Ecosystems

Chapter 3

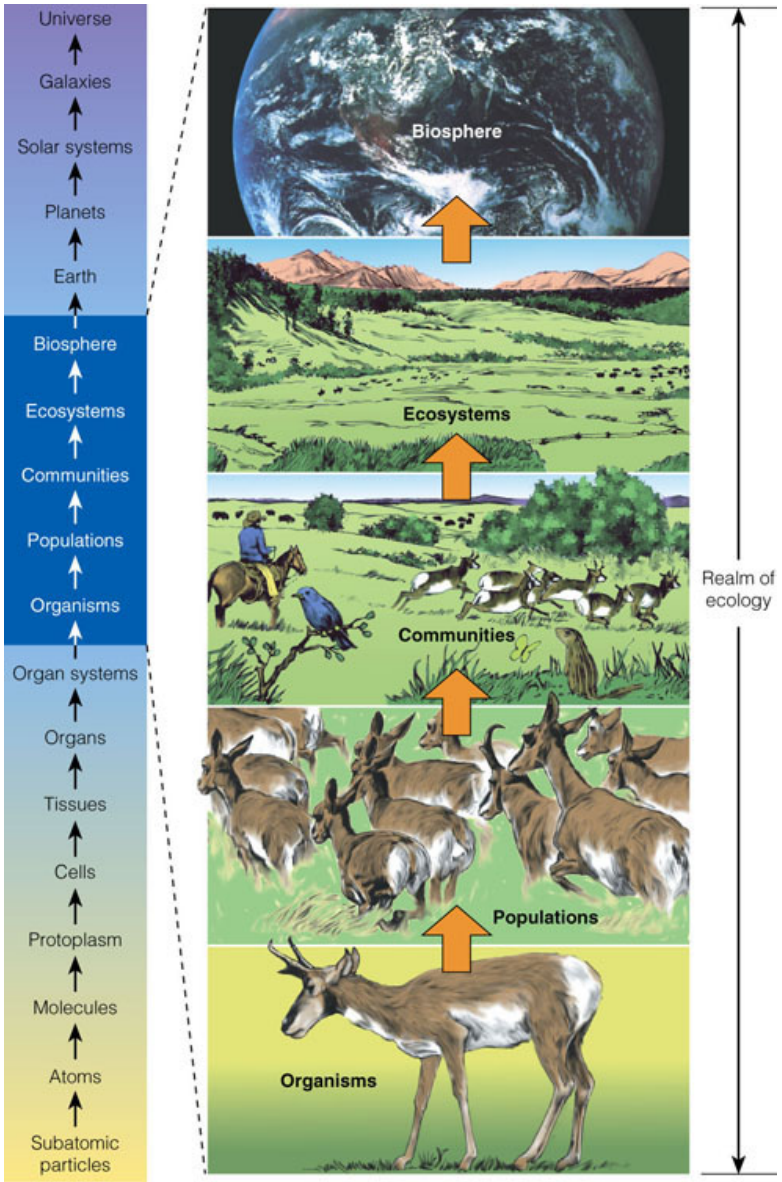
Chapter Overview Questions

- What is ecology?
- What basic processes keep us and other organisms alive?
- What are the major components of an ecosystem?
- What happens to energy in an ecosystem?
- What happens to matter in an ecosystem?
- How do scientists study ecosystems?

What is Life? 3.1

- Characteristics of Life:
  - Composed of cells- eukaryotic or prokaryotic
  - Contain universal genetic code- DNA
  - Obtain & transform matter & energy- used for for growth, survival, & reproduction
  - Maintain homeostasis
  - Reproduce
  - Respond to changes (adapt).
  - Evolve over time

The Nature of Ecology



- Ecology is a study of connections in nature.
  - How organisms interact with one another and with their nonliving environment.

Figure 3-2

What is Ecology?

- Levels of organization:
  - **biosphere-** biotic (living) & abiotic factors (non-living)
  - **ecosystem:** community + non–living environment
  - **community:** populations of different species in given area
  - **population:** a group of interacting individuals of same species
  - **organism (individuals):** any form of life
- Biospheres are composed of ecosystems, which are composed of communities, which are composed of populations, which are composed of organisms

Ecosystems

- **Ecosystem**: communities & the non–living parts of the environment.
  - Example: ducks, fish, and insect larvae living in/on a lake or pond.

Communities

- **Community**: populations of different species living together in a given area.
  - A biological community is a complex interacting network of plants, animals and microorganisms.
    - Example: longleaf pine community

Populations

- A population is a group of interacting individuals of the same species occupying a specific area.
  - The space an individual or population normally occupies is its habitat.

Figure 3-4

Populations

- Genetic diversity
  - In most natural populations individuals vary slightly in their genetic makeup.

Figure 3-5

- Organisms, the different forms of life on earth, can be classified into different species based on certain characteristics.

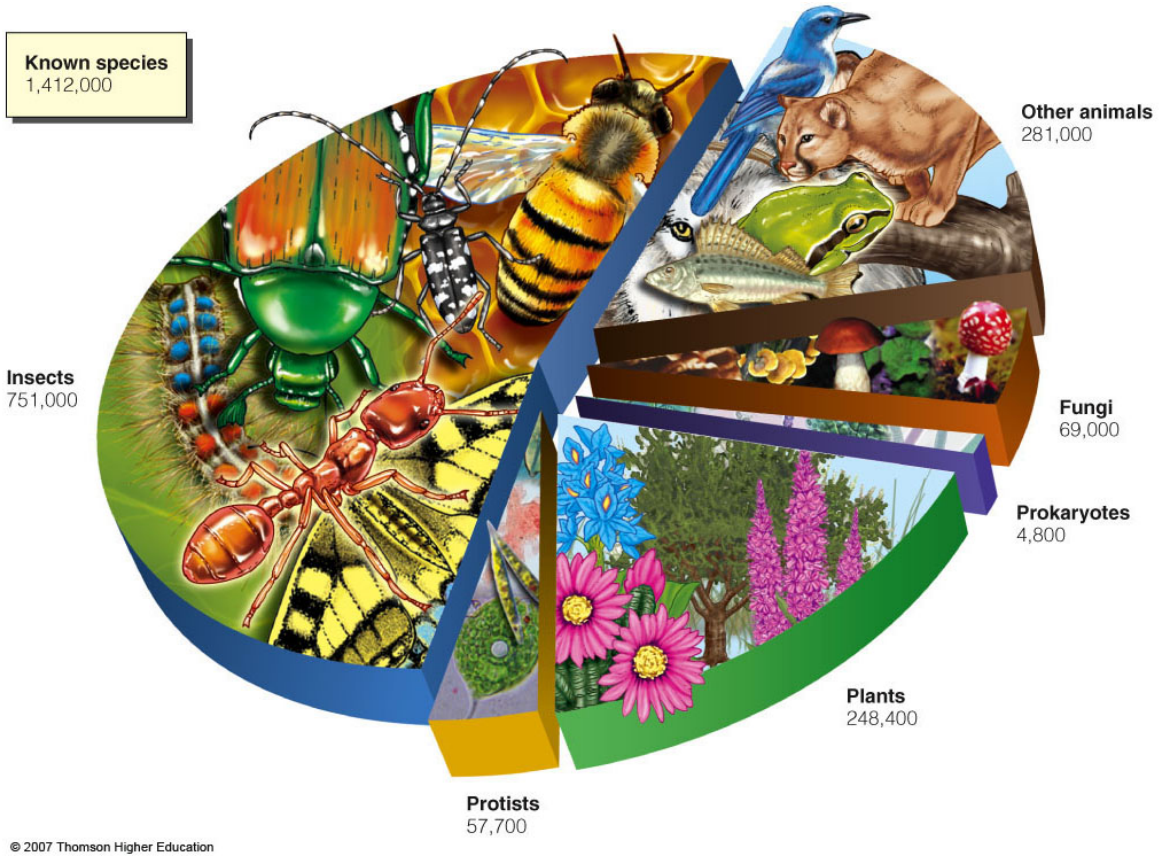


Figure 3-3

Organisms (Individuals)

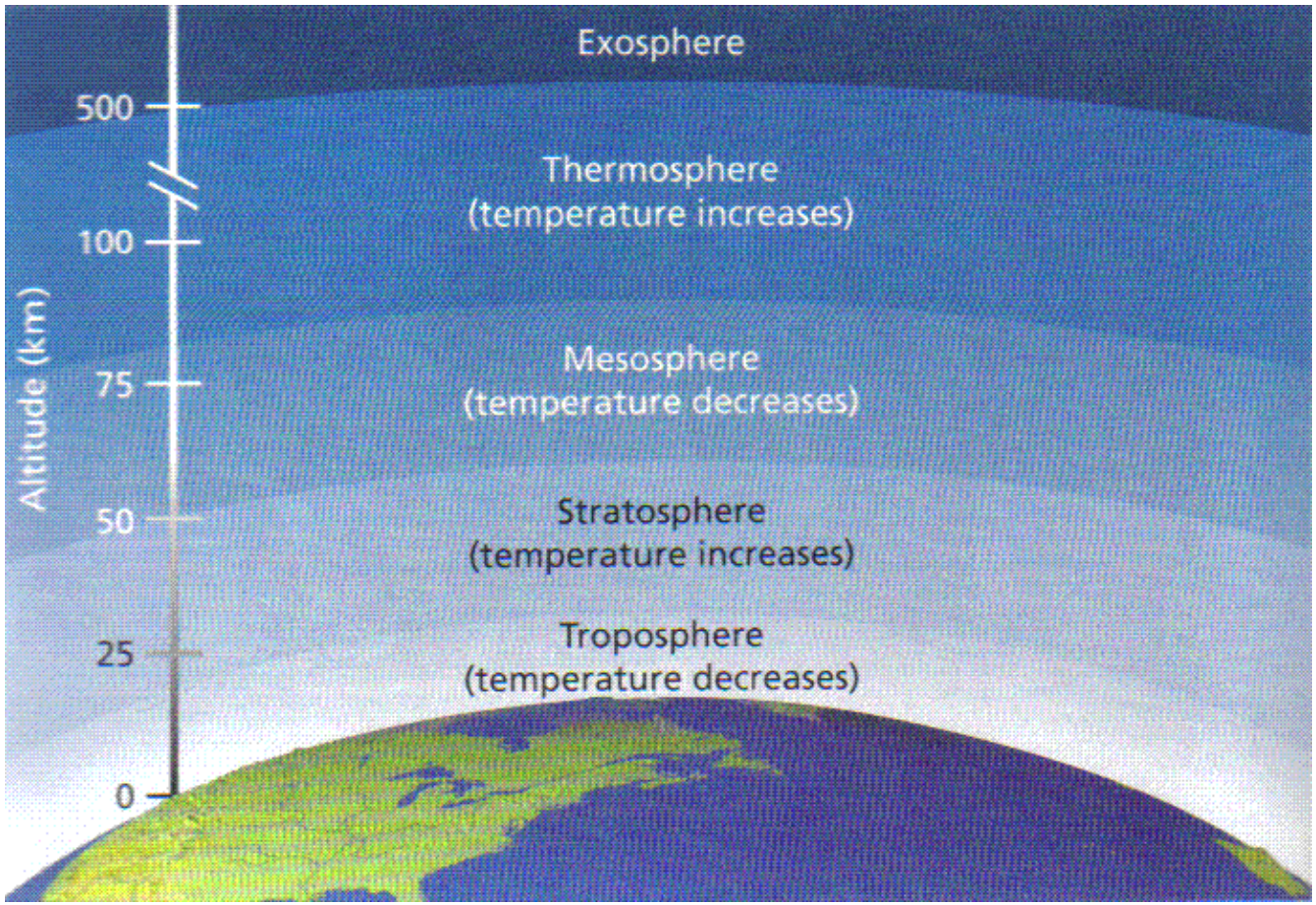
Species: groups of organisms that resemble each other, and in cases of sexually reproducing organisms, can potentially interbreed.

- Estimates of 5 to 100 million species, most are insects & microorganisms; so far only about 1.8 million named; each species is the result of long evolutionary history.
- **Wild or native species**: population that exists in its natural habitat .
- **Domesticated or introduced species**: population introduced by humans (= non–native species).

Layers of the Earth 3.2

- Atmosphere - envelope of air
- Hydrosphere- water layer
  - Liquid, ice, vapor.
- Lithosphere- Earth's crust and upper mantle.
  - Fossil fuels, minerals, soil chemicals.
- Biosphere- biotic & abiotic factors.

