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Soil Resources

Overview of Chapter 14

- The Soil System
- Soil Properties and Major Soil Types
- Environmental Problems Related to Soil
- Soil Conservation and Regeneration

Mudslide in Oso, WA (2014)

- Caused by heavy rainfall in erosion prone area
  - logging and poor management of area
  - Certain topographic areas need different management
- 41 people died in mudslide
- Soil as a resource and in need of protection
  - For our benefit, as well

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Soil

- Uppermost layer of earth's crust that supports plants, animals and microbes
- Soil Forming Factors
  - Weathering of parent material
  - Time
  - Climate
  - Organisms
  - Topography

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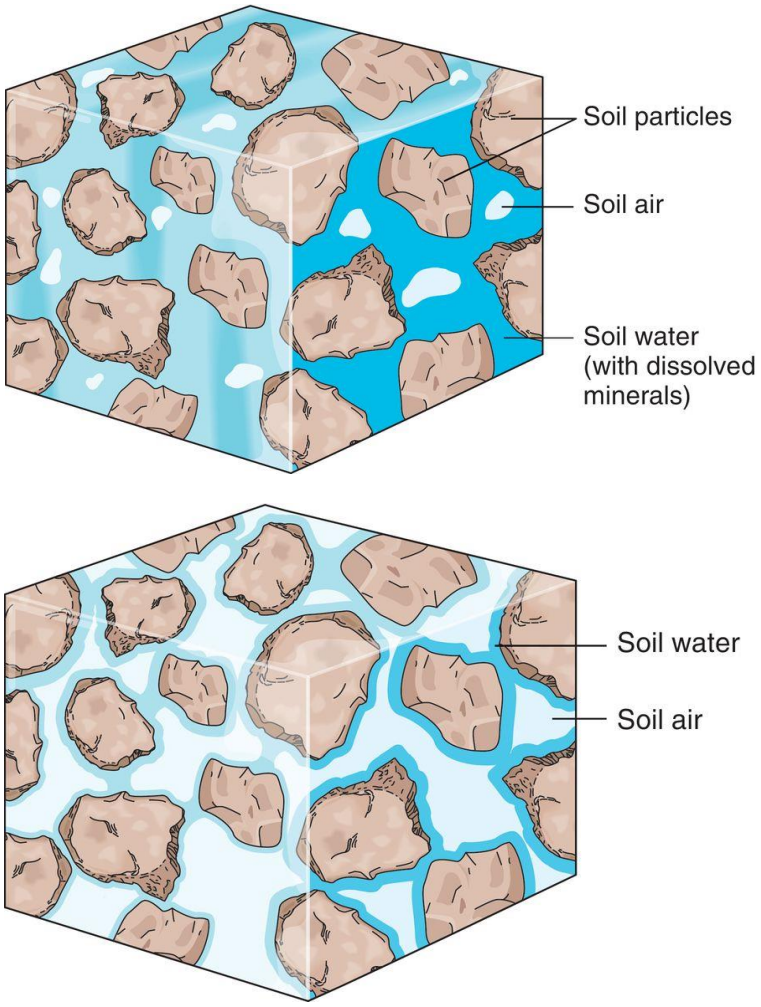
Soil Composition - “typical soil”

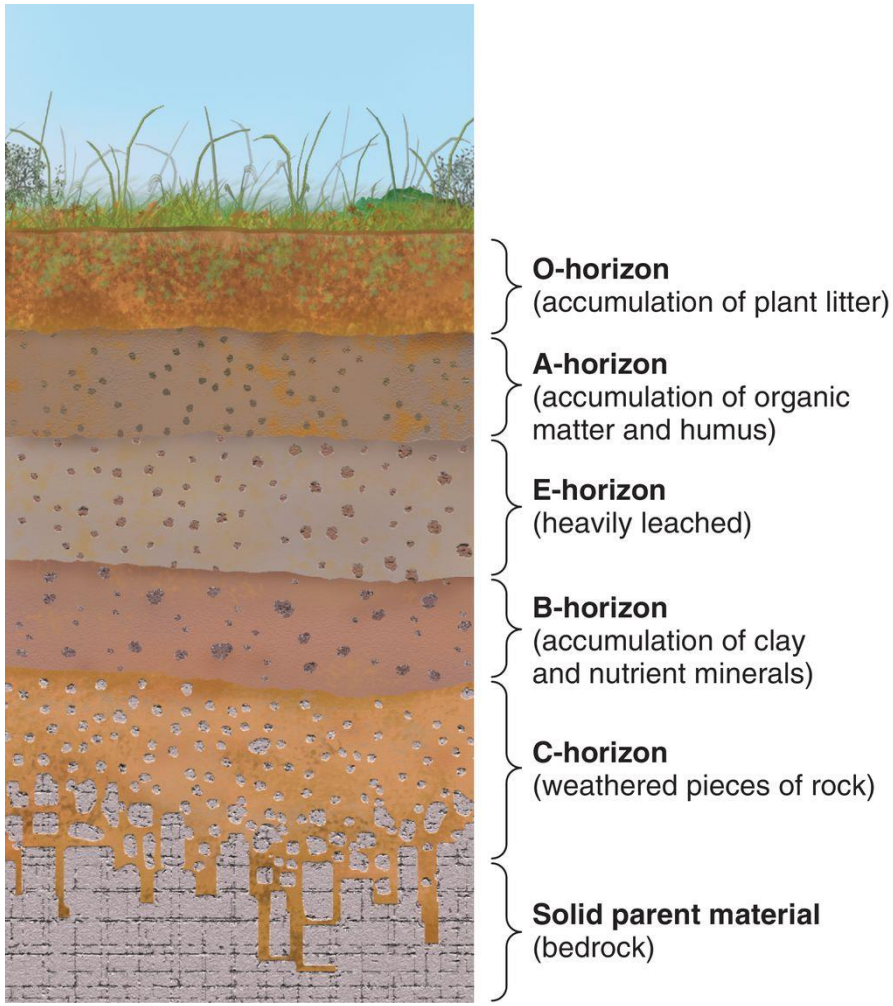
- Mineral Particles (45%)
  - Weathered rock
- Organic Material (5%)
  - Litter, animal dung, dead remains of plants and animals
  - Humus – black organic matter remaining after most decomposition
    - Collective name for many different organic compounds
- Water (25%)
- Air (25%)

