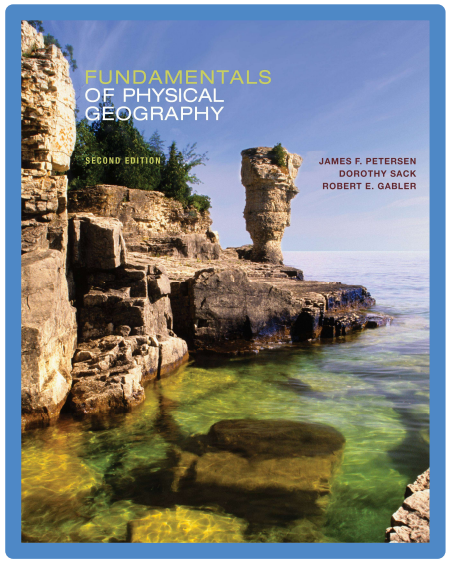
Fundamentals of Physical Geography 2e

Biogeography and Soils

9



- Peterson
  - Sack
    - Gabler

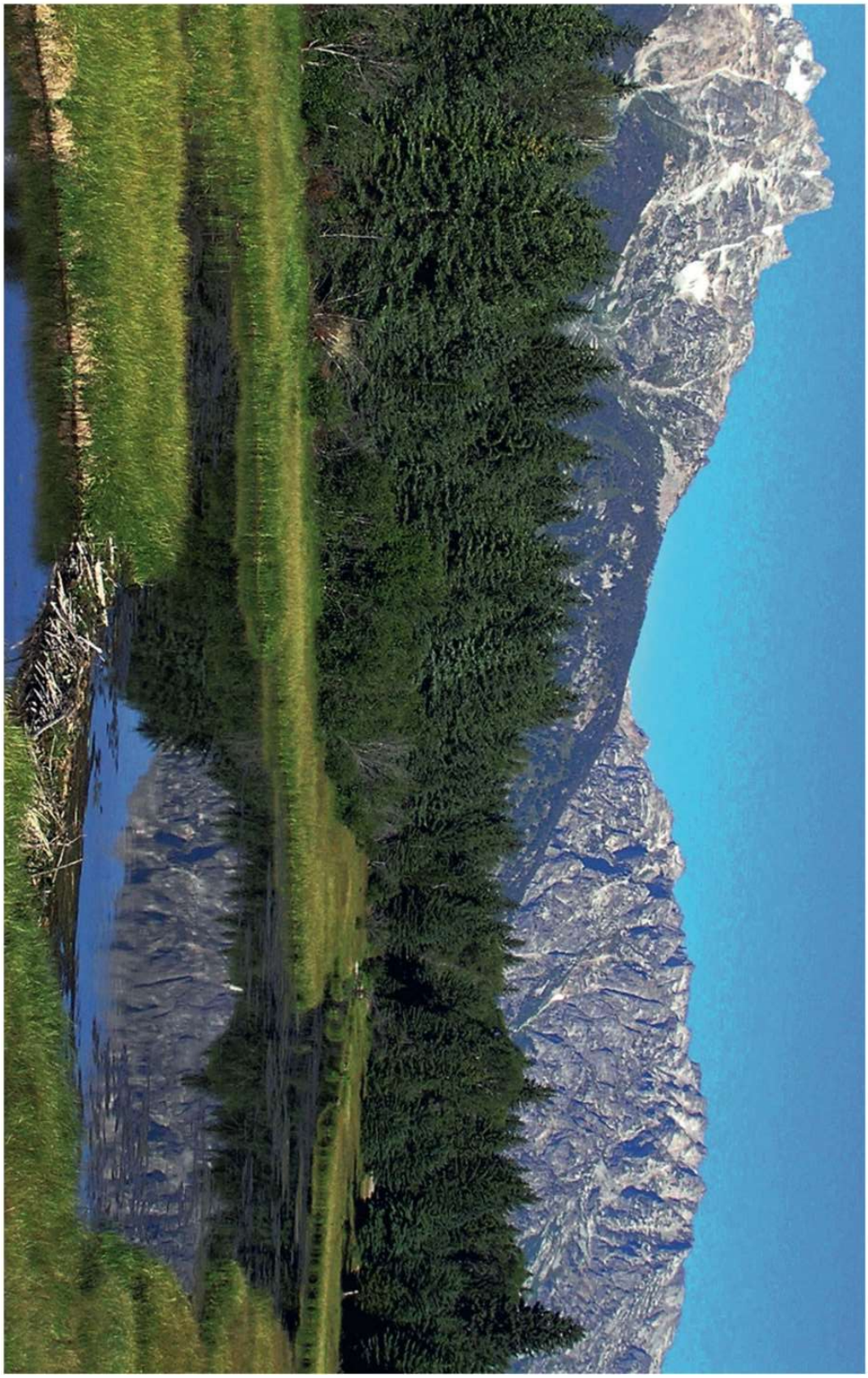
Introduction

- Biogeography
  - Study of how environmental factors affect
    - Plants and animals: locations, distributions, and life processes
- Soil characteristics
  - Reflect interactions: climate, vegetation, rocks, minerals, and fauna
- Microenvironments
  - Organisms above and beneath the surface

Ecosystems

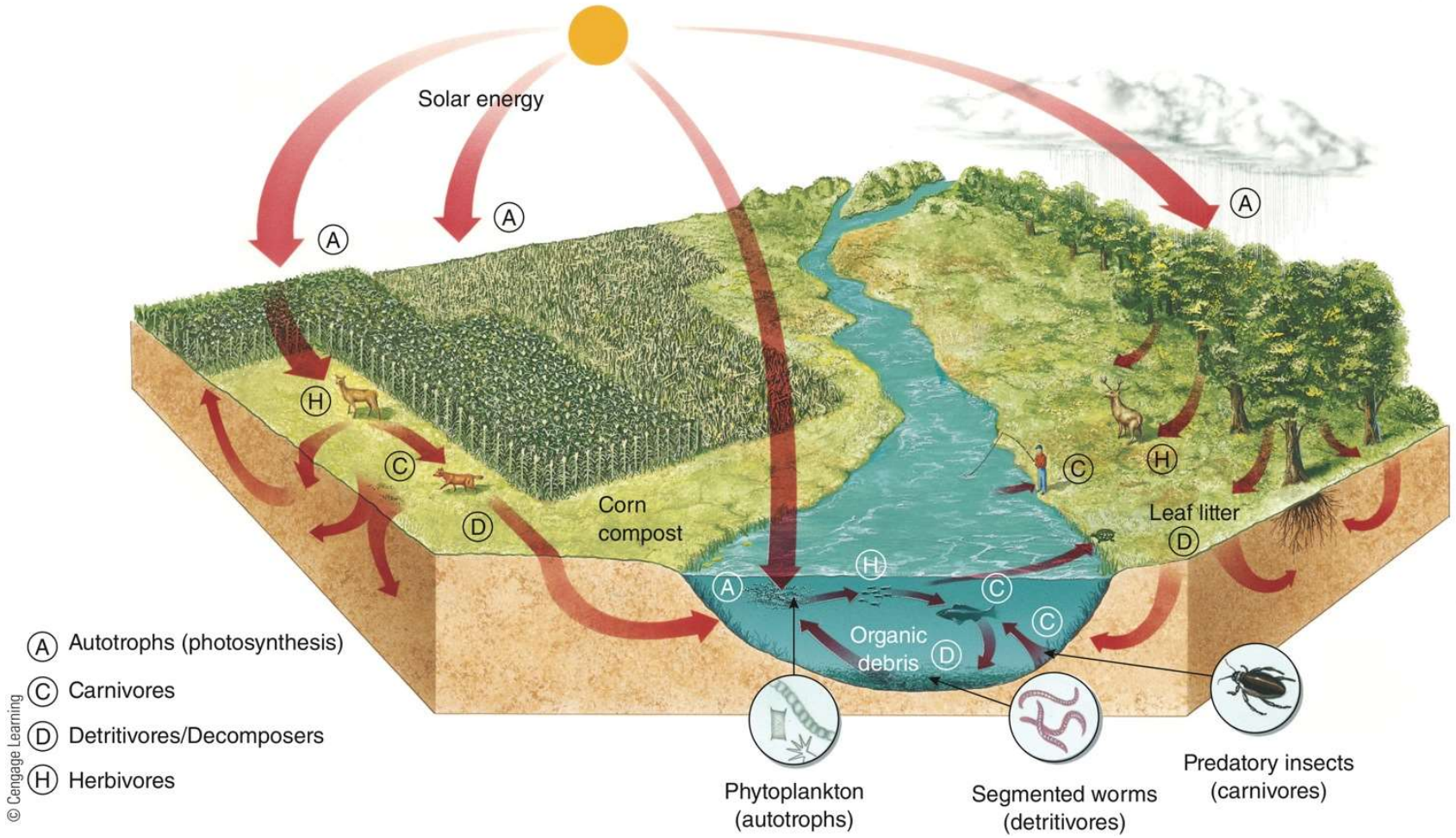
- Communities of organisms that occupy given areas
  - Living together: interdependent relationships
- Studied on local or regional basis
- Ecosphere: entire Earth system
- Open systems
  - Energy and materials move in and out

Erin Himmel/National Park Service



Ecosystems (cont'd.)

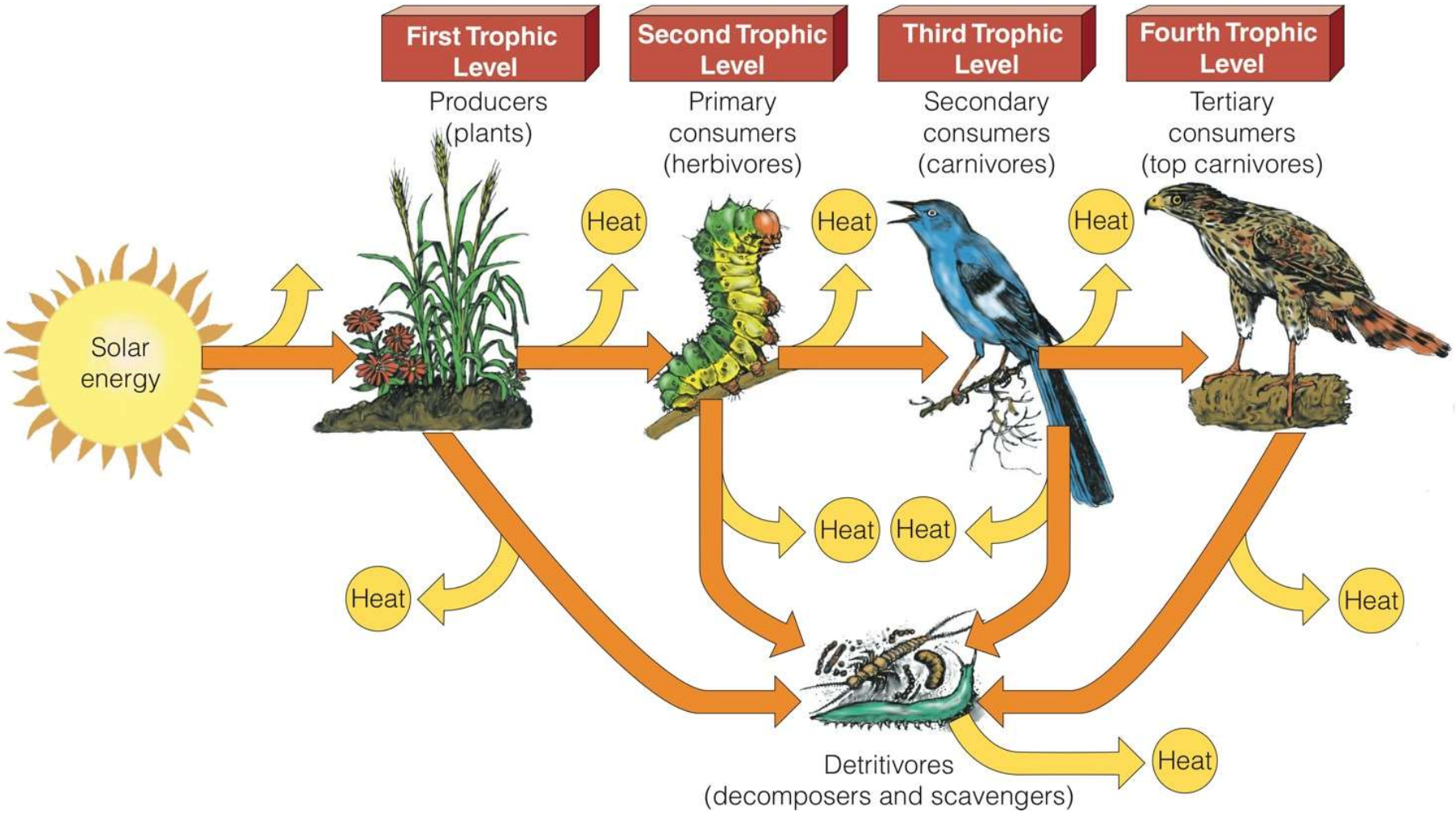
- Ecosystem components
  - Non-living (abiotic) parts
    - Life-supporting elements and compounds
  - Basic producers (autotrophs)
    - Plants, bacteria, and sulfur-dependent organisms
  - Consumers (heterotrophs): eat plants or other animals
    - Herbivores, carnivores, and omnivores
  - Decomposers (detrivores)