Layers of the atmosphere



Earth's Life–Support System

Earth's major components

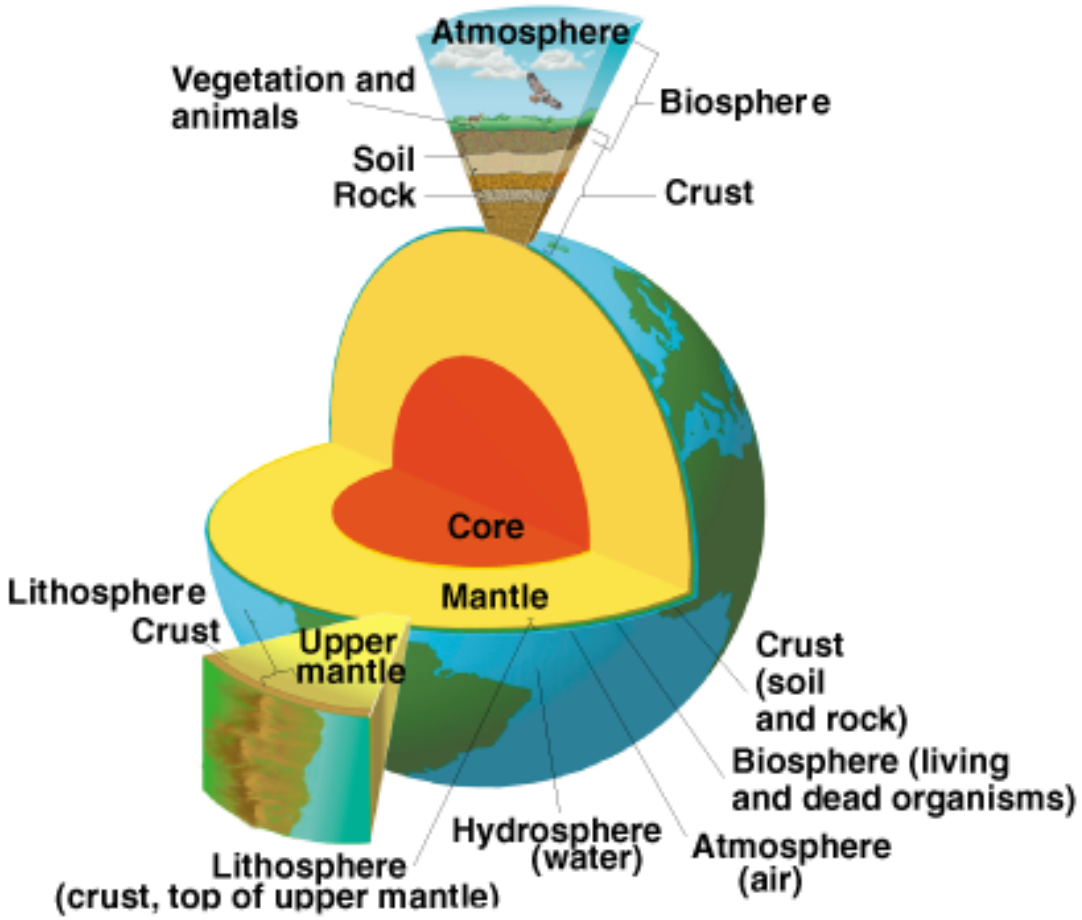
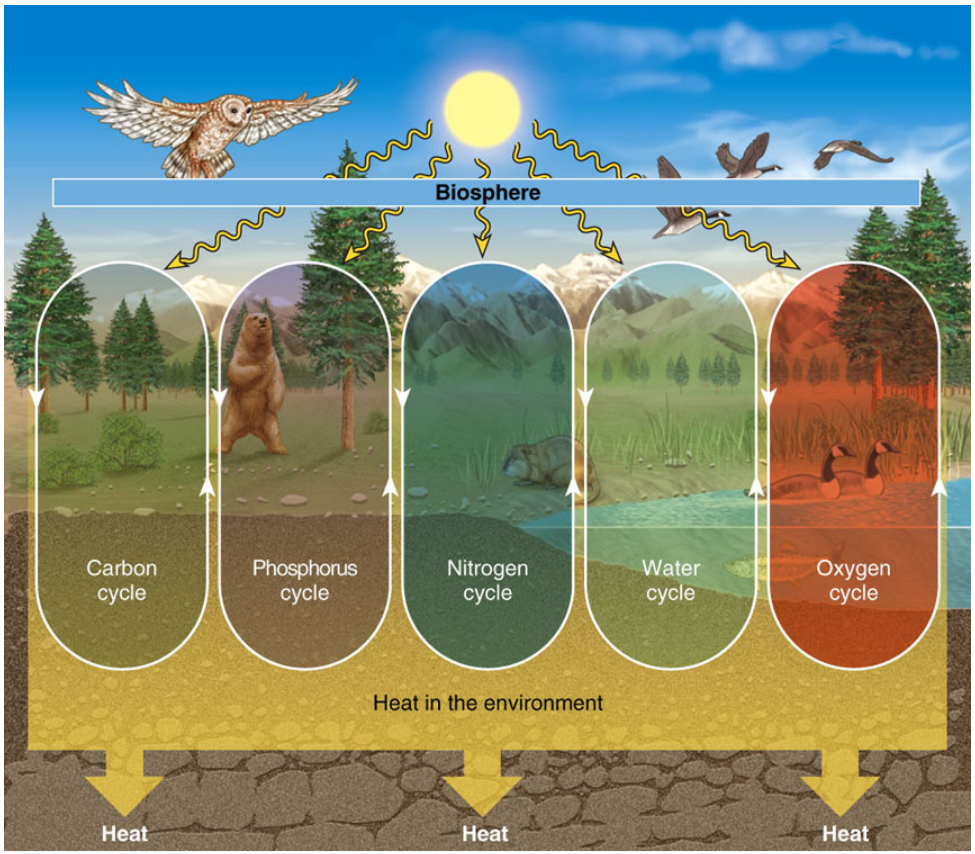


Fig. 4–7

Biosphere

- Organisms exist and interact with one another and their abiotic environment

What Sustains Life on Earth?



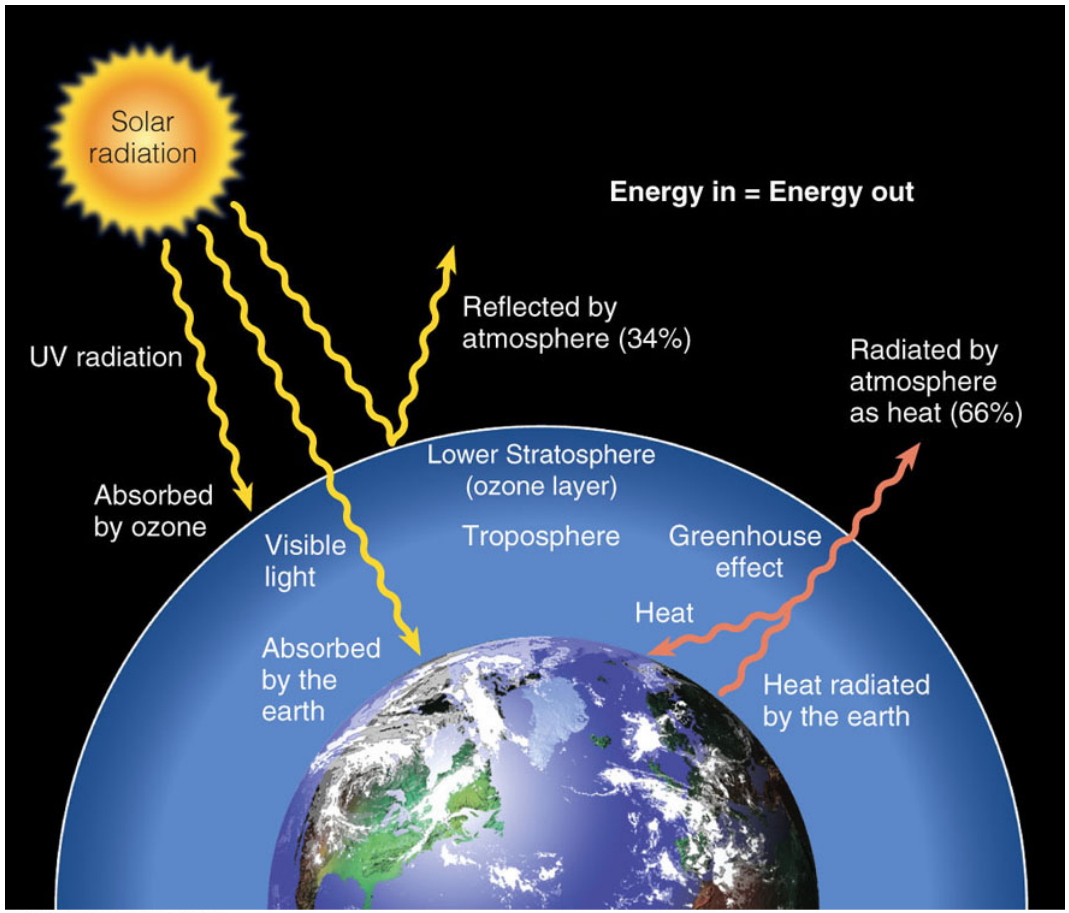
Solar energy, the cycling of matter, and gravity sustain the earth's life.

Figure 3-7

Sun, Cycles and Gravity

- Life on earth depends on 3 interconnected factors:
  - One-way flow of high-quality energy from the sun down
  - Cycling of matter through parts of the biosphere
  - Gravity, which allows the planet to hold onto its atmosphere and causes the downward movement of chemicals in the matter cycles
    - Phosphorus, carbon, nitrogen, water and sulfur

What Happens to Solar Energy Reaching the Earth?



- Solar energy flowing through the biosphere warms the atmosphere, evaporates and recycles water, generates winds and supports plant growth.

Figure 3-8

Ecosystem Concepts

- Biome: large regions characterized by a distinct climate & specific life forms, especially vegetation, adapted to the region.
  - Major biomes: temperate grassland, temperate deciduous forest, desert, tropical rain forest, tropical deciduous forest, tropical savannah, coniferous forest, tundra.
- Aquatic life zone: major marine or freshwater portion of the biosphere
  - Major aquatic life zones: lakes, streams, estuaries, coastlines, coral reefs, & the deep ocean