Soil Composition

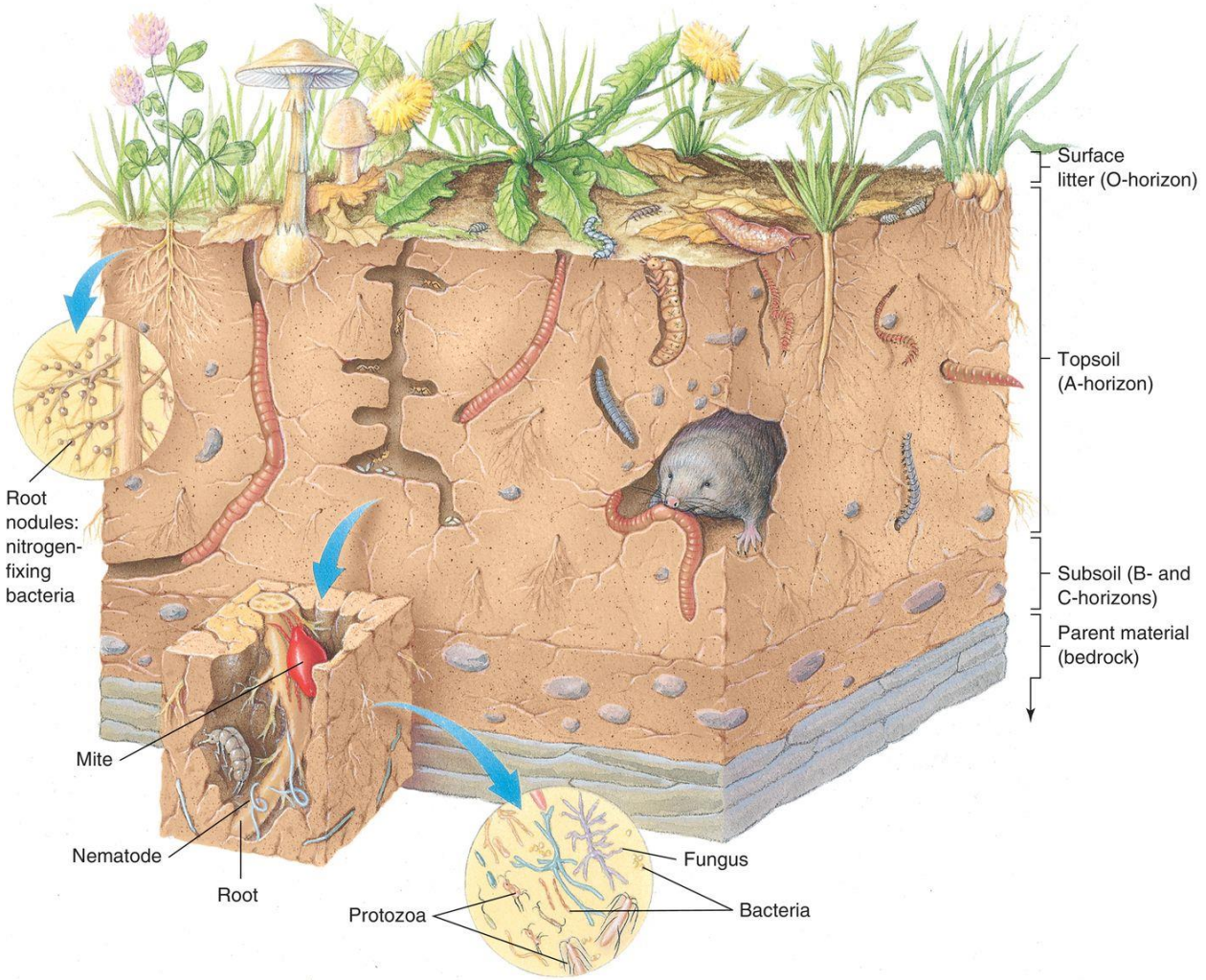
- Pore space
  - 50% of soil
  - Soil air - good for aeration
  - Soil water - provides water to roots



