Soils 101 – *What you should know about soil resources for the AEFP process*

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"Course" Objectives

- Unit 1: Soil formation factors
  - Climate, biology, topography, parent material and time
- Unit 2: Soil description
  - Texture, structure, colour, organic matter
- Unit 3: Soil development and profiles
  - Horizons and classification
- Unit 4: Problems in soils

My Goal:

Is not to cover management options, but to provide a "review" of soil science. Normally this would take a year…

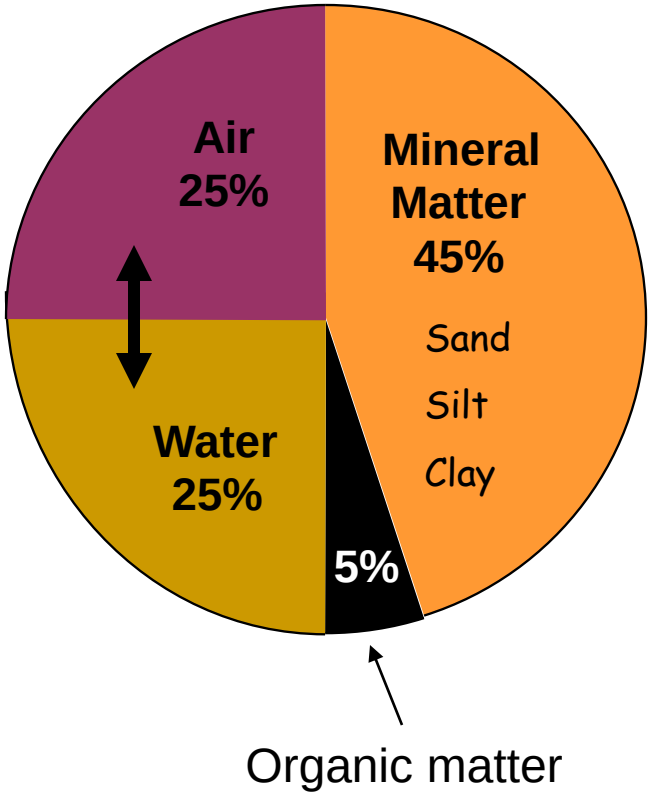
AEFP Soil Objectives

With respect to the AEFP, familiarity with the following soil concepts is important…

- Soil groups
- Surface soil texture
- Slope (gradient and length)
- Related landscape features
- What is salinity, solonetzic soils, erosion
- Organic matter content

Unit 1: What is soil?

- Soil is formed by the weathering of parent materials (rock).
- Following the last glaciation, Canada was mostly rock.
- 50:50 solid: pore.
- Soil is not really renewable. It can take 250+ years to form 1 inch of soil.



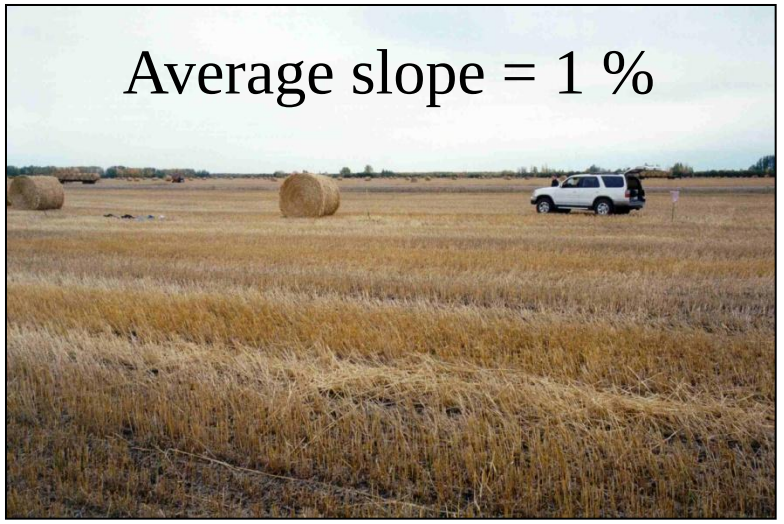
Unit 1: What is soil?

Five Important Soil Factors:

- **Parent Material**: the raw product which weathers to create soil.
- **Climate**: soils form more quickly in warmer and moister conditions.
- **Topography**: the terrain or elevation of landscape features; affects of temperature, rainfall, drainage and erosion.
- **Time**: Alberta's soils are 10,000 years old (since de-glaciation) which is actually quite young!
- **Biota**: type and amount of organic matter, vegetation, animals and humans - they move soil, change drainage patterns and affect microclimates.

Unit 1: Effect of topography: slope gradient

- Slope = (rise / run)x100
  - Steep = >10%
  - Moderate = 2 to 10%
  - Level = <2%
- Outputs from slope become the inputs to other systems.
- Slope exerts a fundamental control on other parts of the landscape/environment.



Unit 1: Effect of topography: slope length

* Assumes slopes are similar in elevation (slope height or “rise”)

<u>>400 m (1/4 mile)</u>

- Long Slopes
- 1 or 2 peaks per 1/4
- *Generally a **<u>higher</u>*** risk of water erosion and surface contamination owing to longer slope area to accumulate surface water flow – increased concentration of flowing water and sediment.

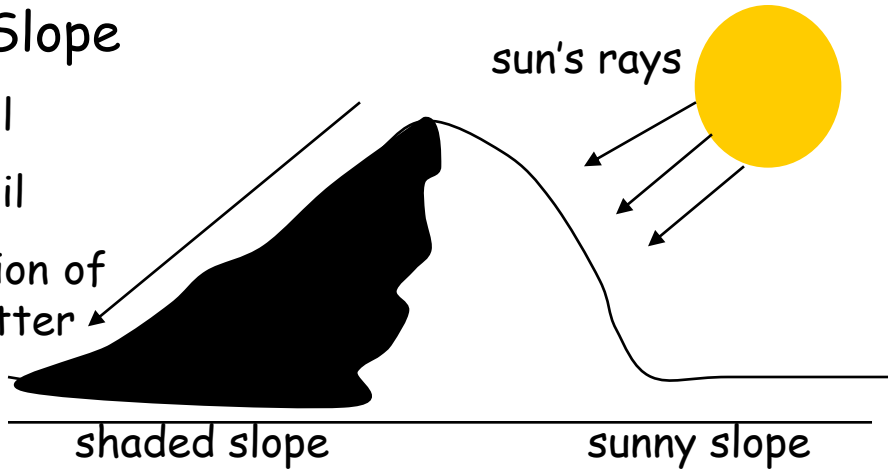
<u><400 m (1/4 mile)</u>

- Short Slopes
- 3 or more “peaks” per 1/4
- *Generally a **<u>lower</u>*** risk of water erosion and surface contamination since there is a smaller area of land being exposed to surface flow – *HOWEVER* – increased slope steepness (i.e., elevation or rise) counter acts this and can lead to increased erosion.

Unit 1: Effect of topography: slope aspect

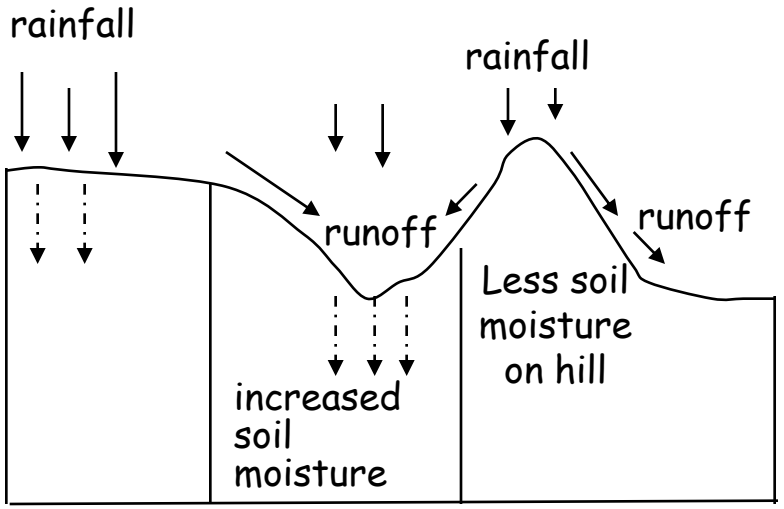
Shaded Slope

- colder soil
- wetter soil
- accumulation of organic matter



Sunny Slope

- warmer soil
- drier soil
- organic matter incorporated/ broken down

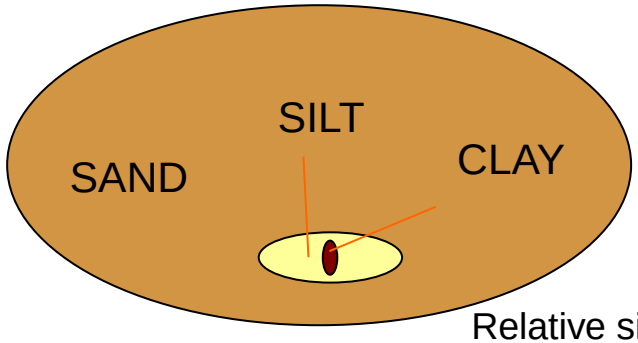


Unit 2: Soil texture

Texture: refers to the relative proportion of different sized soil particles that make up “soil”.

