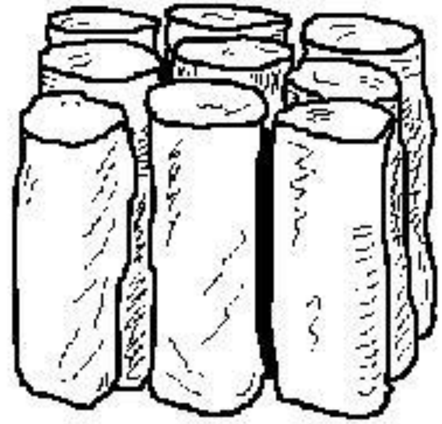
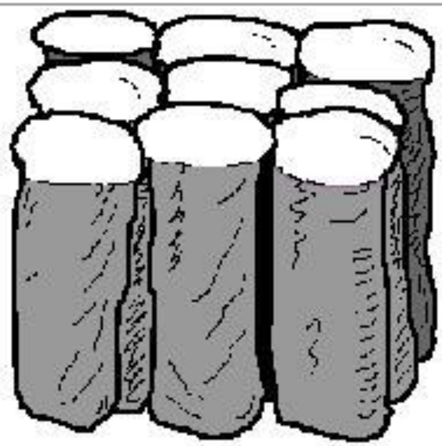
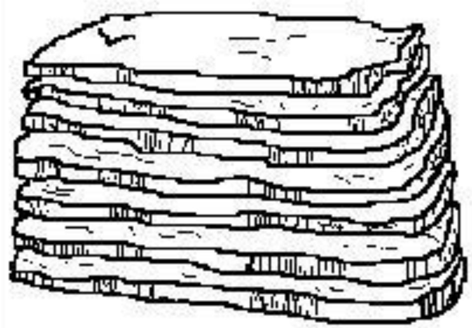
Increase with clay content

- Pore size
  - Water infiltration
  - Air movement
  - Ease of root growth

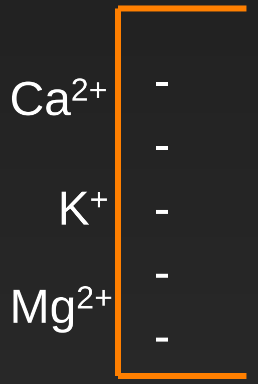
Increase with sand content

Soil Structure

- The arrangement of soil particles in to aggregates
- Aggregates are clusters of sand, silt, clay, and organic material.

		
Granular: Resembles cookie crumbs and is usually less than 0.5 cm in diameter. Commonly found in surface horizons where roots have been growing.	**Blocky**: Irregular blocks that are usually 1.5 - 5.0 cm in diameter.	**Prismatic**: Vertical columns of soil that might be a number of cm long. Usually found in lower horizons.
		
Columnar: Vertical columns of soil that have a salt "cap" at the top. Found in soils of arid climates.	**Platy**: Thin, flat plates of soil that lie horizontally. Usually found in compacted soil. Soil Science Society of America	**Single Grained**: Soil is broken into individual particles that do not stick together. Always accompanies a loose consistence. Commonly found in sandy soils.

Chemical Soil Properties



- Cation and anion exchange capacity
  - **Describes soils ability to adsorb nutrients**
  - Cations are positive: Ca^{2+}, Mg^{2+}, K^{+}, etc.
  - Anions are negative: NO_3^{-}, SO_4^{2-}
- Soils are dominated by cation exchange capacity
- Clay and organic matter contain Cation Exchange sites

Site Characterization

- Soil depth
  - Surface and total Depth
- Drainage
  - Excessive
  - Poor
- Slope

Soil Depth Influences

- Water holding capacity
- Potential root growth volume
- Nutrient supply

Slope Influences

- Water runoff
  - Water availability for crop growth
  - Erosion
- Field operations
- Expressed as % changes in elevation along a slope

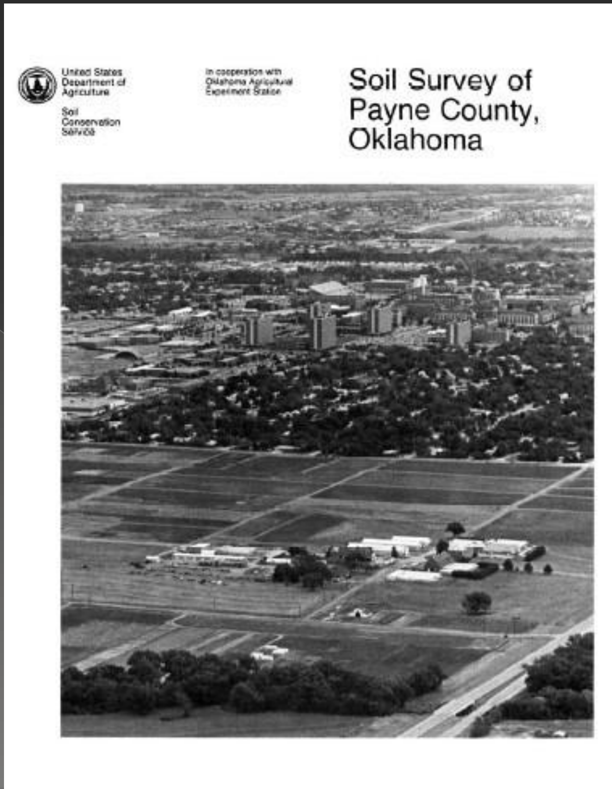
  100*1ft/100ft

Internal Drainage

- Poorly drained soils:
  - High clay content, shallow bedrock, shallow water table
  - Restricts root growth and respiration
  - Delay planting and spring warm up
- Rapidly drained soils:
  - Sandy soils
  - Excessive leaching of nutrients
  - Droughty