Soil Horizons



Soil Organisms

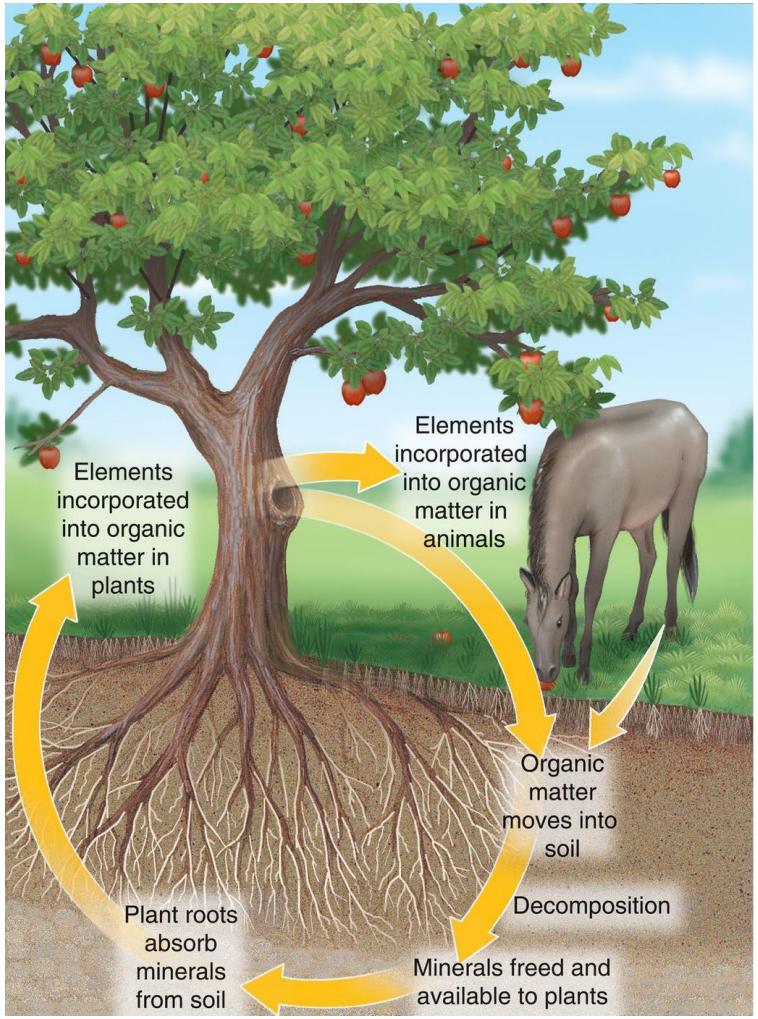


Soil Organisms

- There are millions of microorganisms in 1 tsp of fertile agricultural soil
- Soil organisms provide ecosystem services
  - Def: Important environmental benefits that ecosystems provide
  - Decaying and cycling organic material
  - Castings – from gut of earthworms
  - Breaking down toxic materials
  - Cleansing water
  - Soil aeration
  - Mycorrhizae

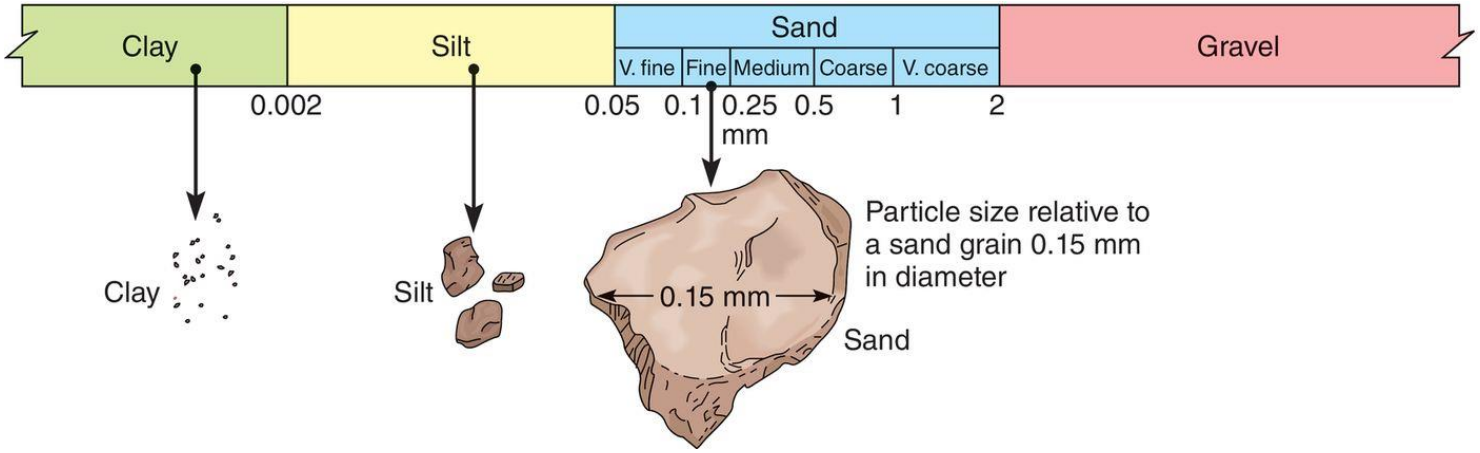
Nutrient Cycling

- The pathway of various nutrient minerals or elements from the environment through organisms and back to the environment



