Soils

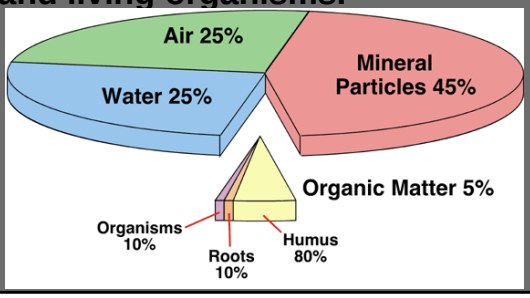
"The nation that destroys its soil destroys itself" - F.D.R.

Outline

- What is Soil?
- How Do We Use, Abuse, and Conserve Soils?
- Pests and Pesticides
- Organic and Sustainable Agriculture

What is Soil?

- **Soil is a mixture of eroded rock, minerals, organic matter, water, air, and living organisms.**



How Soils Are Formed

- **Weathering breaks down rock to form soil.**
- **Formed by 3 types of WEATHERING:**
  - **Biological (plants and fungi)**
  - **Chemical (oxidation & water)**
  - **Physical (frost/thaw actions)**

ORGANIC COMPONENT

- ***Surface-litter*** **leaves, twigs, animal waste, fungi, etc. decomposes into *HUMUS.***
- **Humus does not break down any further.**
- **Contains the majority of minerals in soil.**

Soil Water

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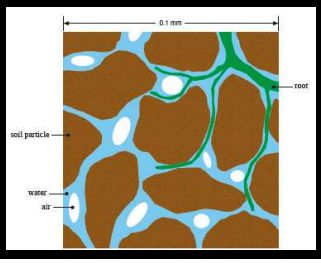


Resources for Agriculture

- Agriculture has dramatically changed our environment, altering patterns of vegetation soils and water resources worldwide.
- Some agricultural lands have been depleted in just a few decades while others have been sustained for centuries.
- Some farming practices degrade agricultural resources and some farming practices help to restore and rebuild these resources.

Soils are Complex Ecosystems

- Soil is a renewable resource that develops gradually through the weathering of rocks and the accumulation of organic material.
- The accumulation of topsoil is a very slow process. Under the best circumstances it accumulates at a rate of about 1 mm/year.
- With careful management, soil can be replenished and renewed indefinitely.
- Most farming techniques deplete soil through erosion and removal of organic material.
- Severe erosion rates can exceed 25 mm soil /year.

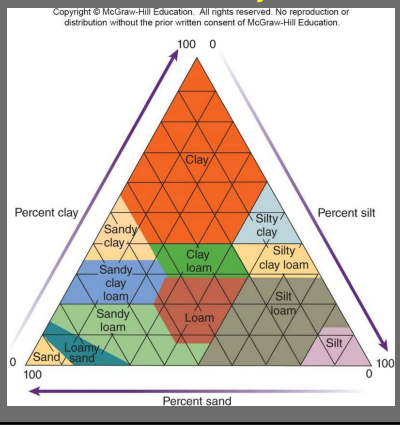
6 Components of Soil

- Soil is a marvelous, complex substance; an entire ecosystem that is hidden to most of us. In general it has 6 components:
  - Sand and gravel
  - Silts and clays
  - Dead organic material
  - Soil fauna and flora
  - Water
  - Air

Variation in Soil Composition

- Variation in the 6 components of soil can produce an almost infinite variety of soil types.
- Soil texture (the amount of sand, silt and clay in the soil) is the most important characteristic of soils.
- Loam soils are considered best for agriculture because they are a mixture of sand, silt and clay.
- Brazilian tropical soils are deeply weathered red clays which have little organic material. They hold few nutrients and water .
- The rich, black soils of the central US are rich in nutrients and organic material and contain a mixture of sand, silt and clay to hold moisture well