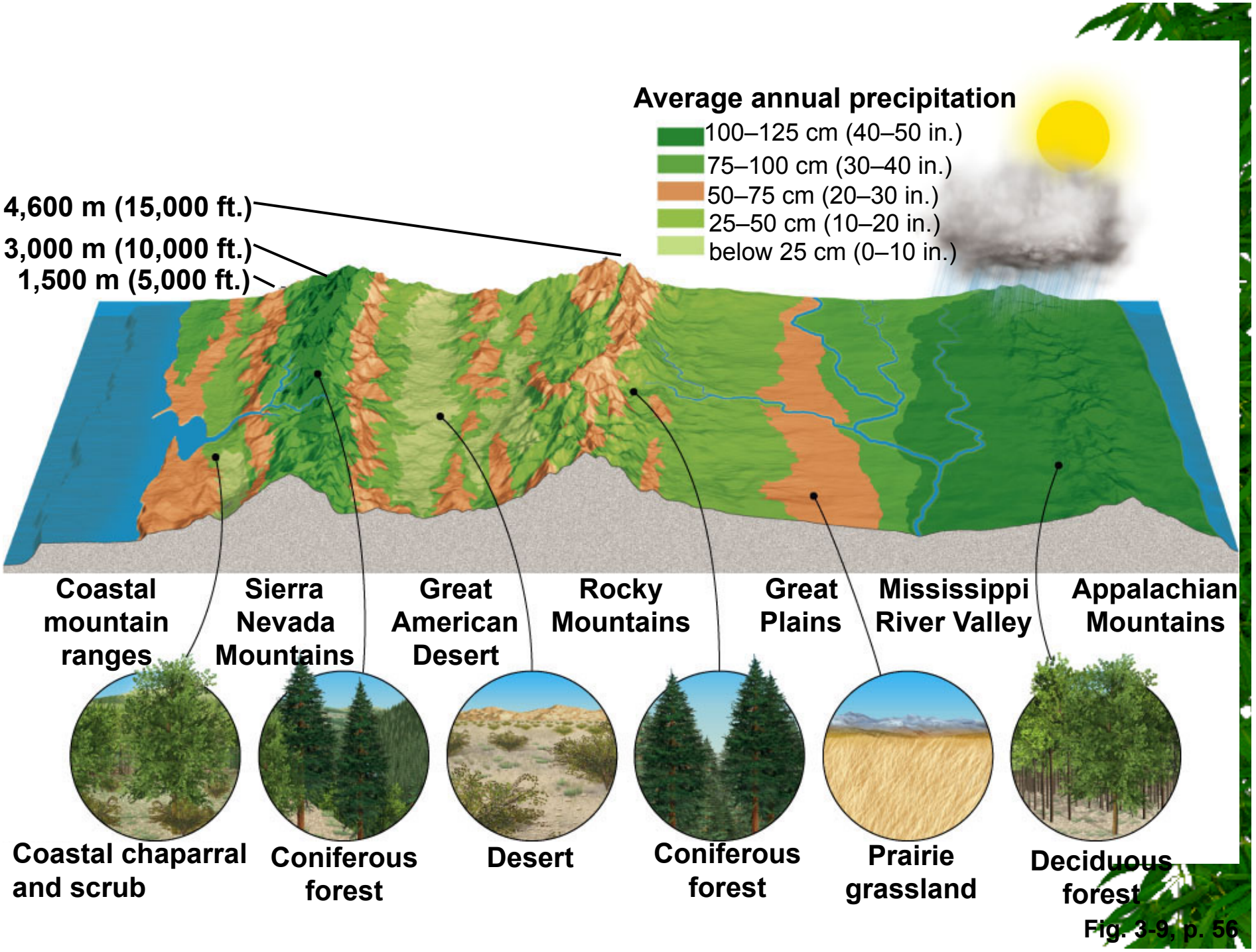
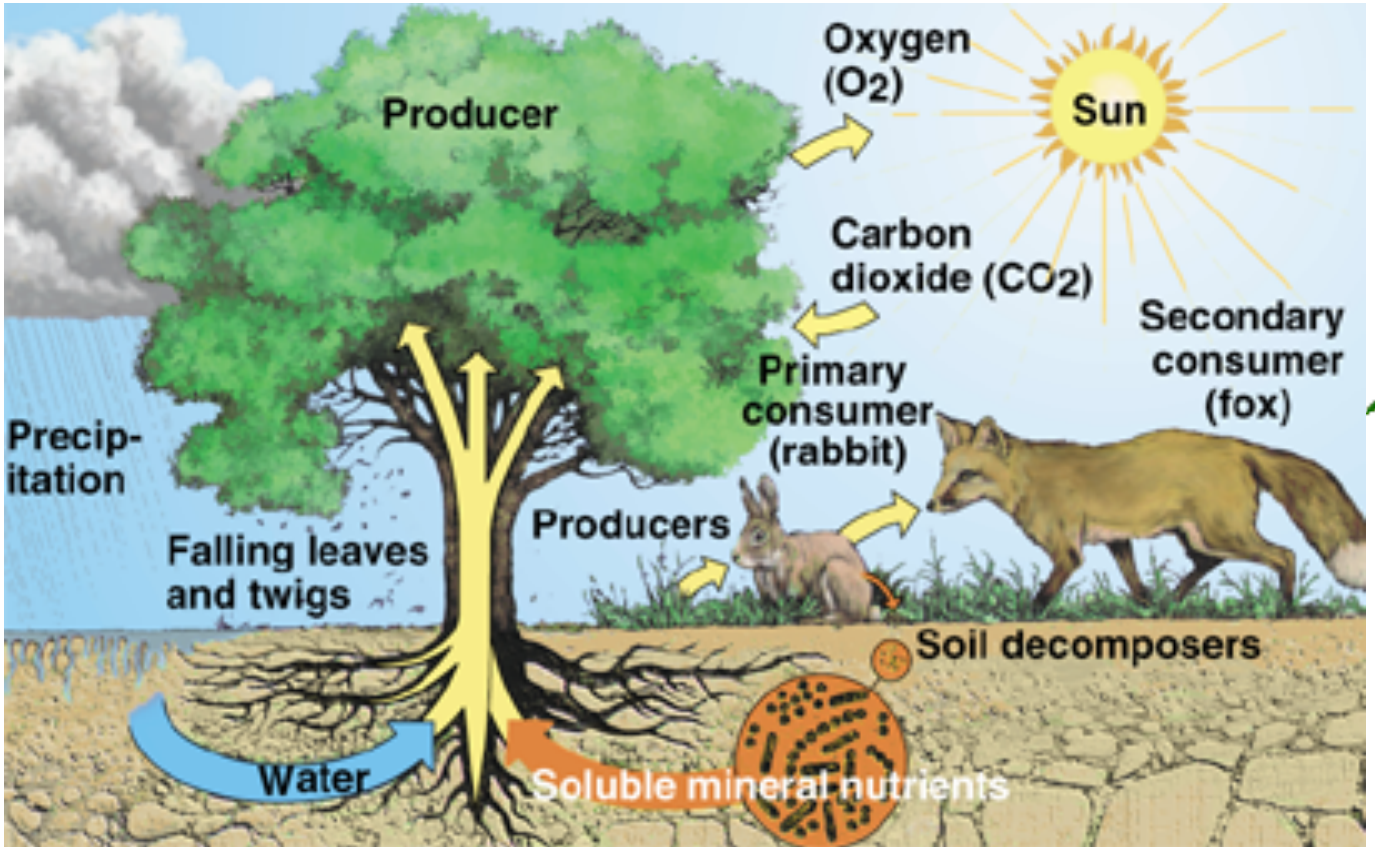
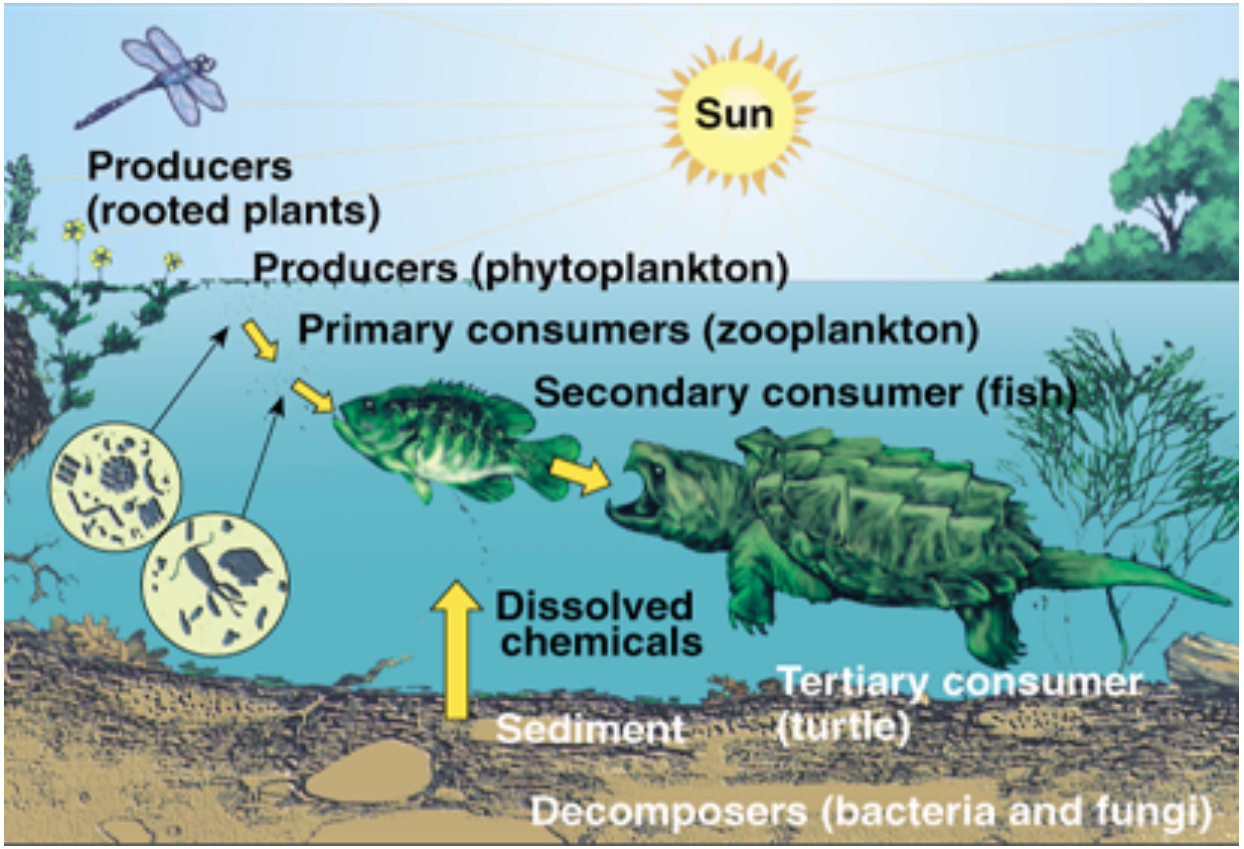

Average annual precipitation
100–125 cm (40–50 in.)
75–100 cm (30–40 in.)
50–75 cm (20–30 in.)
25–50 cm (10–20 in.)
below 25 cm (0–10 in.)
4,600 m (15,000 ft.)
3,000 m (10,000 ft.)
1,500 m (5,000 ft.)
Coastal mountain ranges
Sierra Nevada Mountains
Great American Desert
Rocky Mountains
Great Plains
Mississippi River Valley
Appalachian Mountains
Coastal chaparral and scrub
Coniferous forest
Desert
Coniferous forest
Prairie grassland
Deciduous forest

Fig. 3-9, p. 56

Major components of terrestrial ecosystems



Major components of aquatic ecosystems



Vocabulary for Ecosystems 3.3

- Abiotic: non–living components. Examples: water, air, sun
- Biotic: living components. Examples: plants, animals, bacteria
- Trophic level- feeding level for an organism

Factors Limiting Populations

- **Law of tolerance**: the ability of species to tolerate changes in their environment (physical or chemical factors). Pollution, global warming, habitat loss are some concerns associated with this.
- **Limiting factor**: any environmental factor that reduces survival or reproduction within a population.
  - Ex: predation, temperature
- **Limiting factor principle**: too much or too little of any abiotic factor can limit or prevent growth of a population, regardless if all other factors are near optimum range of tolerance.
  - Ex: too much fertilizer will kill plants.

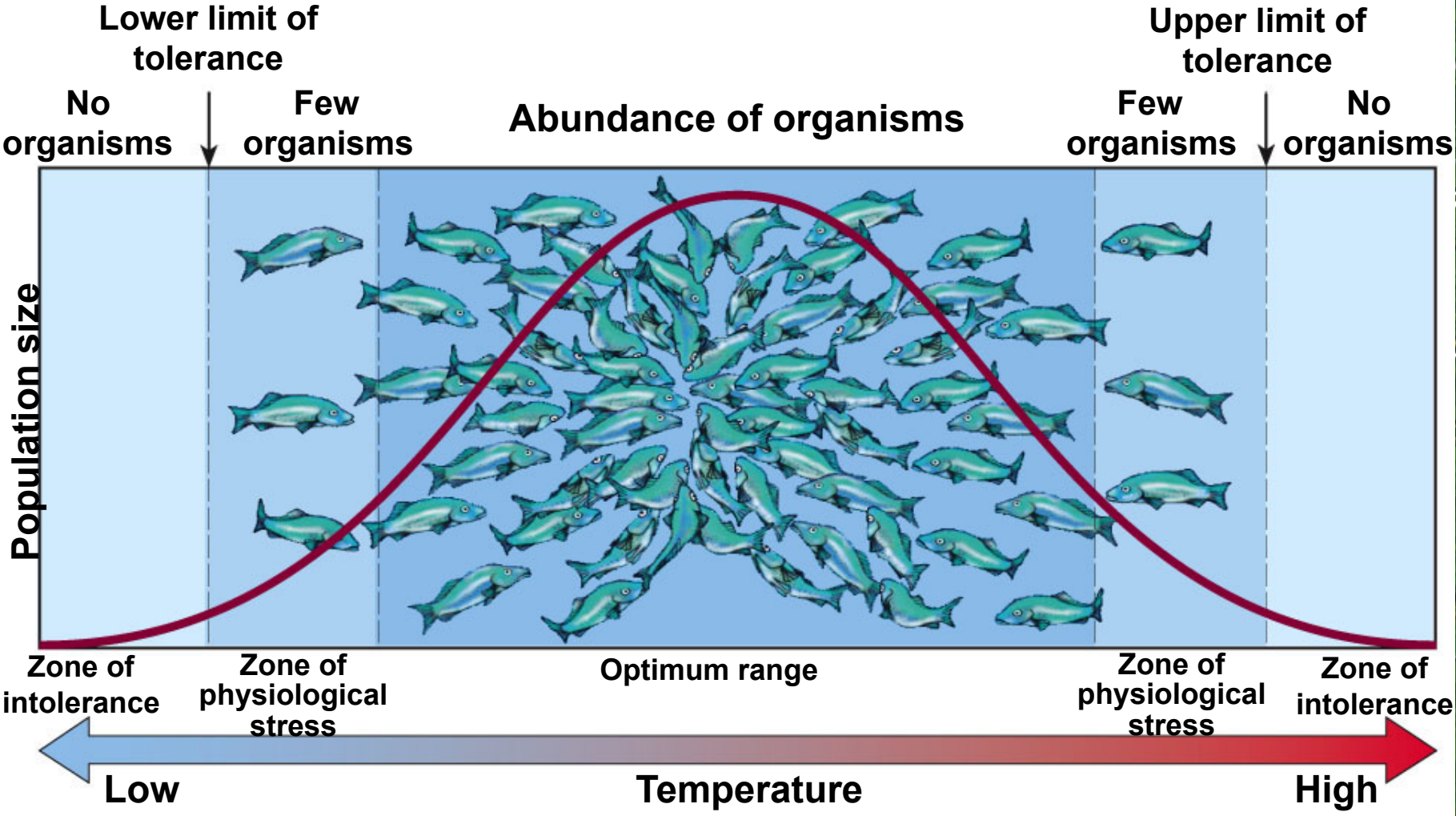


Fig. 3-11, p. 58

Major Biological Components of Ecosystems

- Producers
  - Sometimes called autotrophs
  - Use photosynthesis to produce food
    - $6\ CO_2 + 6\ H_2O + \nu \rightarrow C_6H_{12}O_6 + 6\ O_2$
- Consumers
  - Sometimes called heterotrophs
  - Get energy by feeding on other organisms