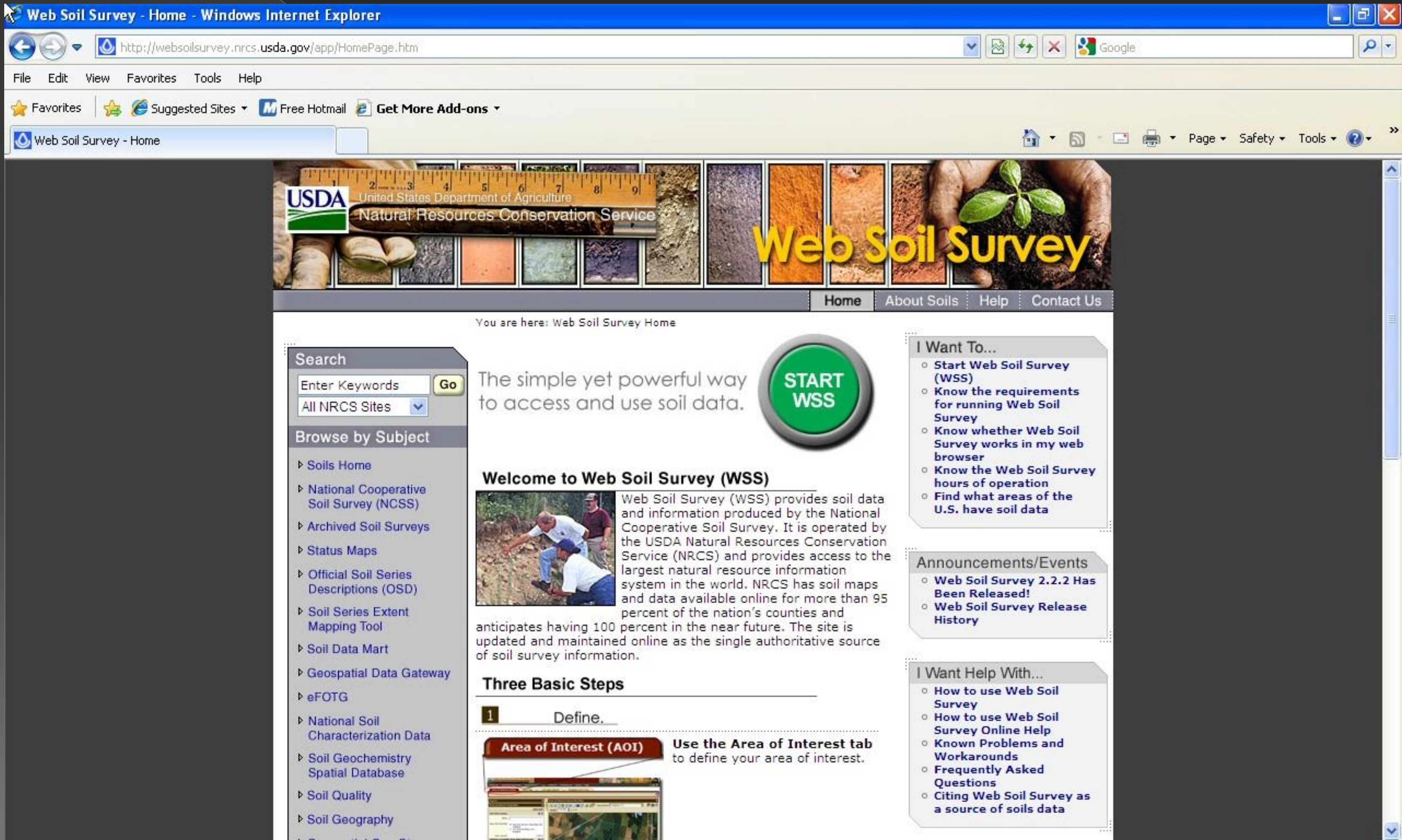
NRCS County Soil Survey

- Soil profile analysis and landscape position are used to map soils
- County Survey provides these maps and soil descriptions
- Can be used to determine
  - Crop production potential
  - Limitations of land
    - Wetness, droughty, low fertility erosivity, etc.
  - Now available on-line



Web soil survey

- http://websoilsurvey.nrcs.usda.gov



Erosion

Impacts of Erosion on Crop Production

- Removes top soil
  - Reduces fertility
  - Degrades soil structure
    - Air and water movement, and root growth
  - Removes organic matter
  - Reduces water holding capacity
- Direct damage to crops
  - Burial and removal of crops

Off-site impacts of Erosion by Water

- Sediment is the #1 contaminate in surface water bodies.
- Sedimentation of waterways and reservoirs
- Air quality degradation and burial of fences, ditches and roads.

Factors that Influence Erosion by Water

- Texture
- Climate
- Slope (steepness and length)
- Residue/crop cover

Texture's influence on Erosion by Water

- Clayey soils are adhesive and therefore resist erosion
  - **Clay Loam**
- Large sands are difficult to move, and rapid infiltration minimizes runoff
  - **Loamy Sand**
- Silty soils are highly erosive because they are not adhesive and are very light weight.
  - **Silt Loam**

Climate's influence on Erosion by Water

- Potential for erosion increases with increasing intensity and magnitude of rainfall
- Rainfall Erosion Index