Soil Properties

- Soil Texture
  - Relative proportion of sand, silt and clay
  - Sand: 2mm–0.05mm
  - Silt: 0.05mm–0.002mm
  - Clay: >0.002mm

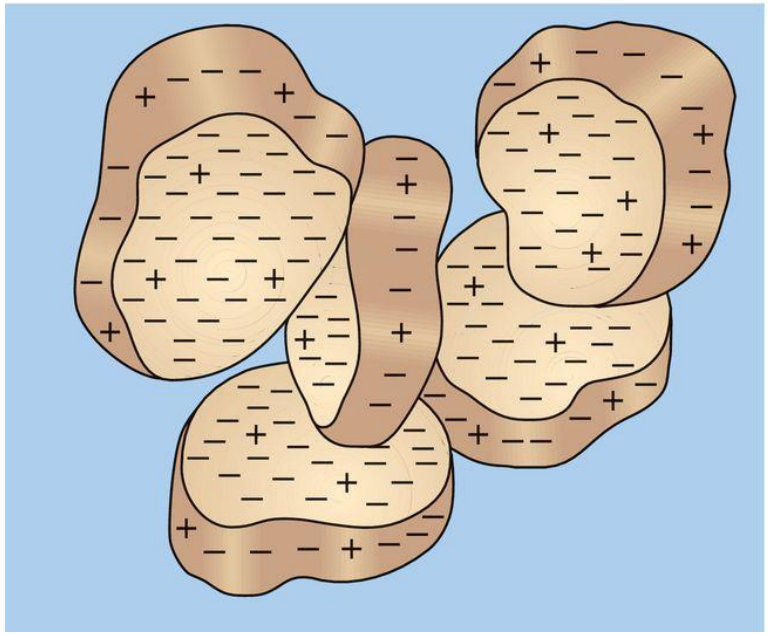


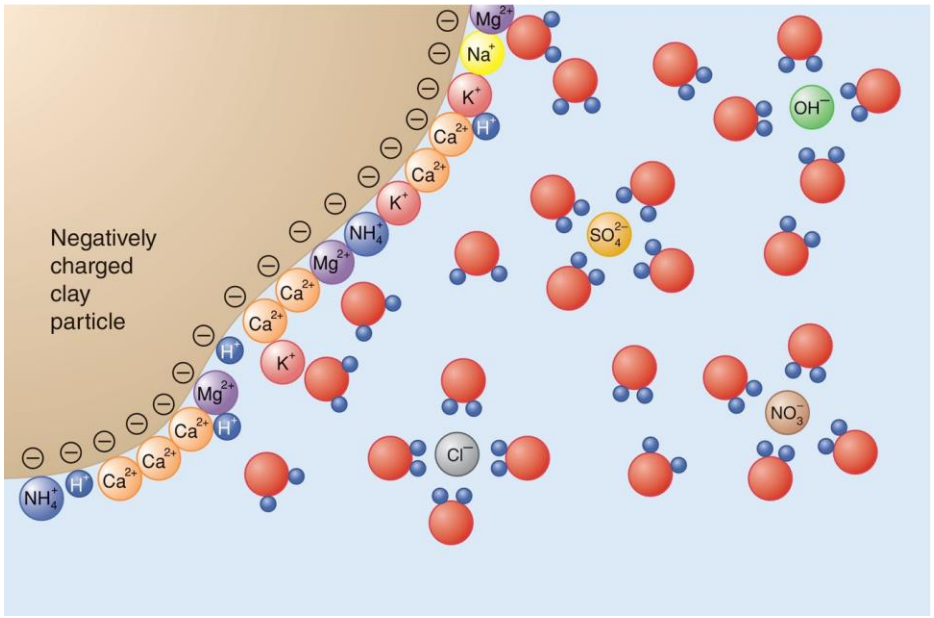
Soil Properties

- Soil texture affects soil properties
- Coarse textured soil (sandy)
  - Excellent drainage
- Fine textured soil (high in clay)
  - Poor drainage
  - Low oxygen levels in soil
  - Due to negatively charged surface, able to hold onto important plant nutrients (K^+, Ca^{2+}, NO_2^-)

Soil Properties

- Negative charge on clay attracts positively-charged nutrients





Soil Properties

Table 14.1 Soil Properties Affected by Soil Texture

	Soil Texture Type		
Soil Property	*Sandy Soil*	*Loam*	*Clay Soil*
Aeration	Excellent	Good	Poor
Drainage	Excellent	Good	Poor
Nutrient mineral–holding capacity	Low	Medium	High
Water-holding capacity	Low	Medium	High
Workability (tillage)	Easy	Moderate	Difficult

Soil Properties

- Soil Acidity
  - Measured using pH scale
  - pH of most soils range from 4–8
  - Affects solubility of certain plant nutrients
  - Optimum soil pH is 6–7, because nutrients are most available to plants at this pH
- Acid precipitation (primarily from industrial emissions)
  - Sulfuric and nitric acids
  - Alters soils, need to add calcium to reverse

