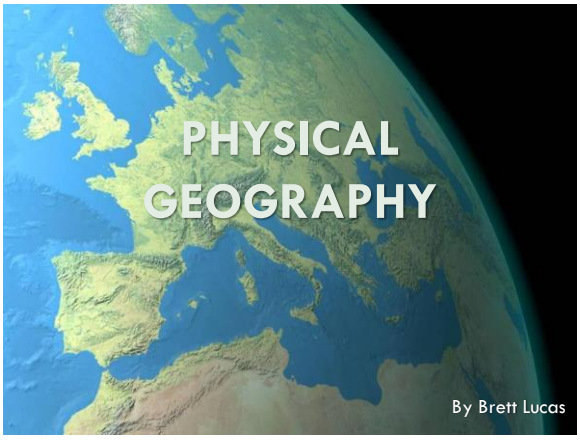



## SOILS

## Soils

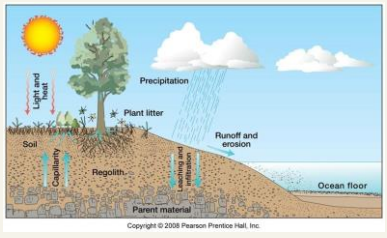
- Soil and Regolith
- Soil-Forming Factors
- Soil Components
- Soil Properties
- Soil Chemistry
- Soil Profiles
- Pedogenic Regimes
- Global Distribution of Soils
- Distribution of Soils in the United States

## Soils and Regolith

- Nature of Soil
  - Mixture of weathered mineral particles, decaying organic matter, living organisms, gases, and liquid solutions
  - Depth
    - Thin, top layer of Earth's crust (average worldwide depth – 6 inches!)
    - From Earth's surface to as far as living organisms penetrate
  - Part of lithosphere (mostly inorganic material)
    - Interface where lithosphere and the atmosphere, hydrosphere, and biosphere interact (see next slide)
    - Begins with the weathering (disintegration) of rock

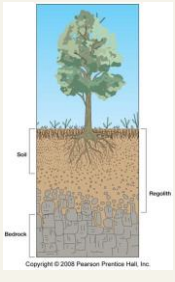
## Soils and Regolith

- As stated before, soil is a product of processes operating above, on and beneath the land surface (atmospheric, weathering, decaying matter, burrowing of animals, etc)



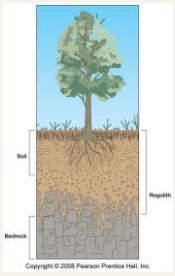

## Regolith

- Regolith
  - layer of fragment rock from which soil eventually develops.
  - Relationship between soil, regolith and bedrock – soil comes from regolith, and regolith comes from the bedrock.



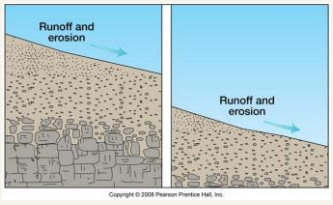
## Soil-Forming Factors

- The Geologic Factors
  - Parent material
    - Raw material for soil formation. This could be ANY of the following:
  - Bedrock
  - Alluvium
  - Volcanic ash
- The Climatic Factor
  - Temperature and weathering rates
  - Moisture and infiltration



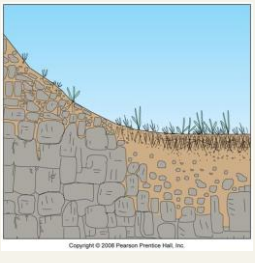

## Soil-Forming Factors

- The Topographic Factor
  - Slope angle and erosion rates
    - Steeper slopes experience more erosion.
    - Usually, bottom layer of soil is lowered by weathering into the bedrock; top layer by erosion




## Soil-Forming Factors

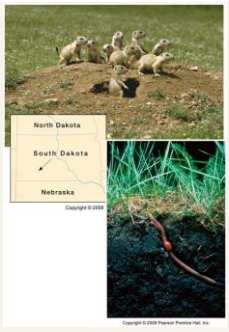
- Slope and soil depth – the deepest soils are usually on flat land (bottom of hills). This is were weathering *exceeds* erosion.