- **Sand:** the only particles visible to the naked eye; feel coarse and gritty (coarse texture).
  - 0.05-2 mm
- **Silt:** smaller than sand; feels powdery and slippery when wet (medium texture).
  - 0.002-0.05 mm
- **Clay:** smallest particle, very high water holding capacity; feels smooth and sticky when wet (fine texture).
  - <0.002 mm

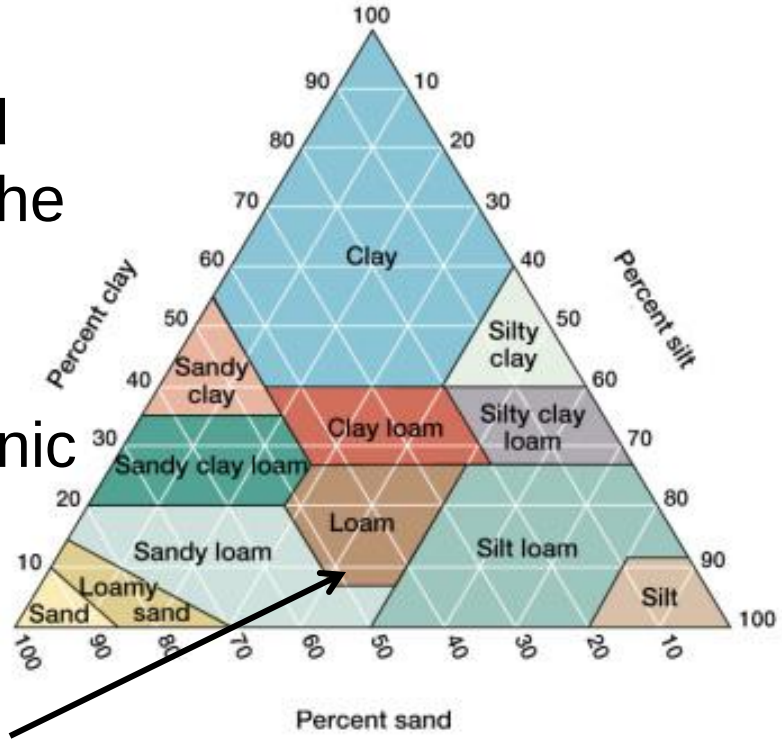
- Texture is very important because it effects water movement and nutrient holding capacity of the soil resource.



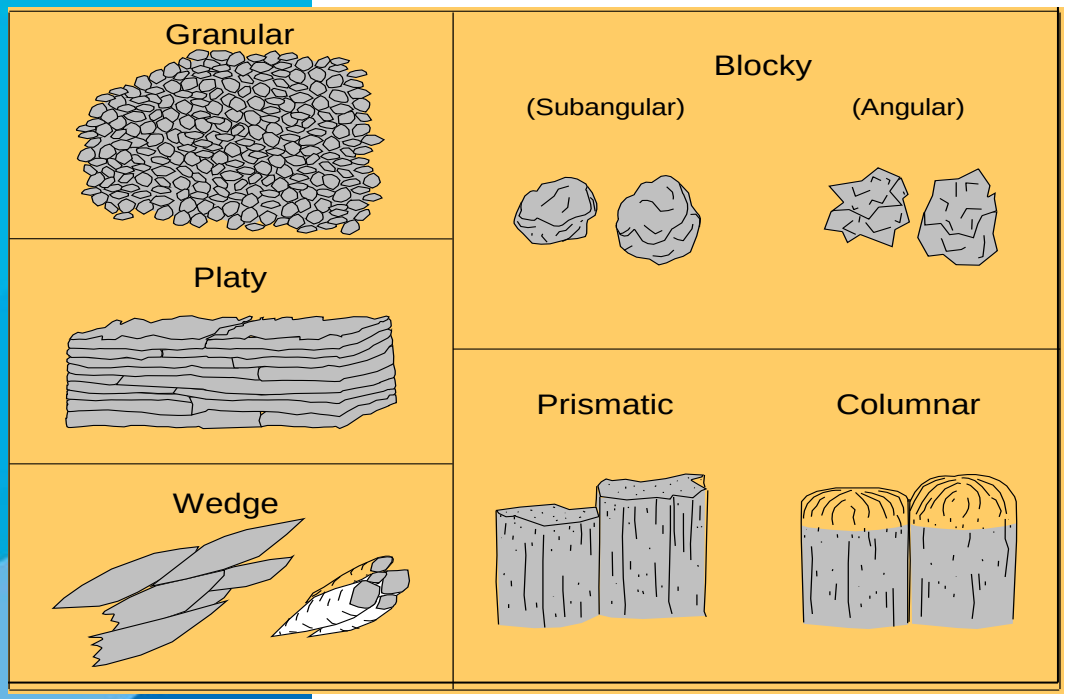
Relative sizes

Unit 2: Soil texture

- AKA: soil type.
- Can be done in the field (ribbon test) or sent to the lab for a Particle Size Analysis (PSA test).
- Does not consider organic matter content.
- Ideal soil tends to be in the “loam” category.