Major Soil Groups

- Variations in soil forming factors cause variation in soils around globe
- Soil Taxonomy
  - Separates soils into 12 orders in U.S.
  - Subdivided into more than 20,000 soil series that vary by locality
- Five common soil orders
  - Spodosols, alfisols, mollisols, aridosols, oxisols

Spodosols

- Form under coniferous forests
  - Cold, ample precipitation, good drainage
- O-horizon composed of decaying needles
- E-horizon is ash-gray under thin A-horizon
- Not good farmland- too acidic

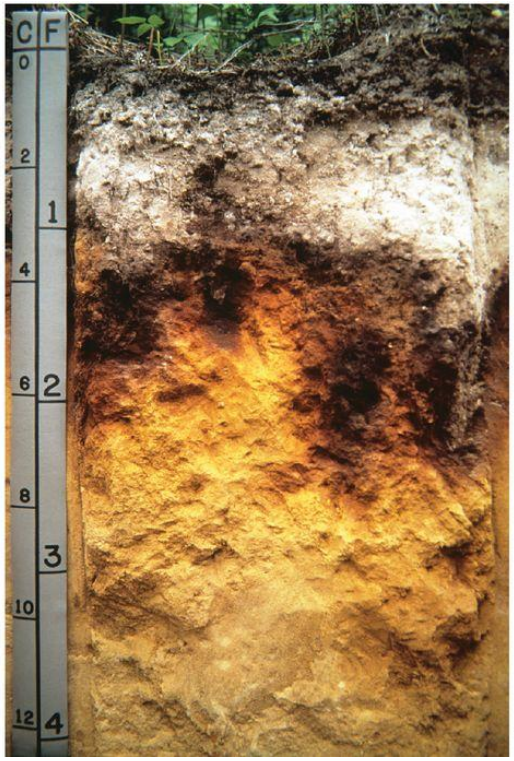


Photo courtesy of USDA NRCS

Thin or absent A-horizon

Leached, acidic E-horizon

Dark-brown illuvial B-horizon; rich in organic matter and aluminum and iron oxides

Alfisols

- Temperate deciduous forests
- Brown to gray-brown A-horizon
- Precipitation high enough to leach most organics and nutrients out of O-, A- and B-horizons
- Soil fertility maintained by leaf litter

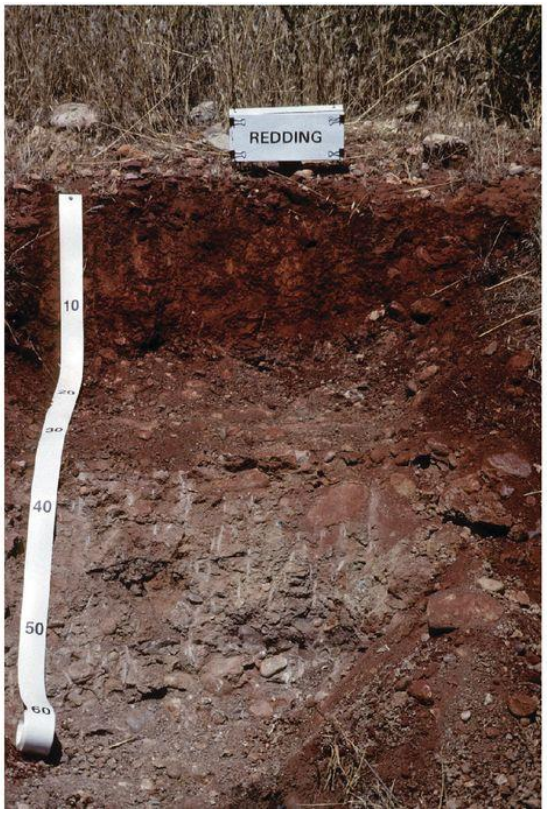


Photo courtesy of USDA NRCS

A-horizon; rich in accumulated humus

Light-colored E-horizon

Brown B-horizon; rich in clay

C-horizon; weathered parent material

Mollisols

- Found in temperate, semi-arid grassland
- Very fertile soil
- Thick, dark brown/ black A-horizon
- Soluble nutrients stay in A-horizon due to low leaching
- Grow most grains
- Deep rooting grasses help form

Photo courtesy of USDA NRCS

Thick dark A-horizon; rich in humus

Thick B-horizon; rich in calcium carbonate in deeper parts

Aridisols

- Found in arid regions of all continents
- Low precipitation preclude leaching and growth of lush vegetation
- Development of salic (salty) horizon possible