Slope is a determinant of soil depth, as seen in this diagram. Soils are deeper at the bottom of a slope.

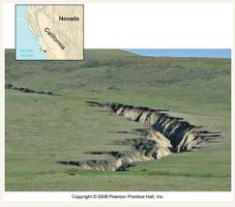
## Soil-Forming Factors

- The Biological Factor
  - Organic matter
    - Nutrients for plants
    - Soil texture and color
  - Soil aeration and mixing
    - Root penetration
    - Burrowing animals
  - Earthworms
    - Soil aeration and mixing
  - Microorganisms in the soil
    - Humus formation



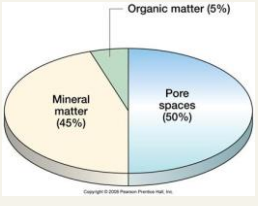

## Soil-Forming Factors

- The Chronological Factor
  - Soil-forming processes are very slow, sometimes requiring centuries for a thin layer.
  - Human perspective
    - Therefore soils are a non-renewable resource from a human time-frame (well, up to a point – i.e. unless left to "fallow" as done by traditional societies).
    - However, soils develop much quickly from sediments than from bedrock.



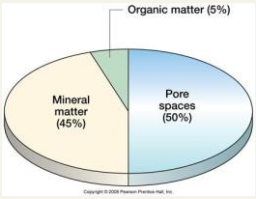

## Soil Components

- Inorganic Materials (Mineral Matter)
  - Granular matter
    - Sand (quartz/$SiO_2$)
    - Silt (feldspars and micas)
    - Clay particles (colloidal-size)



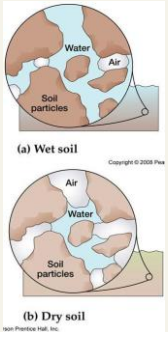
## Soil Components

- Organic Matter
  - Sources
    - Dead plant material (litter) and animals
    - Fecal matter of animals
    - Humus is end product
  - Enhances soil structure and texture
  - Role in Soil fertility
    - Aids in cation (nutrient) exchange
    - Carbon-based nutrients for plants



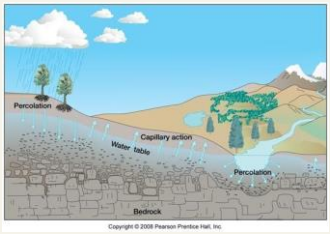

## Soil Components

- Soil Air (Pore Spaces)
  - Interstices (pathways for air)
  - Spaces for water storage
  - Gases
    - $CO_2$ abundant (from plant respiration)
    - $O_2$ depletion (used by roots and soil organisms)



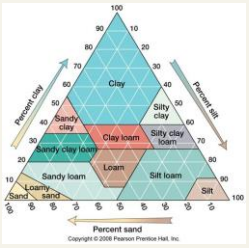

## Soil Components

- Soil Water
  - Percolation from above
    - Rainwater and snowmelt
  - Groundwater from below – *most important* to plants
    - **Capillary action** (pulls water up)



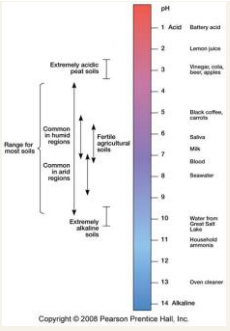
## Soil Properties

- Standard Soil Texture Triangle – loam is the texture in which none of the main types (sand, silt or clay) predominates. The best for plant growth.