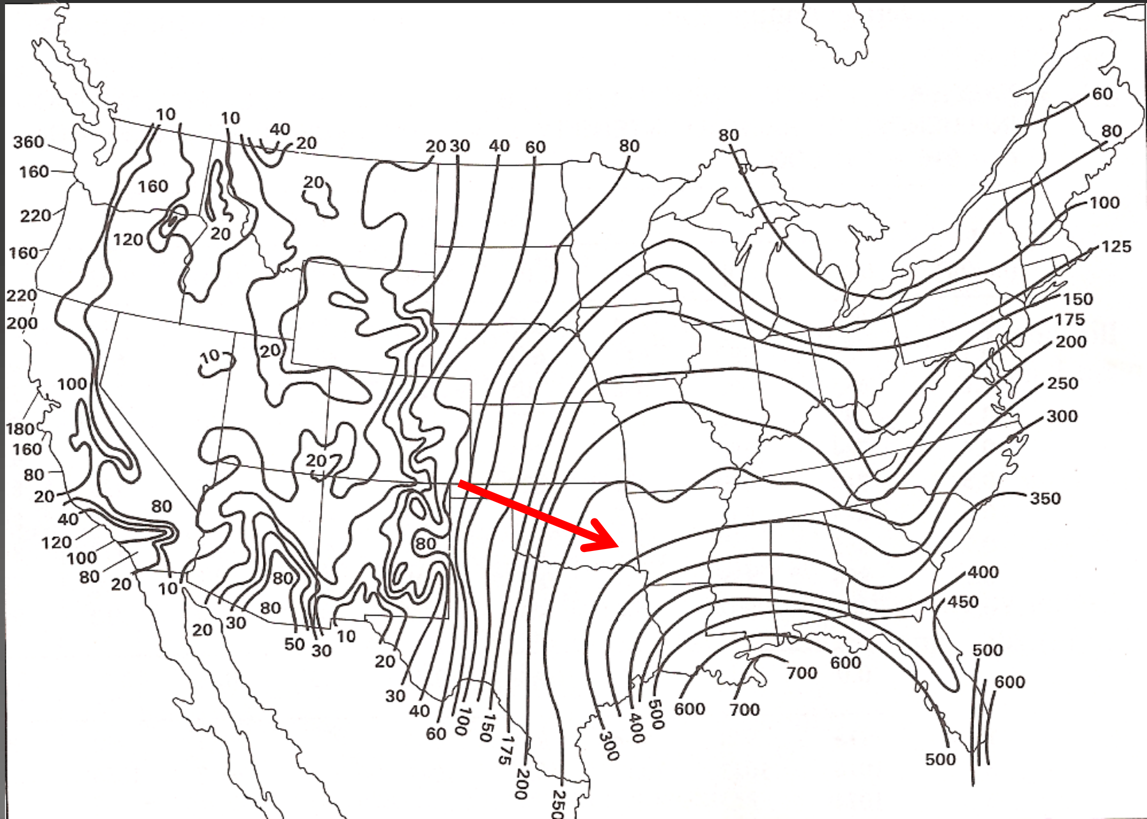


Image from: Troeh, et al. (1991)

Slope's influence on Erosion by water

- **Steepness** of slope influence velocity of runoff.
- **Length** of slope influences volume of water traveling down slope.
- Terraces dissect the slope length to reduce erosion and provide a shallow slope in the terrace channel for water diversion.

Residue and Crop Cover Impacts on Erosion by Water

- Residue protects the soil from raindrop impact.
- Raindrop impacts initiate erosions
- Also causes surface crusting which reduces infiltration.

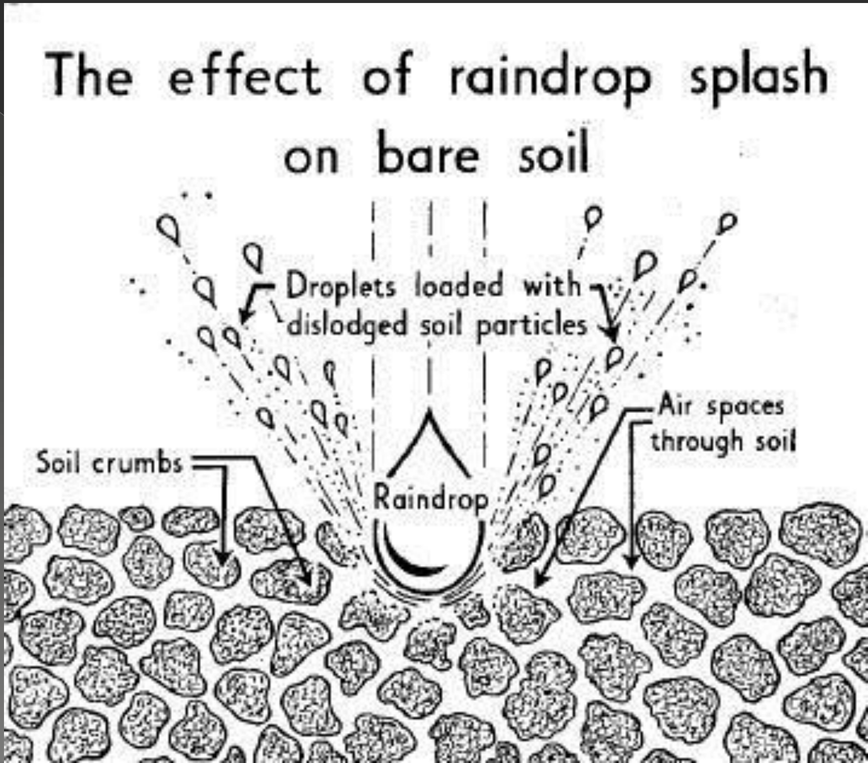


Photo from: www.ramin.com.au/creekcare/catchment-care-soilcare.shtml

Types of Erosion by Water

- **Sheet**:
  - The removal of thin layers of soil over the whole surface
- **Rill**:
  - Occurs when runoff water concentrates in streamlets
  - Rills can be removed with normal tillage
- **Classic Gully**:
  - Channelized erosion that can not be erased by normal tillage.

Universal Soil Loss Equation (USLE)

- Provides estimate of sheet and rill erosion.
- A=R x K x LS x C x P
- R rainfall erosion index (Map of rainfall erosivity)
- K=soil erodibiliy (Soil Survey
- LS=Slope and Length of slope
- C=Crop Management factor (tillage and crop)
- P=Conservation Practice (contour farming)

Factors Controlling Erosion by Wind

- Residue and crop cover
  - Most cost effective method to reduce wind erosion
- Wind velocity
  - 13 mph at 1 ft above soil can cause erosion
- Unsheltered distance
- Soil surface roughness
- Soil texture
  - Loamy sands are highly susceptible.

Types of Wind Erosion

- Suspension:
  - Small particles (<0.05 mm) are suspended in turbulent air until rainfall washes them back to surface or wind velocity is dramatically reduced
- Saltation:
  - Intermediate particles (0.05-0.5 mm)move in a series of leaps.
  - Continued impacts dislodge other particles
- Surface creep:
  - Large grains (>0.5mm) are bumped along surface by saltation.

Residue and Tillage Management

- Temperature
  - Residue buffers against rapid changes
- Moisture
  - Residue buffers rapid changes
- Erosion
  - Maintenance of residue is the cheapest way to control erosion
- Tillage causes rapid decomposition of organic matter

Importance of Organic Matter

- Increasing organic matter improves:
  - Water holding capacity
  - Soil structure
  - Fertility
  - Reduces crusting

Restrictive Layers

- Naturally occuring Layers
  - Clay pans
  - Rock
- Crusts
- Tillage induced compaction
- Traffic Compaction
  - Deep vs shallow