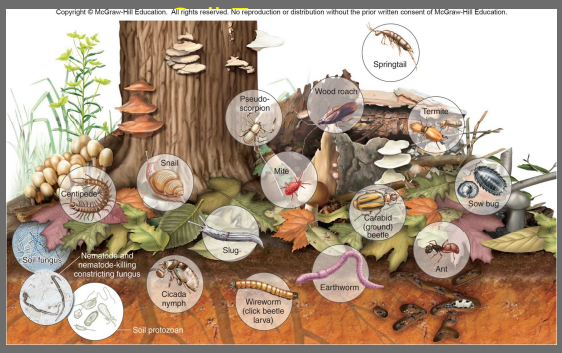
Soil Texture Pyramid



Grassland vs. Tropical Rainforest Soils

Soil Fauna Determine Fertility

- Soil bacteria, algae and fungi decompose leaf litter making recycled nutrients available to plants.
- A single gram of soil can contain hundreds of soil bacteria and 20 meters of tiny fungal strands.
- Tiny worms including nematodes process organic material and create air spaces as they burrow.
- Larger insects, spiders and mites loosen and aerate the soil as well.
- Mycorrhizal symbiosis, an association between plant roots and certain fungi. The plant feeds the fungus and the fungus provides water and inorganic nutrients to the plant enhancing growth.

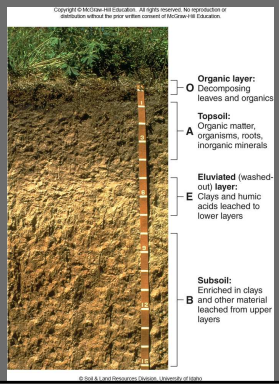


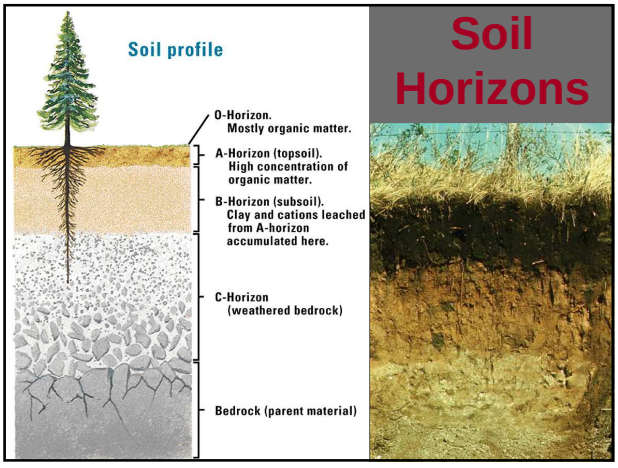
Soils are Layered

- Soils are stratified into horizontal layers called soil horizons.
  - Horizons taken together make up the soil profile.
    - O Horizon (Organic layer)
      - Leaf litter, most soil organisms and partially decomposed organisms
    - A Horizon (Surface soil)
      - Mineral particles mixed with organic material

Soil Profiles (cont.)

- E Horizon (washed out)
  - Depleted of soluble nutrients
- B Horizon (Subsoil)
  - Often dense texture due to clays
- C Horizon
  - Weathered rock fragments with little organic material
- Parent Material is the mineral material on which the soil is built, can be bedrock

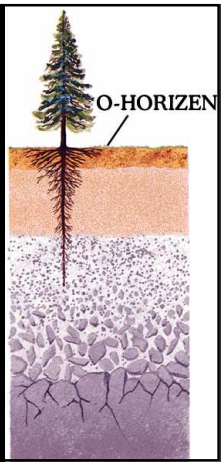




Soil Horizons

Soil Horizons

- O-Horizon
  -



•A-Horizon

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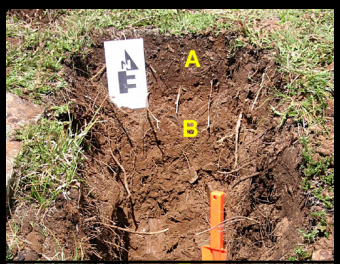