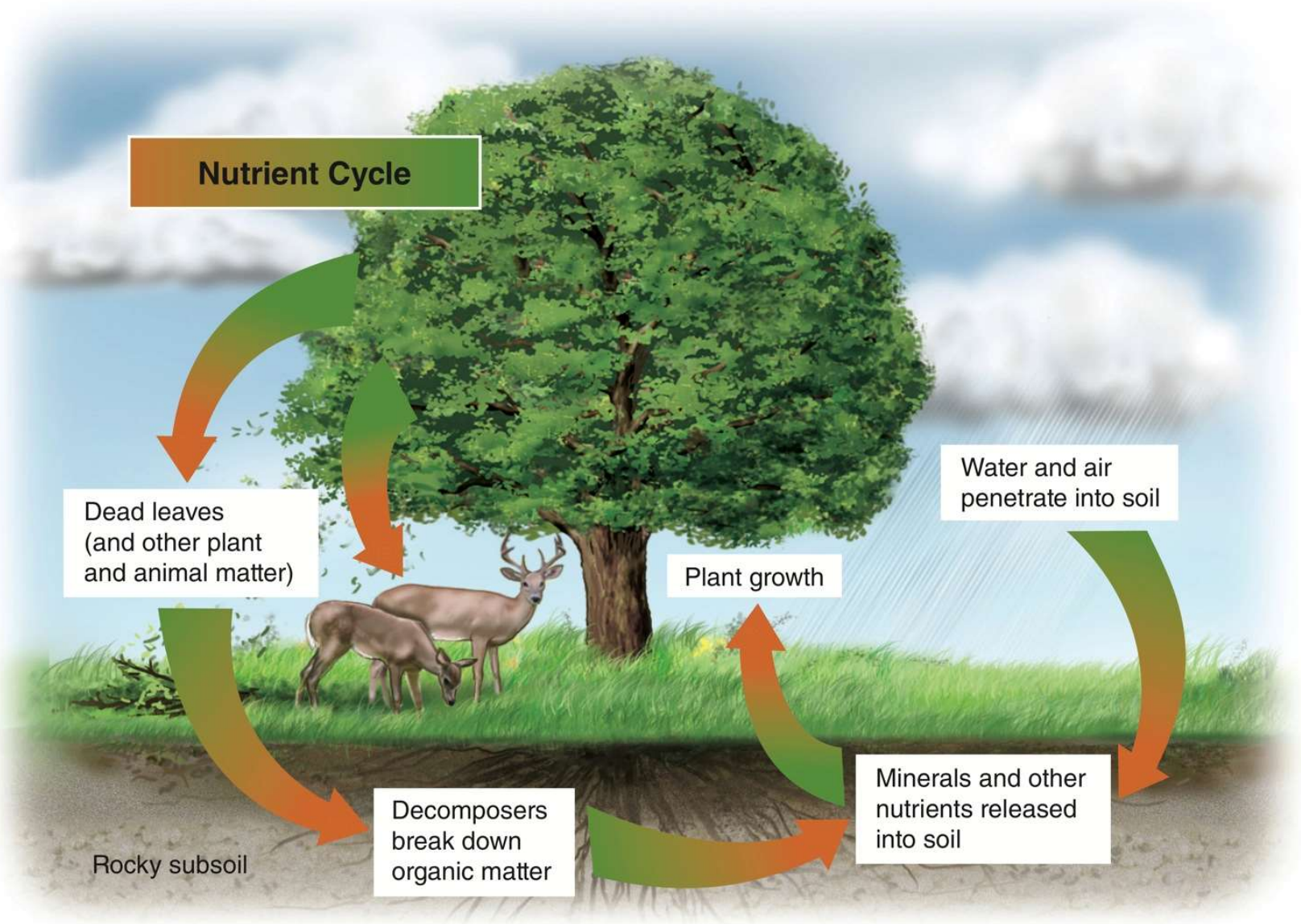
What examples of a producer, a consumer, and a decomposer are in this image?

Ecosystems (cont'd.)

- Trophic structure
  - Food chain
  - Trophic level
    - Number of steps removed from producers
  - Food web
    - Feeding network within an ecosystem
  - Movement of food and energy: traced from one level to another
  - Nutrient cycles: water, carbon, nitrogen, etc.



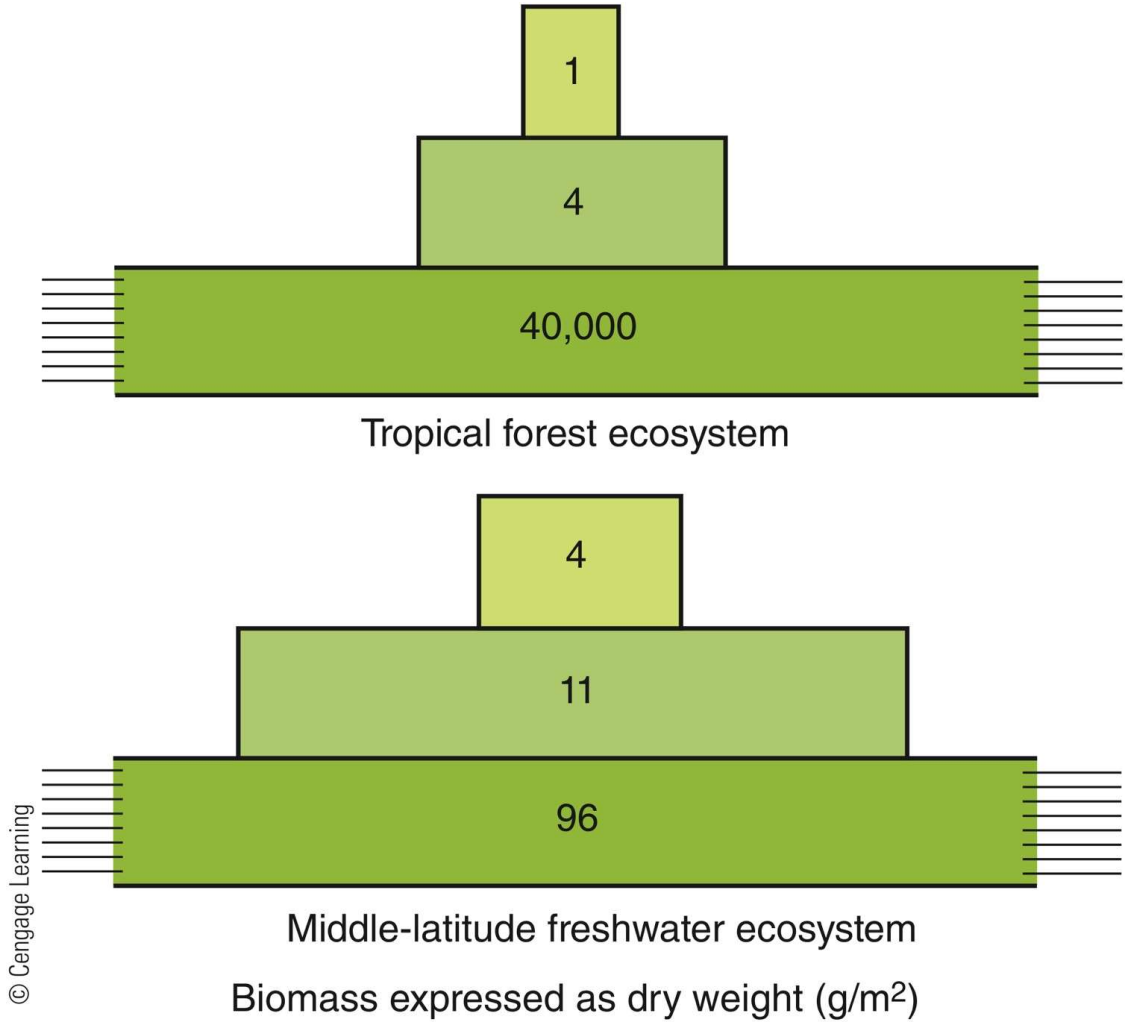
Can you outline a trophic structure through four trophic levels that exists where you live?



What processes are taking place in the soil beneath the surface?

Ecosystems (cont'd.)

- Energy flow and biomass
  - Sunshine ► plants (photosynthesis) ► energy stored in organic materials (plants and animals)
  - Biomass
    - Measured in trophic levels: trace energy flow
  - What accounts for food energy loss between trophic levels?



How can you explain the exceptionally large loss of biomass between the first and second trophic levels of the tropical forest ecosystem?

Ecosystems (cont'd.)

- Primary productivity: new organic material
  - Photosynthesis impacted by:
    - Latitude
    - Soil moisture
    - Temperature
    - Nutrients
    - Carbon dioxide levels
    - Plants: age and species
  - Ecosphere's annual net primary productivity
    - About 170 billion metric tonnes

Ecosystems (cont'd.)

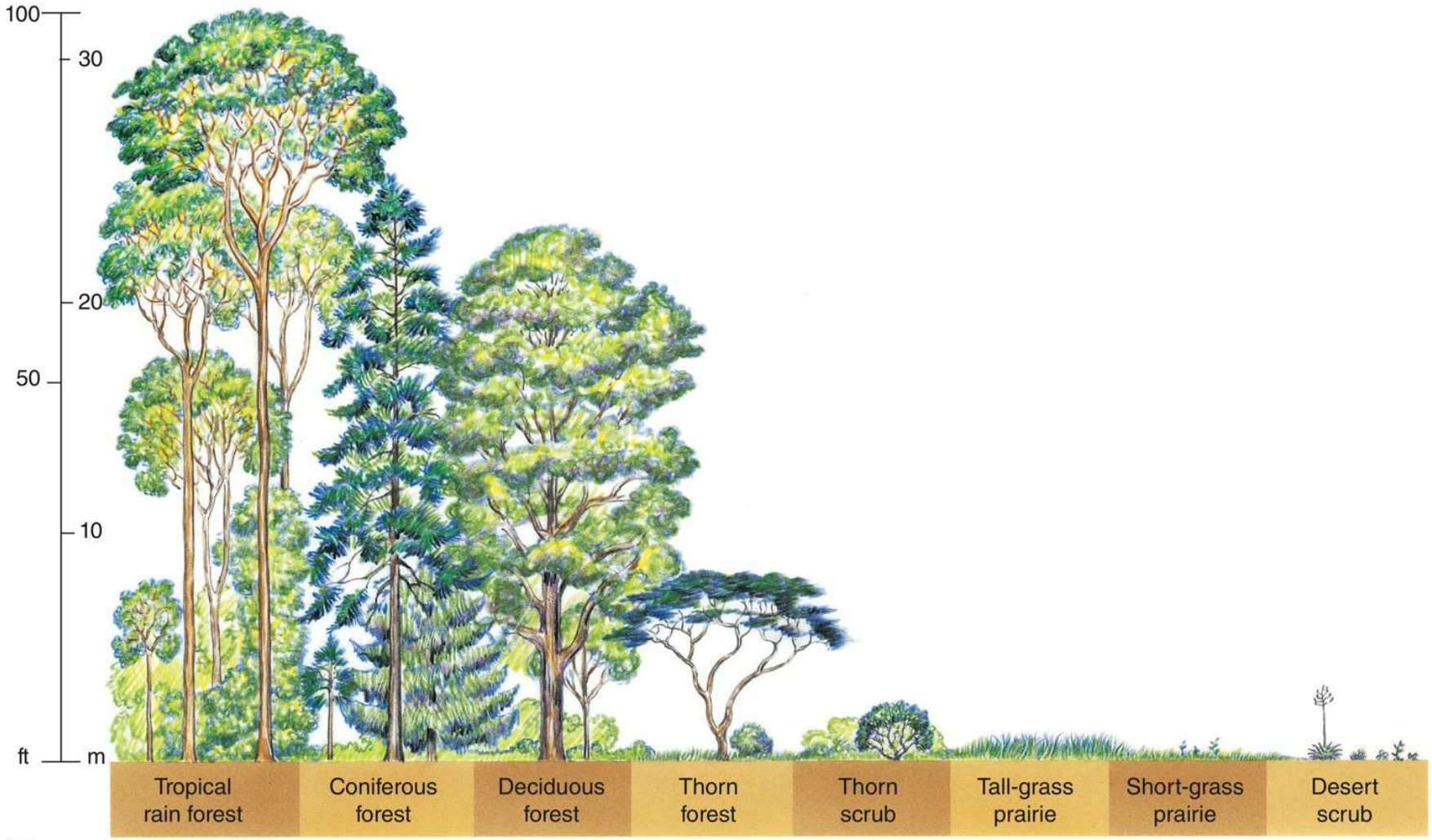
- Invasive exotic species: Burmese pythons
  - Exotic species: introduced by people into non-native environments
  - Ecological problem
    - Major cause or endangered or threatened species
  - Burmese pythons
    - Brought to U.S. by exotic pet trade
    - Proliferation in the Everglades: prey on native species

Ecosystems (cont'd.)

- Primary productivity
  - Aquatic ecosystems
    - Impact of water depth and nutrient availability
- How does the productivity of agricultural ecosystems compare to natural systems?