Soil Crusting

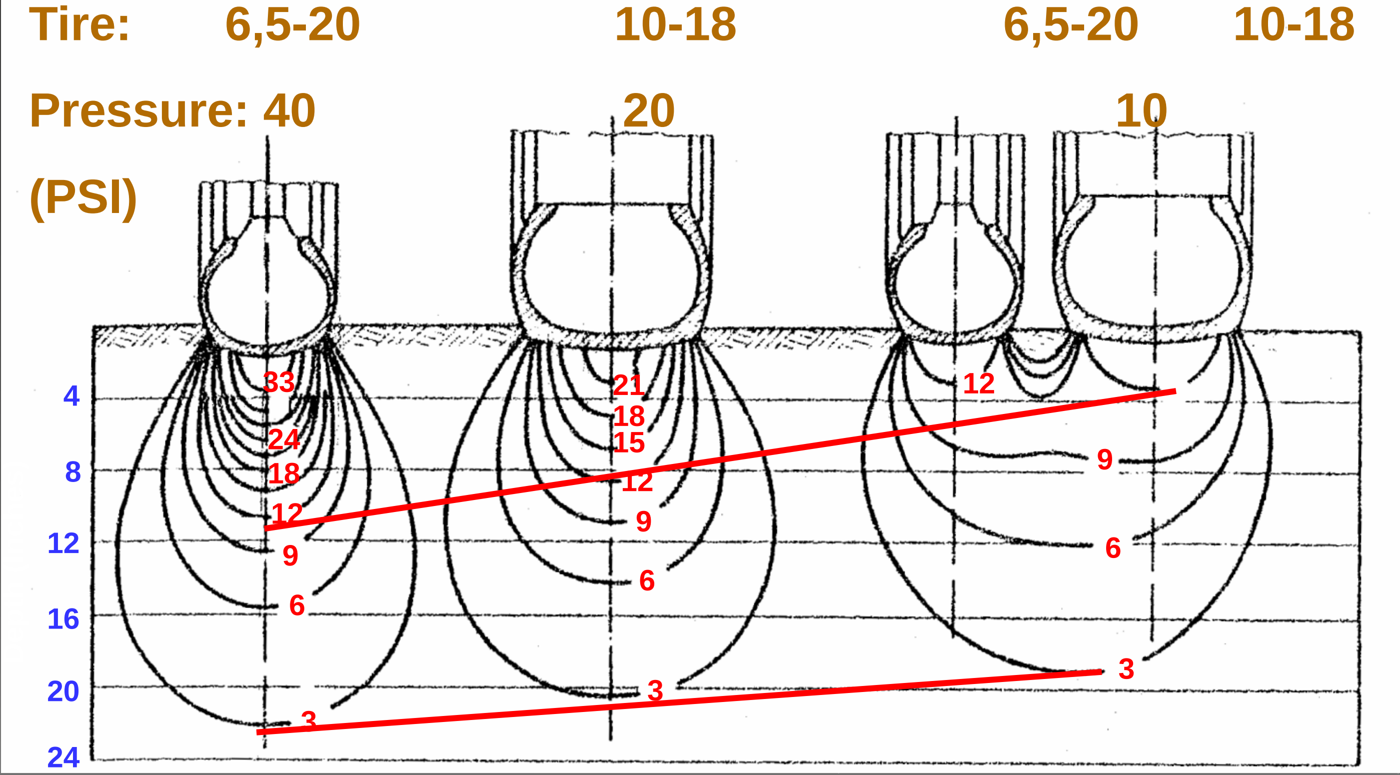
- Reduces water infiltration
- Reduces crop emergence
- A soils susceptibility to crusting is influences by texture, sodium content, and organic matter

Tillage Induced Compaction

- Caused by repeated tillage at a constant depth
- Horizontal soil structure is a visible symptom

Traffic induced compaction

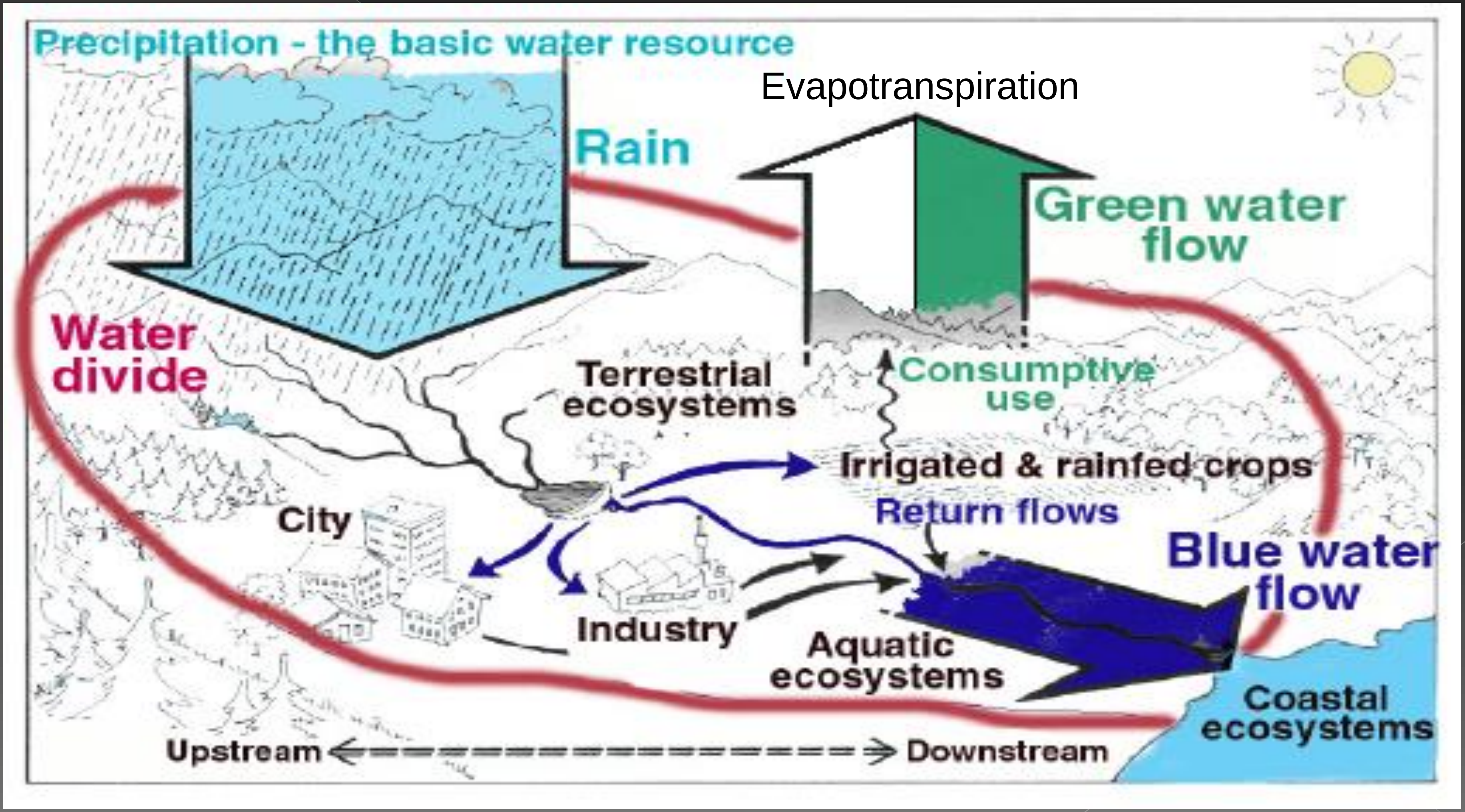
- Surface compaction can be reduced by increasing footprint
- Subsurface compaction is dictated by Axle load



