ENVIRONMENT

THE SCIENCE BEHIND THE STORIES

Jay Withgott • Scott Brennan

Ch 6

Species Interactions and Community Ecology

Part 1: Foundations of Environmental Science

PowerPoint® Slides prepared by
Jay Withgott and Heidi Marcum

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Case Study: Black and white and spread all over

- Small, black and white shellfish
- Introduced to Lake St. Clair, Canada, in 1988, in discharged ballast water
- Within 2 years, the zebra mussels invaded all 5 Great Lakes
- Populations grew exponentially
  - No natural predators, competitors, or parasites
- Hundreds of millions of dollars of damage to property

(a) Clogging a pipe

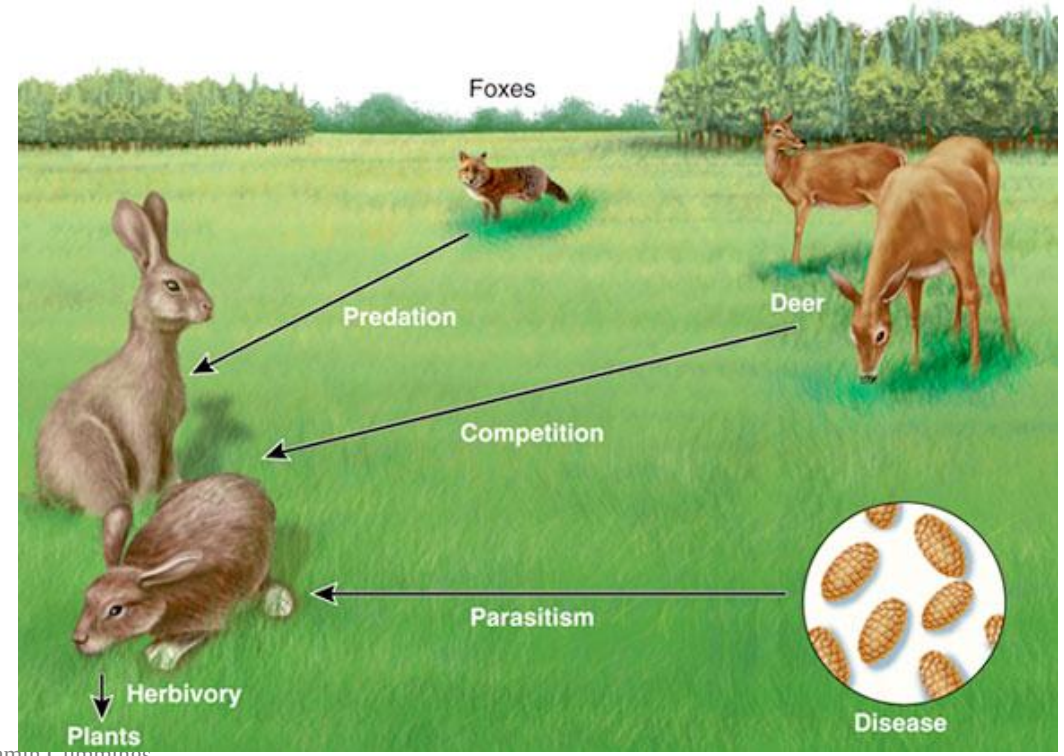
Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Species interactions

- Species interactions are the backbone of communities
- Most important categories
  - **Competition** = both species are harmed
  - **Predation, parasitism,** and **herbivory** = one species benefits and the other is harmed
  - **Mutualism** =