Categories of Consumers

- **Primary consumers**: (=herbivores) feed directly on producers;
- **Secondary consumers**: (=carnivores) feed on primary consumers;
- **Tertiary consumers**: feed only on carnivores;
- **Omnivores**: consumers that feed on both plants & animals;
- **Scavengers**: feed on dead organisms;
- **Detritivores**: feed on *detritus* (partially decomposed organic matter, such as leaf litter & animal dung).
  - **Decomposers (bacteria and fungi)**: consumers that complete the breakdown & recycling of organic materials from the remains & wastes of other organisms
  - **Detritus feeders (carpenter ants, crabs):** extract nutrients from partly decomposed organic matter

Aerobic Respiration

- Uses O_2 to convert organic nutrients back to energy, CO_2, and H_2O
- Survival of any individual depends on flow of matter and energy through its body
- Survival of an ecosystem depends on matter recycling and one-way energy flow

Anaerobic Respiration

- Also called fermentation
- The breaking down of glucose (or other organic compounds) in the absence of O_2
  - Products are methane, ethyl alcohol, acetic acid, and hydrogen sulfide

The Importance of Decomposers

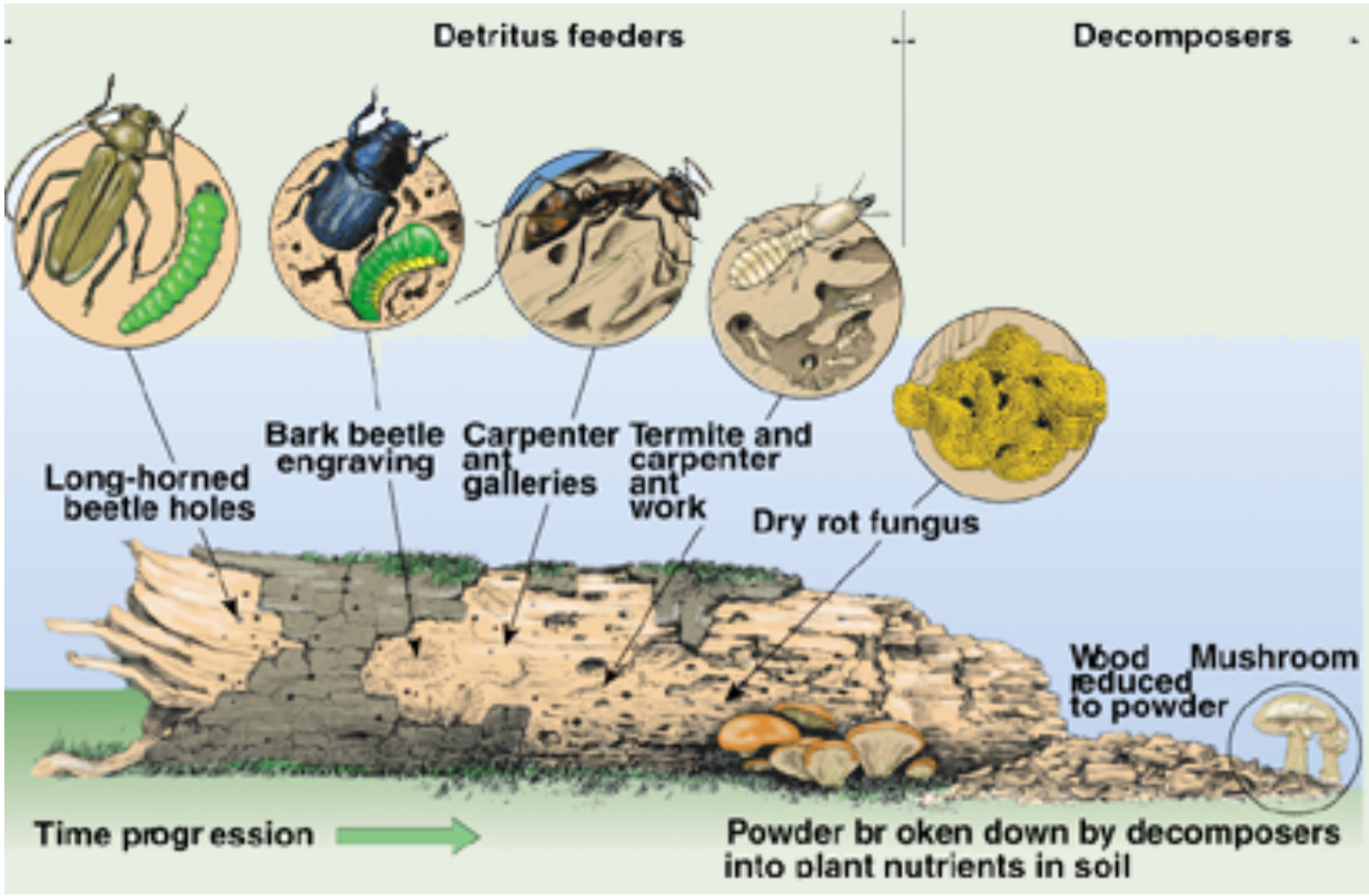
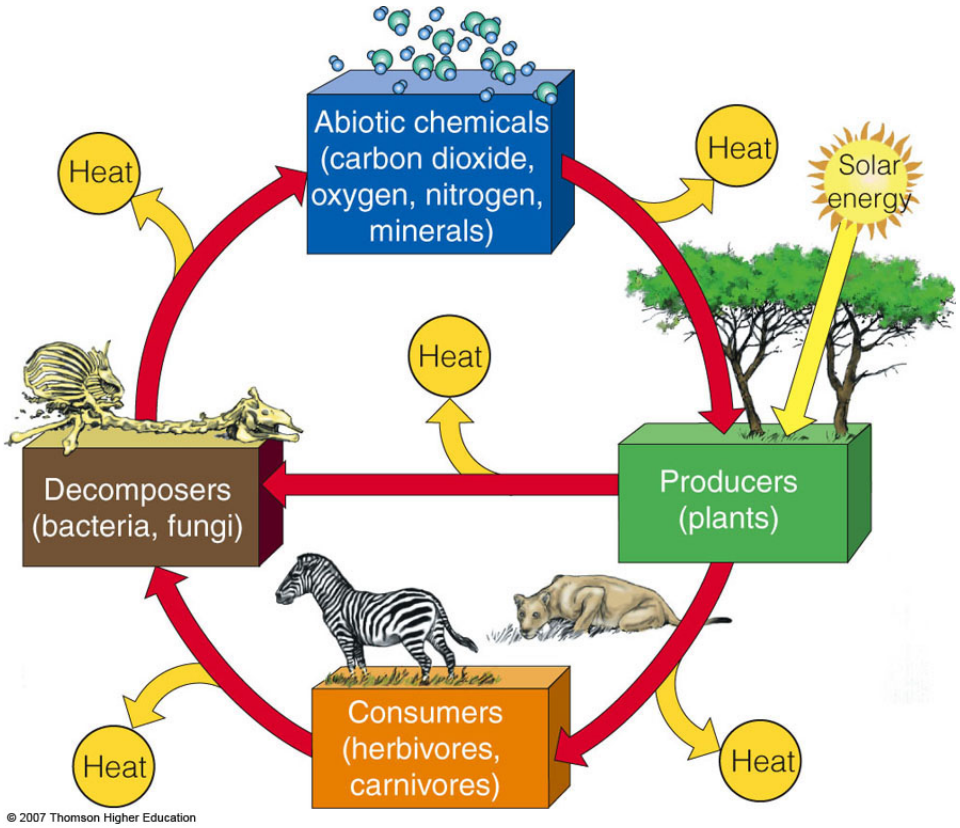


Fig. 4–16


06/17/20

Two Secrets of Survival: Energy Flow and Matter Recycle



- An ecosystem survives by a combination of energy flow and matter recycling.

Figure 3-14

Energy Flow in Ecosystems 3.4

- Food chain: determines how energy and nutrients move from one organism to another through an ecosystem.
- Trophic level: feeding level assigned to each organism in an ecosystem
- Food web: complex network of interconnected food chains

Food Chains

- Food chains are a simple food path involving a sequence of organisms, each of which is the food for the next.

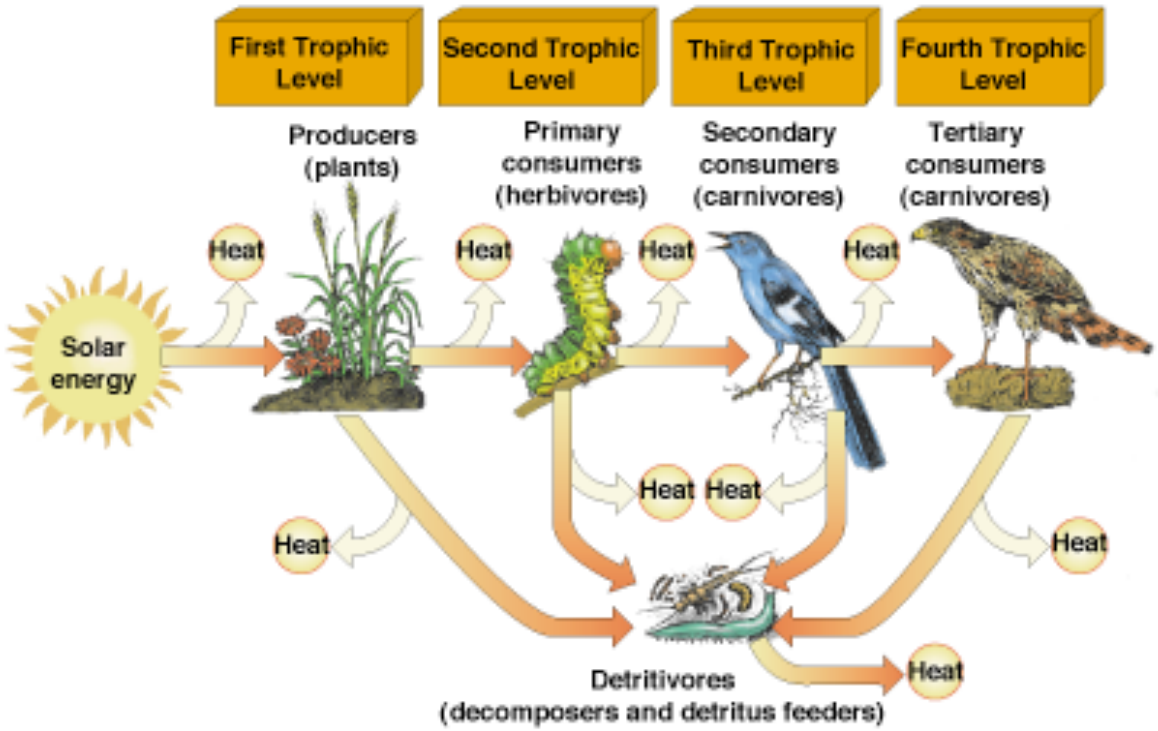


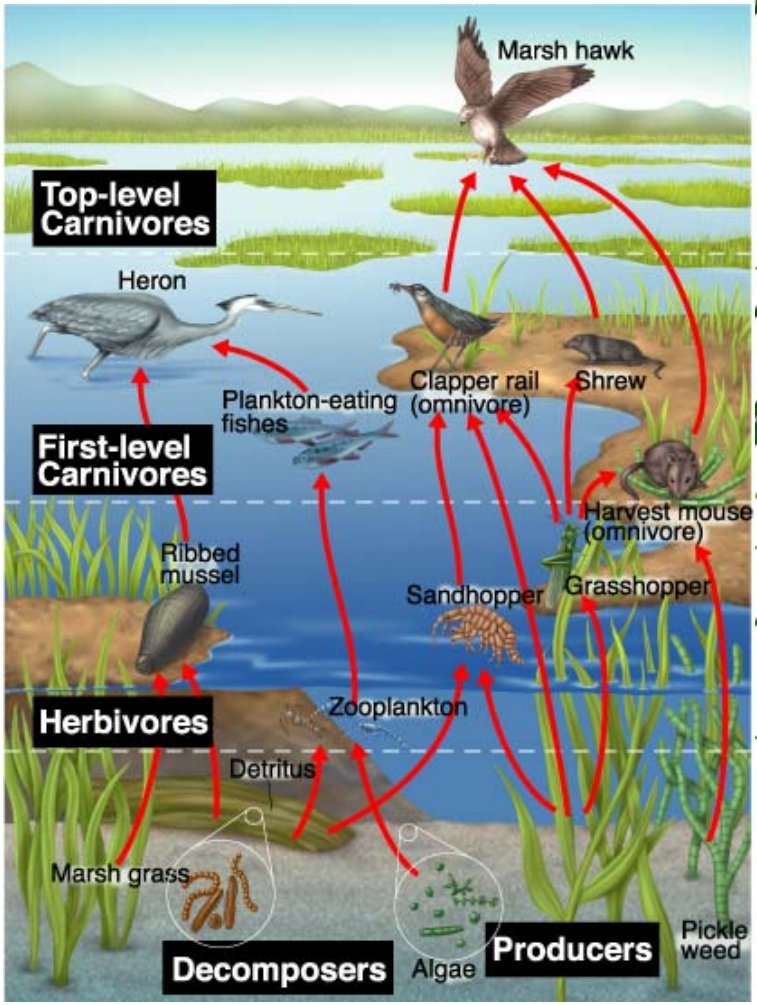
Fig. 4–18

Energy Flow in Ecosystems

- There is a decrease in amount of energy available to each succeeding organism in a food chain or web.
- Each trophic level in a chain or web contains certain amount of biomass.
  - Chemical energy stored here is transferred from one trophic level to another.