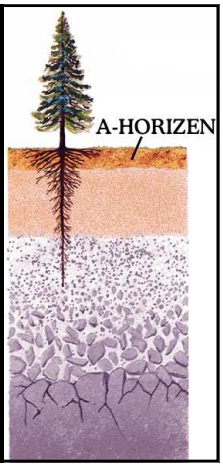

Food Comes from the A-Horizon

- Because soils are so important to our survival, we identify soils largely in terms of the thickness and composition of their upper layers.
- In the farm belt, the dominant soils are mollisols. These soils have a thick, organic-rich A-Horizon which developed from deep, dense roots when this land was covered by prairie grasslands.
- Alfisols are another soil type important for farming. These soils developed in deciduous forests and have a thinner A-Horizon and less organic material.
- Mollisols and Alfisols dominate most of the soils of farming country in the US.

•B-Horizon

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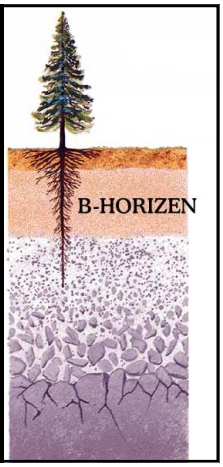

•C-Horizon

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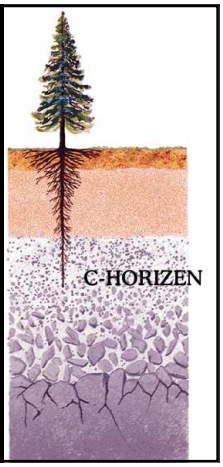
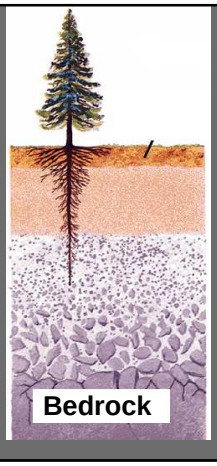


•Bedrock

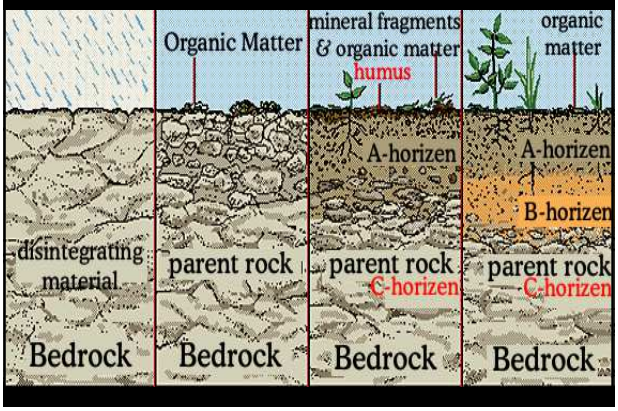
–The parent rock below.

–Helps determine the mineral component of soil.

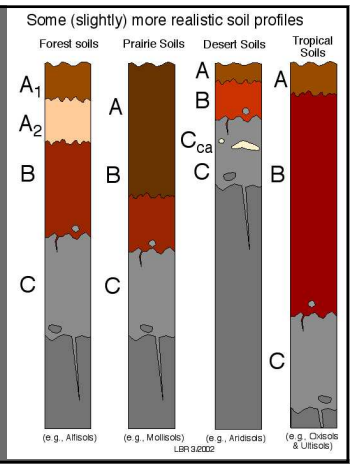
–How?



Horizon Formation

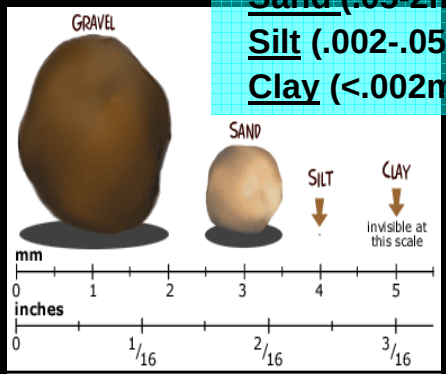


Different Soils have different layer profiles.