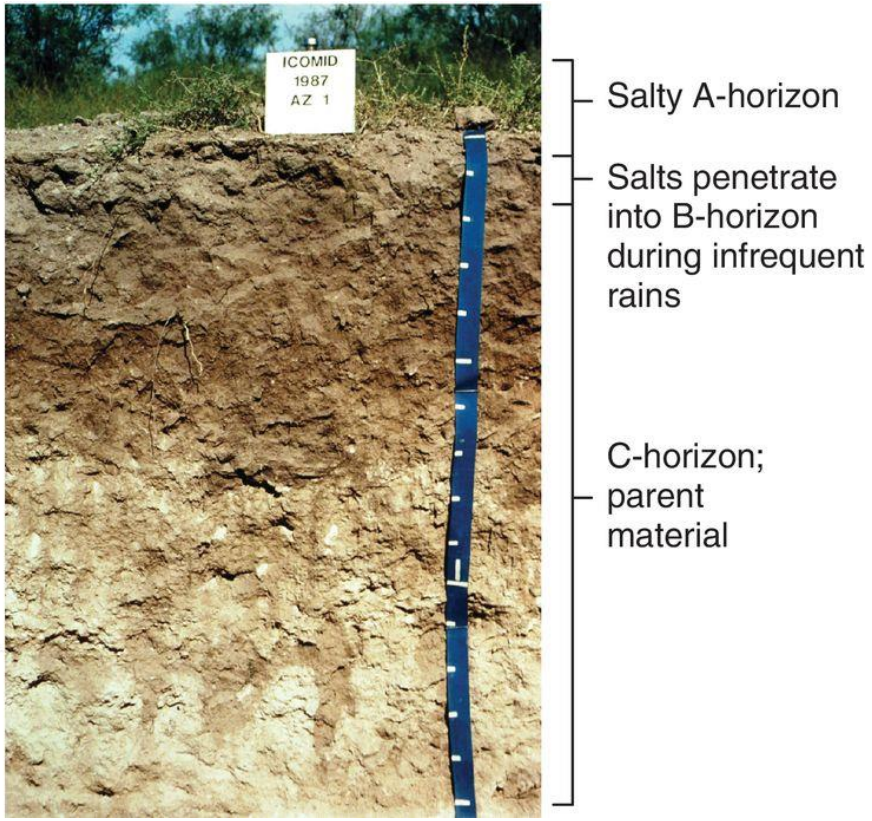


Photo courtesy of USDA NRCS

Oxisols

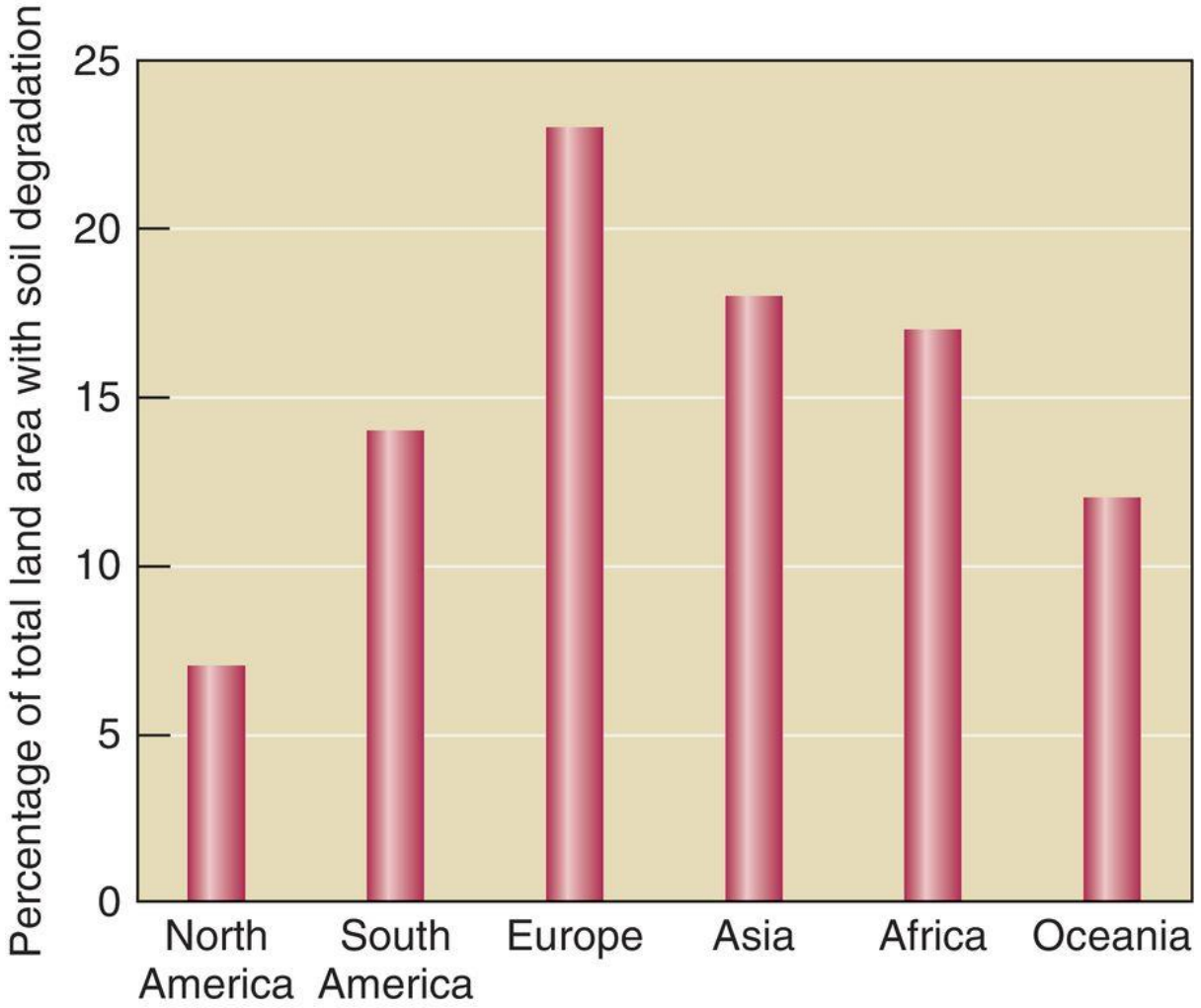
- Found in tropical and subtropical areas with high precipitation
- Very little organic material accumulation due to fast decay rate
- B-horizon is highly leached and nutrient poor