Food Webs

- Food webs are multiple food chains that are interconnected.
- More complex than food chains



Ecological Pyramids

- Represent the flow of energy through an ecosystem.
- Typically each trophic level has a certain amount of BIOMASS (dry weight of organic matter)
- Ecological efficiency- amount of usable energy transferred as biomass. ***Usually 10% at each transfer.***
- Food chains and webs only have 4-5 trophic levels, because too little energy is left to support top consumers.

Energy Pyramid

Generalized pyramid of energy flow showing decrease in usable energy available at each succeeding trophic level, assuming 90% loss in usable energy to the environment, in the form of low-quality heat.

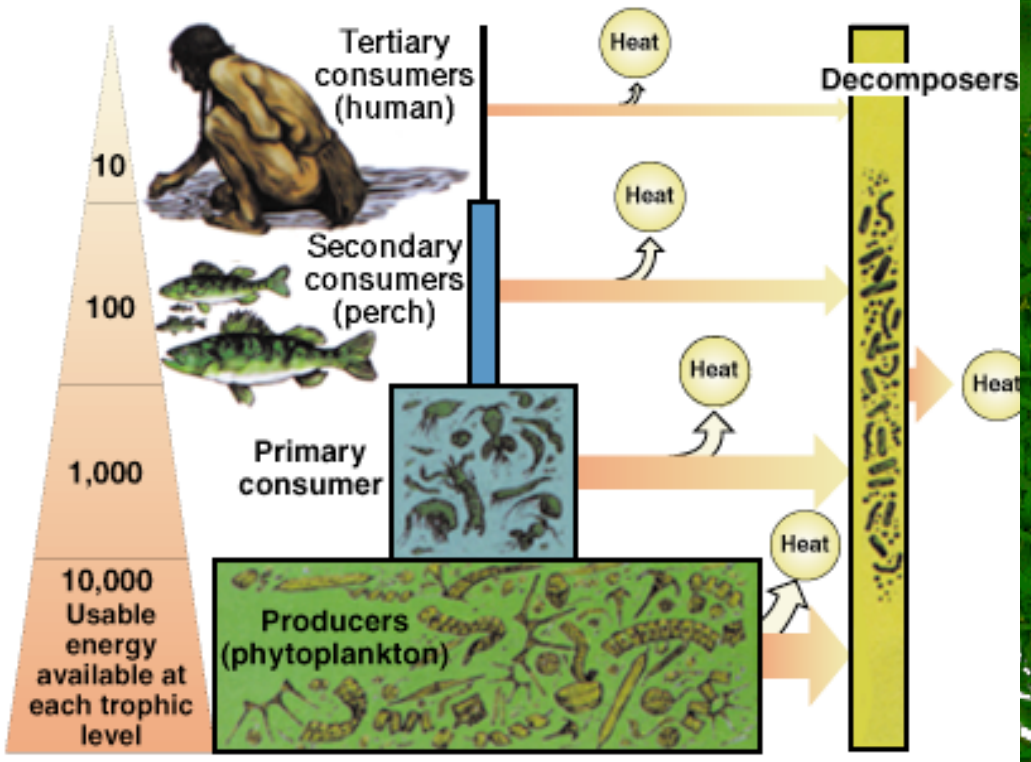
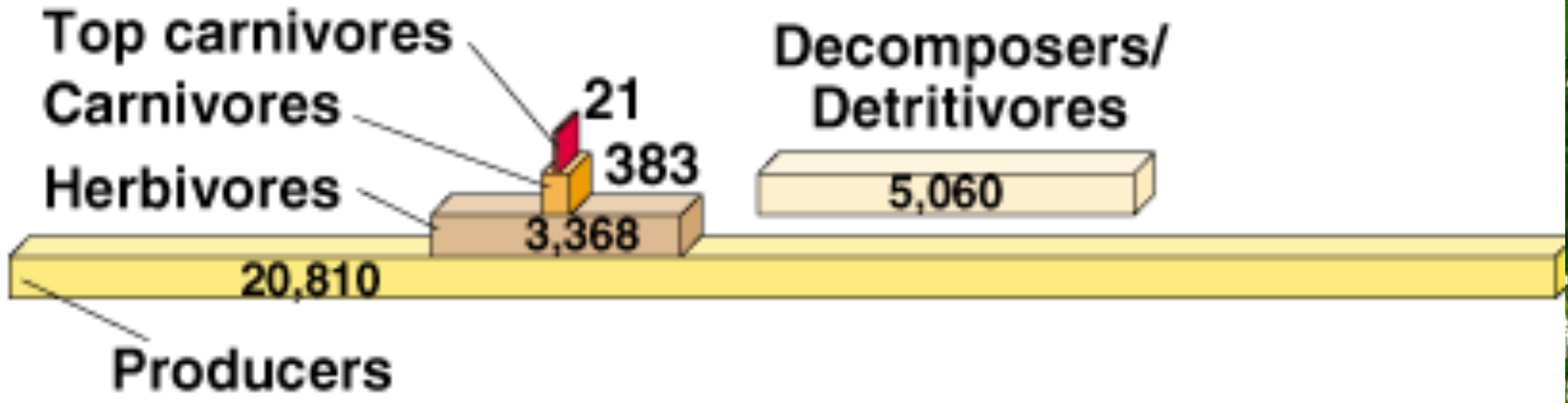


Fig. 4–19

Another Energy Pyramid

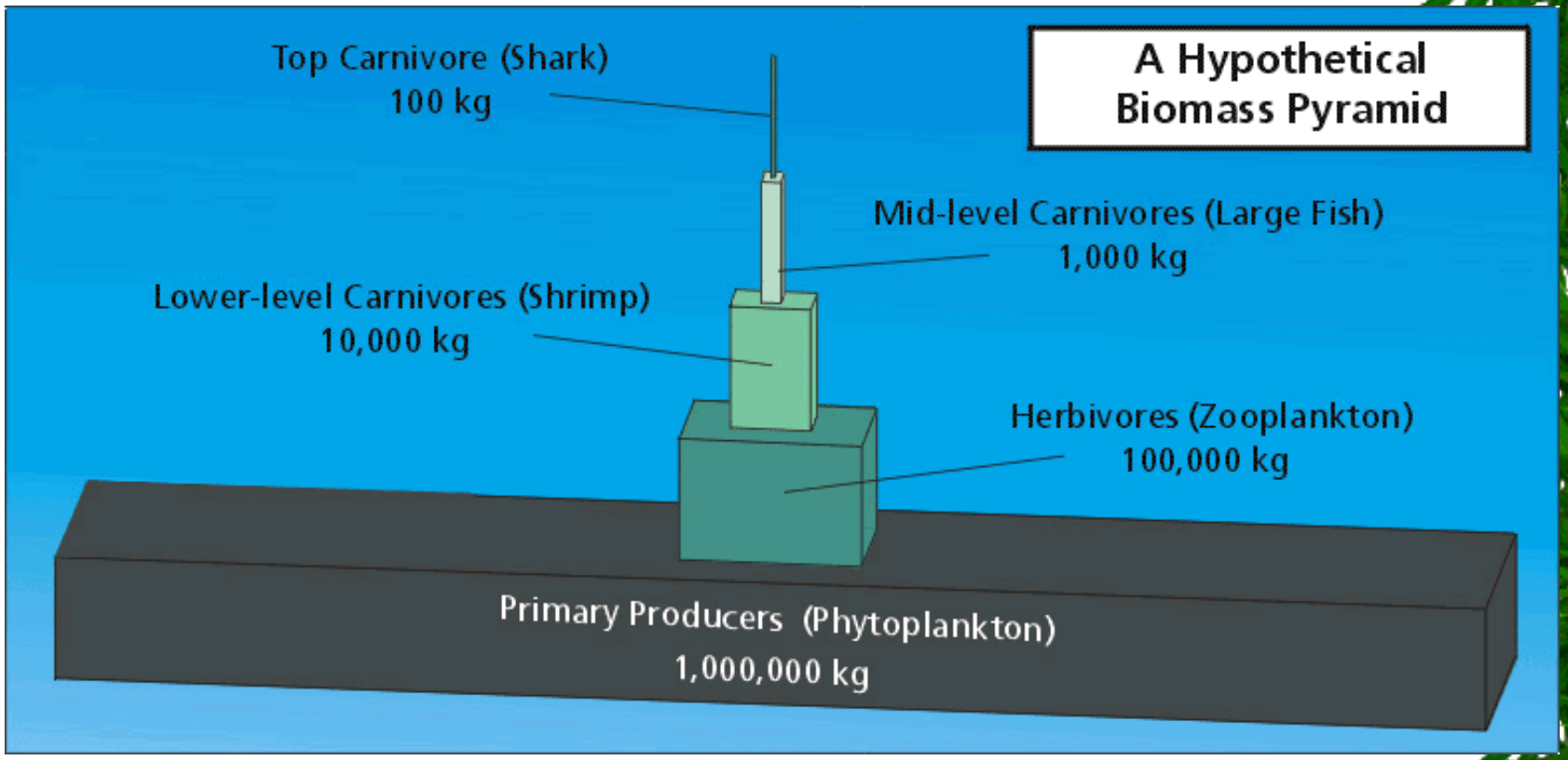
- *Annual pyramid of energy flow (in kilocalories per square meter per year) for an aquatic ecosystem in Silver Springs, FL.*

Note: More individuals can be supported at lower trophic levels. Less energy is lost.



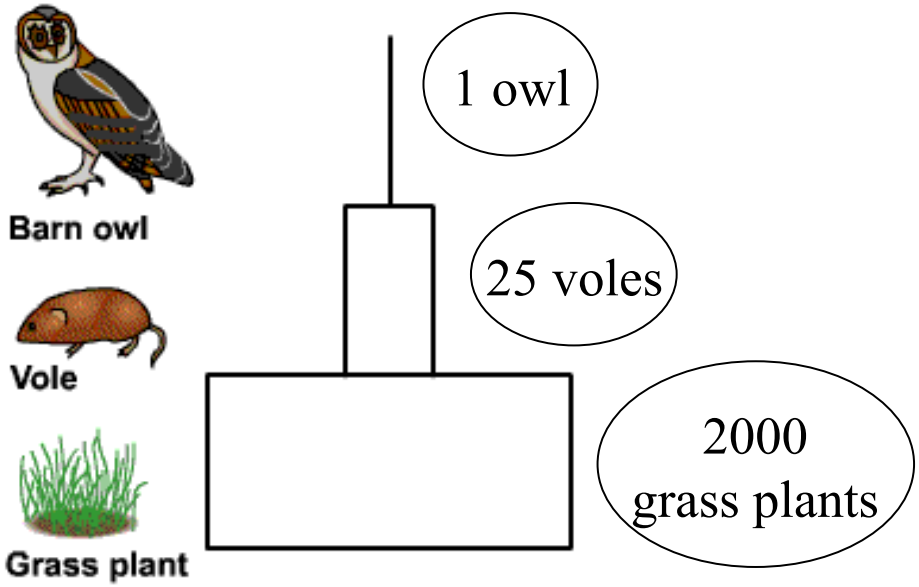
Biomass Pyramids

Displays the biomass of organisms at each trophic level. Size of each tier represents the dry weight per square meter of all organisms at that trophic level.