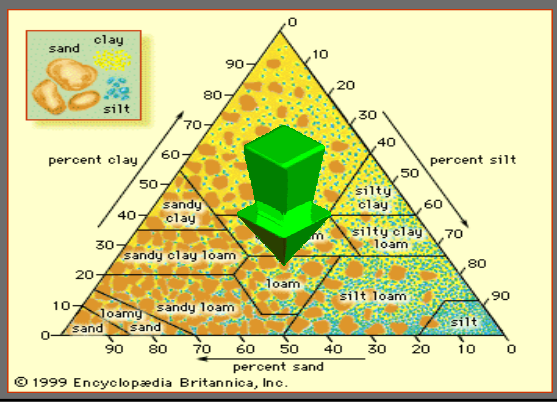


Soil Texture

Sand (.05-2mm)
Silt (.002-.05mm)
Clay (<.002mm)

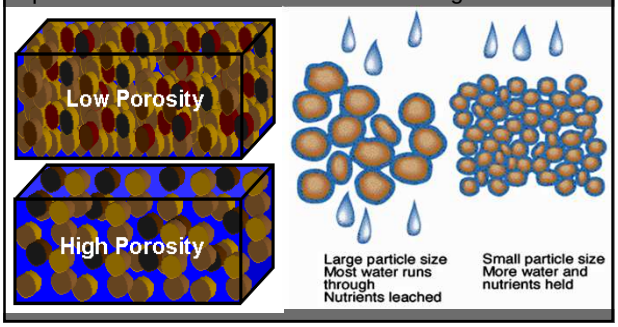


Soil Texture



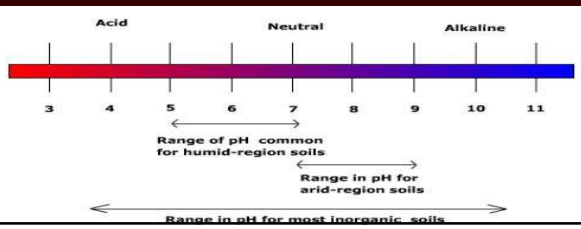
Porosity and Permeability

- ***Porosity-*** is the amount of space in-between soil particles.
- ***Permeability –*** how easily can water moved down through the soil.



Soil Acidity

- Acidic soil with a low pH inhibits uptake of positively charged calcium and magnesium because negative clay takes up the H+ ions.
- Optimum soil ph for plants is 6.5-7.5



Age of Soil

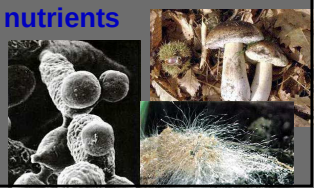
- **Older soils are mineral deficient (due to leeching over time).**
- **Recently- formed soils are mineral rich.**
- **The San Joaquin Valley is geologically recent with fertile soils (hence all the agriculture here).**

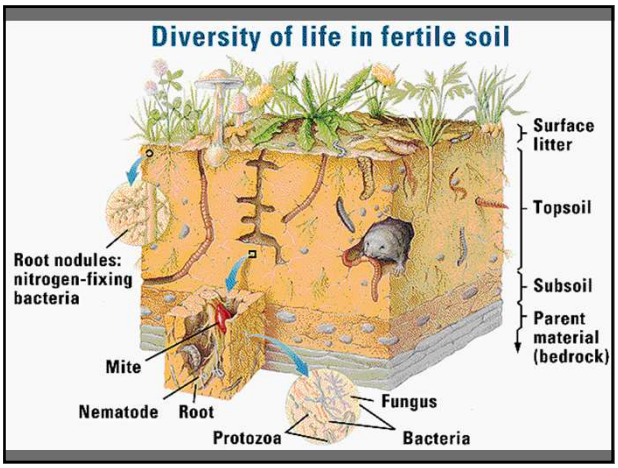
Soil Organisms

- Soil organisms breakdown organic material releasing inorganic nutrients for plants.