both species benefit



Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

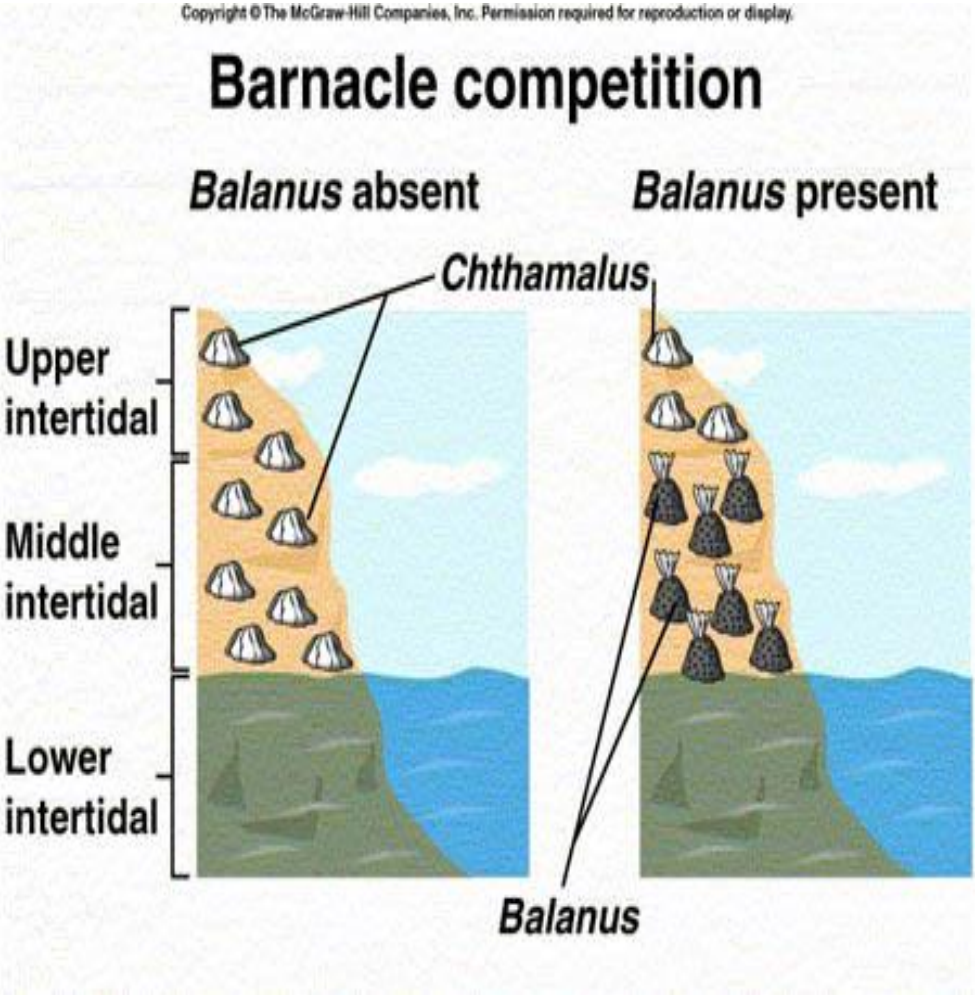
Competition

- **Competition** = relationship where multiple organisms seek the same limited resources they need to survive:
  - Food - Water
  - Space - Shelter
  - Mates - Sunlight
- **Intraspecific competition** = between members of the same species
  - High population density = increased competition
- **Interspecific competition** = between members of 2 or more species
  - Leads to competitive exclusion or species coexistence

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Results of interspecific competition

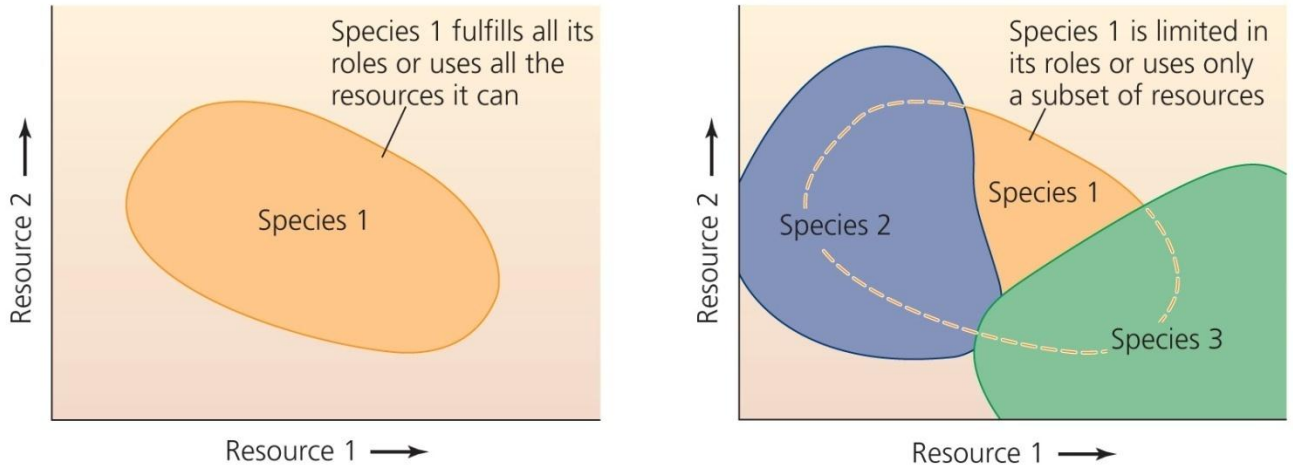
- **Competitive exclusion** = one species completely excludes another species from using the resource
- **Species coexistence** = neither species fully excludes the other from resources, so both live side by side
  - This produces a stable point of equilibrium, with stable population sizes



Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Niche: an individual's ecological role

- **Fundamental niche** = when an individual fulfills its entire role by using all the available resources
- **Realized niche** = the portion of the fundamental niche that is actually filled
  - Due to competition or other species' interactions

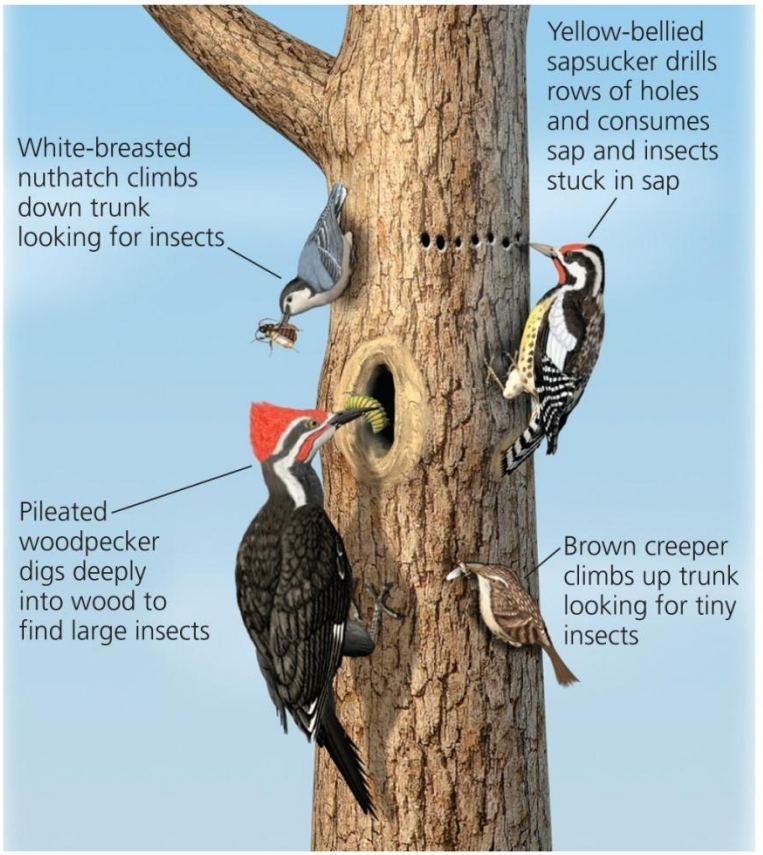


Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Resource partitioning

- **Resource partitioning** = when species divide shared resources by specializing in different ways
  - Ex: one species is active at night, another in the daytime
  - Ex: one species eats small seeds, another eats large seeds



Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Predation

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

- **Exploitation** = one member exploits another for its own gain
  - Predation, parasitism, herbivory
- **Predation** = process by which individuals of one species (**predators**) capture, kill, and consume individuals of another species (**prey**)
  - Structures food webs
  - Influences community composition through number of predators and prey