Pyramid of Numbers

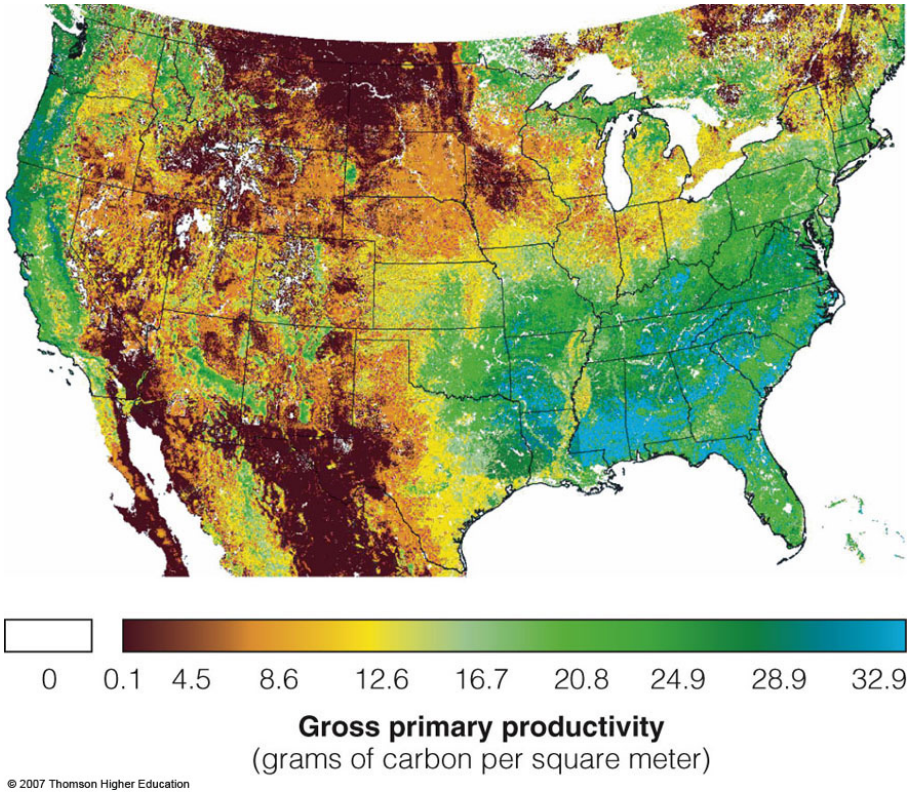
Pyramid of numbers displays the number of individuals at each level.



Primary Productivity of Ecosystems

- Gross primary productivity (GPP) is the rate at which an ecosystem's producers convert solar energy into chemical energy as biomass.
- Net primary productivity (NPP) is the rate at which chemical energy is stored for use by consumers in new biomass.
- **NPP =rate at which producers store chemical energy as biomass minus the rate at which producers use chemical energy stored as biomass**

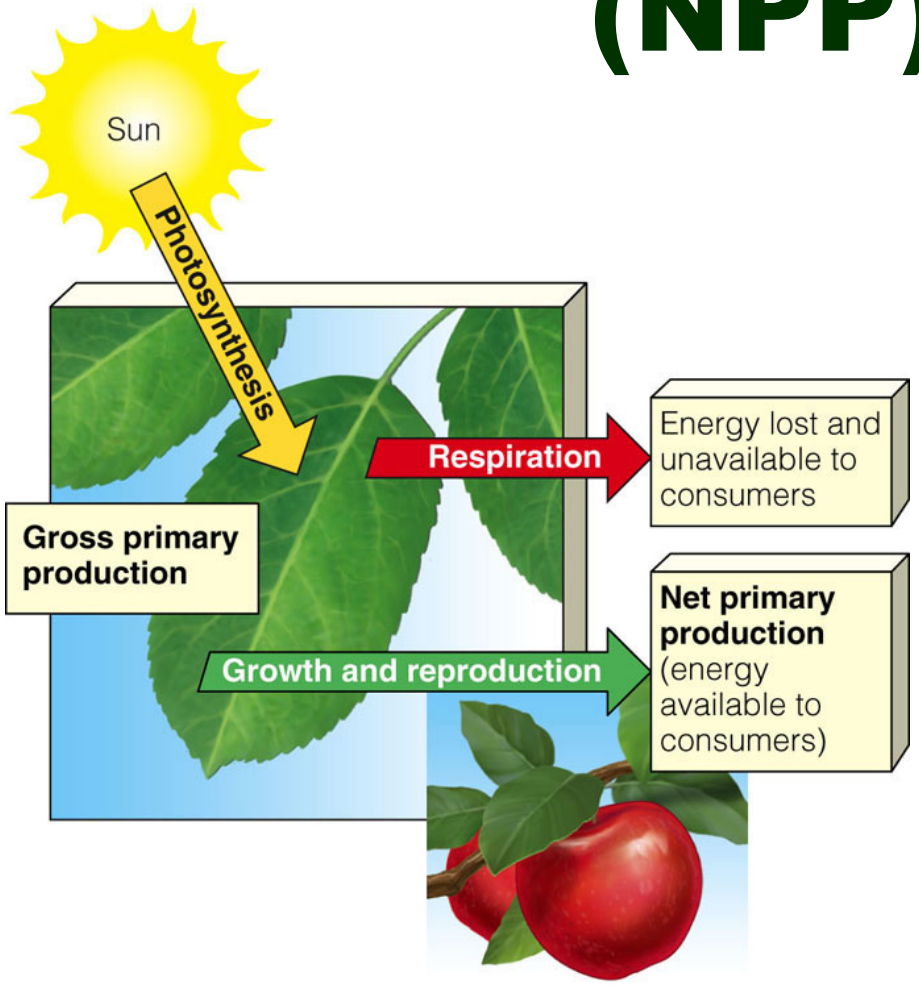
Productivity of Producers: The Rate Is Crucial



- Gross primary production (GPP)
  - Rate at which an ecosystem's producers convert solar energy into chemical energy as biomass.

Figure 3-20

Net Primary Production (NPP)

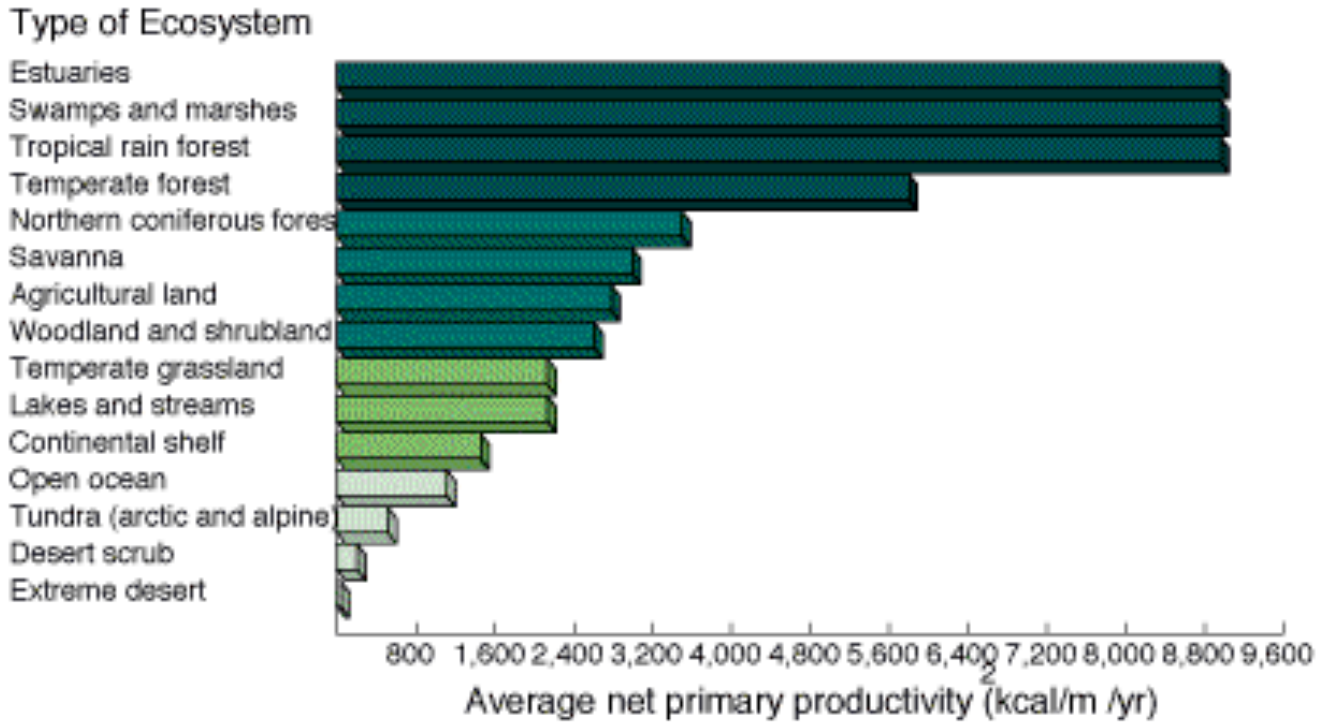


- NPP = GPP – R
  - Rate at which producers use photosynthesis to store energy minus the rate at which they use some of this energy through respiration (R).

Figure 3-21

Net Primary Productivity

Estimated annual net primary productivity of major biomes & aquatic life zones, expressed as kilocalories per square meter per year.



MATTER CYCLING IN ECOSYSTEMS 3.5

- Nutrient Cycles: Global Recycling
  - Global Cycles recycle nutrients through the earth's air, land, water, and living organisms.
  - Nutrients are the elements and compounds that organisms need to live, grow, and reproduce.
  - Biogeochemical cycles move these substances through air, water, soil, rock and living organisms.

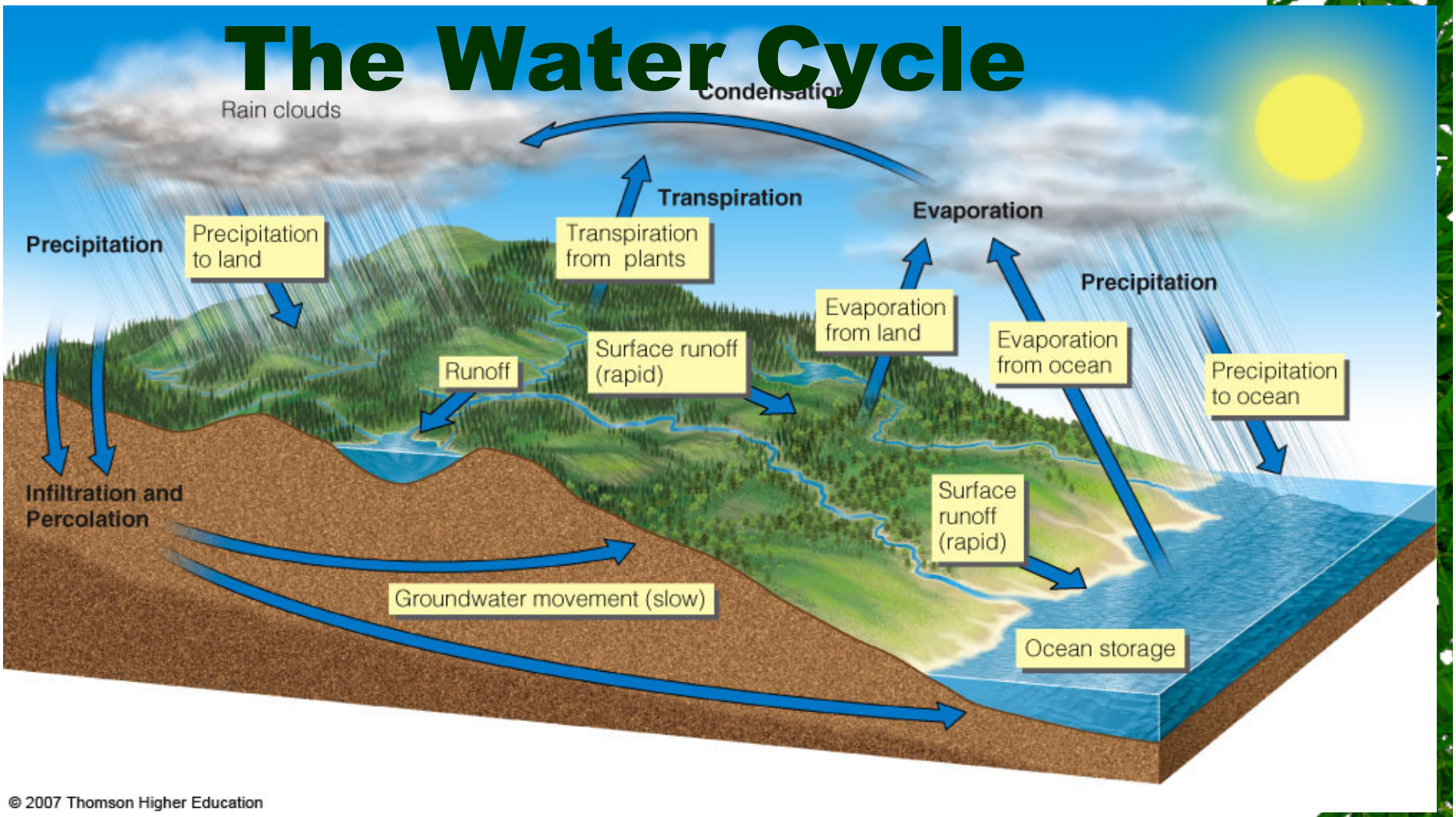

The Water Cycle
Rain clouds
Condensation
Transpiration
Evaporation
Precipitation
Precipitation to land
Transpiration from plants
Evaporation from land
Precipitation
Runoff
Surface runoff (rapid)
Evaporation from ocean
Precipitation to ocean
Infiltration and Percolation
Surface runoff (rapid)
Groundwater movement (slow)
Ocean storage
© 2007 Thomson Higher Education

Figure 3-26

Effects of Human Activities on Water Cycle

- We alter the water cycle by:
  - Withdrawing large amounts of freshwater.
  - Clearing vegetation and eroding soils.
  - Polluting surface and underground water.
  - Contributing to climate change.