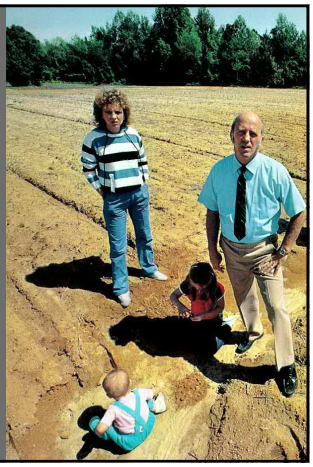
Primary decomposers
- Worms, snails, pillbugs
- Aerate soil

Secondary decomposers
- Bacteria and fungi
- Help to cycle nutrients





Soil Problems



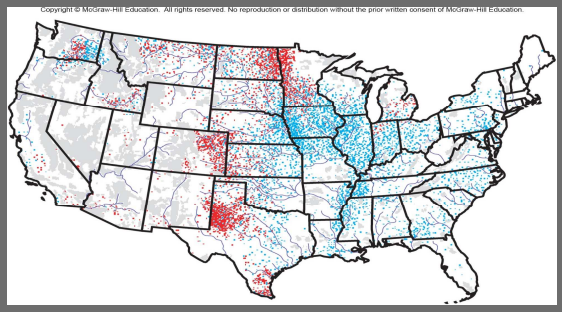
Ways We Use and Abuse Soil

- Approximately 12.5% of the earth's land area is currently in agricultural production.
  - Up to four times as much could potentially be converted to agricultural use.
    - However, much of this additional land suffers from constraints such as steep slope, soggy soil, is too cold, too dry or has too much salt.
- The ecological effects of converting these lands to agriculture include loss of biodiversity, clean water and other ecological services provided by these grasslands or forests.

Arable Land Unevenly Distributed

- Arable land is unevenly distributed across the world. The best farming occurs in moderate climates with thick fertile soils.
- North America and Europe are particularly well suited to growing while some other parts of the world lack suitable soil, topography and climate.
- Gains in agricultural production have come from increased fertilization, pesticides and irrigation rather than more land.
- As productivity in North America and Europe has increased in recent years some marginal lands have been retired and less land is now cultivated than in the past.

Excess Wind and Water Erosion in the US



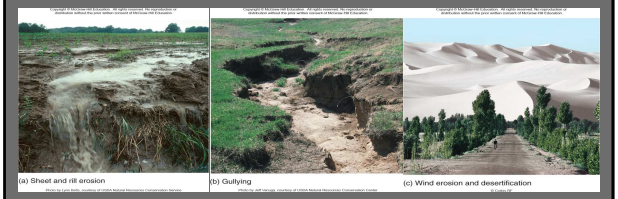
Soil Losses Cut Farm Production

- Every year, about 3 million hectares of cropland worldwide are made unusable by erosion and another 4 million hectares are converted to non-agricultural uses.
- Most land degradation happens slowly as soil washes or blows away, salts accumulate and organic matter is lost.
- As a consequence of these processes, as well as increases in world population, arable lands worldwide have shrunk from 0.38 ha/person in 1970 to 0.23 ha/person in 2000.

Water Moves Soil in Various Ways

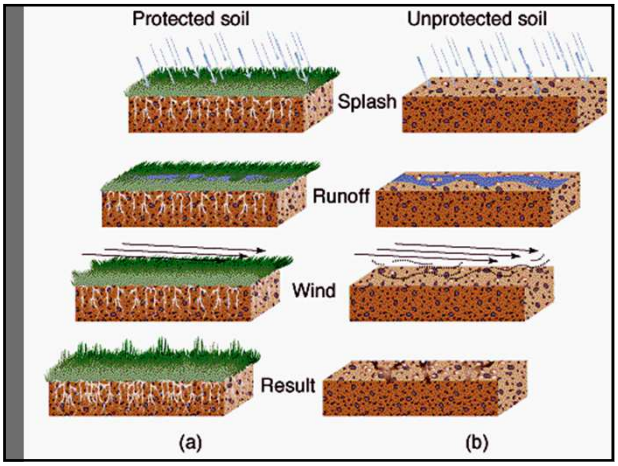
- A farm can lose up to 20 metric tons of soil/hectare/year from one of these processes:
  - Sheet Erosion - thin layer of surface removed
  - Rill Erosion - small rivulets of running water gather together and cut small channels
  - Gully Erosion - rills enlarge to form bigger channels too large to be removed by normal tillage
  - Stream Bank Erosion - washing away of soil from banks of streams and rivers