Photo courtesy of USDA NRCS

Soil Problems

- Soil Erosion
  - Caused primarily by water and wind
  - Wearing away or removal of soil (usually topsoil)
- Why a problem?
  - Causes a loss in soil fertility as organic material and nutrients are eroded
  - More fertilizers must be used to replace nutrients lost to erosion
- Accelerated by poor soil management practices

Soil Erosion, Desertification and Salinization



Soil Erosion

- Increases movement of sediment among ecosystems
  - Into streams and waterways
  - Increases water pollution
  - Degradation of water infrastructure (ex: dams)

Richard Hansen/Science Source

Soil Erosion

- Accelerated by poor soil practices
  - Not just agriculture
- National Resources Conservation Service estimates erosion (5 year intervals)
  - Water erosion in grain belt (large rainstorm can remove ~1mm, but can add up)
  - Annual loss of 75 billion metric tons of topsoil?
    - Problems from loss and problems from where it goes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Case in Point: American Dust Bowl

- Great Plains has low precipitation and is subject to drought
  - 1930–1937 severe drought
  - No natural vegetation roots to hold soil in place
    - Replaced by annual crops
  - Winds blew soil as far east as NYC and DC.
  - Farmers went bankrupt

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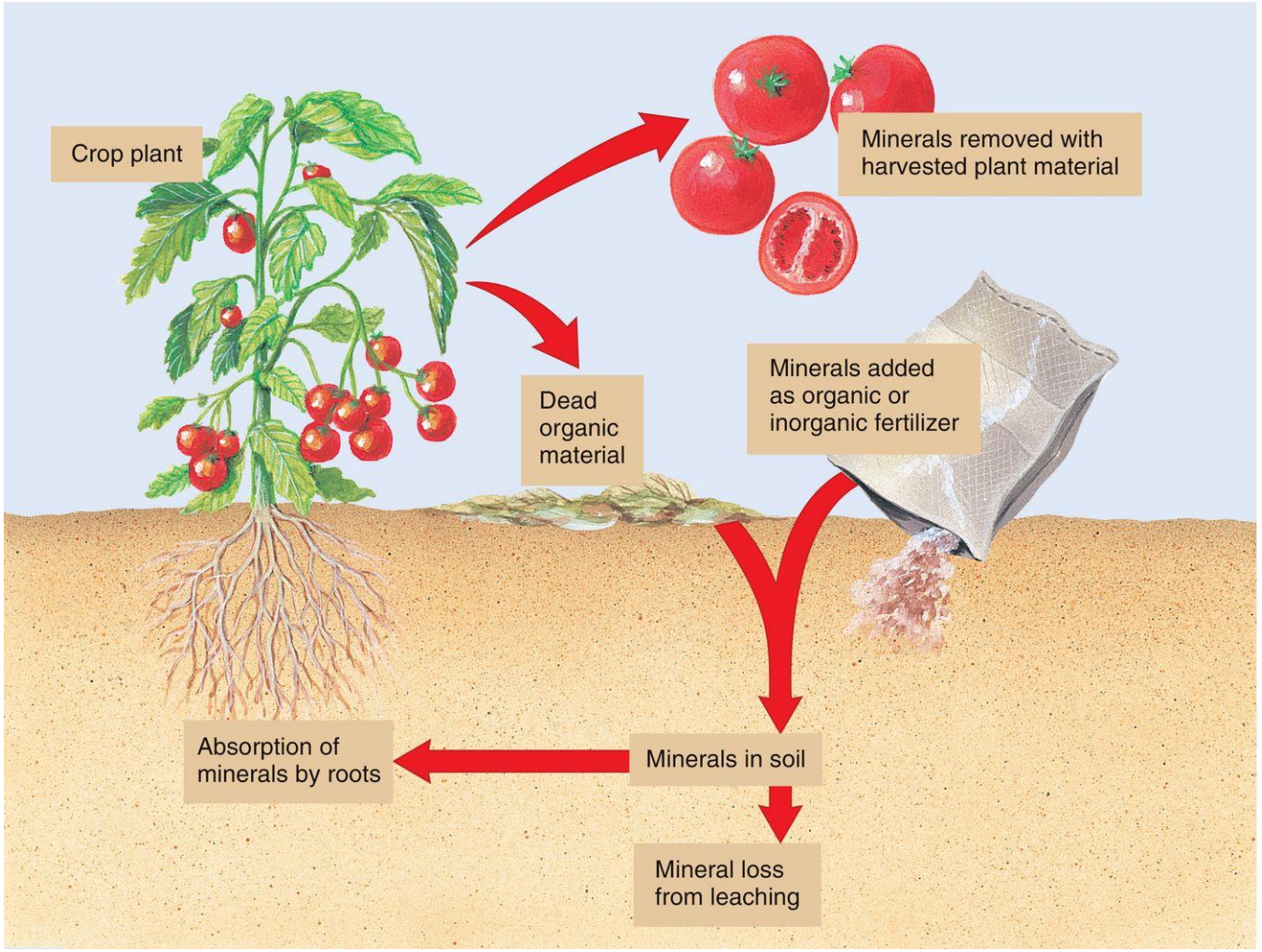
Soil Problems - Nutrient Mineral Depletion