Table 9.1
Net Primary Productivity of Selected Ecosystems

Type of Ecosystem	Normal Range ($g/m^2/year$)	Mean ($g/m^2/year$)
Tropical rainforest	1,000–3,500	2,200
Middle-latitude evergreen forest	600–2,500	1,300
Middle-latitude deciduous forest	600–2,500	1,200
Boreal forest (taiga)	400–2,000	800
Woodland and shrubland	250–1,200	700
Savanna	200–2,000	900
Middle-latitude grassland	200–1,500	600
Tundra and alpine	10–400	140
Desert and semidesert scrub	10–250	90
Extreme desert, rock, sand, and ice	0–10	3
Cultivated land	100–3,500	650
Swamp and marsh	800–3,500	2,000
Lake and stream	100–1,500	250
Algal beds and reefs	500–4,000	2,500
Estuaries	200–3,500	1,500



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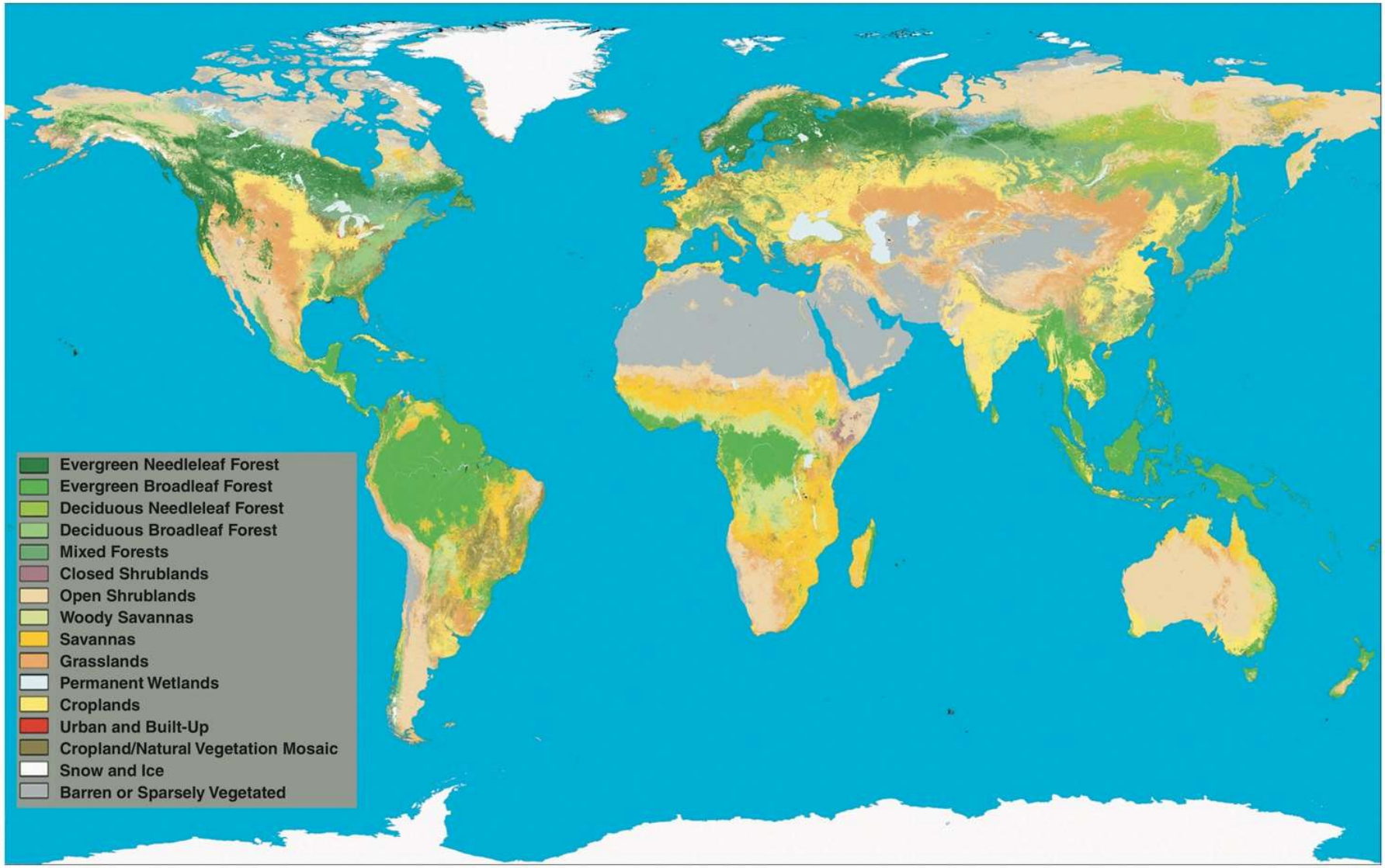
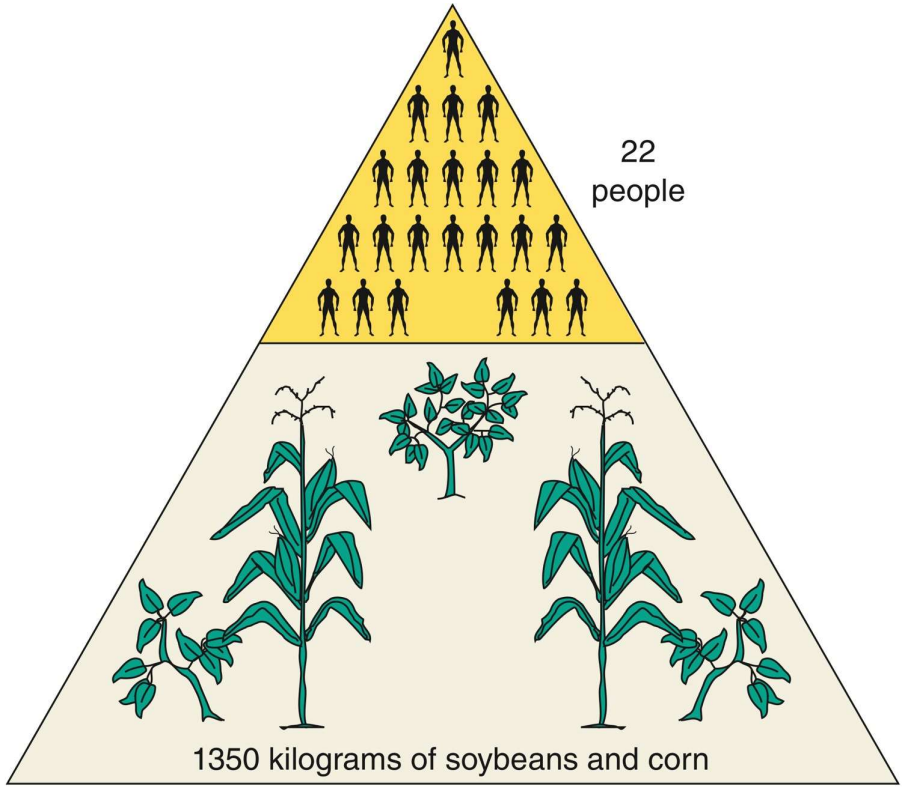
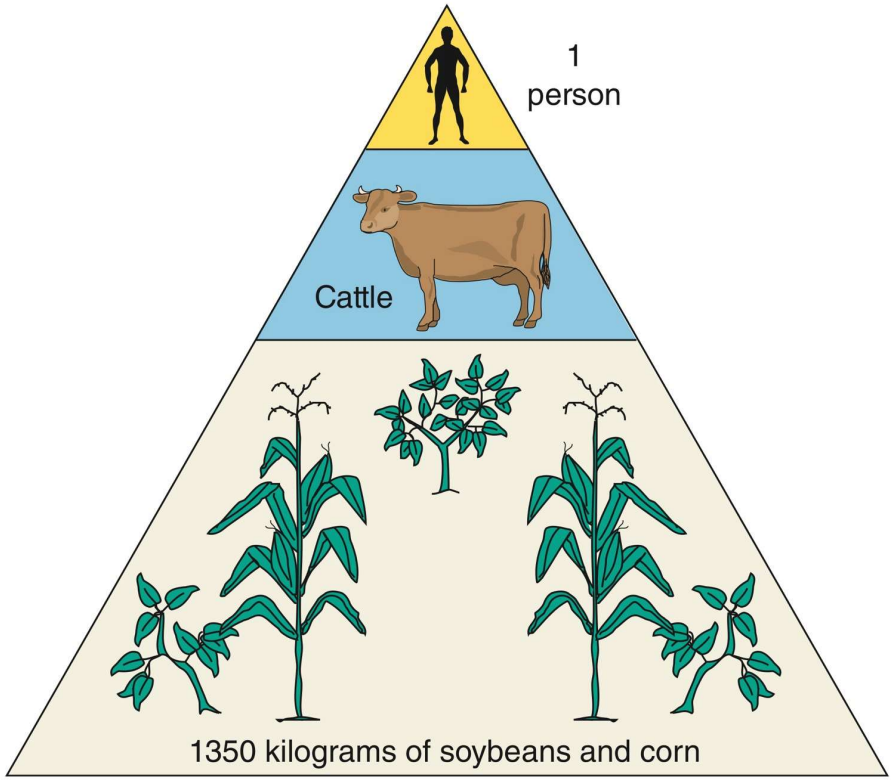


(b)

Ecosystems (cont'd.)

- Secondary productivity
  - Conversion of plant materials to animal substances
- Low rate of energy transfer
  - One trophic level to the next



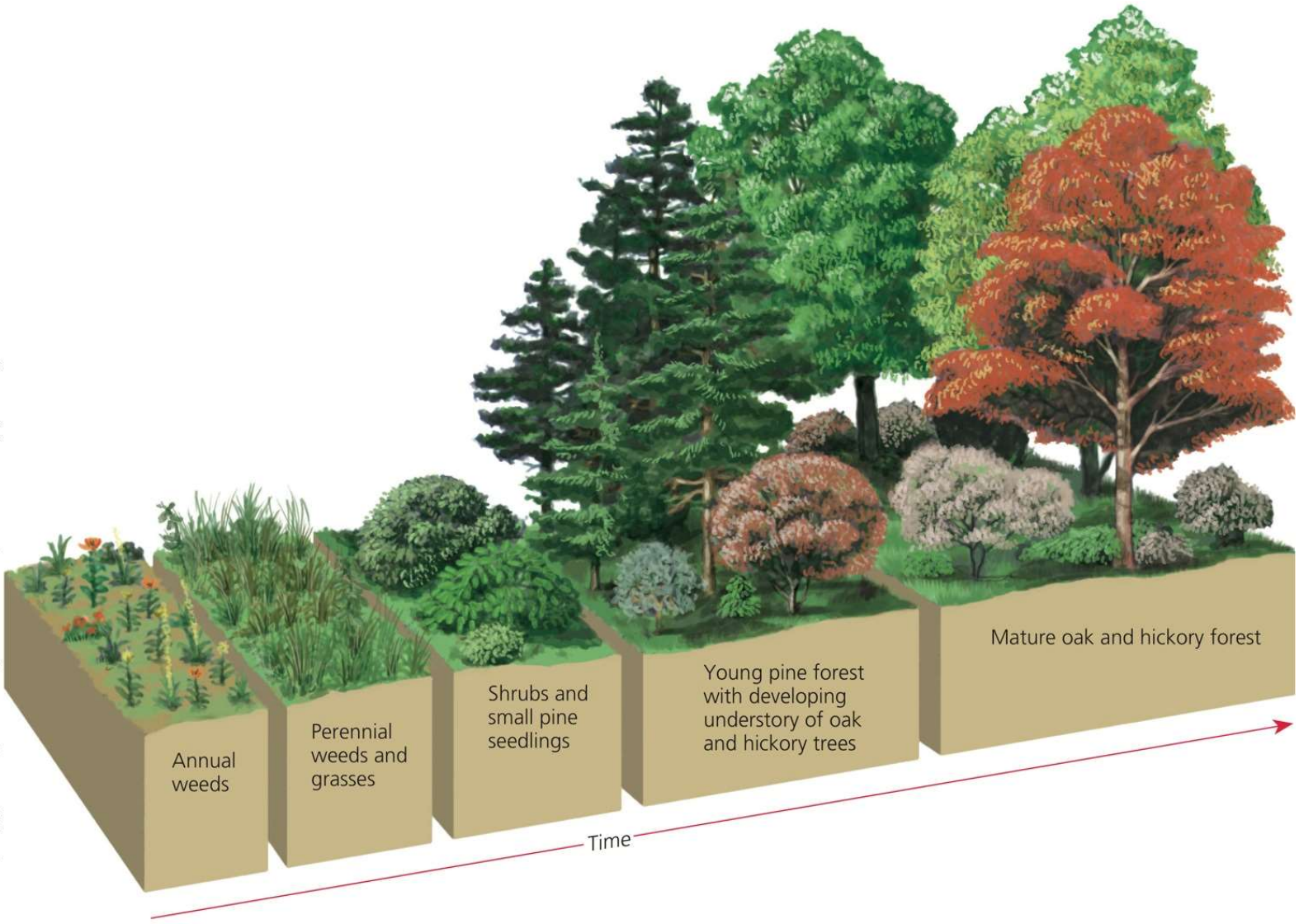


Ecosystems (cont'd.)

- Habitat
  - Location where an organism lives and performs its specific role
- Ecological niche
  - Particular species' role and habitat
  - Impact of food supplies
    - Generalists
    - Specialists

Succession and Climax Communities

- Plant communities
  - Aggregations of vegetation species
    - Adapted to existing environmental conditions
  - Natural vegetation
- Plant succession
  - Progressive sequence
  - Types
    - Primary: pioneer community invades barren area
    - Secondary: gap creation

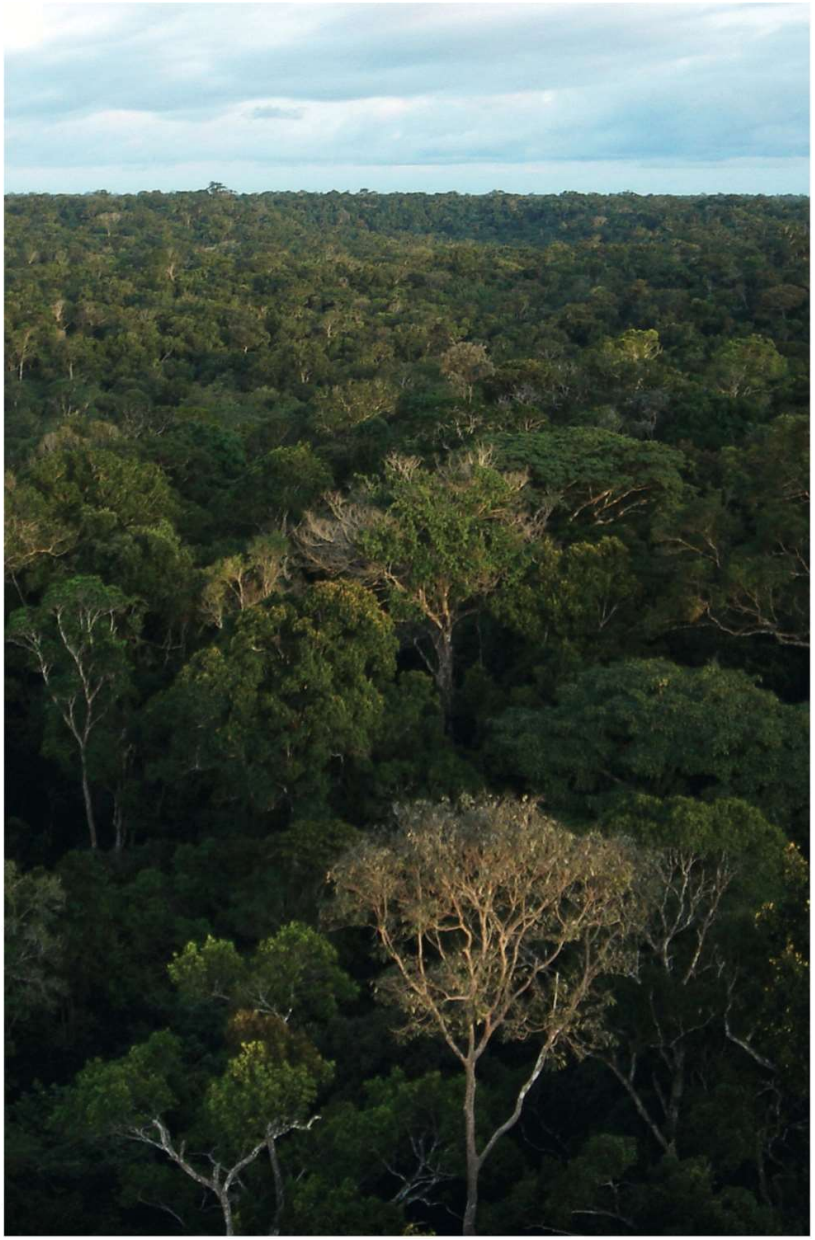


Why would plant succession be quite different in another region of the United States?