The Carbon Cycle: Part of Nature's Thermostat

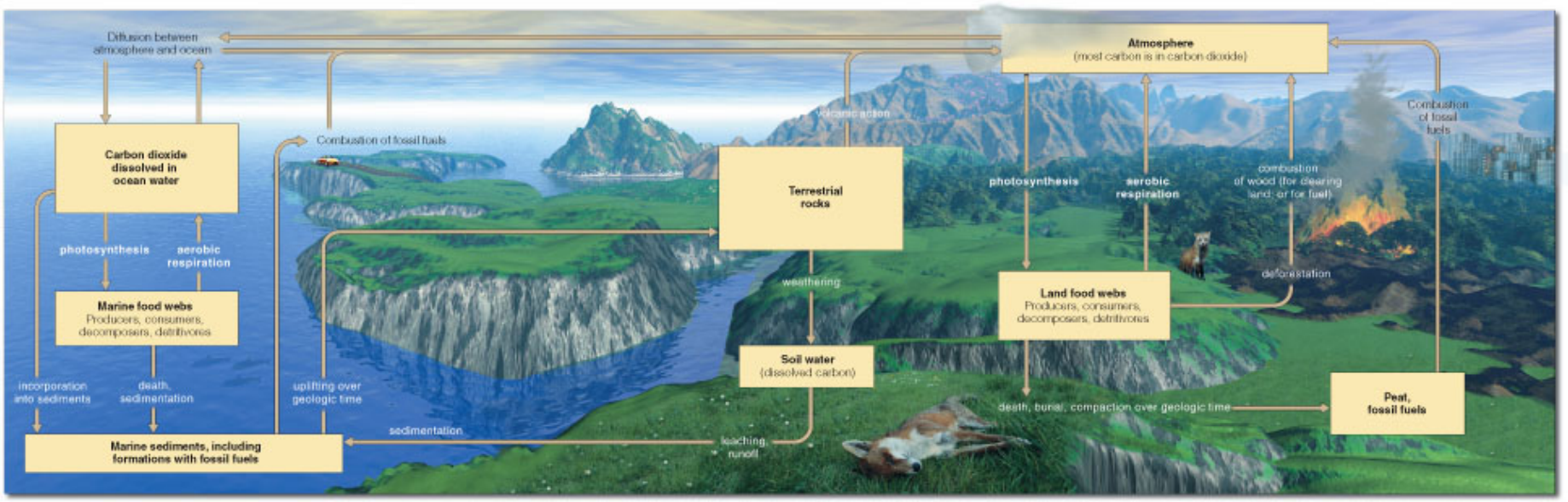


Figure 3-27

Effects of Human Activities on Carbon Cycle

- We alter the carbon cycle by adding excess CO_2 to the atmosphere through:
  - Burning fossil fuels.
  - Clearing vegetation faster than it is replaced.

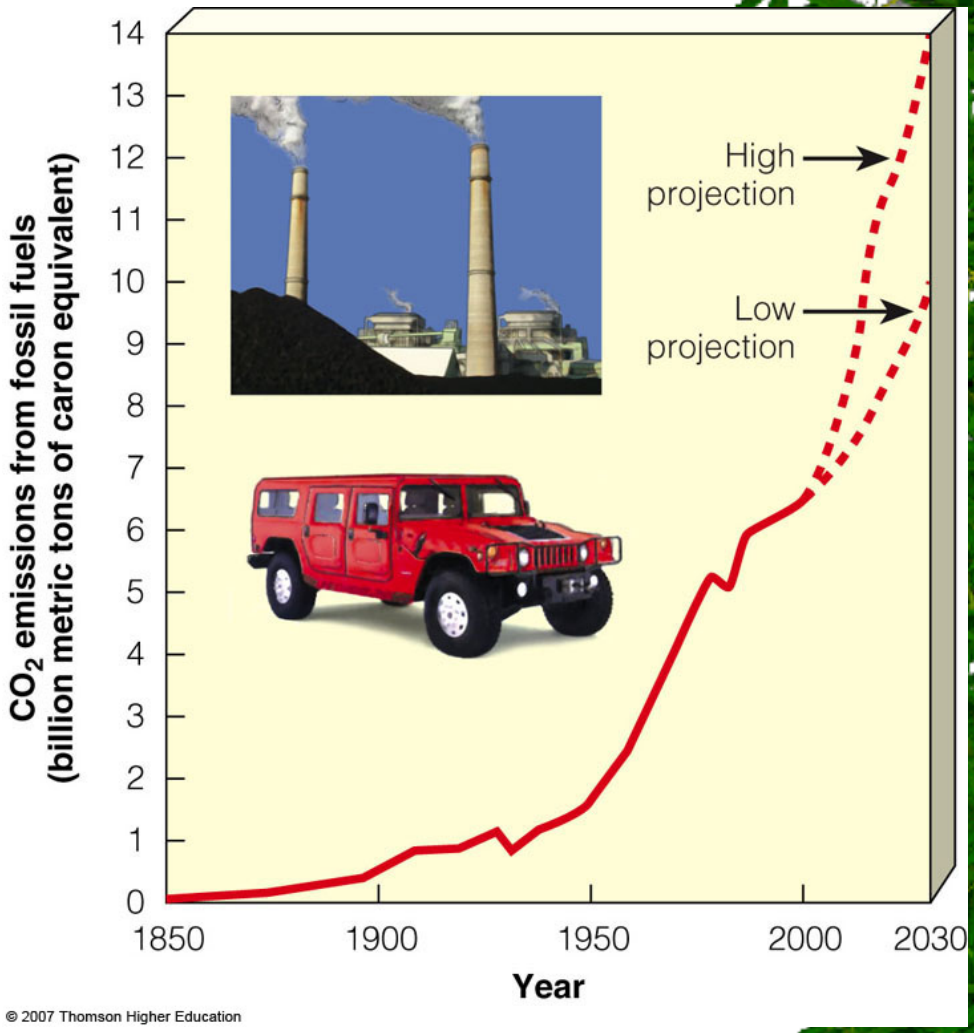
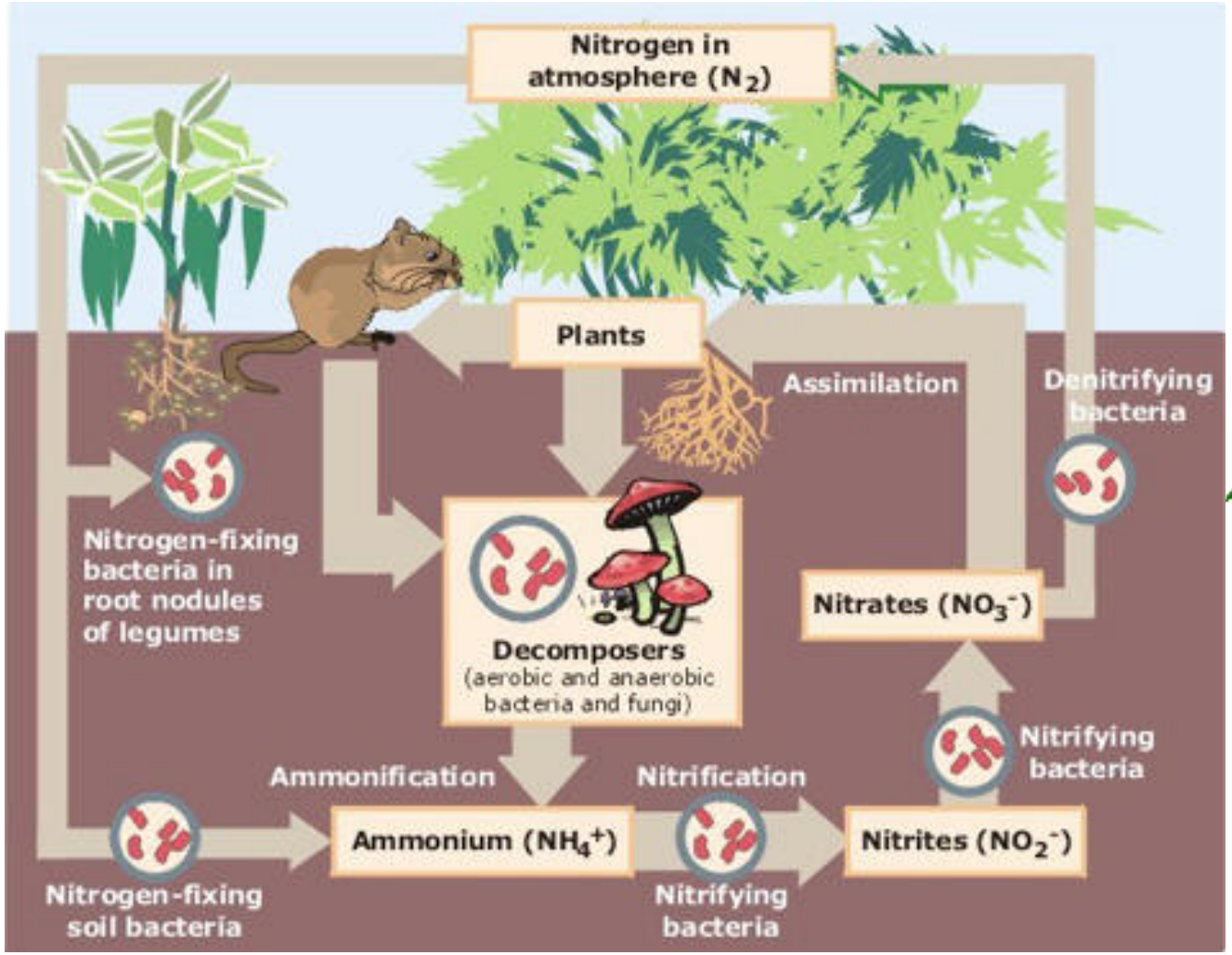


Figure 3-28

The Nitrogen Cycle: Bacteria in Action



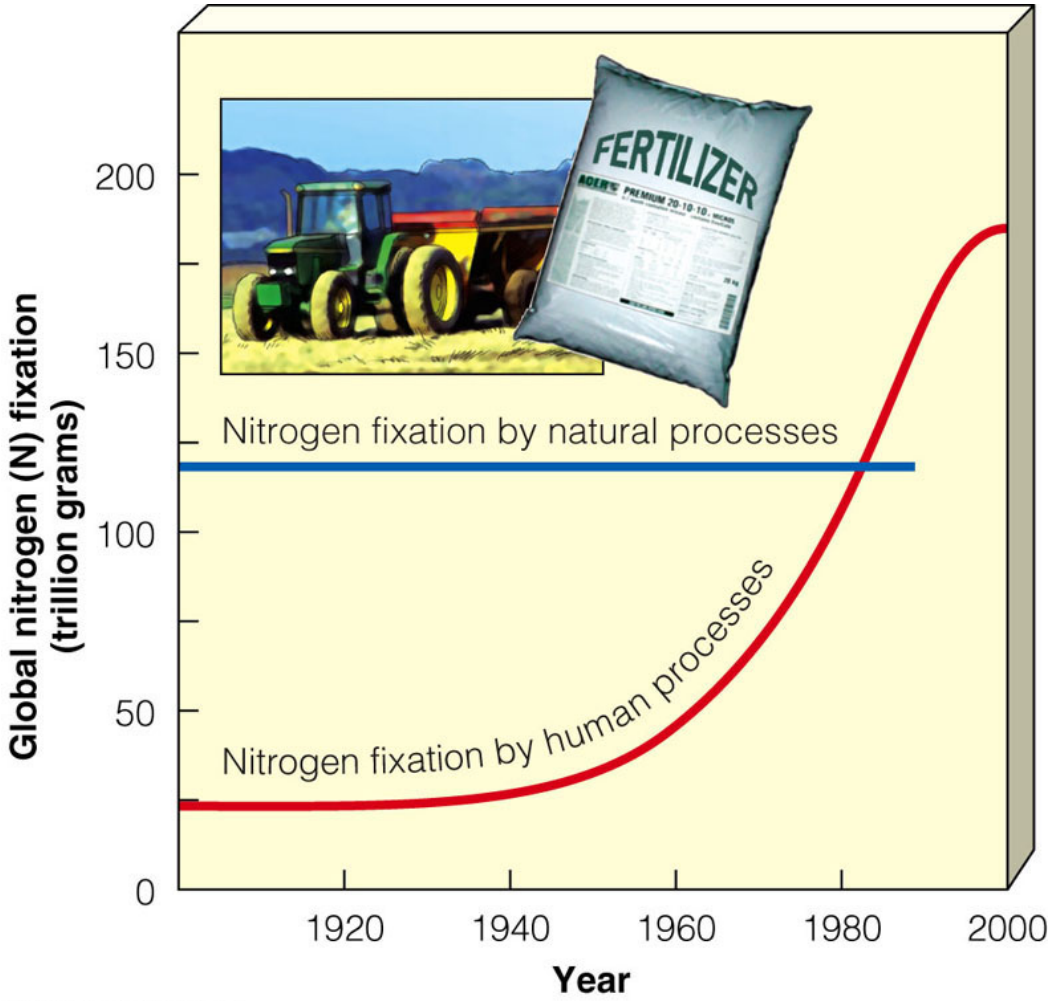
http://www.epa.gov/maia/html/nitrogen.html

Figure 3-29

Effects of Human Activities on the Nitrogen Cycle

- We alter the nitrogen cycle by:
  - Adding gases that contribute to acid rain.
  - Adding nitrous oxide to the atmosphere through farming practices which can warm the atmosphere and deplete ozone.
  - Contaminating ground water from nitrate ions in inorganic fertilizers.
  - Releasing nitrogen into the troposphere through deforestation.