Air Quality

- Manure application methods
  - Odor and NH_3
- Tillage and wind erosion
  - Can produce Paticulate matter
- Tillage can influence CO_2 in the atmosphere
- N fertilizer applications produce $N_2O$and NH_3

Soil Water Cycle



Water Cycle

- Precipitation
- Irrigation
- Runoff
- Drainage
- Evaporation
- Transpiration

Factors effecting Infiltration and Runoff

- Texture
- Structure
- Organic Matter
- Surface Residues
- Landscape Position
- Surface roughness

Factors influencing Leaching Potential

- Texture
  - Sands > clays
- Cation Exchange Capacity
- Concentrations
- Nutrient and/or solute chemistry
  - Cations (positively charge) generally don’t leach as readily as anions

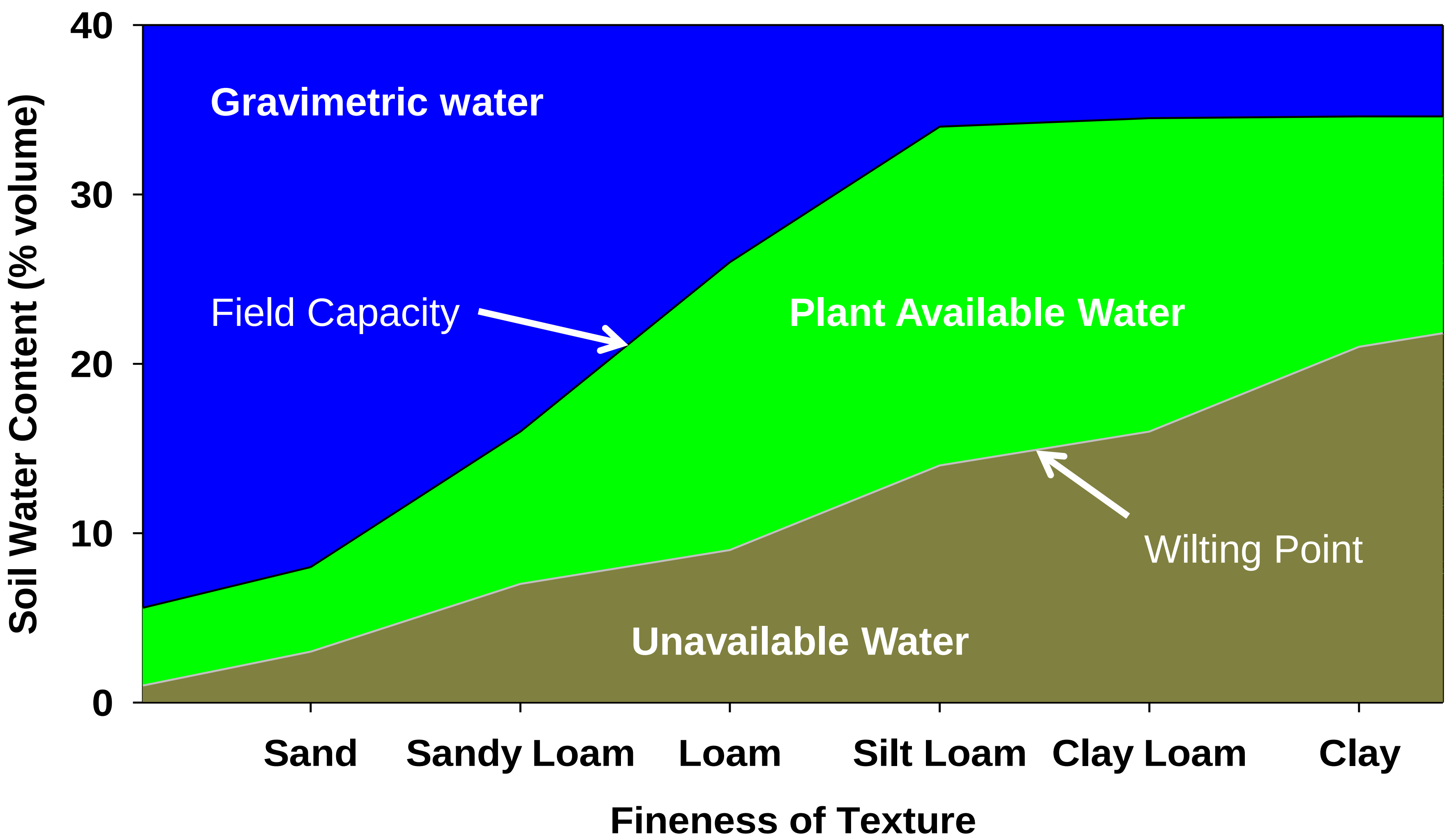
Factors that impact Runoff losses of Nutrients

- Application Timing
- Rate of application
- Erosion
- Runoff amounts
- Drainage
- Cropping system
- Tillage.