Soil Loss Due to Water



Wind Also Moves Soil

- Wind can equal or exceed water as an erosive force, especially in a dry climate and on flat land.
- Desertification - conversion of productive land to desert
  - Intensive farming practices responsible for erosion:
    - Row crops leave soil exposed
    - Weed-free fields
    - Removal of windbreaks
    - No crop-rotation or resting periods for fields
    - Continued monoculture cropping can increase soil loss tenfold

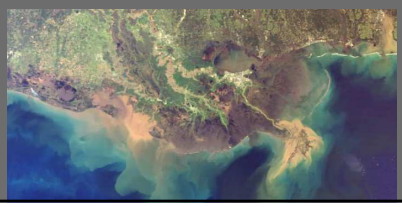


Soil Erosion

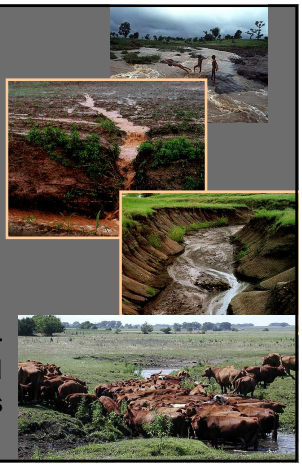
•Soil Erosion is the movement of soil from one place to another.
•Caused by wind and flowing water.
•Plants anchor soil preventing erosion.

The problem with Erosion

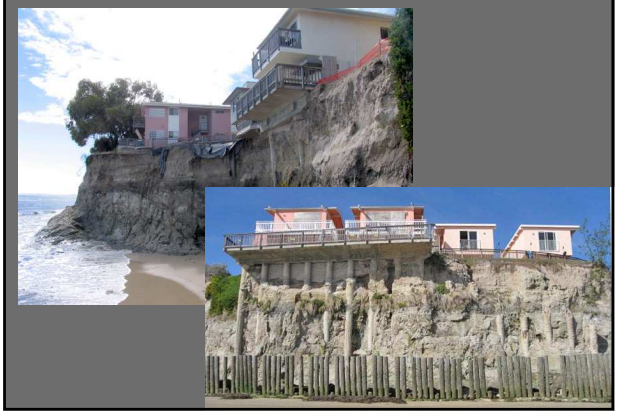
- Soil erosion causes loss of minerals, agricultural productivity, stability, aesthetic.
- Human activities such as logging, farming, and grazing, can destroy in decades what nature took hundreds to thousands of years to produce.



- **Sheet Erosion** – uniform sheets of soil are removed
- **Rill Erosion** – rivulets gather water and cut small channels
- **Gully Erosion** – water follows channels and cuts
- **Streambank Erosion** – vegetation is removed and loose soil washes away



Erosion at UCSB – Isla Vista

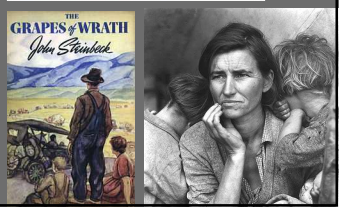


American Dust Bowl

Dust storm outside of Barstow, CA

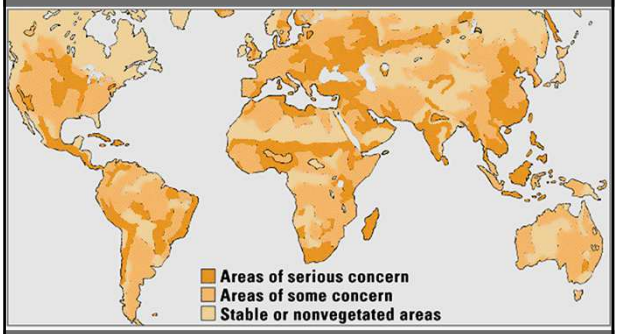
The American Dust Bowl

- Root Cause:
- Farmers removed native plants that anchored the soil year round and planted crops that only anchored the soil part of the year.
- This left loose soil on the surface.