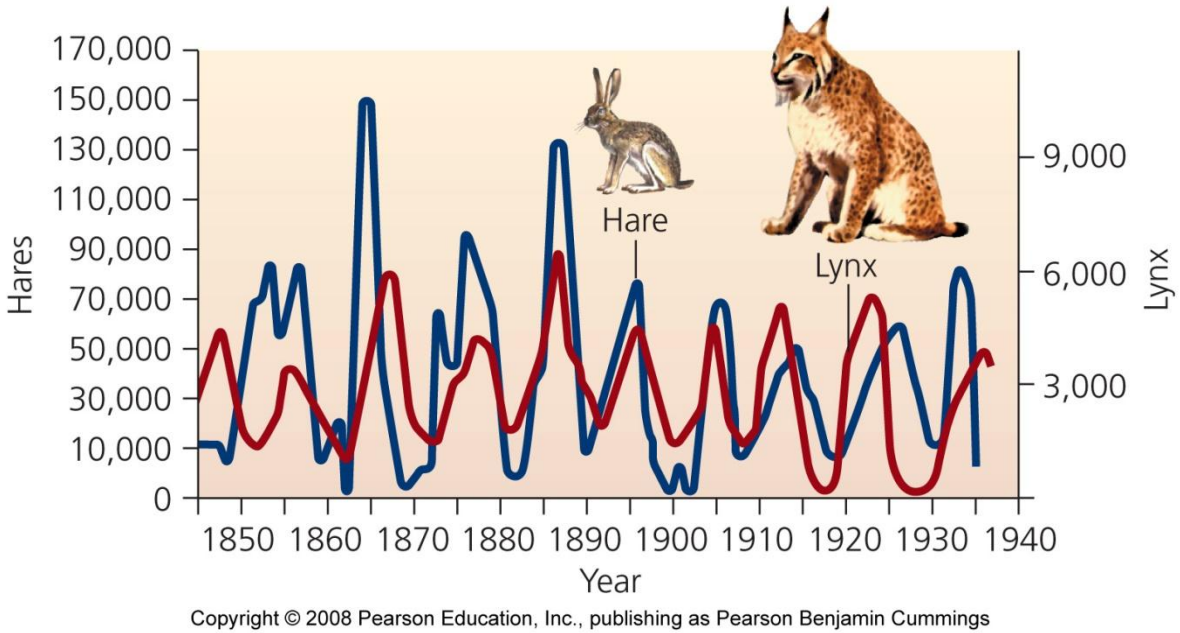
Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Effects of zebra mussels

- Zebra mussels eat phytoplankton and zooplankton
  - Both populations decrease in lakes with zebra mussels
- They don't eat cyanobacteria
  - Population increases in lakes with zebra mussels
- Zebra mussels are becoming prey for some North American predators:
  - Diving ducks, muskrats, crayfish, flounder, sturgeon, eels, carp, and freshwater drum

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Effects of predation on populations



Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

- Increased prey populations increases predators
  - Predators survive and reproduce
- Increased predator populations decrease prey
- Decreased prey population causes starvation of predators
- Decreased predator populations increases prey populations

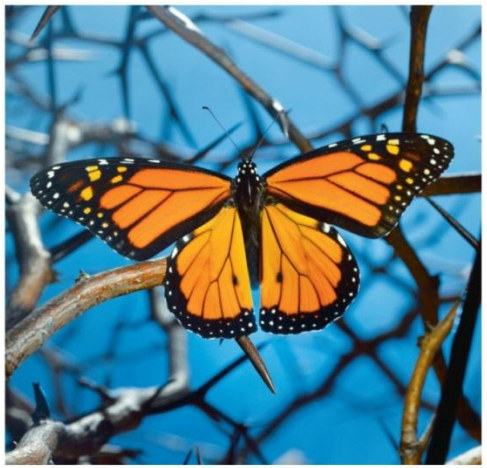
Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Natural selection

- Natural selection leads to evolution of adaptations that make predators better hunters
- Individuals who are better at catching prey:
  - Live longer, healthier lives
  - Take better care of offspring
- Predation pressure: prey are at risk of immediate death
  - Prey develops elaborate defenses against being eaten