Succession and Climax Communities (cont'd.)

- Climax community
  - Final result in a vegetative succession
- Succession model: original ideas challenged
  - Predictable sequence of progression
  - "Final result" remaining indefinitely

How might this rainforest differ from the rainforests of the Pacific Northwest of the United States?



Delphine Farmer, Colorado State University

Succession and Climax Communities (cont'd.)

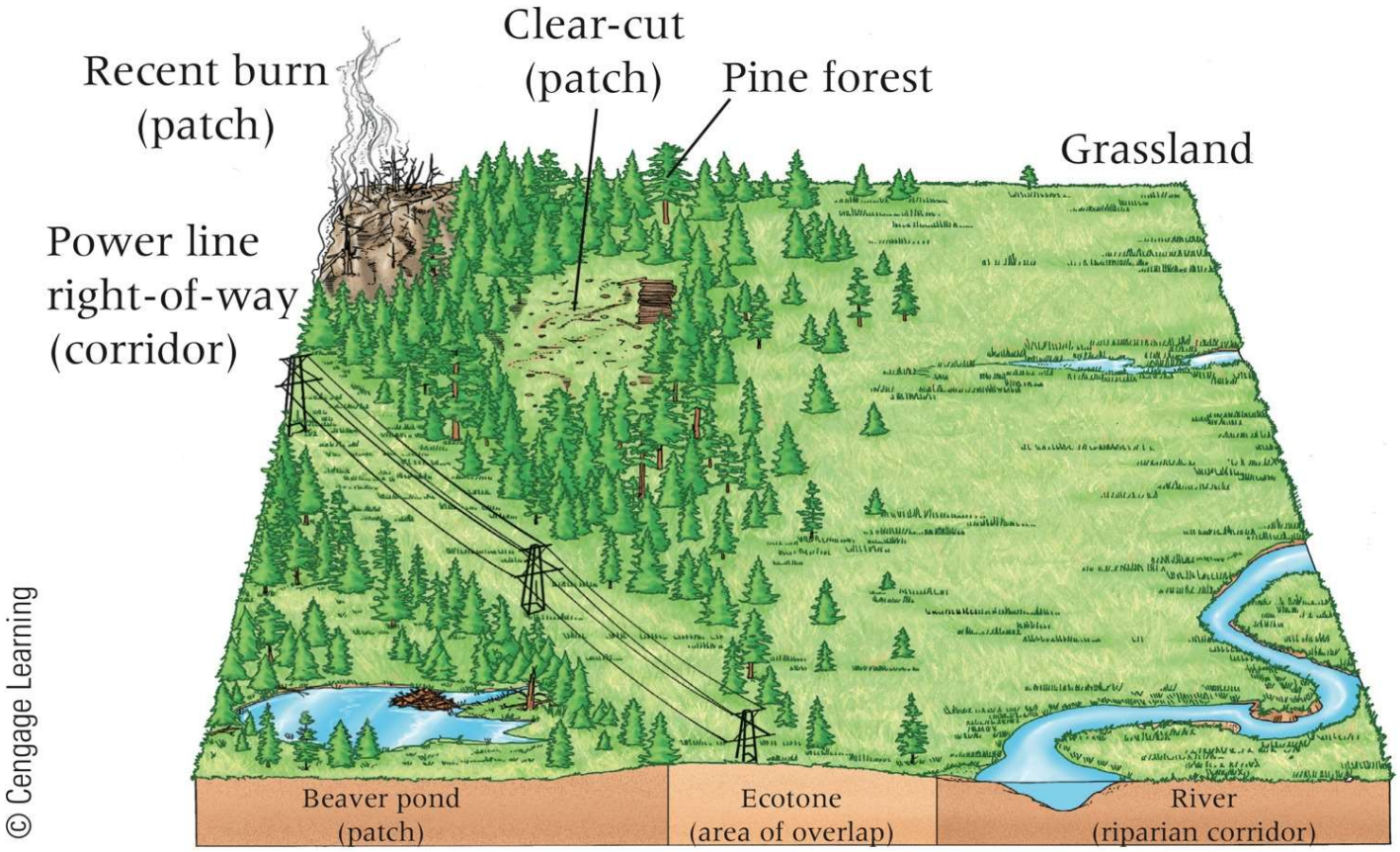
- Landscape: expression of environmental factors functioning together
  - Vegetative mosaic
    - Matrix: dominant area
    - Patches: gaps
    - Corridors: natural features and human-created structures
- Habitat: constantly changing
  - Plants and animals: must constantly adjust
  - Climate: dominant environmental influence

How does a corridor differ from a patch?

April Bahen, CBNERRVA/NOAA National Estuarine Research Reserve Collection

Environmental Controls

- Range of tolerance
  - Environmental conditions, e.g., temperature
- Ecological optimum
  - Species thrives
- Ecotone
  - Overlap of two plant or animal communities
- Biomes: terrestrial ecosystems



What effect would a change to drier climate in this area have on the relative sizes of the two ecosystems as well as the position of the ecotone?

Environmental Controls (cont'd.)

- Climatic factors
  - Sunlight: energy for photosynthesis and affect on behavior or plants and animals
    - Competition for light
    - Light intensity
    - Daylight duration
  - Temperature extremes
  - Water availability

Heather Henkel, USGS

(a)

Heather Henkel, USGS

(b)

Environmental Controls (cont'd.)

- Climatic factors
  - Life zones: variations due to elevation
  - Why are animals less dependent on climatic conditions than plants?
  - Animal sensitivity
    - Cold-blooded vs. warm-blooded species
  - Wind

Alaska Image Library/USFWS

What other physical adaptations do polar bears have for living in their Arctic environment?

R. Gabler

What type of vegetation would be found at elevations higher than the one depicted here?

Environmental Controls (cont'd.)

- The theory of island biogeography
  - Explanation for how natural factors interact
    - Successful colonization and species extinction
  - Considerations
    - Spatial isolation, island size, and number of species
  - Factors impacting species diversity
    - Distance from large landmasses, island size, and extinction rate

Environmental Controls (cont'd.)

- Soil variations: moisture and minerals
- Topography
  - Highlands: diverse microclimates within relatively small areas
  - Slope aspect
    - North- vs. south-facing
    - Steepness and shape

J. Petersen

Are there good examples of the influence of slope aspect on vegetation in the area where you live?

Environmental Controls (cont'd.)

- Natural catastrophes
  - Natural processes
  - Produce gaps in a region's vegetative mosaic
  - Resulting succession
  - Patch dynamics

Why are there so many broken tree stumps in the foreground?

USGS/P. Carrara

Environmental Controls (cont'd.)

- Human impact on ecosystems
  - Plant communities: eliminated or modified
    - Farming, fire, domesticated animal grazing, deforestation, road building, dam building, etc.
  - Land degradation
  - Desertification
  - Wetland destruction

UNEP-Sudan

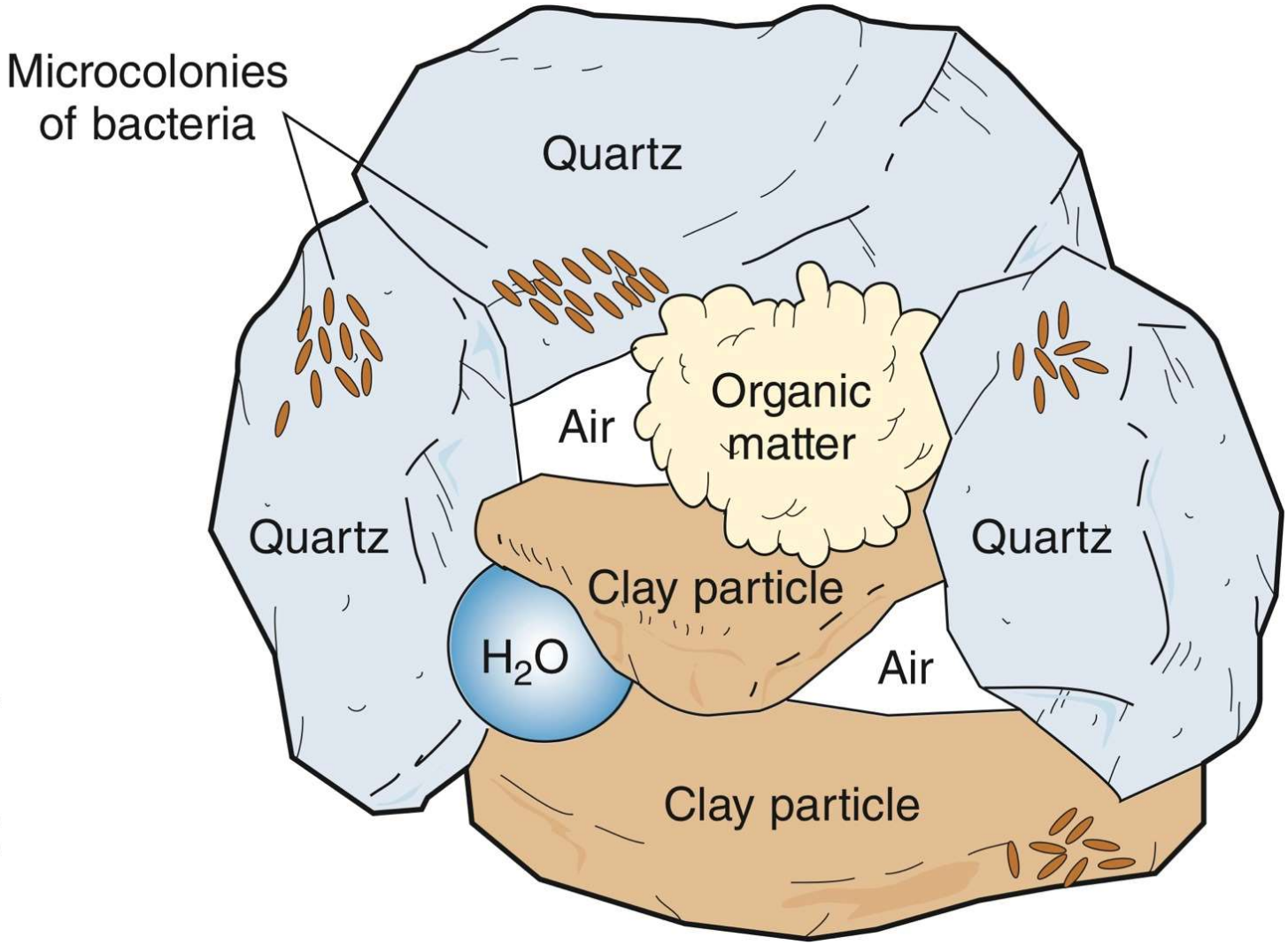
What are some of the other causes of desertification?

Soils and Soil Development

- Soil
  - Dynamic body of natural materials
    - Capable of supporting vegetative cover
  - Interactions
    - Physical, chemical, and biological processes
  - Fertility
    - Effectiveness in producing vegetation types or plant communities

Soils and Soil Development (cont'd.)

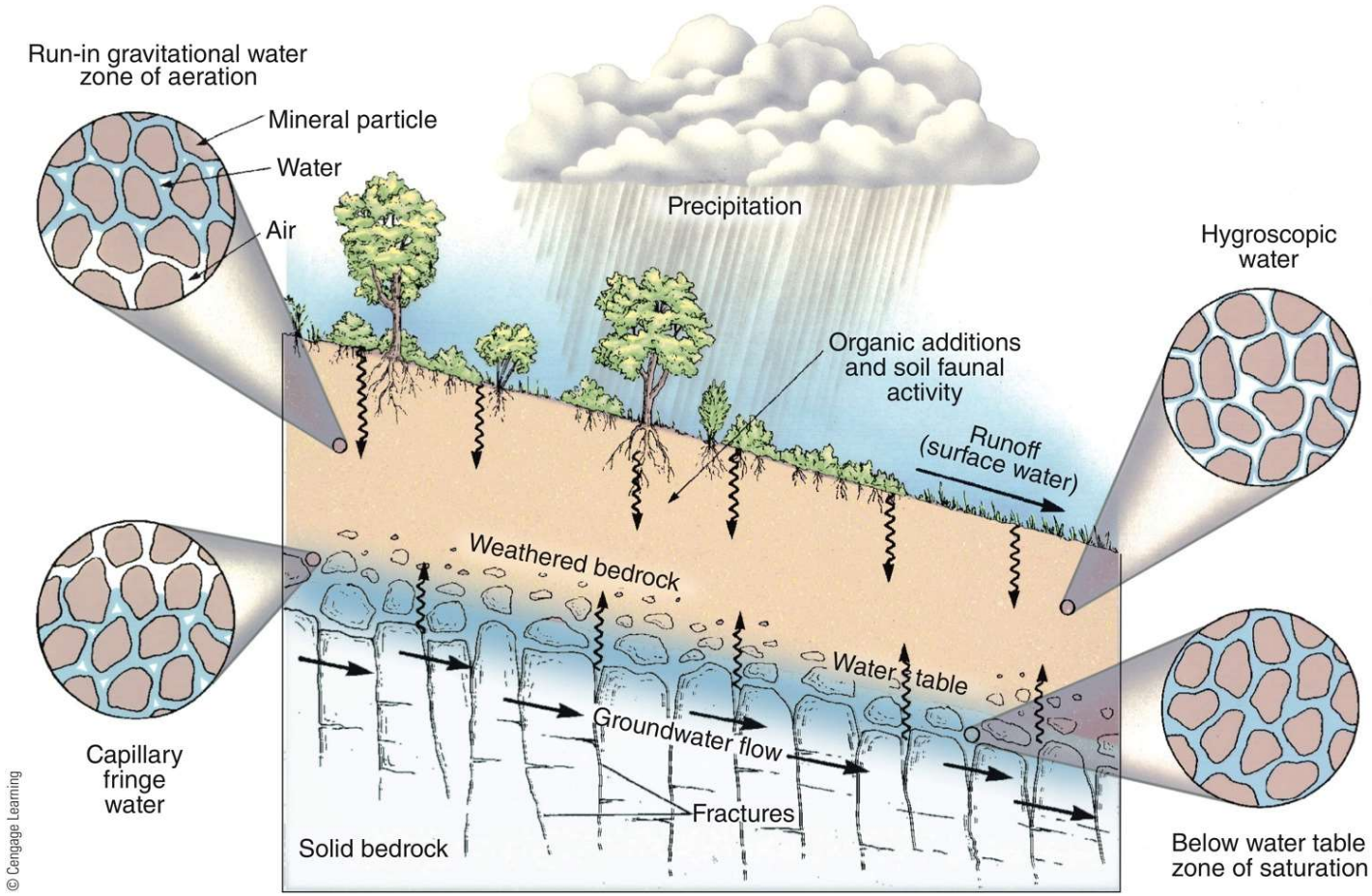
- Major soil components
  - Inorganic materials
  - Soil water
  - Soil air
  - Organic matter



How do each of these soil components contribute to making a soil suitable to support plant life?