The American Dust Bowl

World-wide Soil Degradation



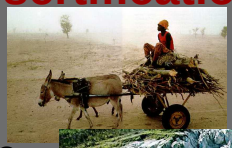
Desertification

- ***Arable (farmable) land next to dry areas is being converted into desert.***
- ***Caused by climate change and human population needs.***

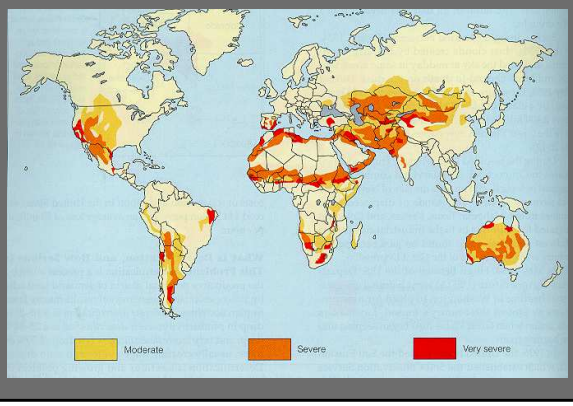
- *Greatest losses occurring in nutrient poor soils of Africa and India*
- *1 Billion people depend on nutrient-poor soil for food*

Leading to Desertification

- **Overgrazing of rangelands**
- **Deforestation**
- **Surface mining w/o reclamation**
- **Farming low quality land**
- **Soil compaction**

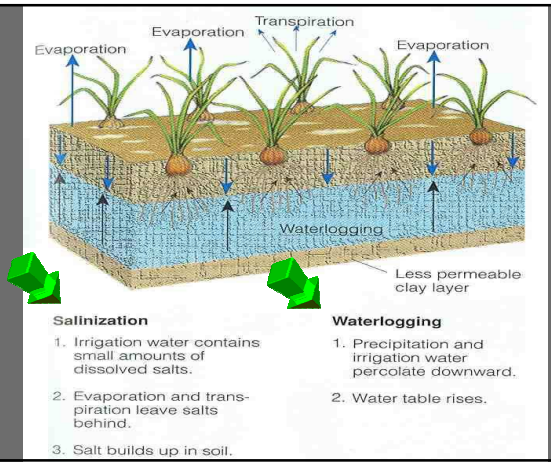


Desertification



Deserts are Spreading

- Desertification of productive lands threatens 1/3 of the earth's surface and over 1 billion people
- Rangelands and pastures are highly susceptible (overgrazing, soil degradation).
- Africa and China are of particular concern.
  - Rapid population growth and poverty create unsustainable pressures.
  - Removal of trees for fodder and firewood triggers climate change that spreads desertification.

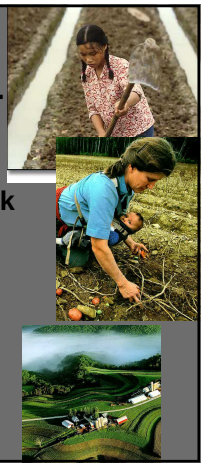


Solutions

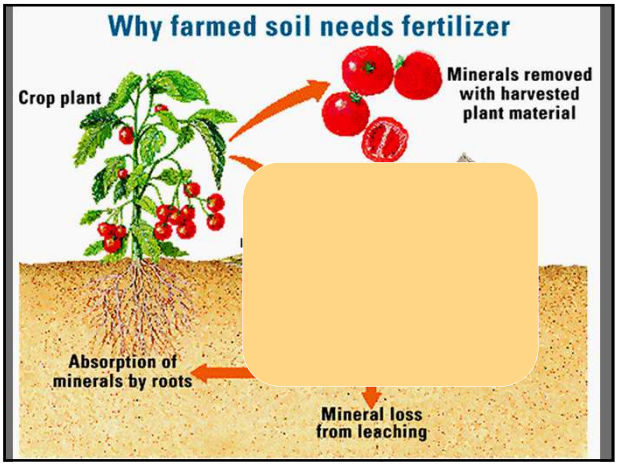
- Soil Erosion Act of 1935.
  - Gave technical assistance to farmers.
- 1985 Farm Act
  - *Conservation Reserves* give farmers a subsidy for not farming and planting soil-saving grasses or trees for 10 years. (1994 15 million Hectares)
  - Required 5 year soil conservation plans
  - Forgave debts for not farming highly erodable croplands or wetlands and restoring them.