Soil water terms

- Saturation
- Field Capacity (-33 kPa, water held against the force of gravity)
- Permanent wilting point (-1500 kPa, water that can't be extracted by plants)
- Gravitation water (removed by gravity)
- Plant available water

Texture and Soil Water



Irrigation Systems

- Furrow
- Flood
- Sprinkler
- Drip/trickle
- Subsurface

Sprinkler Irrigation (Low Pressure Applicators)

- Listed from lowest to highest efficiency
  - Impact Sprinklers
  - Mid-elevation spray application (MESA)
    - 18-36 inches above the ground
  - Low-elevation spray application (LESA)
    - 12-18 inches above ground
  - Low energy precision application (LEPA)
    - Drag lines and bubblers


MESA


LESA


LEPA

Flood Irrigation

- Listed from lowest to highest efficiency
- Wild flooding
- Basin flooding
- Boarder flooding
- Furrow


Furrow

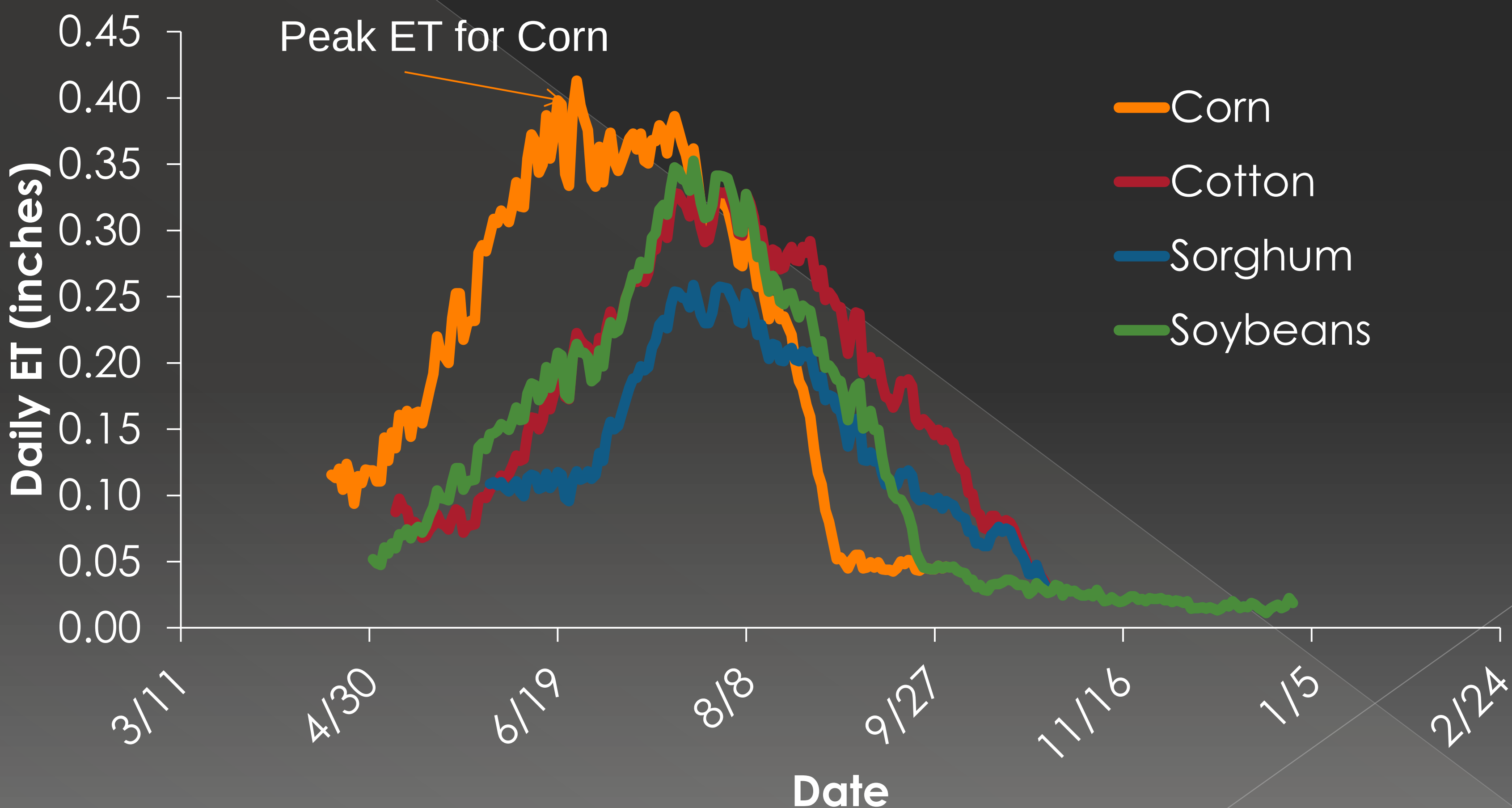

Boarder

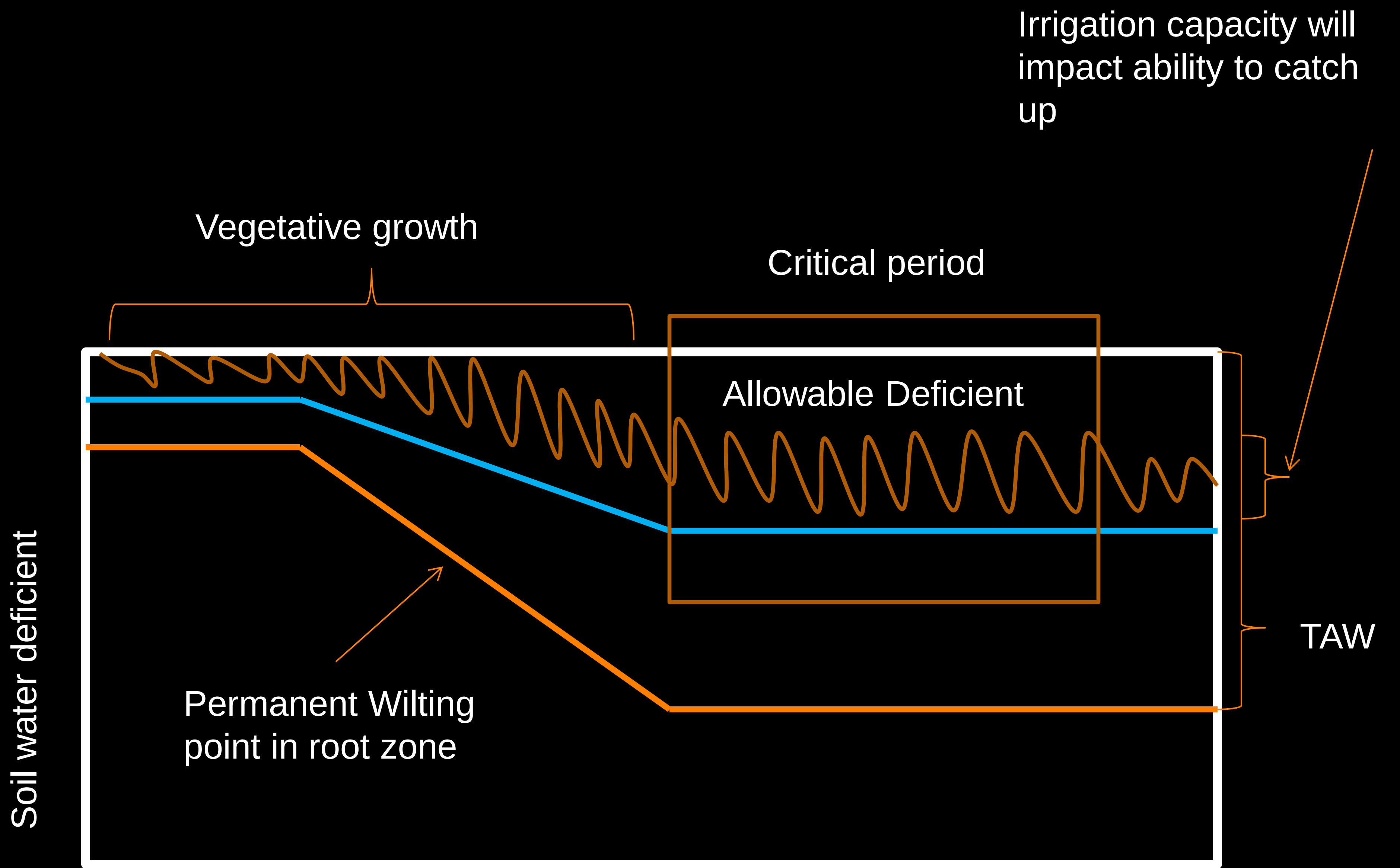

Basin

Water Balance Equation

- Dc=Dp + Etc – P – Irr + RO + DR
- Where
  - Dc= current soil water deficient
  - Dp=soil water deficient of previous day
  - ETc= Evapotranspiration
  - P= Precipitation
  - Irr= irrigation
  - RO= runoff
  - DR= Drainage

15 year average Daily Evapotranspiration

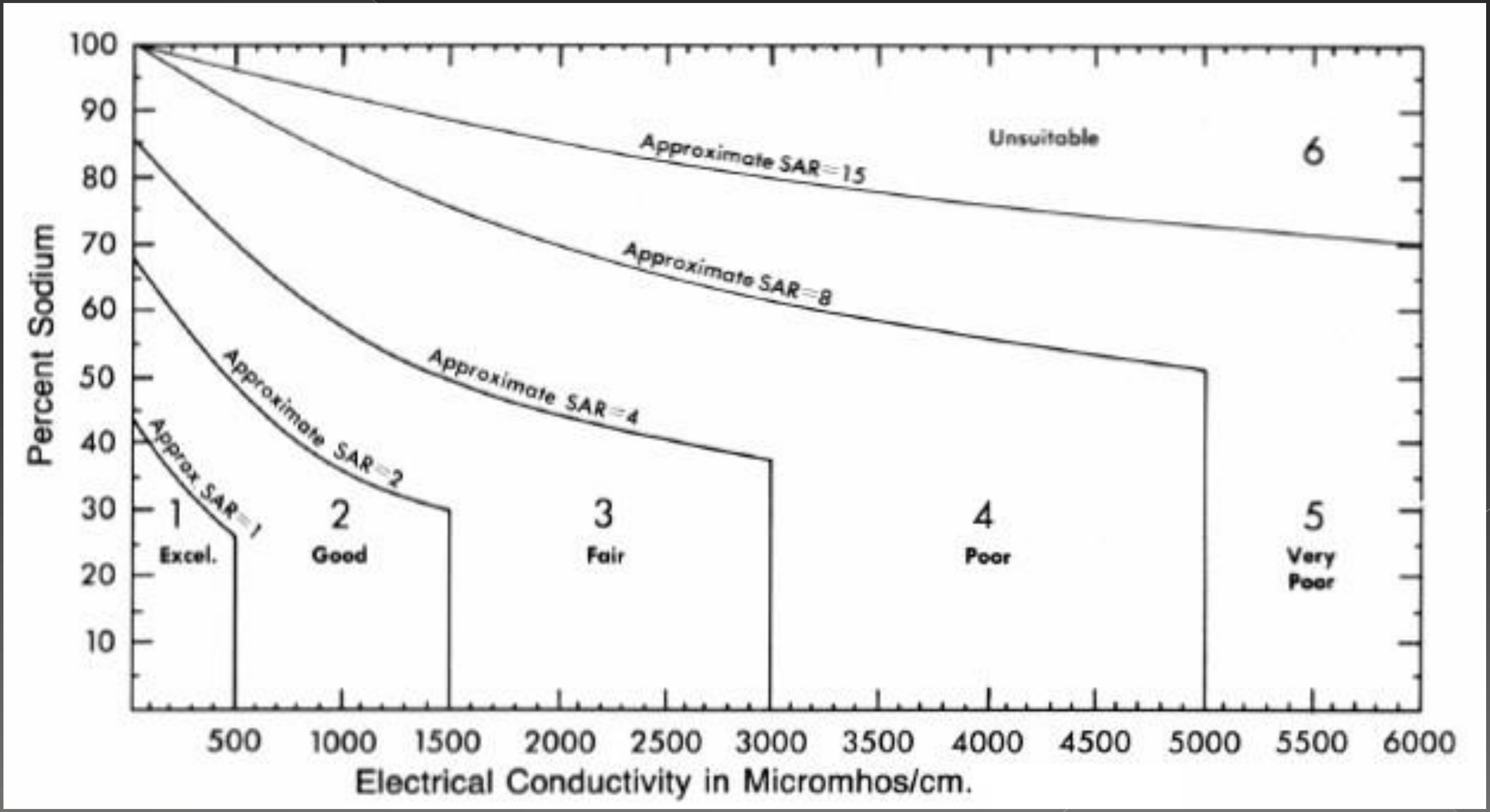



Irrigation capacity will impact ability to catch up
Vegetative growth
Critical period
Allowable Deficient
TAW
Permanent Wilting point in root zone
Soil water deficient