Soils and Soil Development (cont'd.)

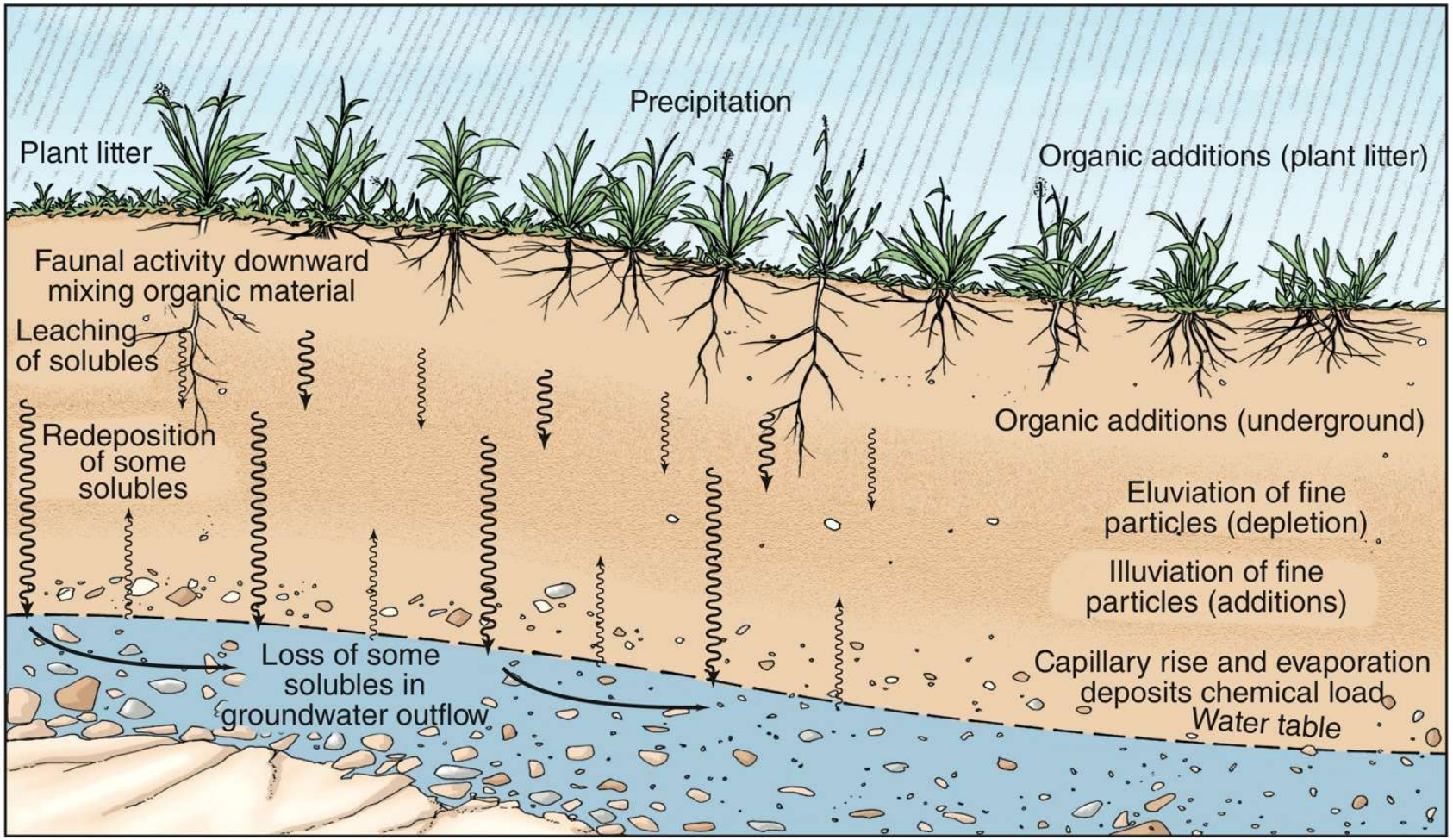
- Inorganic materials
  - Rock fragments: not readily dissolved in water
  - Chemical constituents: weathering of rocks
  - Soil fertilization
- Soil water
  - Precipitation
  - Impure: contains dissolved nutrients
  - Soil: functions as an open system



What are some examples of energy and matter that flow into and out of the soil system?

Soils and Soil Development (cont'd.)

- Soil water
  - Capillary water
  - What are the functions of gravitational water?
  - Soil stratification:
    - Influenced by leaching, eluviation, and illuviation



How does deposition by capillary water differ from deposition (illuviation) by gravitational water?

Soils and Soil Development (cont'd.)

- Soil air
  - Nearly 50% of a soil consists of open spaces
  - Why do many plants find it difficult to survive in water-saturated soils?
- Humus
  - Decayed plant and animal materials
  - Increases capacity for water retention
  - Supplies nutrients and minerals
  - Food source: microorganisms

Soils and Soil Development (cont'd.)

- Soil characteristics
  - Color
  - Texture
  - Structure
  - Acidity or alkalinity
  - Capacity to hold and transmit water and air

Soils and Soil Development (cont'd.)

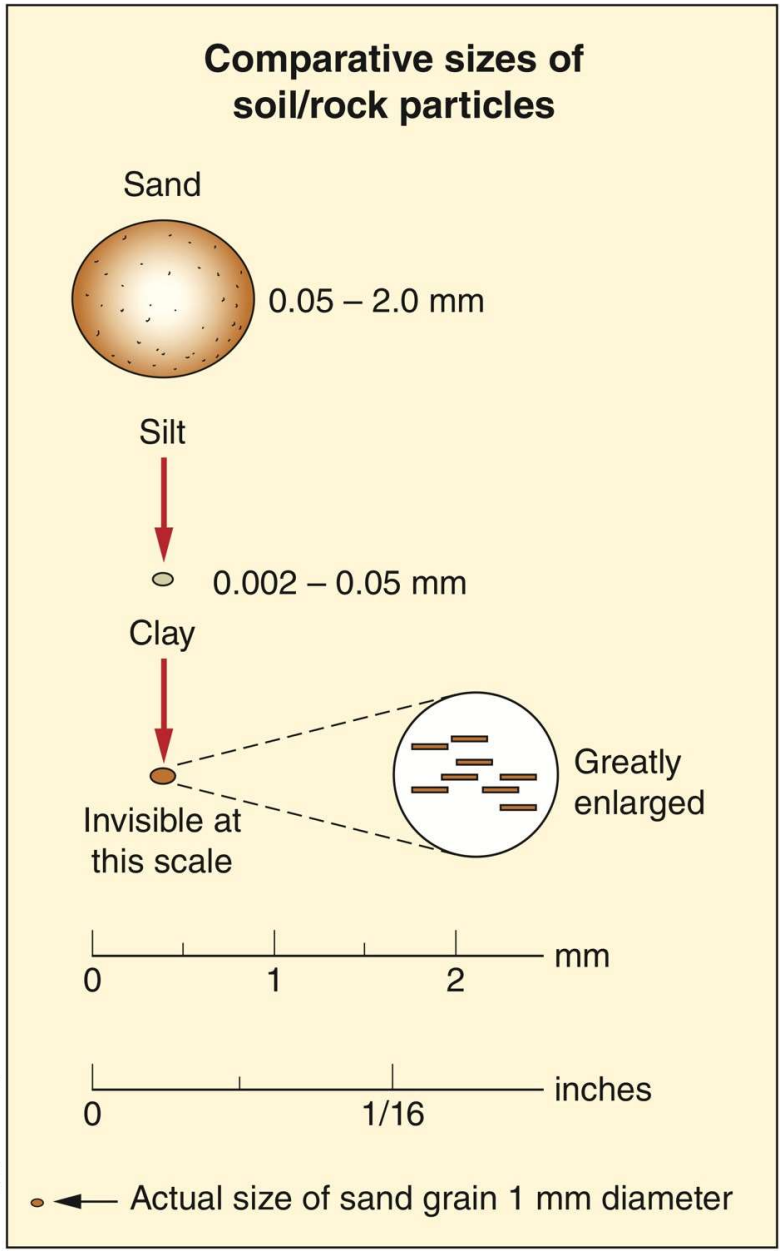
- Color
  - Related to its physical and chemical characteristics
  - Dark brown or black
    - Rich in humus
  - Red or yellow
    - Iron content
  - Color alone does not indicate fertility

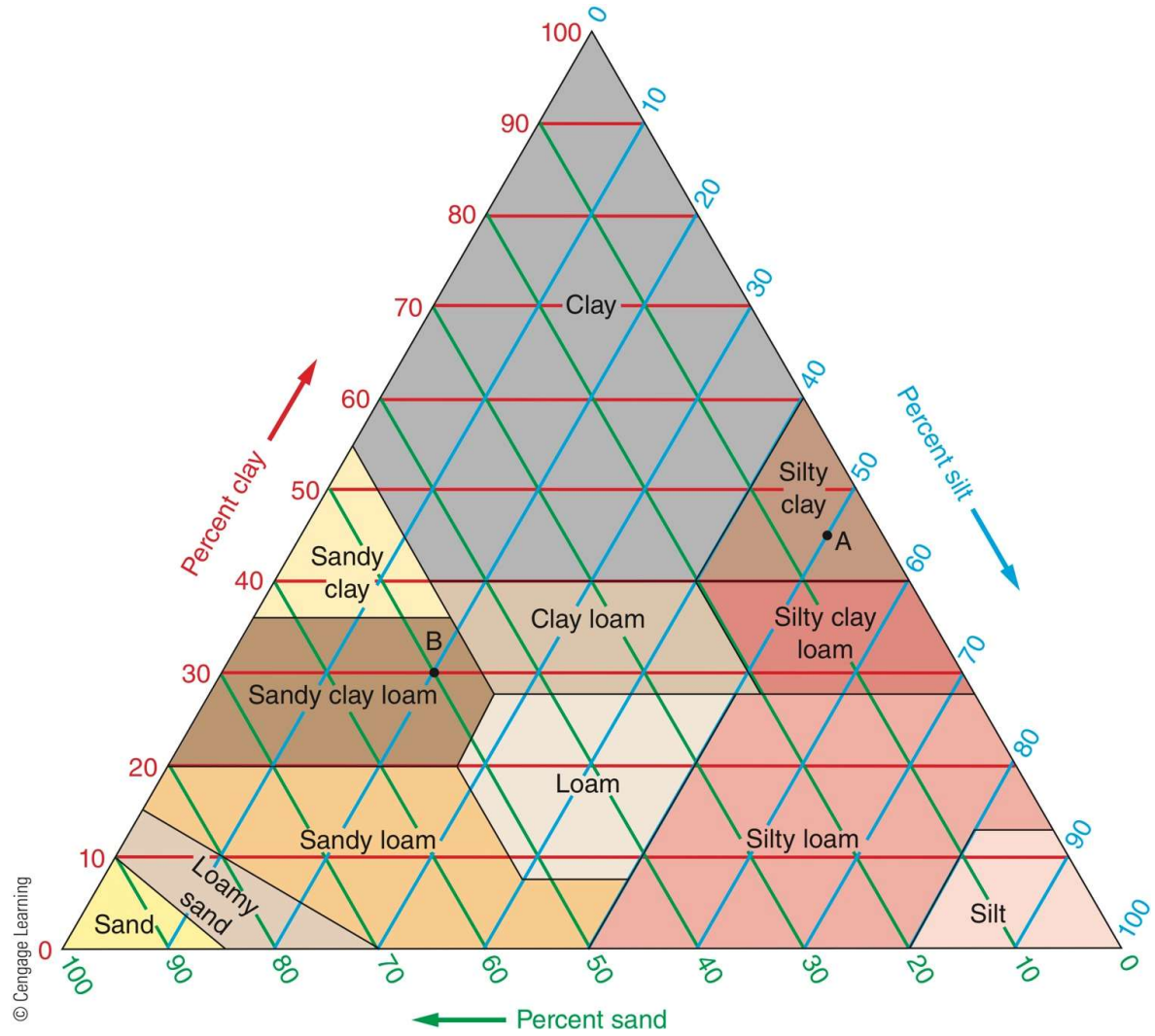
Courtesy of James P. Shoryer, Kansas State University Research and Extension

In general, how would you describe the color of soils where you live?

Soils and Soil Development (cont'd.)