(a) Cryptic coloration

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings



(b) Warning coloration

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

(c) Mimicry

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjam

Parasites

- **Parasitism** = a relationship in which one organism (**parasite**) depends on another (**host**) for nourishment or other benefit
- Some species live within the host
  - Disease, tapeworms
- Others are free-living, and have infrequent contact with their hosts
  - Ticks, sea lampreys

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Coevolution

- **Coevolution** = hosts/prey and parasites/predators become locked in a duel of escalating adaptations
  - Has been called an "evolutionary arms race"
  - Each evolves new responses to the other
  - It may not be beneficial to the parasite to kill its host

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Herbivory

- Exploitation in which animals feed on the tissues of plants
  - Widely seen in insects
  - May not kill the plant, but affects its growth and survival
- Defenses against herbivory include
  - Chemicals: toxic or distasteful parts
  - Physical: thorns, spines, or irritating hairs
  - Other animals: protect the plant

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Mutualism

- Two or more species benefit from their interactions
- **Symbiosis** = mutualism in which the organisms live in close physical contact
  - Microbes within digestive tracts
  - Plants and fungi
- **Pollination** = In exchange for nectar, bees, bats, birds and others transfer pollen from one flower to another, fertilizing its eggs

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Be

Relationships with no effect on one member

- **Amensalism** = a relationship in which one organism is harmed while the other is unaffected
  - Difficult to confirm, because usually one organism benefits from harming another
  - **Allelopathy** = certain plants release harmful chemicals
  - Or, is this competition?
- **Commensalism** = a relationship in which one organism benefits, while the other remains unaffected
  - **Facilitation** = plants that create shade and leaf litter allow seedlings to grow

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

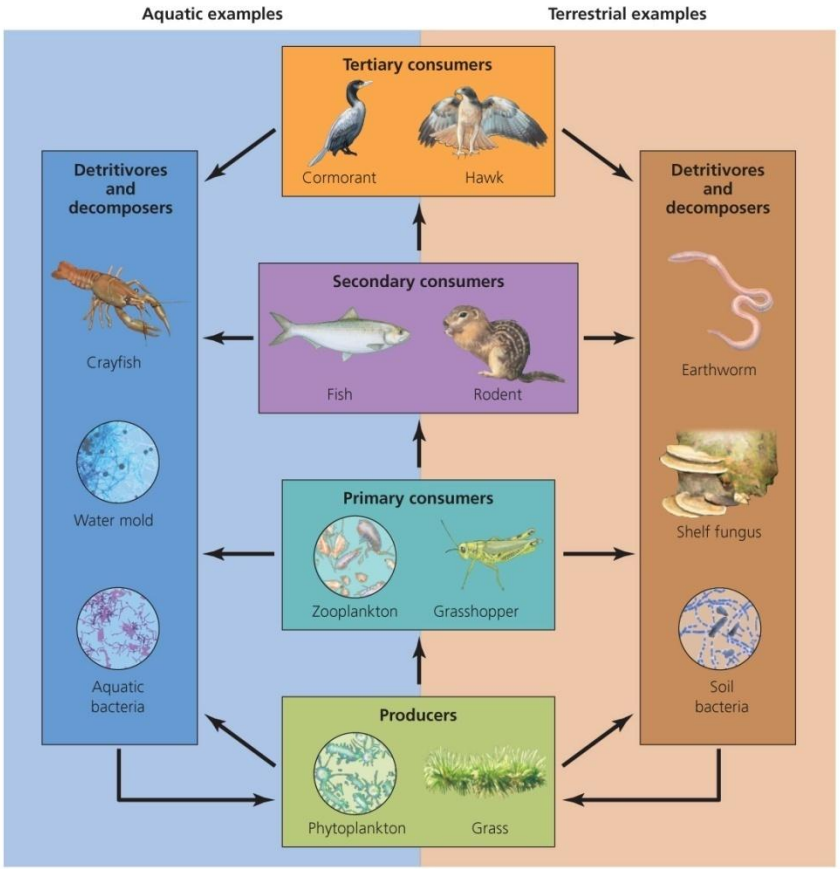
Ecological communities

- **Community** = an assemblage of species living in the same place at the same time
  - Members interact with each other
  - Interactions determine the structure, function, and species composition of the community
- **Community ecologists** = people interested in how:
  - Species coexist and relate to one another
  - Communities change, and why patterns exist