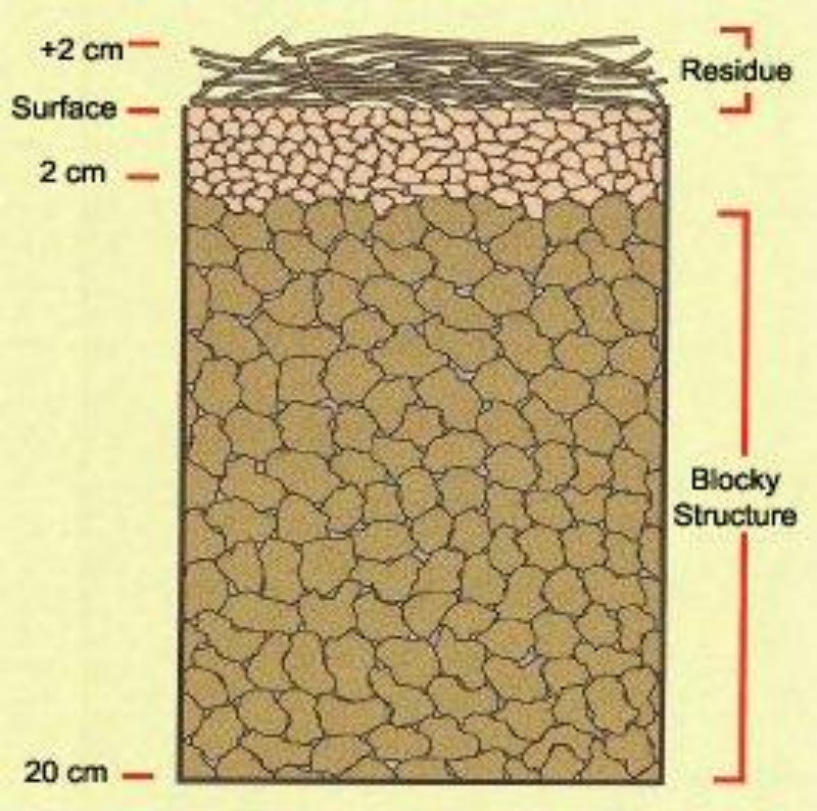


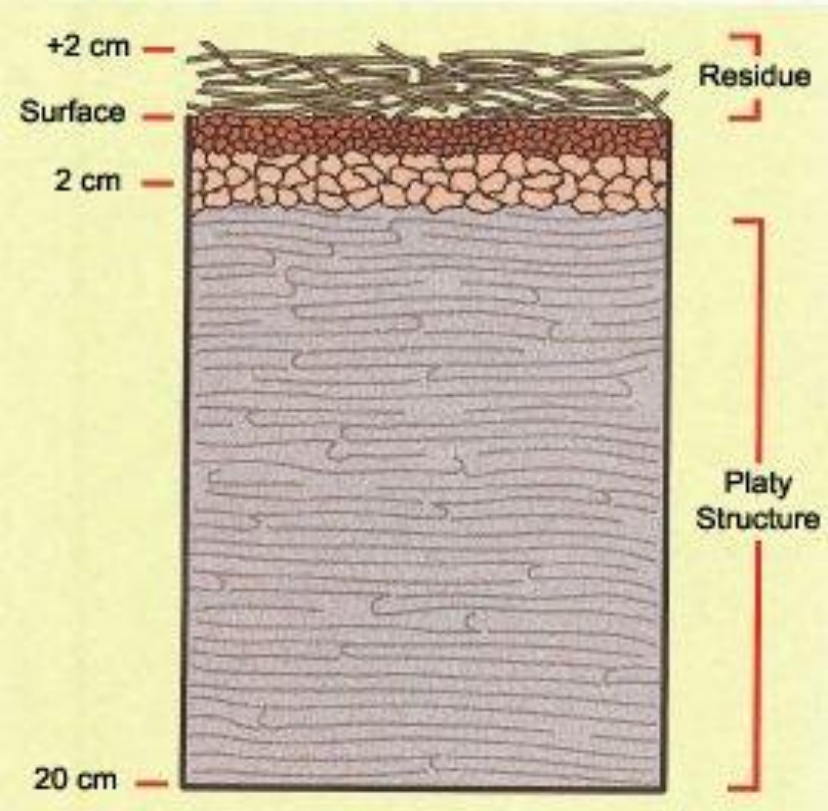
Unit 2: Soil structure



- Refers to how the individual soil particles (sand, silt and clay) are arranged in space.
- Organic matter and clay act as “glue”, based on their negative charges.
- Structure affects plant growth, water infiltration, aeration, soil erosion and bulk density.

Unit 2: Soil structure

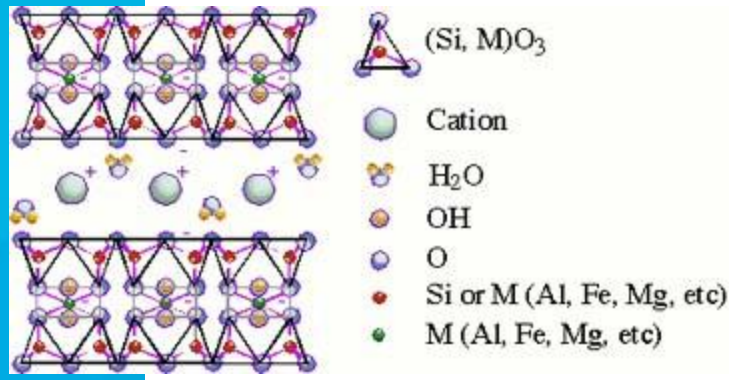


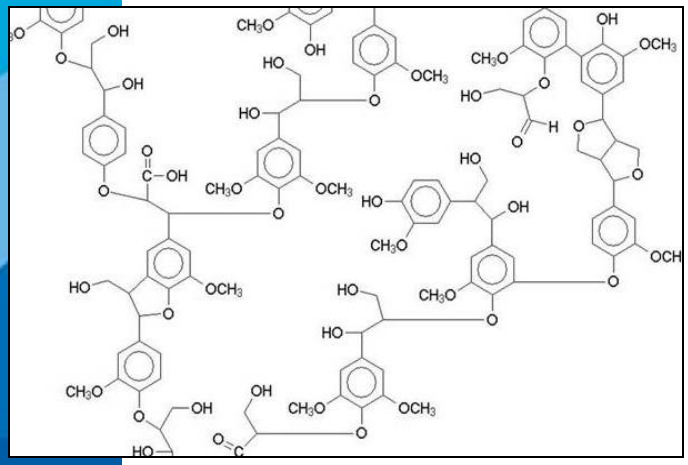


Which one of these soil leads to better crop growth?

Hint: think like a root or a worm…

Unit 2: Soil structure





A word or two about soil chemical charges…

- Soil and OM typically maintain a net negative charge.
  - Anions (negative charged ions): e.g., NO_3^-
  - Cations (positive charged ions): e.g., NH_4^+
- Soil charge effects the ability to adsorb inputs and aggregate with other soils.

Unit 2: Soil structure

MASSIVE TYPE

GRANULAR TYPE

Conventional

Reduced till

Sod surface

Infiltration in cm/hour:

Conventional: 23

Reduced Till: 63

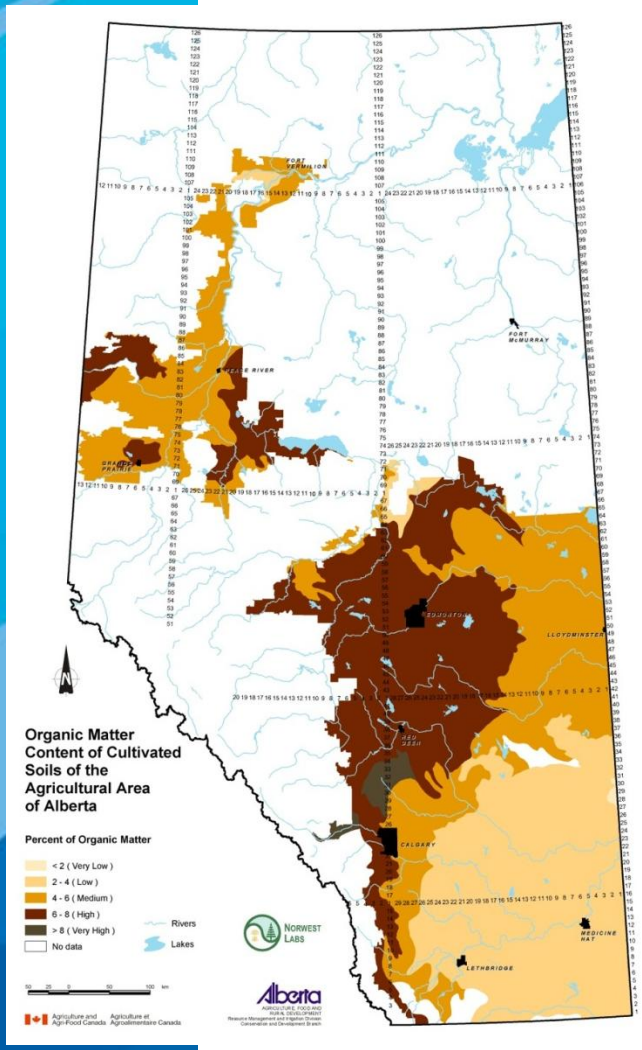
Sod surface: 68

How might this effect erosion potential of the soil?

Unit 2: Soil colour

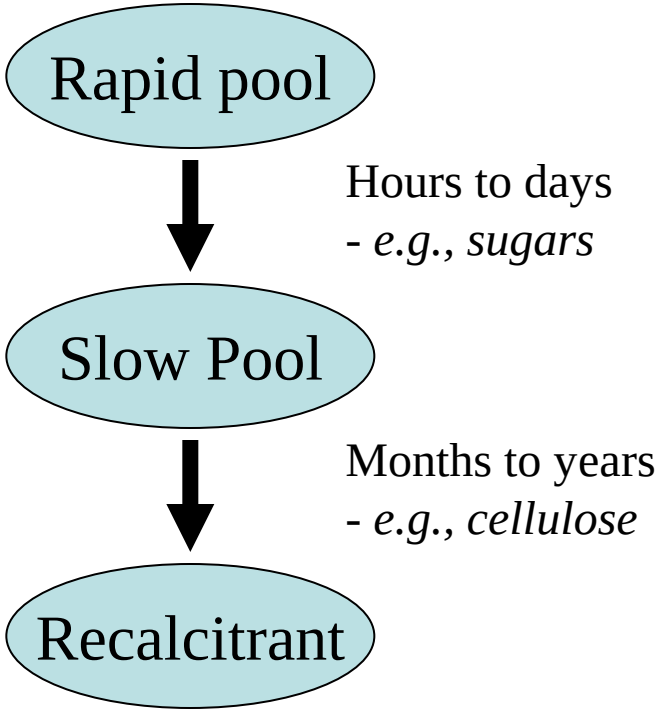
- Measured using the Munsell Colour System:
  - Hue – spectral colour
  - Value – lightness/darkness
  - Chroma – purity of colour
- Typically read from a “moist” sample.
- Reflects soil mineralogy, moisture regime and organic matter content.
- Effects solar radiation absorption (albedo).
  - snow (high) versus soil (low)

Unit 2: Soil organic matter



- SOM is found naturally in all Alberta soils.
  - Range: 1 to 17% in mineral soils.
    - Depends on region.
  - Considerably variable.
    - Provincially and across the landscape.
- SOM plays a significant role in the physical, chemical and biological characteristics of soil.

Unit 2: Soil organic matter



- Soil Organic Matter: *Its complicated!*
- Plant, animal and microbial residues.
- Different stages of decomposition:
  - Described as “pools”:
    - Simplest: 3 pools
    - Complex: 5 pools
  - Significantly different decomposition rates.