- Texture
  - Particle sizes in soil (diameter)
    - Clayey soils: less than 0.002 millimeter
    - Silty soils: between 0.002 and 0.05 millimeter
    - Sandy soils: between 0.05 and 2.0 millimeters
  - Determined by proportion of particle sizes
  - Relates to aeration and infiltration

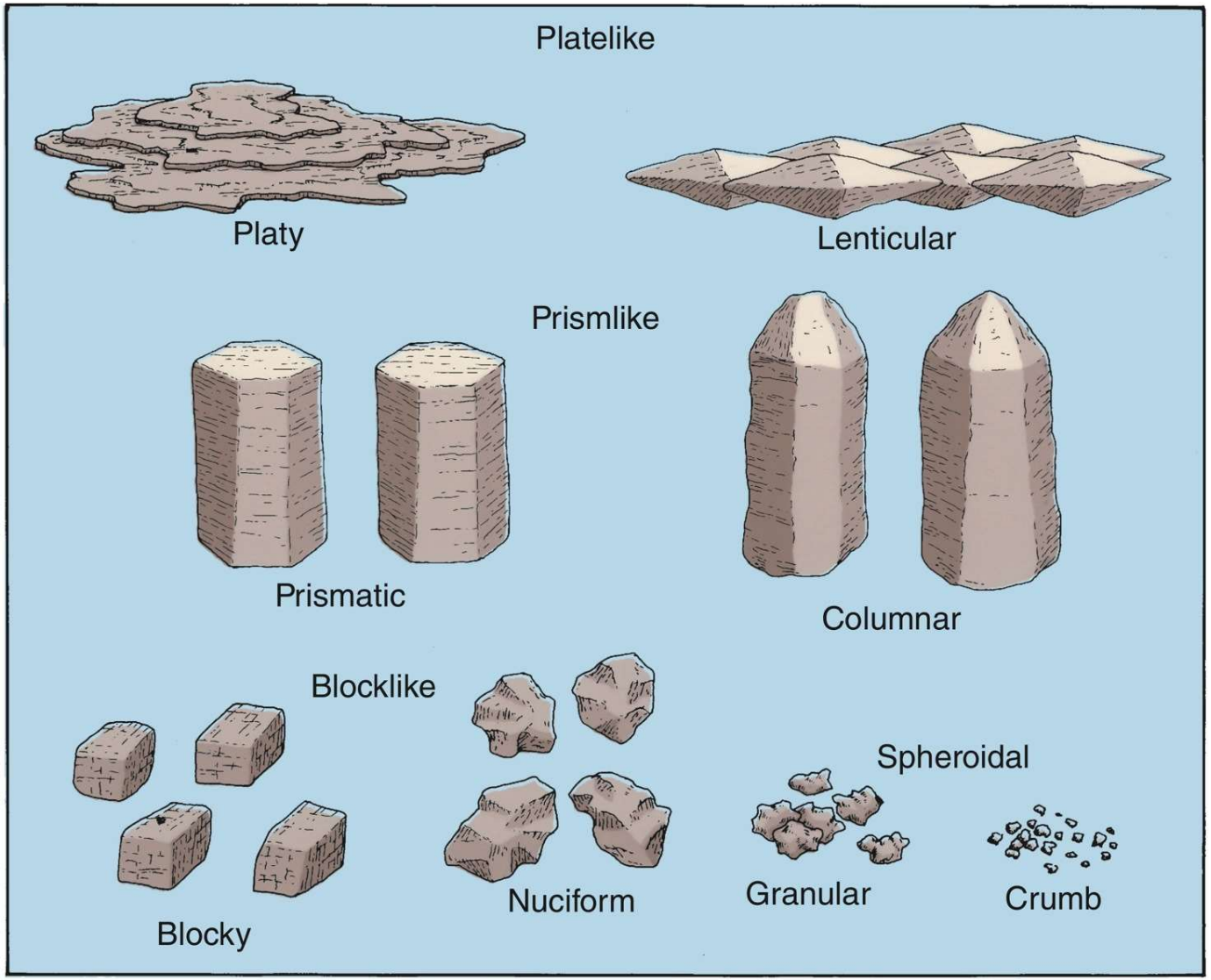




What is the classification of a soil that contains 40% sand, 40% silt, and 20% clay?

Soils and Soil Development (cont'd.)

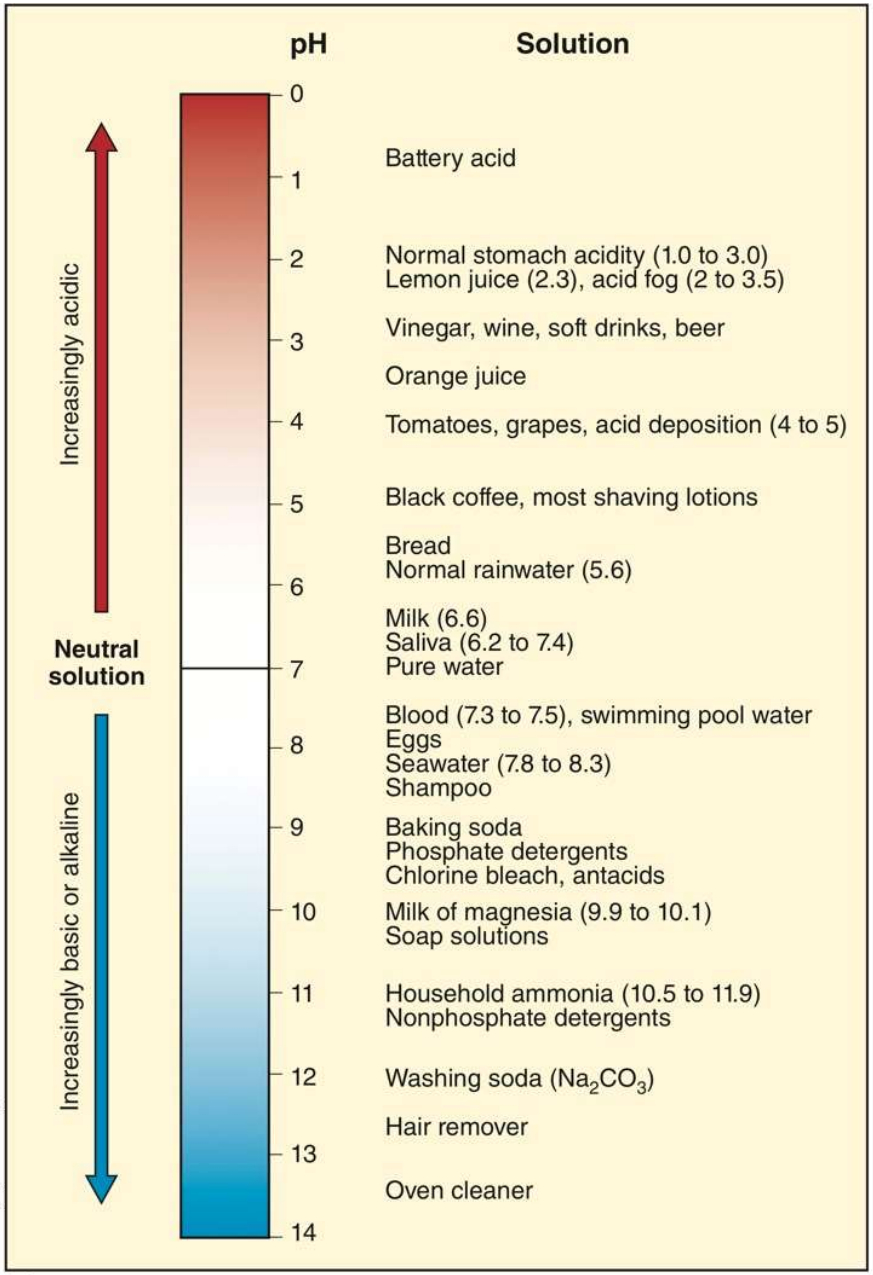
- Structure
  - Soil peds: particle clumps
    - Columns, prisms, and angular blocks to nutlike spheroids, laminated plates, crumbs, and granules
  - Impact on
    - Porosity
    - Permeability
  - What type of soil has the greatest permeability?

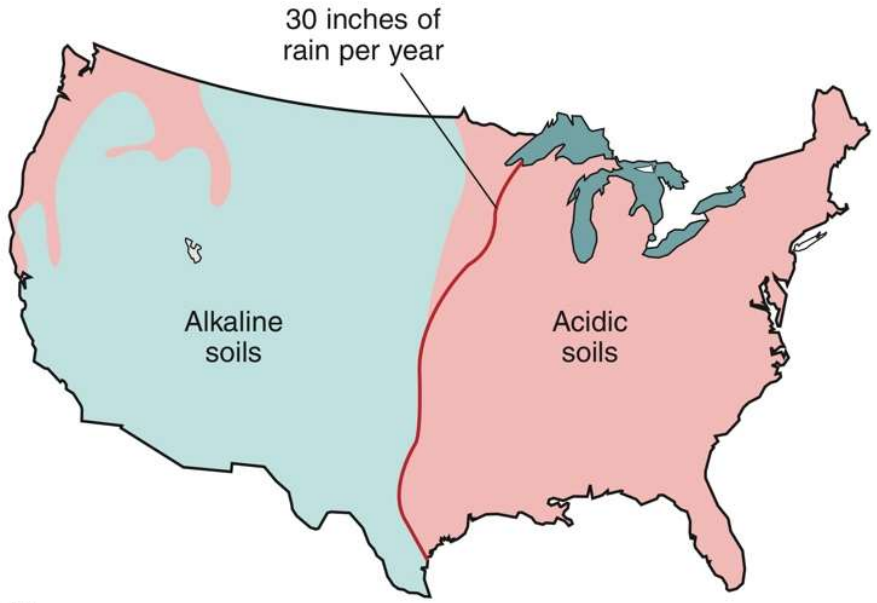


How does soil structure affect a soil's usefulness or suitability for plant growth?

Soils and Soil Development (cont'd.)

- Acidity or alkalinity
  - pH scale: 0 to 14
    - Low pH: acid soil
    - High pH: alkaline soil
  - Soil pH range for most plants
    - Between pH 4 and pH 10
  - What corrective actions can be taken to correct soil alkalinity? soil acidity?





Other than climate, what environmental factors might cause this east–west variation, and why are some places in the west acidic?

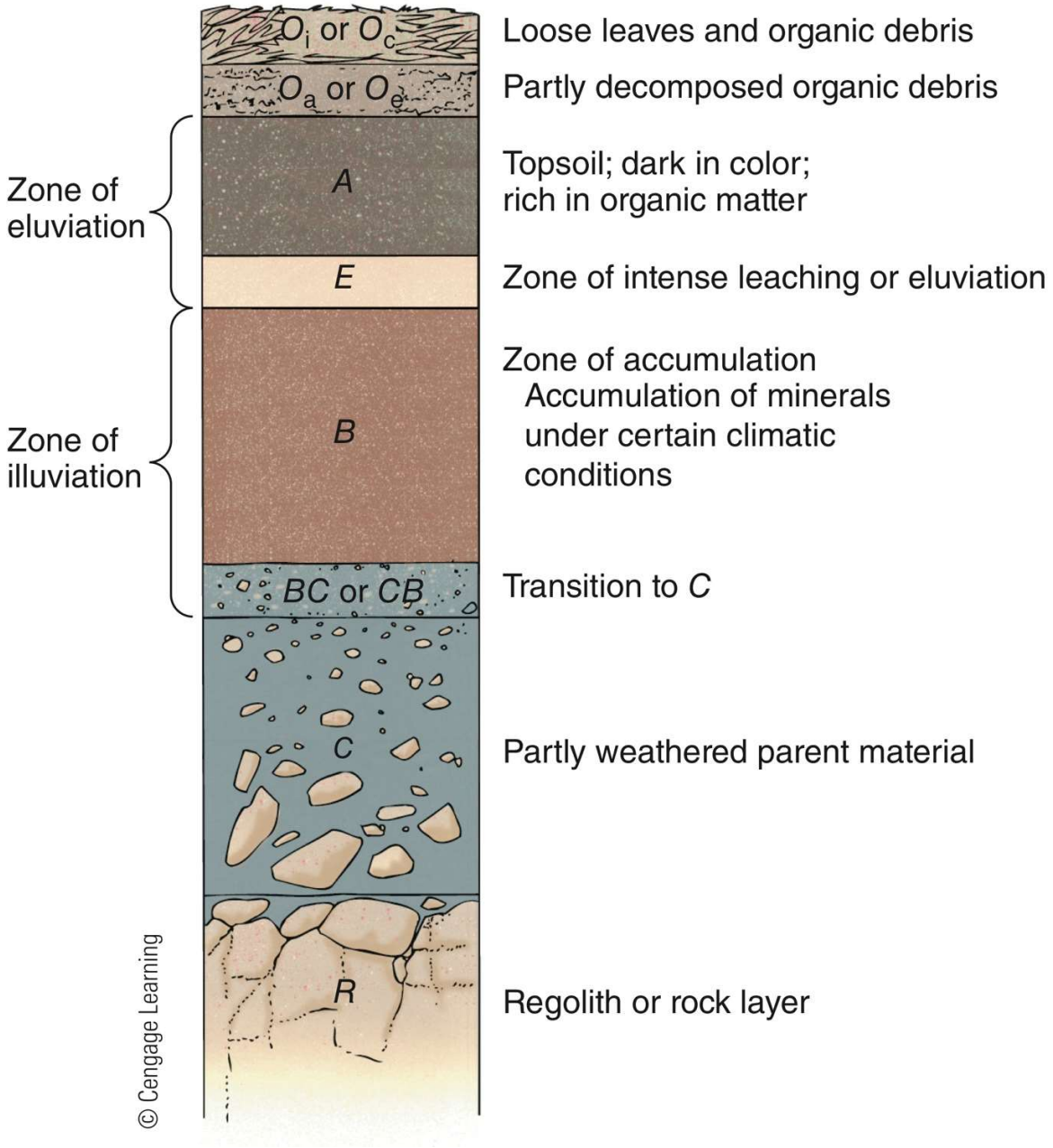
Soils and Soil Development (cont'd.)

- Development of soil horizons
  - Parent material
    - Chemical and physical differences develop from the surface down
  - Soil profile
    - Vertical section of a soil from the surface down to the parent material
    - Soil horizons: distinguished by physical and chemical properties

Why might you think that this is a fertile soil for vegetation growth?

Hari Eswaran, USDA/NRCS

What are some of the reasons why soils change color and texture with depth?