Effects of Human Activities on the Nitrogen Cycle



- Human activities such as production of fertilizers now fix more nitrogen than all natural sources combined.

Figure 3-30

The Phosphorous Cycle

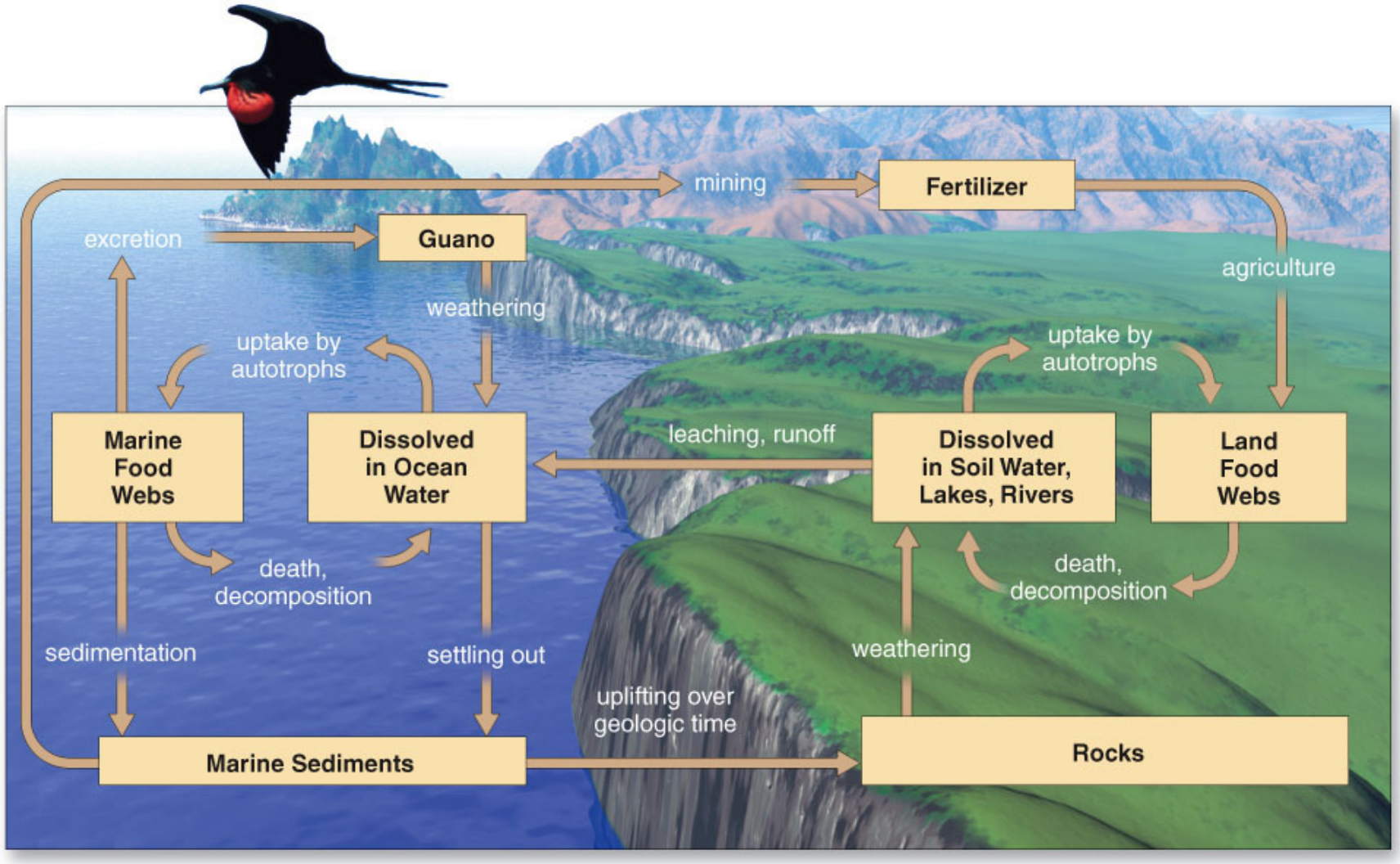


Figure 3-31

Effects of Human Activities on the Phosphorous Cycle

- We remove large amounts of phosphate from the earth to make fertilizer.
- We reduce phosphorous in tropical soils by clearing forests.
- We add excess phosphates to aquatic systems from runoff of animal wastes and fertilizers.

The Sulfur Cycle

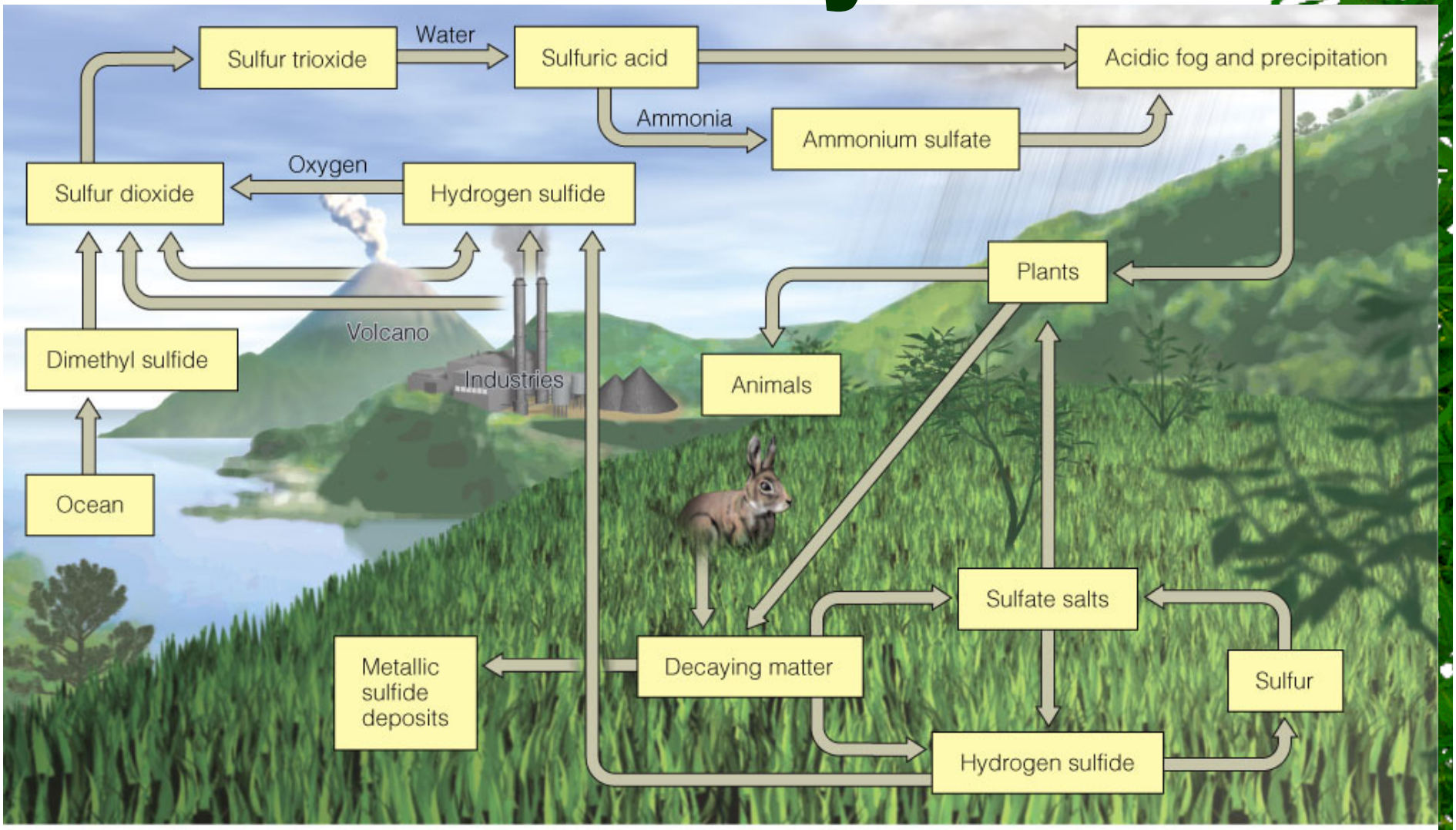


Figure 3-32

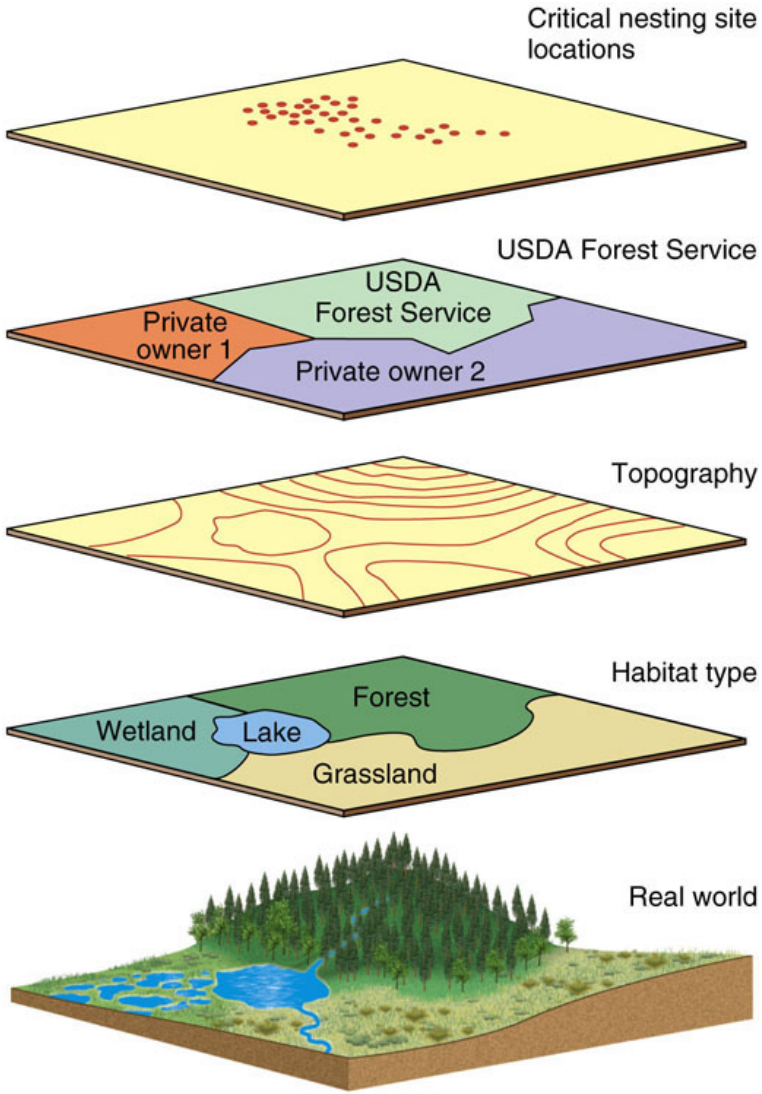
Effects of Human Activities on the Sulfur Cycle

- We add sulfur dioxide to the atmosphere by:
  - Burning coal and oil
  - Refining sulfur containing petroleum.
  - Convert sulfur-containing metallic ores into free metals such as copper, lead, and zinc releasing sulfur dioxide into the environment.

How Do Ecologists Learn About Ecosystems? 3.3

- Field Research- observing/measuring ecosystem structure and function
- Remote sensing and Geographic information systems (GIS)- new technologies that gather data fed through a computer for analysis. (ie. *Computer generated maps of forest cover, coastal changes,etc*)
- Laboratory Research- controlled chambers such as tanks, greenhouse; control CO_2, temperature, light, humidity
- Mathematical models- simulations of ecosystems that are large, complex, or difficult to study in the field/lab *(ocean floor)*

Geographic Information Systems (GIS)



- A GIS organizes, stores, and analyzes complex data collected over broad geographic areas.
- Allows the simultaneous overlay of many layers of data.