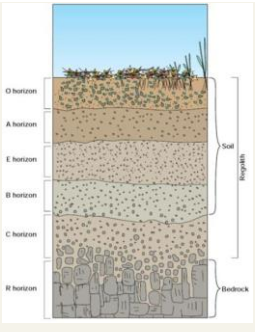

## Soil Chemistry

- Acidity/Alkalinity
  - pH of a solution
    - Acidic solution
    - Basic solution (alkaline)
  - pH scale (0 to 14)
  - Role in soil fertility (neutral is best for plants, pH 7)



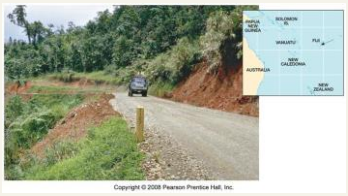

## Soil Horizons

- O horizon
  - Organic matter - Esp. found in forests
- A horizon
  - Top soil/dark color
- E horizon
  - Eluviation layer (mineral particles carried downwards)
- B horizon
  - Illuviation layer (minerals deposited); and true soil (solum) only extends to this layer
- C horizon
  - Beyond reach of roots
- R horizon
  - bedrock



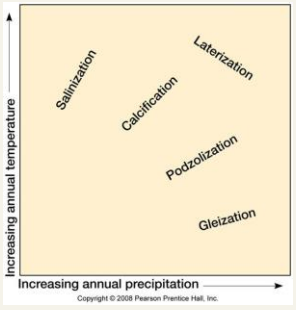
## Pedogenic (Soil-Forming) Regimes

- Laterization
- Podzolization
- Gleization
- Calcification
- Salinization




## Pedogenic (Soil-Forming) Regimes

- Climate and Pedogenic Regimes
- Temperature–Moisture Relationships

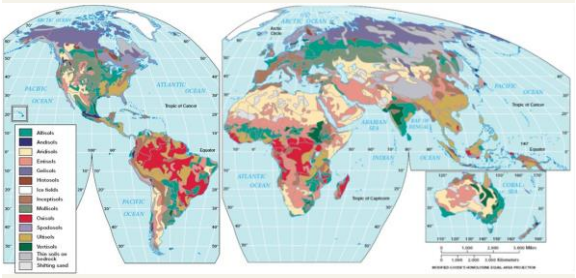



## Soil Classification

- The Soil Taxonomy (U.S. System)
  - Based on observable/existing soil characteristics and a hierarchical system
  - Levels*
    - Orders (highest and most generalized level) – 12 of them, see next slides. Pg 372-374. *See Appendix VII for more details.
    - Suborders – about 50
    - Great groups – about 250
    - Subgroups, families, and series (about 19,000 soil series in the United States)

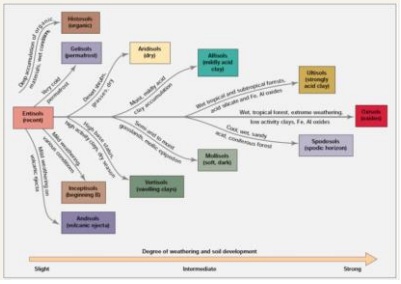
    More info can be obtained from the USDA and the U.S. Soils Conservation Service.

## Soil Classification



## Global Distribution of Major Soils

- The general relationship among the soil orders in terms of weathering, soil development, and broad environmental conditions.



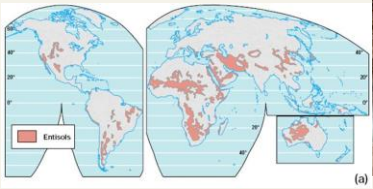

## Global Distribution of Major Soils

**TABLE 12-2** Name Derivations of Soil Orders

| Order | Derivation |
|---|---|
| Alfisols | "al" for aluminum, "f" for iron (chemical symbol Fe), two prominent elements in these soils |
| Andisols | andesite, rock formed from type of magma in Andes Mountains volcanoes; soils high in volcanic ash |
| Aridisols | Latin *aridus*, "dry"; dry soils |
| Entisols | last three letters in "recent"; these are recently formed soils |
| Gelisols | Latin *gelatio*, "freezing"; soils in areas of permafrost |
| Histosols | Greek *histos*, "living tissue"; these soils contain only organic matter |
| Inceptisols | Latin *inceptum*, "beginning"; young soils at the beginning of their "life" |
| Mollisols | Latin *mollis*, "soft"; soft soils |
| Oxisols | soils with large amounts of oxygen containing compounds |
| Spodosols | Greek *spodos*, "wood ash"; ashy soils |
| Ultisols | Latin *ultimus*, "last"; soils that have had the last of their nutrient bases leached out |
| Vertisols | Latin *verto*, "turn"; soils in which material from O and A horizons falls through surface cracks and ends up below deeper horizons; the usual horizon order is inverted |