Factors Affecting Soil Formation

- Rock weathering
  - Natural processes that break down rocks
    - Chemical reactions
    - Physical processes
- **Cl**imate, **O**rganic matter, **R**elief, **P**arent material, and **T**ime
  - **Cl**, **O**, **R**, **P**, **T**

Factors Affecting Soil Formation (cont'd.)

- Parent material
  - Residual parent material
    - Breakdown of bedrock
  - Transported parent material
    - Fragments carried to the site
  - Varying degree of influence
    - Diminishing effect over time
  - What is the prime determinant of a soil's texture and structure?

What other parent materials provide the basis for continuously fertile soils in wet tropical climates?

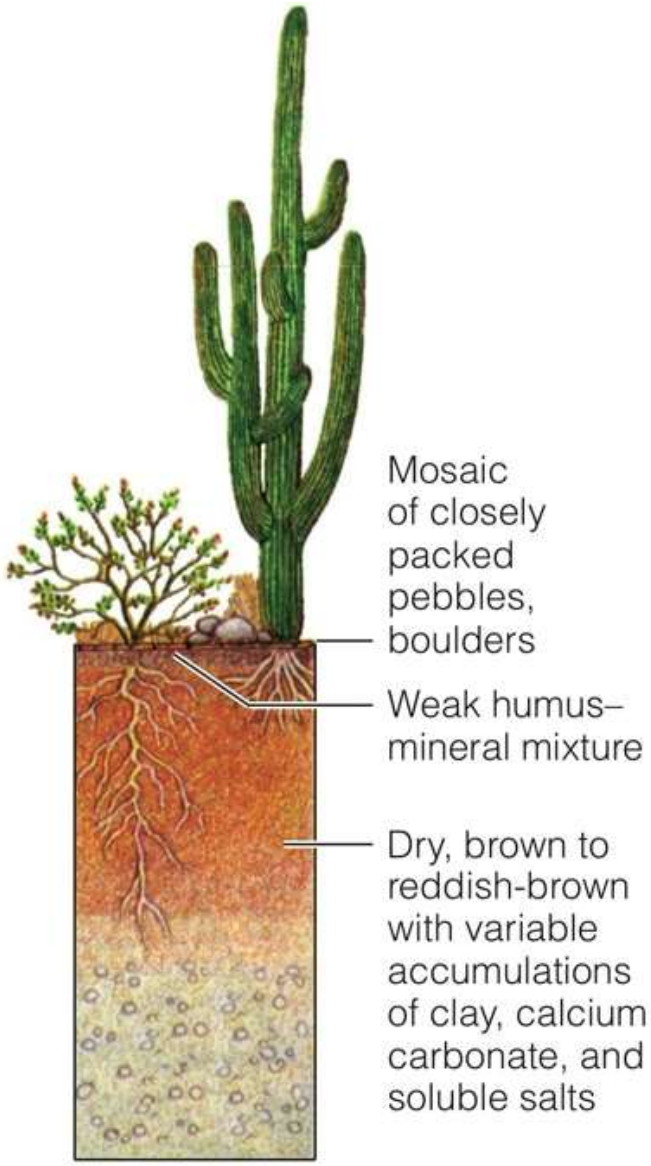
R. Gabler

Factors Affecting Soil Formation (cont'd.)

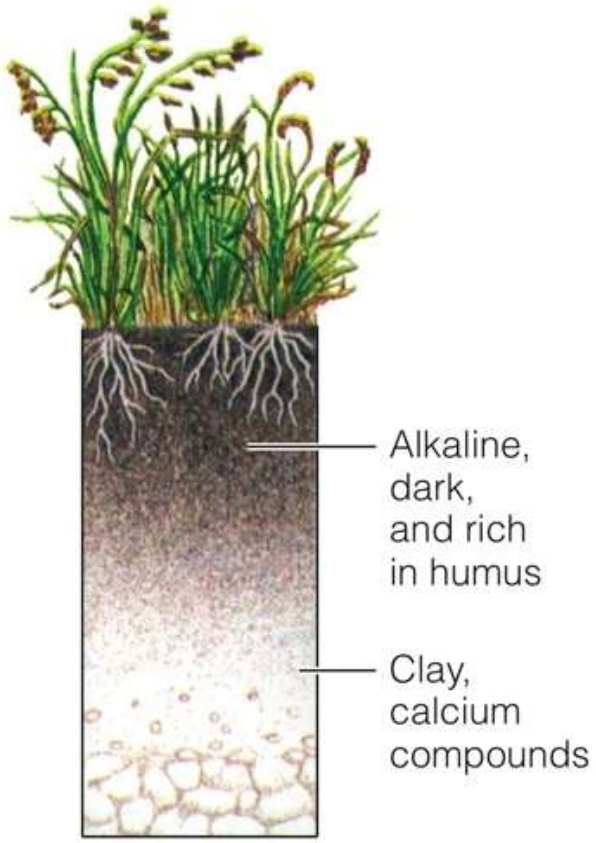
- Organic activity
  - Plant community
    - Density of cover: evapotranspiration rates
    - Litter and dead plants
    - Roots: contribute to porosity
  - Bacteria
    - Break down organic matter
  - Earthworms, ants, termites, etc.
    - Mix mineral and organic components

Factors Affecting Soil Formation (cont'd.)

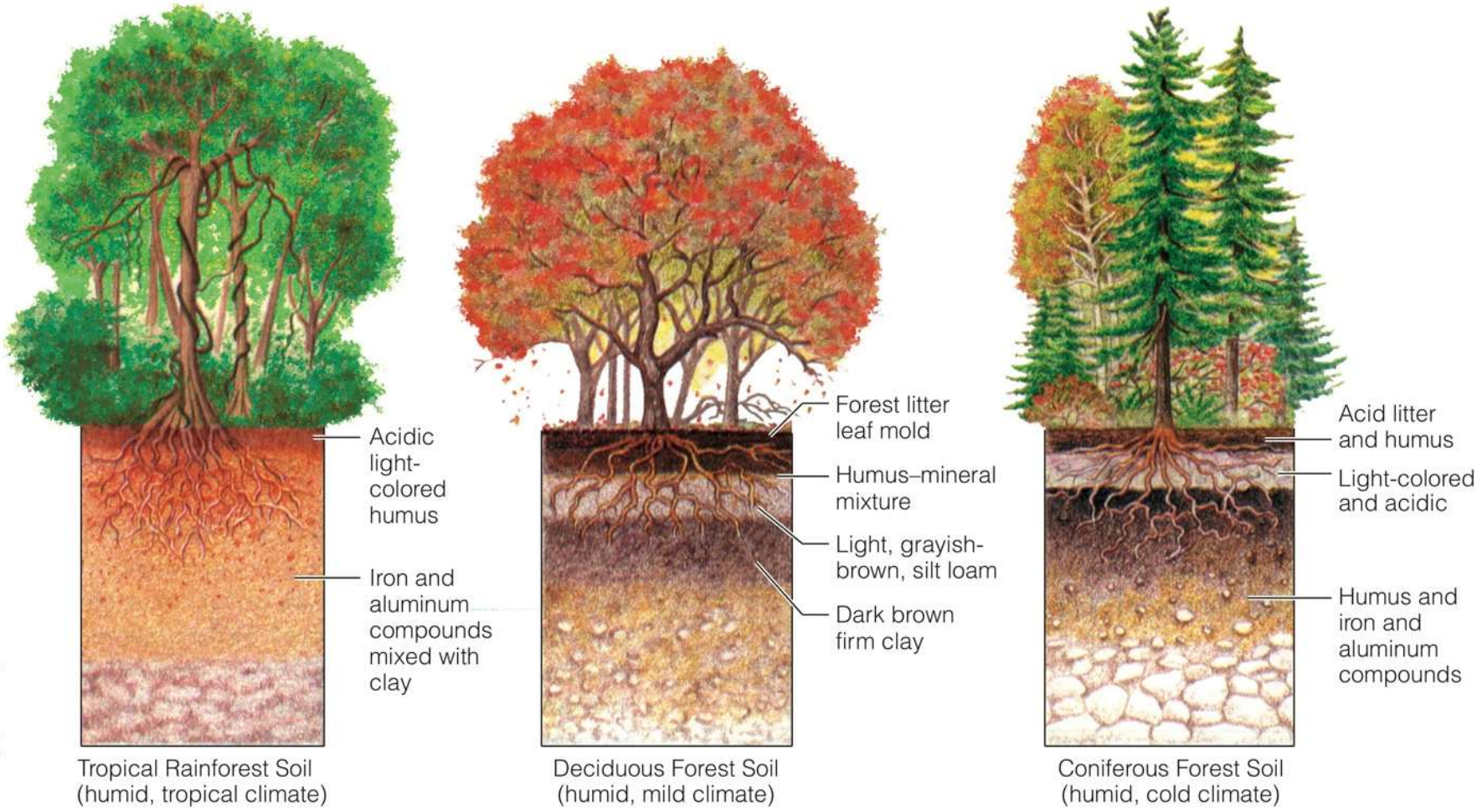
- Climate
  - How does temperature affect soil formation?
  - Moisture
    - Soil's organic content and fertility
    - Precipitation amount: leaching, eluviation, and illuviation
    - Evaporation: upward migration of capillary water



Desert Soil
(hot, dry climate)



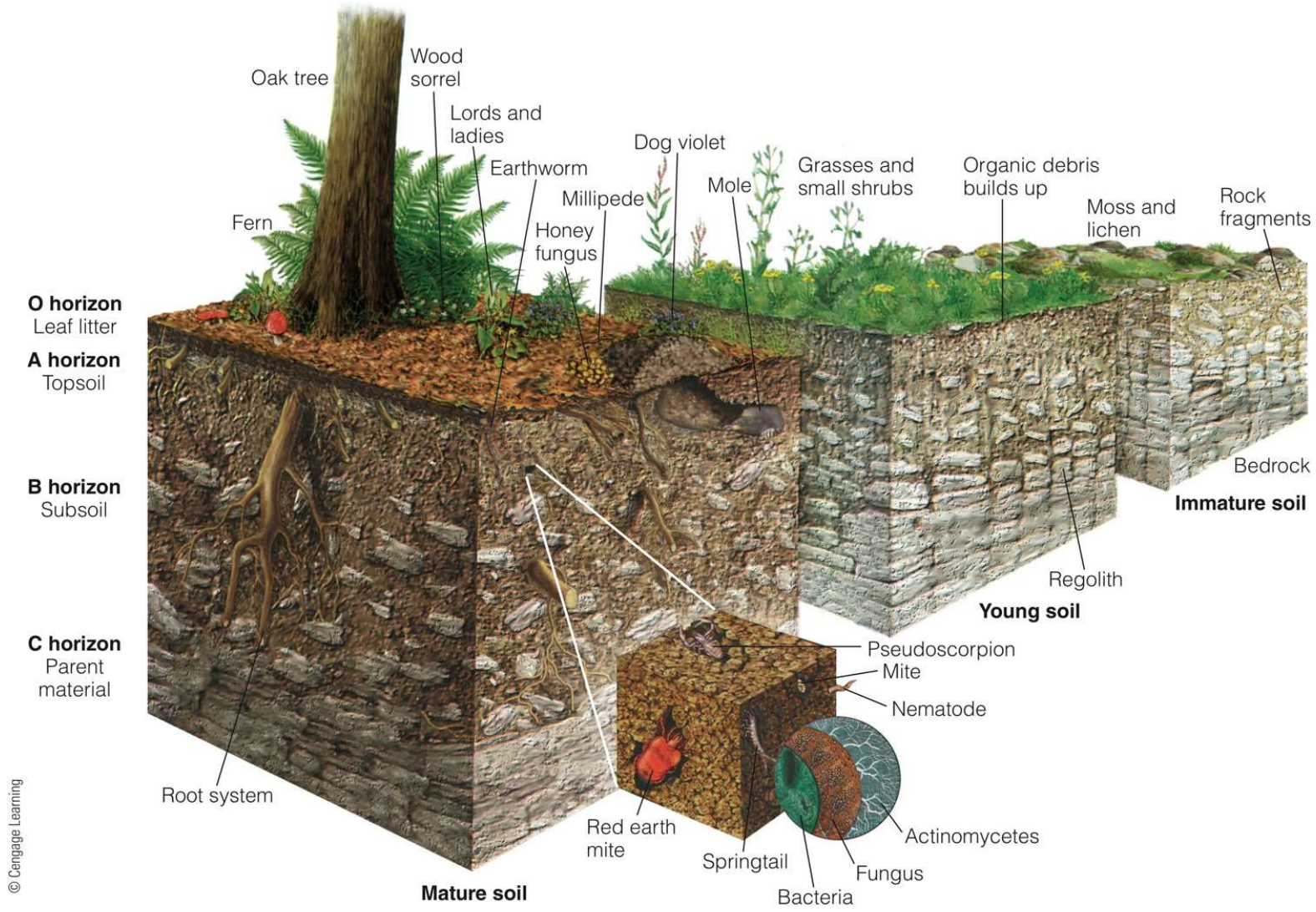
Grassland Soil
(semiarid climate)



Which two environments produce the most humus and which two produce the least?

Factors Affecting Soil Formation (cont'd.)

- Land surface
  - Slope
  - Relief
  - Aspect
- Time
  - Mature vs. young soils
  - Transported soils
    - Alluvium, loess, glacial deposits
  - How long does it take for a soil to mature?



What major changes would occur as the soil illustrated here becomes better developed over time?

Soil-Forming Regimes and Classification

- Three primary soil-forming regimes
  - Laterization
  - Podzolization
  - Calcification

Soil-Forming Regimes and Classification (cont'd.)