Irrigation Water Quality

- Salts and Sodium
  - Salt decreases water availability
  - Sodium caused dispersion and reduced permeability
  - Both can catastrophically impact productivity
- Excess Alkalinity (Ca and/or Mg Carbonates)
  - Cause scale build up in system
- Boron
  - Toxic to crop growth

Interaction between Sodium and Salinity (EC) of irrigation water

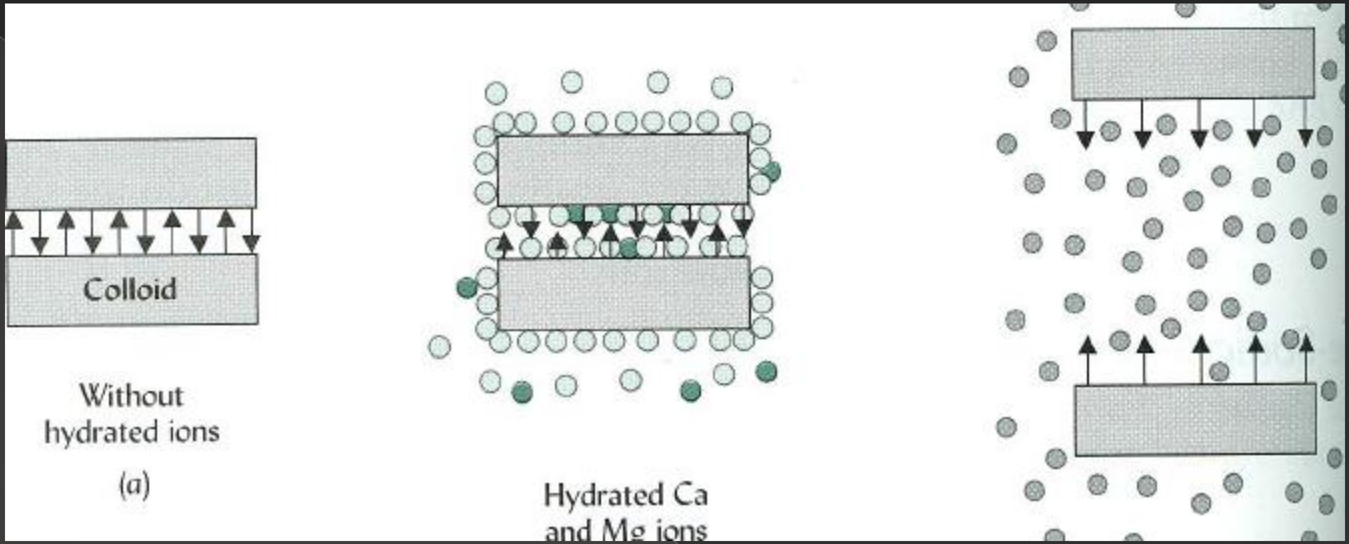


Sodium Adsorption Ratio (SAR)

$$SAR = \frac{[Na^+]}{\sqrt{\frac{1}{2}\left([Ca^{2+}] + [Mg^{2+}]\right)}}$$

- SAR is the ratio of Na/Ca+Mg in a saturated soil extract
- High levels of sodium cause soil particles to disperse
- Soil becomes structureless because of loss of aggregate stability and structure

Na and soil structure



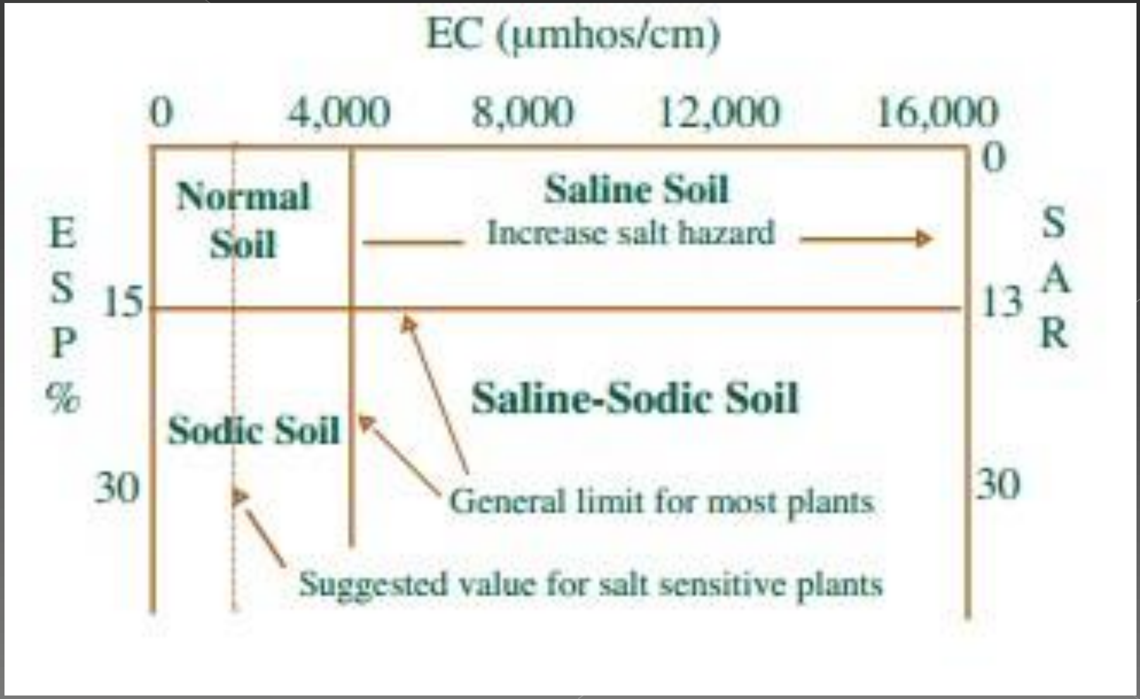
- Sodium has a large hydrated radius
- Prevents adhesion of clay particles
- Causes disintegration of aggregates

Soil Salinity

- Measured using Electrical Conductivity (micromhos/cm)
- EC is can be converted to Salt concentration
  - EC (micromhos/cm)*0.66= Salt Conc. (ppm)
  - 1000 micromhos/cm= 660 ppm

Classification of Saline and Sodic Soils

- Thresholds at which adverse soil conditions will occur
- Remediation Strategies are also different



URL for Study guide

- http://okcca.okstate.edu/exam-study-resource
- http://soilwater.okstate.edu/
  - Go to CCA
  - Click on Study Guide
- This slide set will also be on soilwater.okstate.edu