After Van Veen et al. 1984

Unit 2: Soil organic matter

Physical:

- “Glues” soil particles together to enhance aggregation, improve aeration, water infiltration and nutrient availability.
- Increases soil resistance to water and wind erosion.

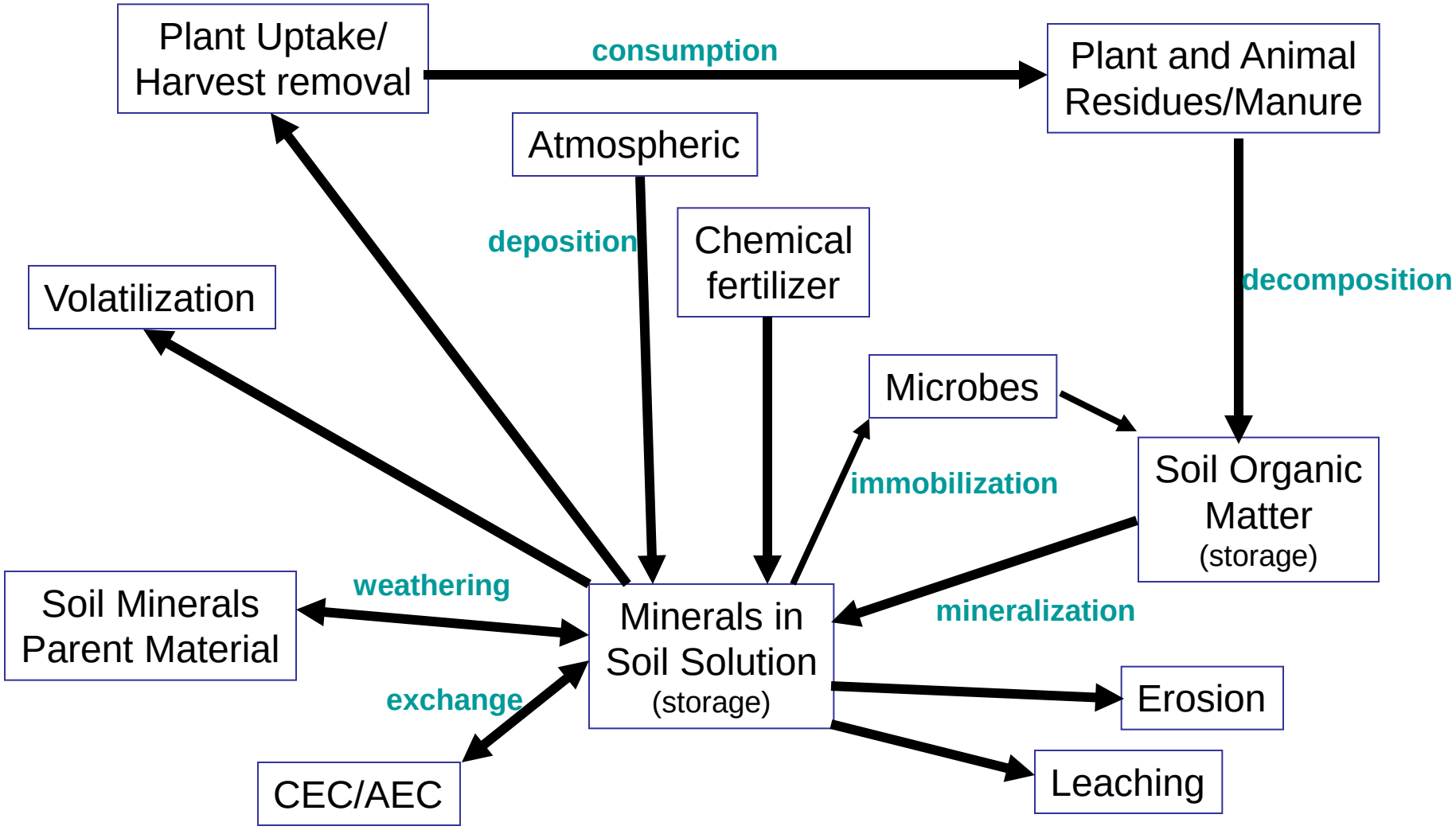
Chemical:

- Maintains a high surface area and the ability to hold and release nutrients through CEC system.
- Strong absorber of pollutants.
- Buffers soil pH.
- Important sink for carbon.

Biological:

- Represents both a resource and waste product.

Unit 2: General Nutrient Cycling



Unit 3: Soil Development

Soil Development Processes

- Additions:
  - Weathering, organisms, wind-blown, atm. deposition, nutrients, water
- Losses:
  - Water, nutrients, sediment/erosion, salts, organic matter, leaching
- Transfers:
  - Vertical movement clay: AP develops into an Ae and Bt.
- Transformations:
  - Structure, chemical, particle size, organisms (biological)

Unit 3: Soil Development

Soil horizon characterization and nomenclature:

- Horizon name
- Thickness and depth
- Colour
- Texture
- Structure
- Consistence
- Boundary
- pH

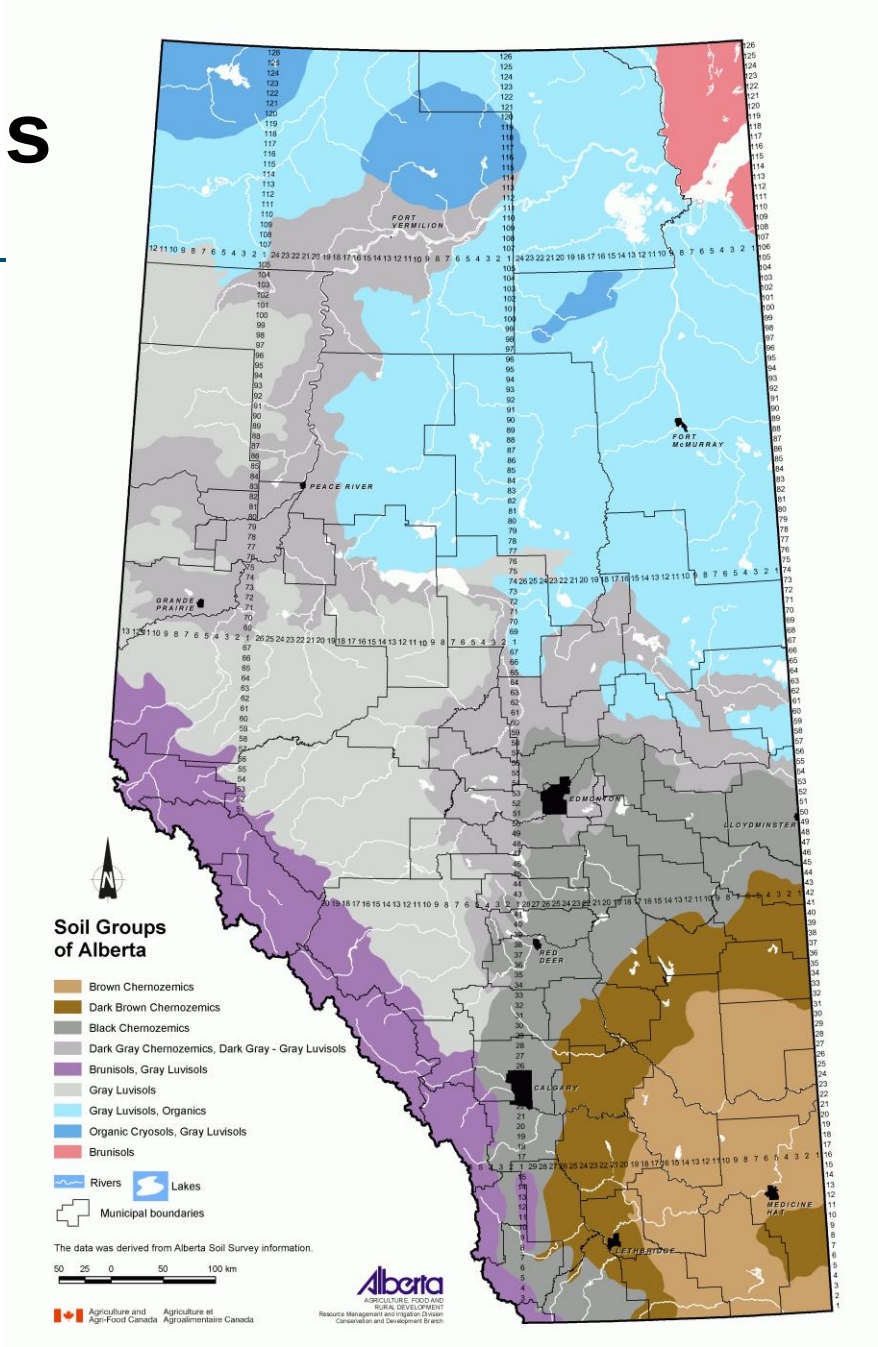
- *Main horizon identifiers and modifiers:*
- **A:** h, p, e,
- **B:** f, t, n, m, g
- **C:** k, s, g
- Organic Soils
  - **O:** h, f, m,
  - **LFH**