- Laterization
  - Humid tropical and subtropical climates
    - High temperatures and abundant precipitation
  - Rapid breakdown of rocks
  - Decomposition of nearly all minerals
  - Soil type: laterite
  - Year-round process

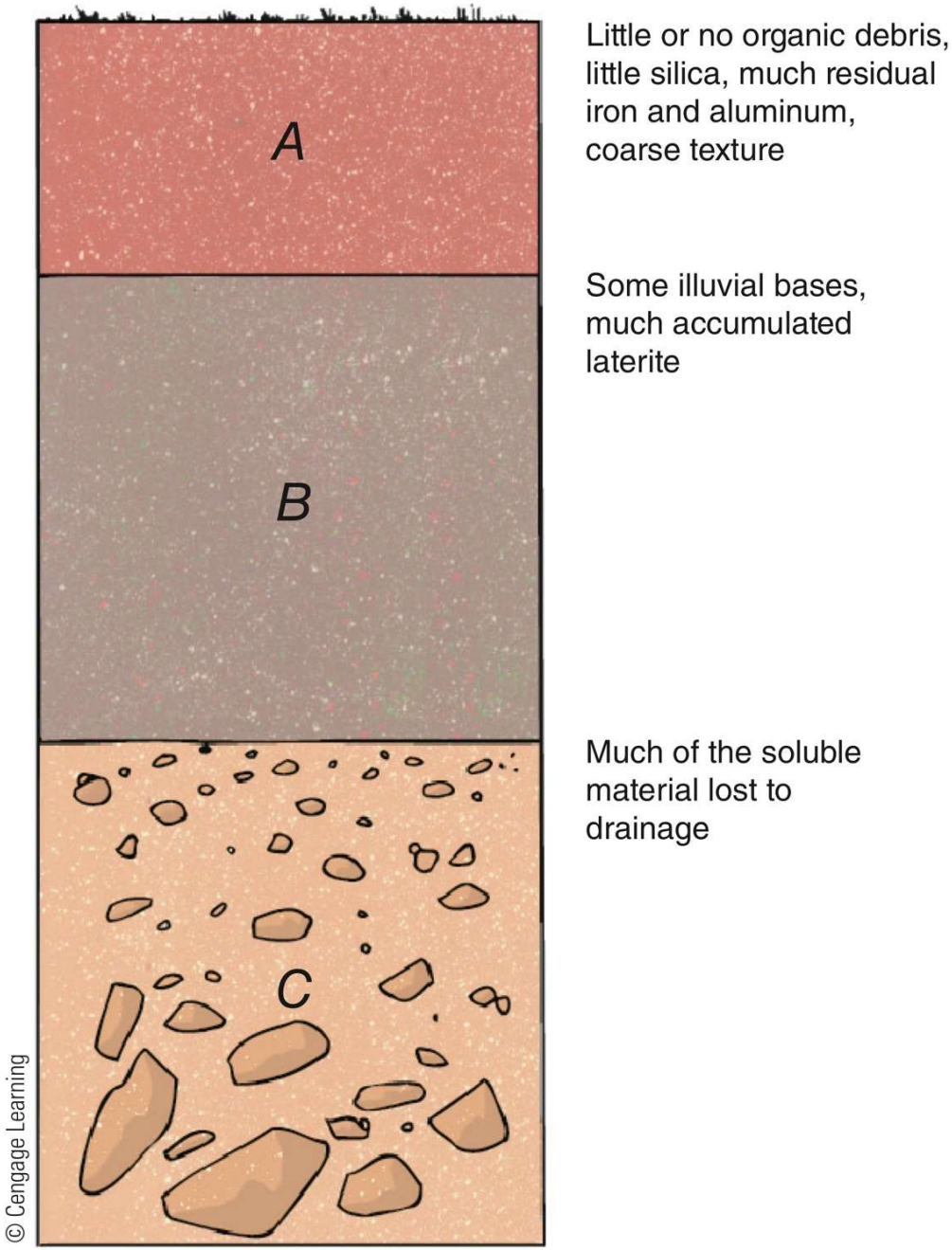
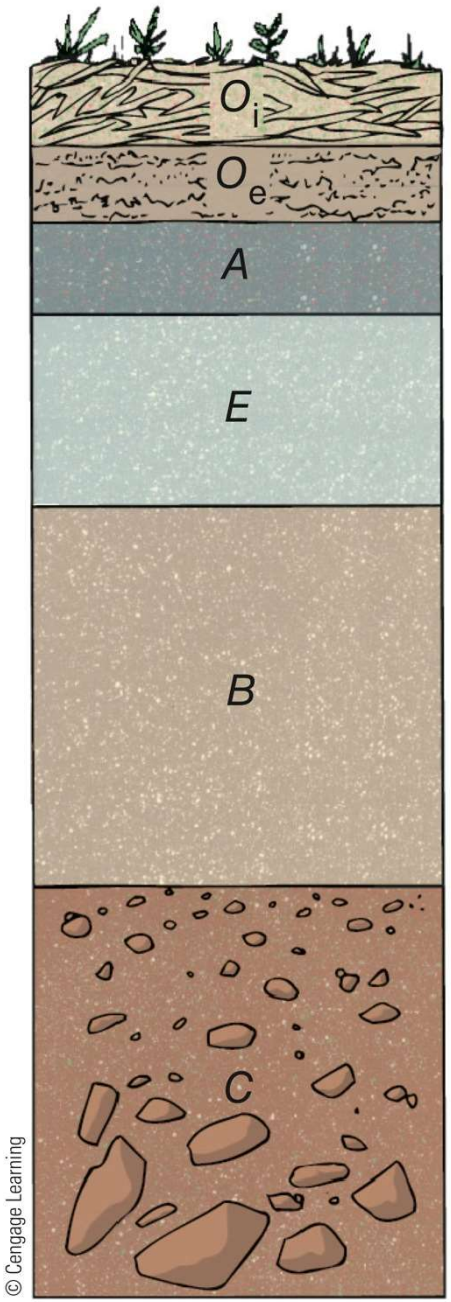


FIGURE 9.32 Soil profile horizons in a laterite. Laterization is a soil-development process that occurs in wet tropical and equatorial zones that experience warm temperatures all year.

Soil-Forming Regimes and Classification (cont'd.)

- Podzolization
  - High middle latitudes
    - Short, cool summers; long, severe winters
  - Reduced microorganism activity
  - Little mixing of humus
  - Podzol



Well-developed organic horizons

Thin, dark

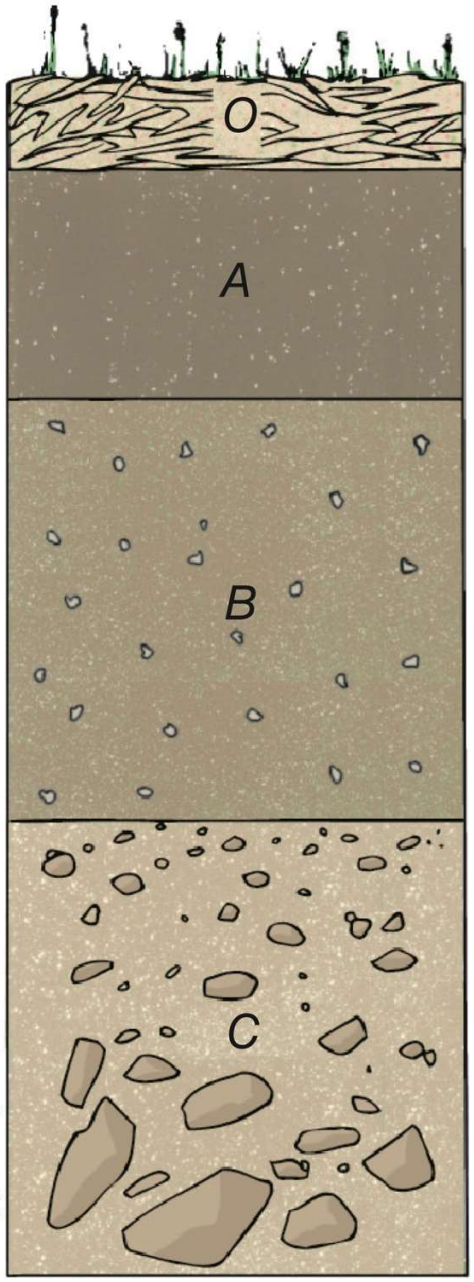
Heavily leached, light in color, largely Si

Darker than E; often colorful; accumulations of humus; Fe, Al, N, Ca, Mg, Na, K

Some Ca, Mg, Na, and K leached down from B is lost to lateral movement of water below water table

Soil-Forming Regimes and Classification (cont'd.)

- Calcification
  - Middle-latitude grasslands
  - Desert soils: American West
  - Alkali dusts: calcium carbonate
    - Translocate to *B* horizon: caliche
    - Thicker accumulations: calcretes



Soil-Forming Regimes and Classification (cont'd.)

- Regimes of local importance
  - Salinization
    - Concentration of salts
    - Arid areas
    - Intensive irrigation: arid or semiarid conditions
  - Gleization
    - Poorly drained areas
    - Cold, wet environments

USDA/NRCS/Tim McCabe

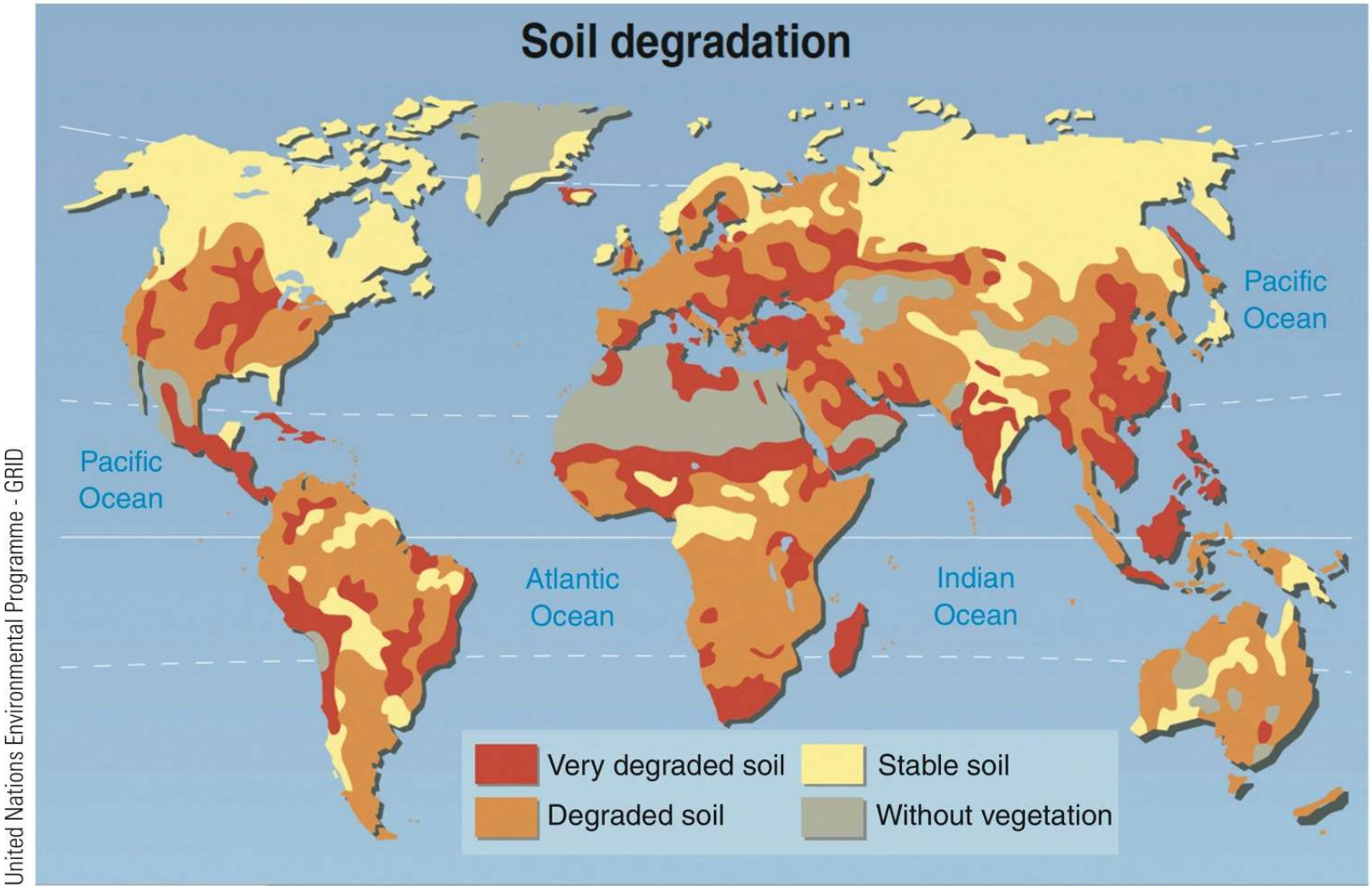
What negative soil effects can result when irrigated agriculture is practiced in regions that experience great evaporation rates?

Soil-Forming Regimes and Classification (cont'd.)

- Soil classifications
  - Natural Resource Conservation Service (NRCS)
    - Responsible for soil taxonomy and mapping
    - Published in soil surveys
    - Based on the development and composition of soil horizons
    - Soil order (largest division): 12 recognized by NRCS
    - Names and classification: describe distinguishing characteristics

Ecosystems and Soils: Critical Natural Resources

- Global concerns
  - Soil erosion, degradation, depletion, and mismanagement of environments
  - Negative consequences
    - Natural ecology
    - Agricultural productivity
- Importance of
  - Conserving soils
  - Maintaining soil fertility



United Nations Environmental Programme - GRID

Is there a general relationship between human population density and soil degradation?

Fundamentals of Physical Geography 2e

Biogeography and Soils

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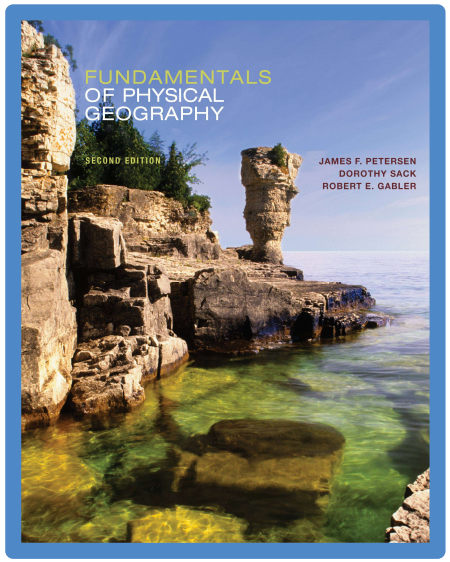
<end of chapter>



- Peterson
  - Sack
    - Gabler