Soil Problems - Salinization

- Gradual accumulation of salt in the soil, usually due to improper irrigation techniques
- Often in arid and semi-arid areas
- Salt concentrations get to levels toxic to plants

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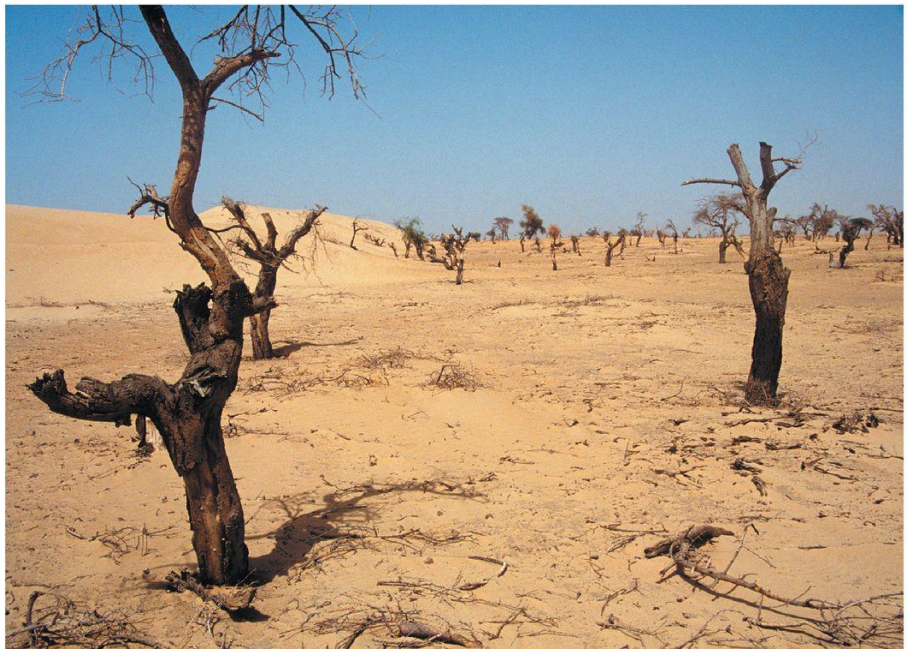
Soil Problems- Desertification

- Degradation of once-fertile rangeland, agricultural land, or tropical dry forest into nonproductive desert



K. Tumanowicz / Science Source

Soil Conservation

- Conservation tillage
  - Residues from previous year's crops are left in place to prevent soil erosion
- Crop rotation
  - Planting a series of different crops in the same field over a period of years

Courtesy U. S. Department of Agriculture

Soil Conservation

- Contour Plowing
  - Plowing around hill instead of up-down
- Strip Cropping
  - Alternating strips of different crops along natural contours
- Terracing
  - Creating terraces on steep slopes to prevent erosion

Courtesy U. S. Department of Agriculture

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Soil Conservation

- Cover cropping
  - Crops grown between seasons of other crops
  - Otherwise soil lies bare

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Preserving Soil Fertility

- Organic fertilizers
  - Animal manure, crop residue, bone meal and compost
  - Nutrient available to plants only as material decomposes
- Inorganic fertilizers
  - Manufactured from chemical compounds
  - Soluble
    - Fast acting, short lasting
    - Mobile- easily leach and pollute groundwater

Soil Reclamation

- Two steps
  - Stabilize land to prevent further erosion
  - Restoring soil to former fertility
- Best way to do this is shelterbelts
  - Row of trees planted to reduce wind erosion of soil

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Soil Conservation Policies in US

- Soil Conservation Act 1935
  - Authorized formation of Soil Conservation Service, now called Natural Resource Conservation Service (NRCS)
  - Assess soil damage and develop policies to improve soil
- Food Security Act (Farm Bill) 1985
  - Farmers with highly erodible soil had to change their farming practices
  - Instituted Conservation Reserve Program
    - Pays farmers to stop farming highly erodible land

Soil Conservation Policies in US

- Conservation Reserve Program (CRP)
  - Voluntary subsidy program
  - Pays farmers to stop producing crops on highly erodible land
  - Plant native grasses and retire production on it for 10-15 years
  - Land not harvested or used for production
  - Provides other ecosystem services such as habitat and increases water quality
  - Has saved ~7.1 metric tons of soil per hectare

Composting and Mulching

- Make your own compost
  - Degrade organic waste materials
  - Add to property to naturally increase fertility
- Mulch
  - Weed control
  - Reduces evaporation
  - Natural mulches can add to soil organic content

Courtesy U. S. Department of Agriculture