Unit 3: AB Soils

Soil Great Groups:

- Soil distribution highly diverse in AB:
  - Brown Chernozem (18 %)
  - D. Brown Chernozem (20 %)
  - Black Chernozem (29 %)
  - Dark Gray Luvisol (13 %)
  - Gray Luvisol (19 %)

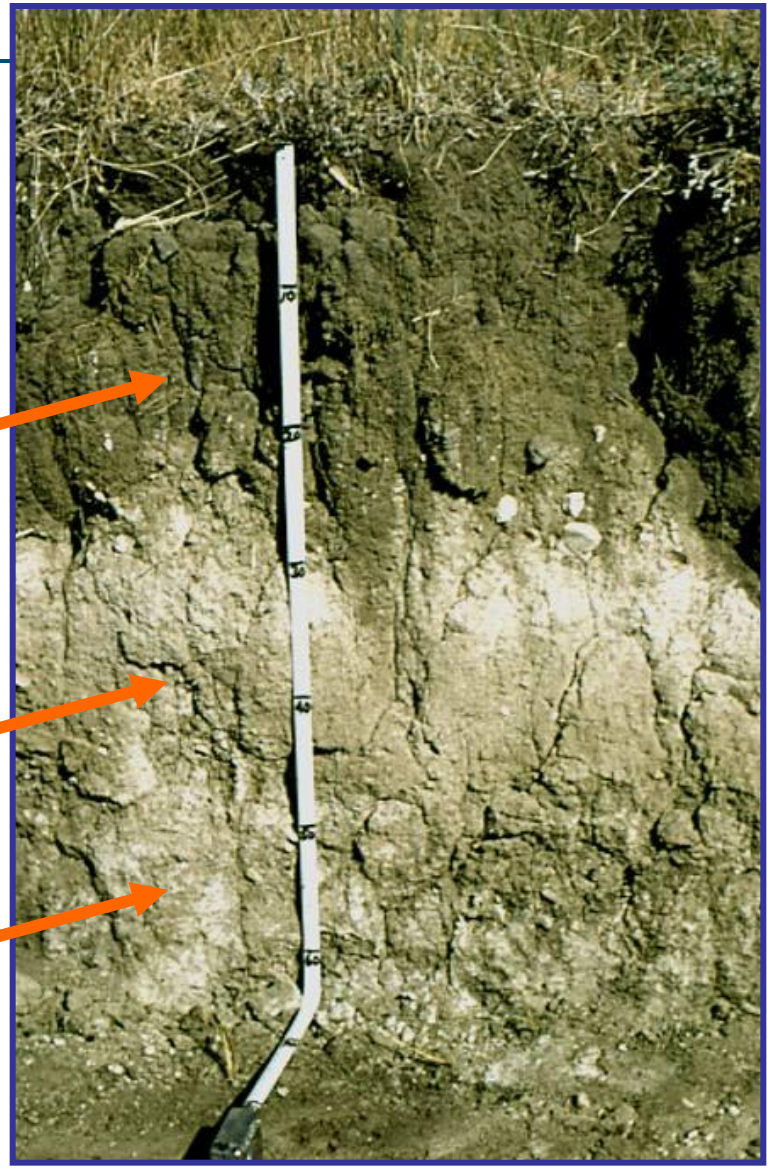
- Strong link to climate, vegetation and parent materials.



Unit 3: Soil Groups

BROWN CHERNOZEM

- Occur in the most arid of Alberta's environments.
- Associated with Xerophytic and/or mesophytic grasses and forbs.
- Upper Ah similar in colour to lower Ah.



Unit 3: Soil Groups

BLACK CHERNOZEM

- Characterized by a deep, dark (black) coloured A horizon.
- Developed in association with native vegetation of grasses and forbs and some tree cover in central Alberta.

Unit 3: Soil Groups

DG/G LUVISOL

- Eluvial horizons with accumulation of clay in the B horizon. Overall gray/brown coloration.

- Occur under boreal and mixed forest vegetation and in the forest-grassland transition zones under a wide variety of climates.

Unit 3: Soil Groups

SOLONETZIC

- Burnout or “gumbo” soils.
- Formed from parent materials high in sodium salts.
- Presence of sodium in the soil prevents the aggregation of sand, silt and clay.

Unit 4: Problems in soils - compaction – bulk density

Bulk density: What is it?

- Mass of oven dried solids/total bulk volume of sample.
  - $g/cm^3 = Mg/m^3$
    - Sand = 1.5
    - Loam = 1.2
    - Clay = 1.7
    - Rock = 2.65

Compaction: What affects it?

- Soil texture
- Soil structure
- OM content
- Management factors
  - Tillage
  - Crop rotation

Unit 4: Problems in soils - Erosion

Types: wind, water (and tillage)

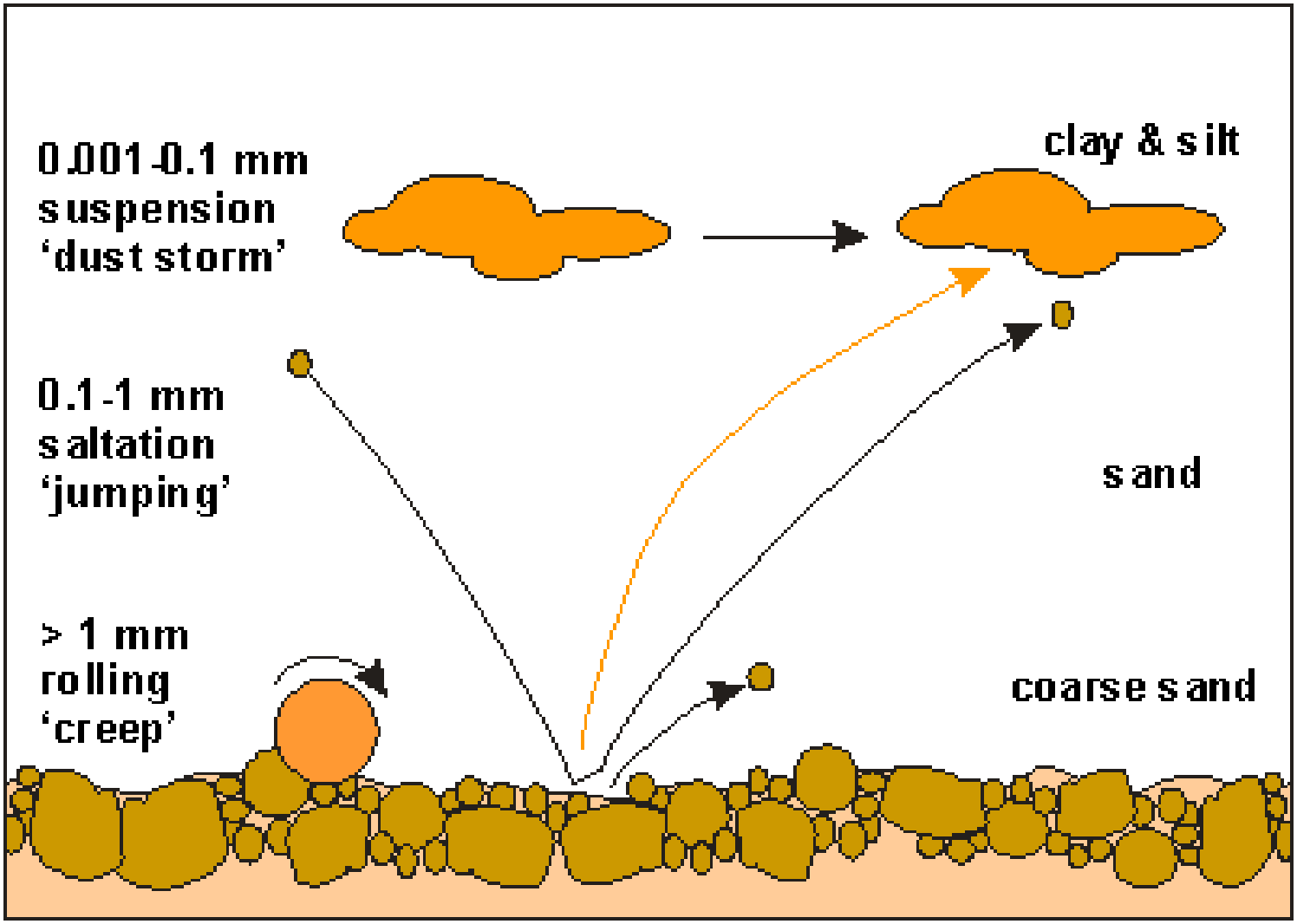
The problems?