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Energy passes through trophic levels

- One of the most important species interactions is who eats whom
- Matter and energy move through the community
- **Trophic levels** = rank in the feeding hierarchy
  - Producers
  - Consumers
  - Detritivores and Decomposers



Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Producers: the first trophic level

- **Autotrophs** ("self-feeders") = organisms that capture solar energy for photosynthesis to produce sugars
  - Green Plants
  - Cyanobacteria
  - Algae
- **Chemosynthetic bacteria** use the geothermal energy in hot springs or deep-sea vents to produce their food

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Consumers: organisms that consume producers

Primary consumers = second trophic level

- Organisms that consume producers
- **Herbivores** consume plants
- Deer, grasshoppers

- **Secondary consumers** = third trophic level
  - Organisms that prey on primary consumers
  - **Carnivores** consume meat
  - Wolves, rodents

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Consumers occur at even higher trophic levels

- **Tertiary Consumers** = fourth trophic level
  - Predators at the highest trophic level
  - Consume secondary consumers
  - Are also carnivores
  - Hawks, owls

- **Omnivores** = consumers that eat both plants and animals

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Detritivores and decomposers

- Organisms that consume nonliving organic matter
  - Enrich soils and/or recycle nutrients found in dead organisms
- **Detritivores** = scavenge waste products or dead bodies
  - Millipedes
- **Decomposers** = break down leaf litter and other non-living material