Soil Conservation & Regeneration

- Problem: Traditional Tillage (farming) removes all plant material. Increases Leaching.
- Solutions
- Conservation Tillage – last years crop residue mixed back into soil. Increasing water holding capacity and nutrients.
- Crop rotation – alternation of crops (corn-soybeans oats-corn)

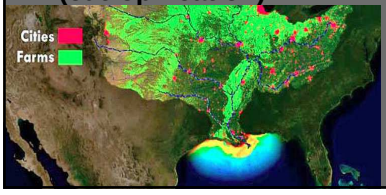


- Contour Plowing – plowing against the slope to reduce runoff.
- Strip Farming – planting different crops in rows. Harvesting at different times.
- Terracing – creating flat shelves in steep slopes.
- Alley Cropping – trees and crops planted in alleys.
- Windbreaks – reduce wind erosion



Adding Fertilizer: N, P, K

- Inorganic Fertilizers:
  - + fast-acting, soluble,
  - - don't add humus, quick to leach out and pollute waterways (eutrophication)



Animal Manure – adds nutrients

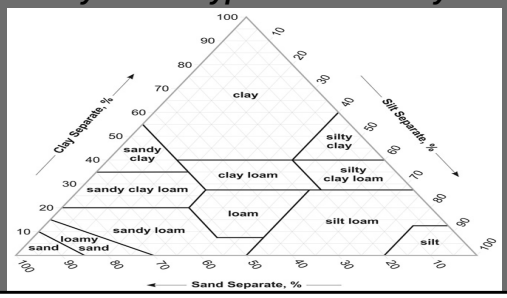
Compost– adds humus, nutrients, water retention, etc.

We can no more manufacture a soil with a tank of chemicals than we can invent a rain forest to produce a single bird. We may enhance the soil by helping its processes along, but we can never re-create what we destroy. The soil is a resource for which there is no substitute.

Historian Donald Worster.

What type of soil did you have?

- *Calculate the % of sand, silt, clay.*
- *Use the soil triangle to determine type.*
- *Record your soil type at the end of your lab.*



(a)

Courtesy Natural Resource Conservation Service

Soil Conservation

– Managing Topography

- Contour Plowing - plowing across slope to slow flow of water
- Strip Farming - planting different crops in alternating strips along land contours
- Terracing - shaping land to create level shelves of earth to hold water and soil
- Plant perennial species.

(a)

Photo by Lynn Betts, courtesy of USDA Natural Resources Conservation Service

(b)

Ground Cover Protects Soil

- Methods of Providing Ground Cover
  - Annual row crops cause highest rates of erosion because they leave soil bare for much of the year.
    - Plant cover crops such as clover after harvest.
    - Interplant two different crops in the same field. Harvest one; the other is left to hold the soil. Double harvests are an advantage as well.
    - Mulch

Low Input Sustainable Agriculture

- Small scale, low input agriculture
- No synthetic chemicals
- Raising cows on pasture grass rather than grain
- Antibiotics used only to treat diseases
- Typically produces smaller yield, but production costs are lower and prices are higher so net gain is higher
- Preserves rural culture

Consumers Play an Important Role

- A vegetarian diet can reduce environmental impact related to energy input
- An organic diet can reduce environmental impact related to pesticide use.
- An even greater impact can be made by becoming a locavore, a person who eats locally grown, seasonal food.
- Join a community supported agriculture program (CSA) in which you make a payment to a local farm in return for weekly deliveries of food.