- Runoff during storms
- Eroded knolls
- Rills and gullies
- Topsoil removal
- Air and water quality

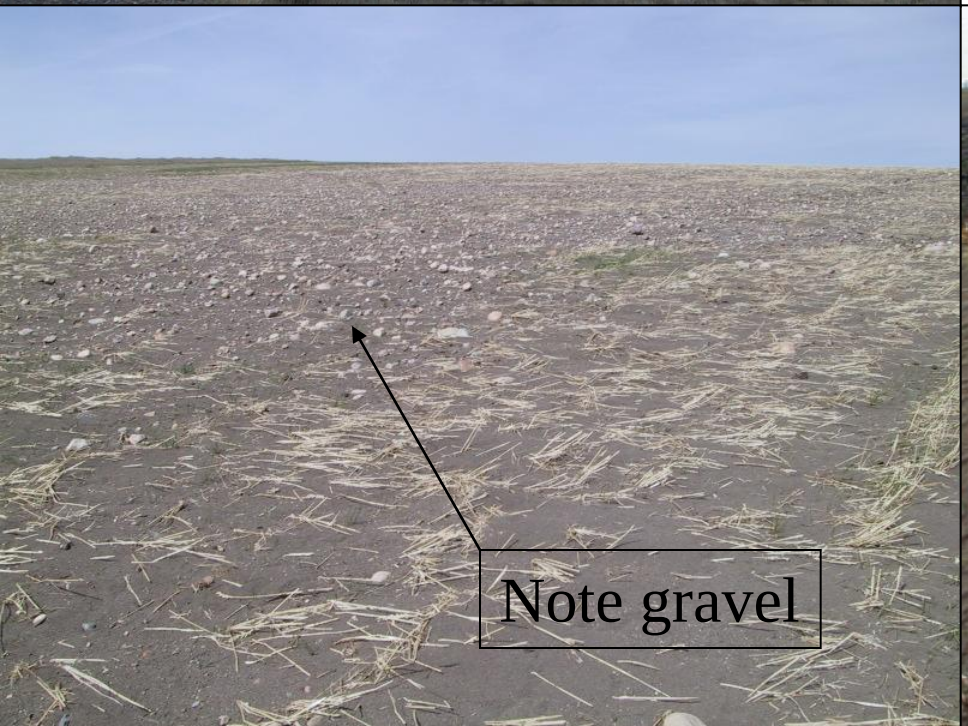
What affects it?

- OM levels
- Soil structure
- Soil type (texture)
- Topography
- Tillage/residue cover

Unit 4: Problems in soils - Erosion



Wind Erosion



Unit 4: Problems in soils - Erosion

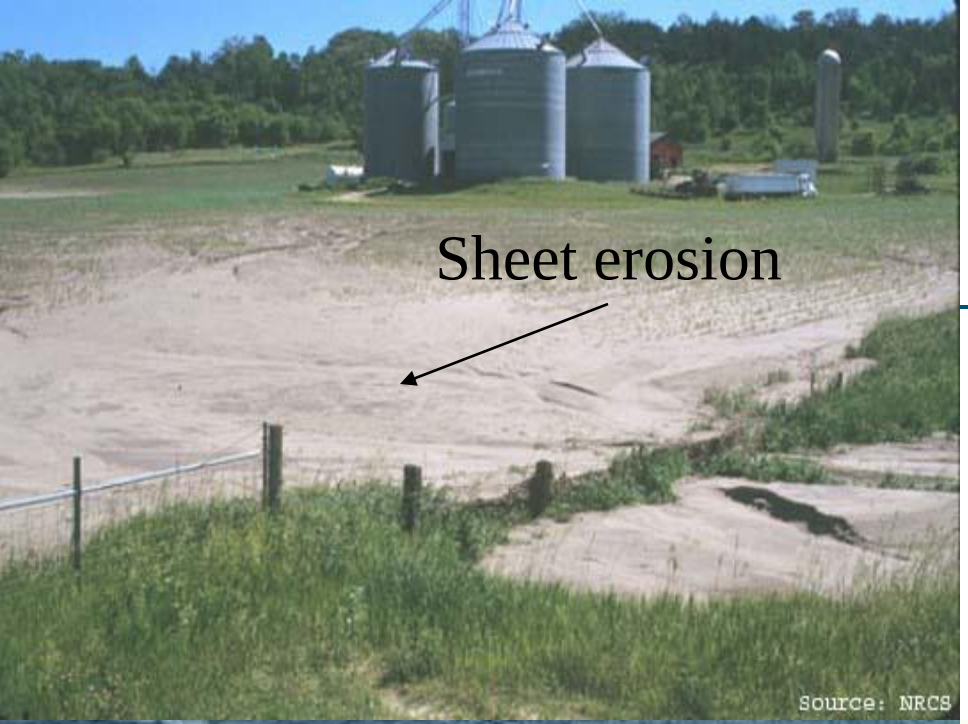
What is infiltration?

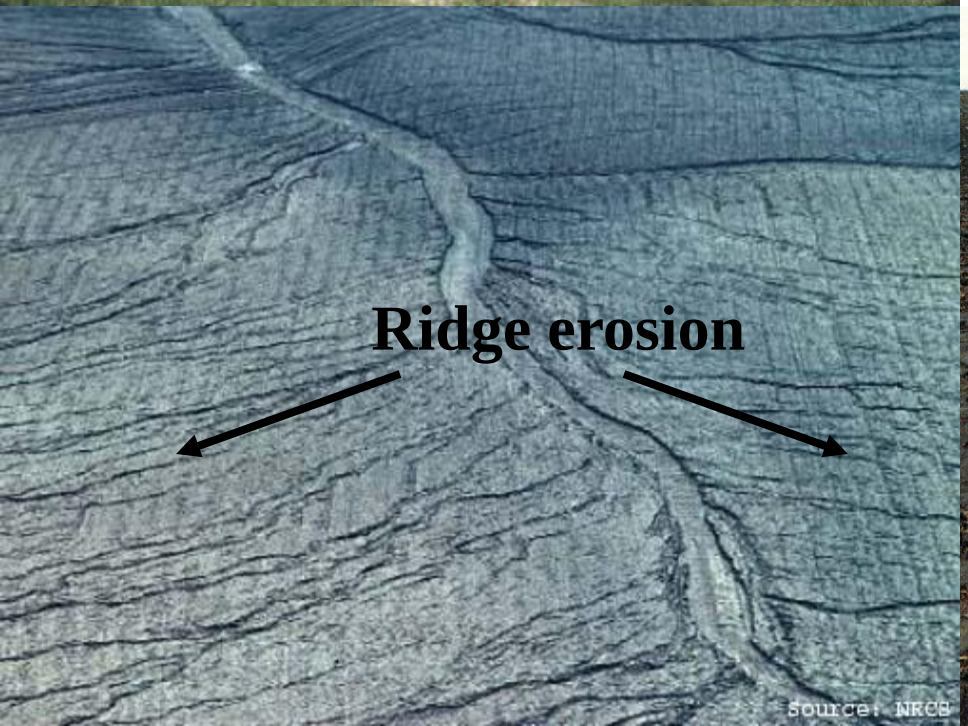
- Entry rate of water into soil.
- Water must pass the soil surface to be conserved.
- Reduces erosion risk.

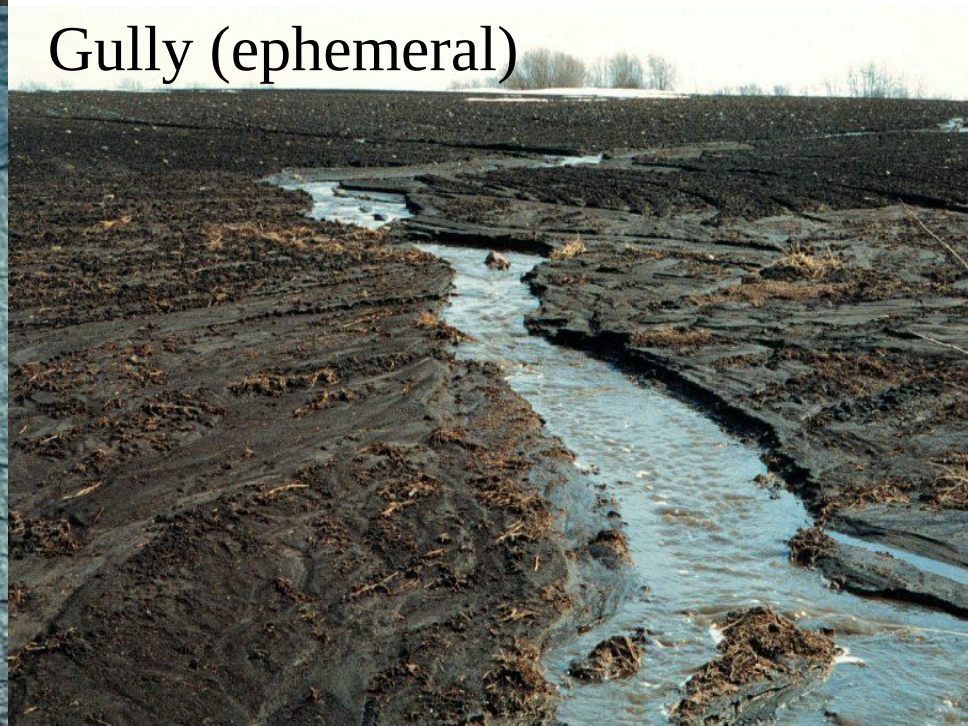
What affects it?