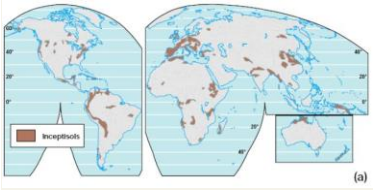
## Entisols

- "Ent", from recent formation
- Very little profile development
  - Thin and sandy
  - Low fertility



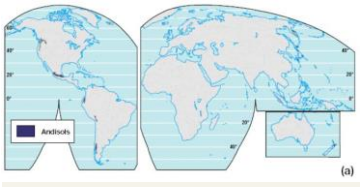

## Inceptisols

- Latin *Inceptum*, "beginning", young
- Few Diagnostic Features
  - Faint horizons
- Tundra, mountains, old valley bottoms



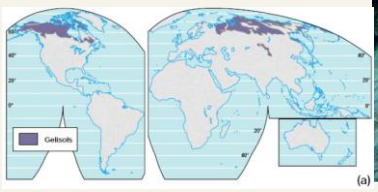

## Andisols

- "Andi", andesite (a lava rock) named after the Andes Mts.
- Volcanic ash soils
- Mild weathering
- Inherently very fertile




## Gelisols

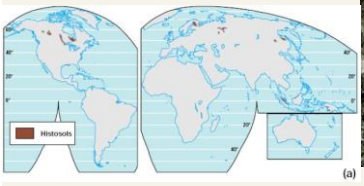
- Latin *gelatio*, "freezing"
- Permafrost layer
- Young soils
- Arctic and subarctic regions





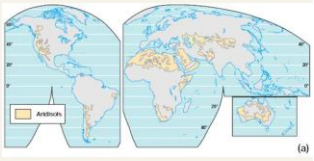
## Histosols

- Greek *histos*, "living tissue"
- Organic soils
- Waterlogged conditions
  - Glaciated areas
  - Poorly drained coastal areas



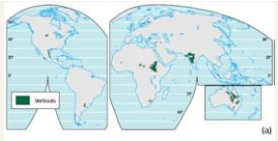

## Aridisols

- Latin *aridus*, "dry"; dry soils
- Thin, low organic content
- High in soluble minerals
- Unproductive due to lack of moisture, but can become some of the most productive lands, if irrigated. E.g. the Middle East.



## Vertisols

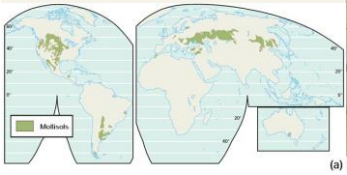
- Latin verto, "turn"
- Swelling and cracking clays (as they absorb water and then dry out)
- Alternating wet and dry climate
  - Causes churning effect that inhibits soil-horizon development





## Mollisols

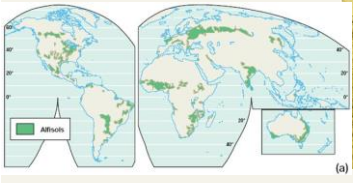
- Latin *mollis*, "soft"; soft soils
- Best agricultural soil
  - Rich clay-humus content
- Central Eurasia, Pampas of Argentina, North American Great Plains