- Pore size.
- Channels at soil surface.
- Tillage.
- Previous years moisture.

Water Erosion







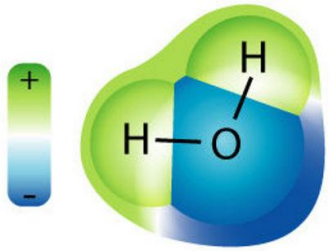
Unit 4: Properties of Water

groundwater contamination

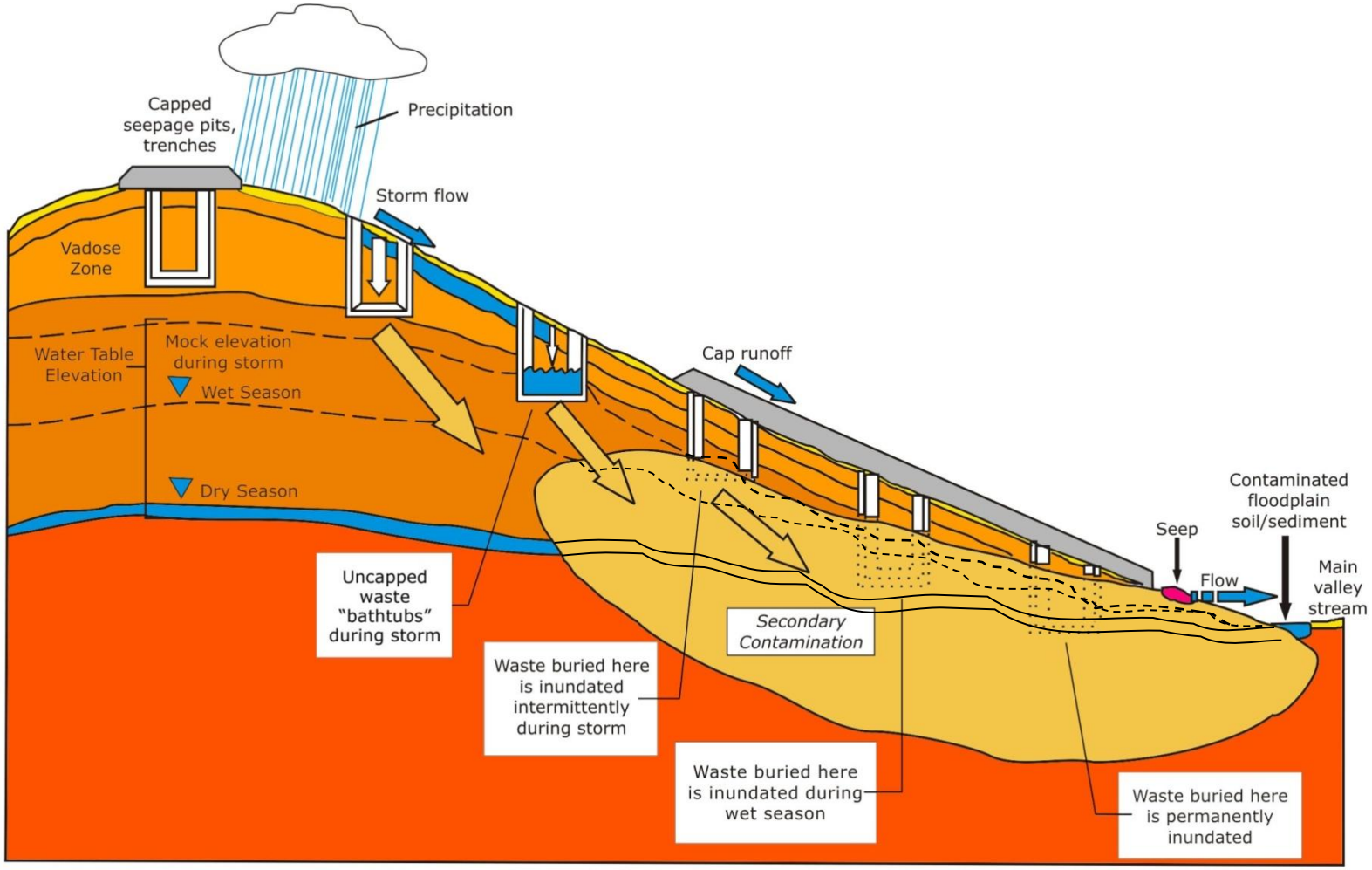
- **Cohesion:** the attraction between water molecules.
- **Adhesion:** the attraction of water and other surfaces.

- Movement from areas of high to low water potentials (wet to dry).
  - Capillary rise
  - Hydraulic conductivity

- Sand: large pores with good pore continuity.
- Loam: wide range of pore sizes and decent continuity.
- Clay: small pores with poor pore continuity.



Unit 4: Properties of Water
groundwater contamination



http://www.oakridge.doe.gov/em/ssab/Stewardship-Kit/Files/HistoricalPhotos/15-hydrologic%20process.jpg

Unit 4: Problems in soils - Salinity

- Soil salinity: concentration of soluble salts:
  - Na^+, Cl^-, Ca^{2+}, Mg^{2+}, SO_4^{2-}
- Electrical Conductivity (E.C.) of a saturated paste extract (dS/m):
  - Saline soil > 4 dS/m
  - Surface crusting may be visible at 4.5 to 5 dS/m
- Sodium Adsorption Ratio (SAR)
  - Often associated with the quality of irrigation water
  - $[Na^+] / ([Ca^{2+}]+[Mg^{2+}])^{1/2}$
  - Sodic soil > 13 (interferes with crop growth)

Unit 4: Problems in soils - Salinity

- What causes it?

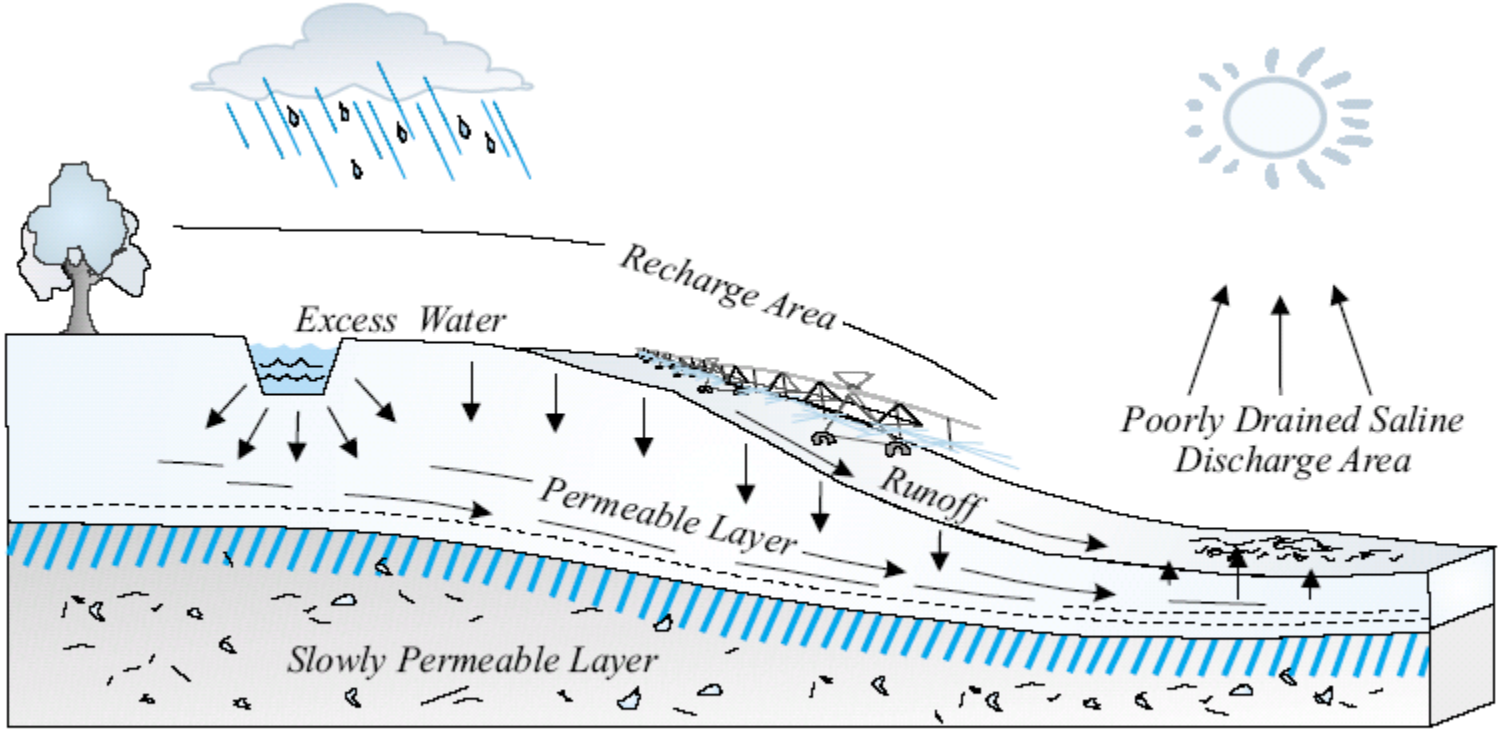


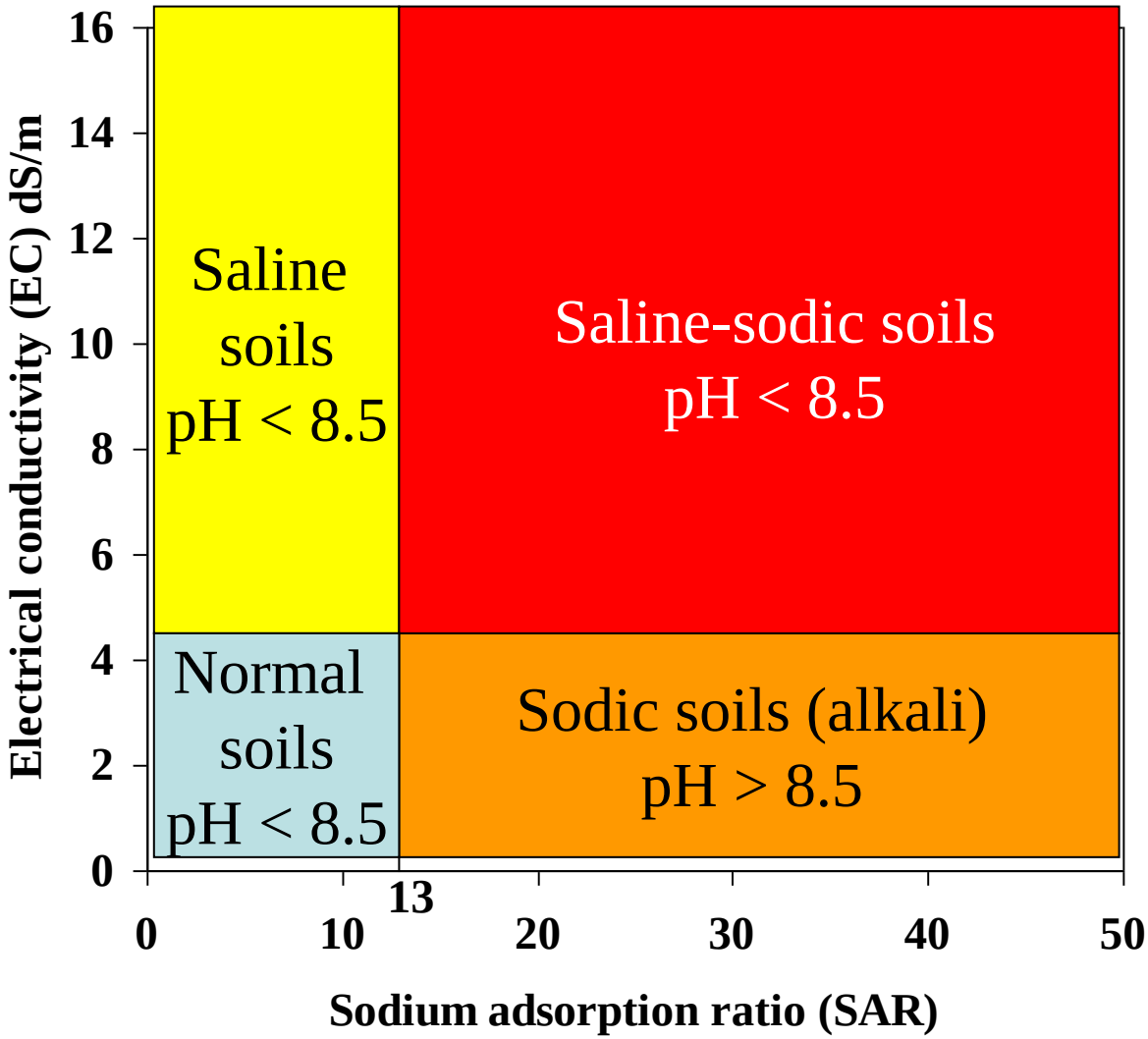
Figure 3. Lateral movement of excess water above a slowly permeable layer.

Unit 4: Problems in soils - Salinity

Classes of salt - affected soils

	pH	EC (dS/m)	ESP
Normal soils	6.5-7.2	<4	<15
Acid soils	<6.5	<4	<15
Saline soils	<8.5	>4	<15
Sodic soils	>8.5	<4	>15
Saline-Sodic	<8.5	>4	>15

Source: University of Idaho
*ESP = exchangeable sodium %

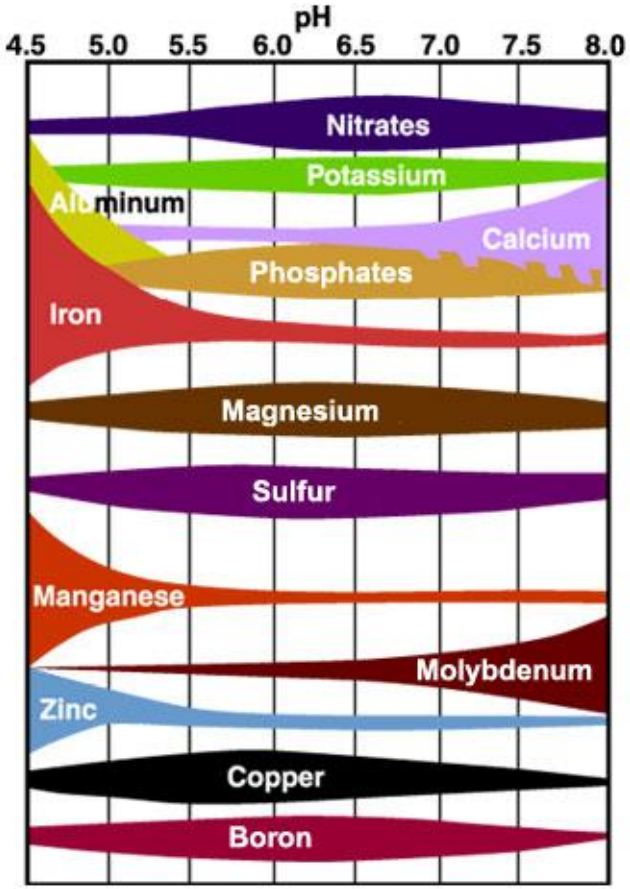


Unit 4: Problems in soils - Salinity

VISIBLE
> 4.5- 5 dS/m

HIDDEN
< 4 dS/m

Unit 4: Problems in soils - pH



- Most nutrients are available at a pH of 6-7.
- Outside of this range, are potentially toxic elements
- Optimum crop growth is species specific:
  - Alfalfa: 6.25 - 7
  - Canola: 5.5 - 6.5/7.0
  - Cereals: 5.5 - 7.0
  - Timothy: 5.75 - 7.25

Summary & Review

- **Unit 1:** Soil is complex, derived from 5 soil forming factors.
  - Climate, biology, topography, parent material and time
- **Unit 2:** Soil is characterized using a number of different characteristics.
  - Texture, structure, colour, organic matter,
- **Unit 3:** Soil profiles reflect vertical process that have occurred over the past 10,000 years.
  - Horizons and classification
- **Unit 4:** Many of the problems encountered in the soils, are derived from the effects of management on the natural resource.
  - Compaction, erosion, salinity and pH

Thank you!

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