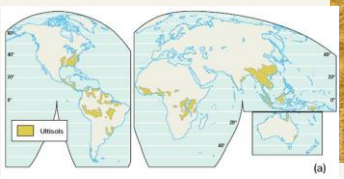
## Alfisols

- "al" for aluminum, "f" for iron
- Moderate leaching
  - Subsurface clay accumulation with high nutrient bases
- Second to Mollisols in fertility




## Ultisols

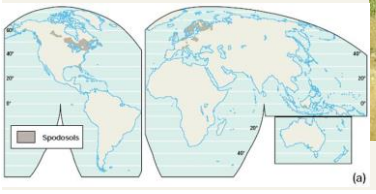
- Latin ultimus, "last"; has the last of their nutrient bases leached out
  - Low fertility due to leaching
  - Reddish color throughout
- Possible fate of Alfisols





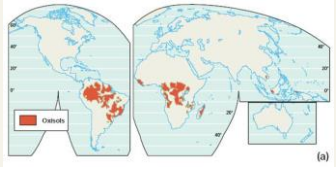
## Spodosols

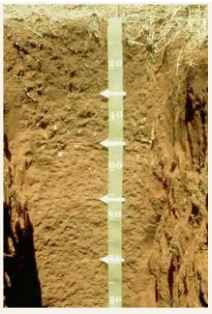
- Greek *spodos*, "wood ash"
- Light color due to heavy leaching
  - Notoriously infertile
- Acid, sandy forest soils
  - Forms under coniferous forest



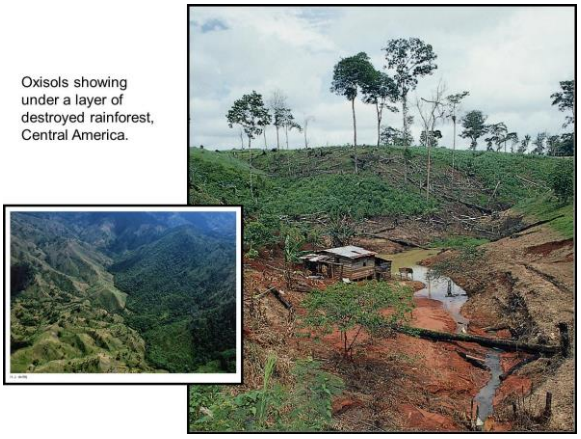

## Oxisols

- "Ox", large amount of oxygen and iron containing compounds
- Highly weathered and leached
  - laterization (Alt. : Latosols)
  - Infertile
- Humid tropics (esp. rainforests)

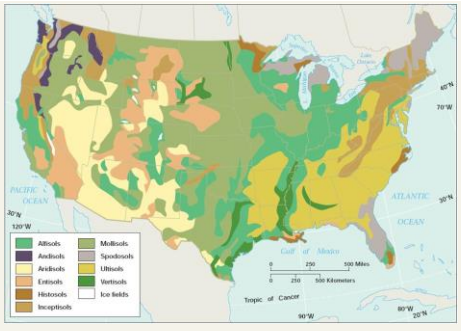


Oxisols showing under a layer of destroyed rainforest, Central America.



## Distribution of Soils in the United States (Lower 48 States)




## Soils

**TABLE 12-3** Approximate Proportional Extent of Soil Orders

| | *Percentage of Land Area Occupied* | |
|---|---|---|
| Order | United States | World |
| Alfisols | 14.5 | 9.7 |
| Andisols | 1.7 | 0.7 |
| Aridisols | 8.8 | 12.1 |
| Entisols | 12.2 | 16.3 |
| Gelisols | 7.5 | 8.6 |
| Histosols | 1.3 | 1.2 |
| Inceptisols | 9.1 | 9.9 |
| Mollisols | 22.4 | 6.9 |
| Oxisols | — | 7.6 |
| Spodosols | 3.3 | 2.6 |
| Ultisols | 9.6 | 8.5 |
| Vertisols | 1.7 | 2.4 |

Source: Nyle C. Brady and Ray R. Weil, *The Nature and Properties of Soils*, Upper Saddle River, NJ: Prentice Hall, 1999, p. 86.