  - Fungi, bacteria
  - Enhance topsoil and recycle nutrients

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

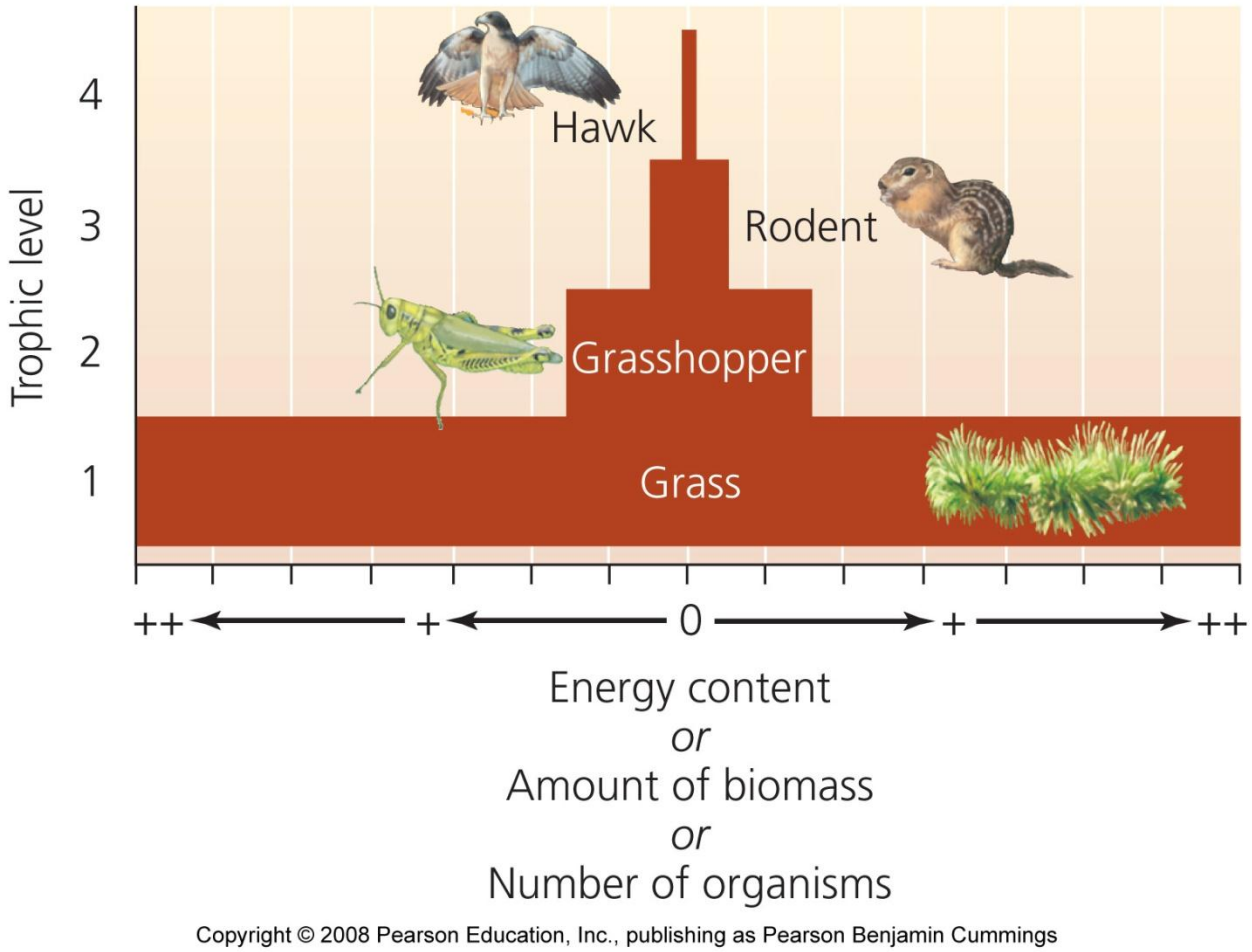
Energy, biomass, and numbers decrease

- Most energy organisms use is lost as waste heat through respiration
  - Less and less energy is available in each successive trophic level
  - Each level contains only 10% of the energy of the trophic level below it
- There are far fewer organisms at the highest trophic levels, with less energy available

A human vegetarian's ecological footprint is smaller than a meat-eater's footprint

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Pyramids of energy, biomass, and numbers

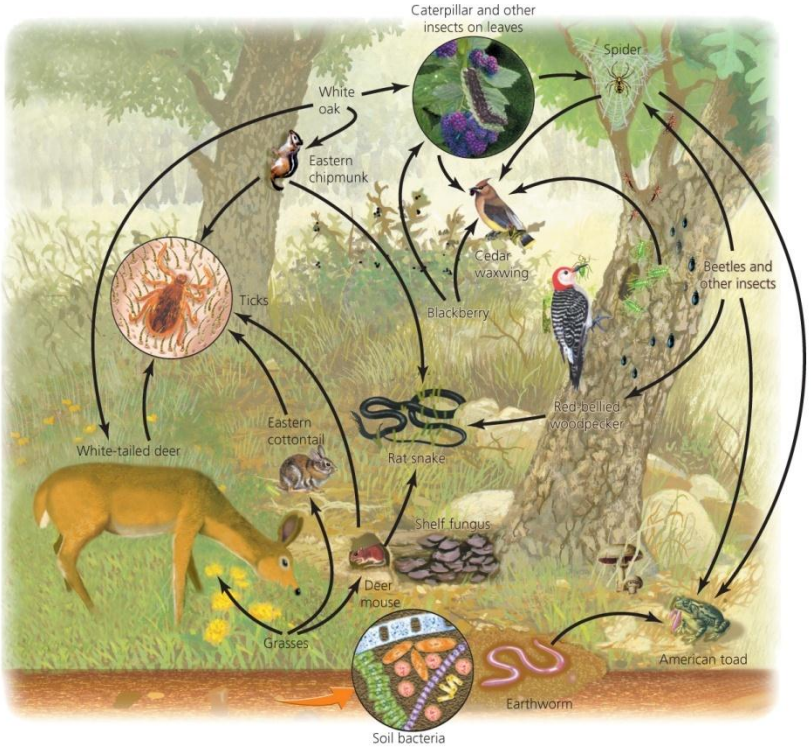


Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Food webs show relationships and energy flow

- **Food chain** = the relationship of how energy is transferred up the trophic levels
- **Food web** = a visual map of feeding relationships and energy flow
  - Includes many different organisms at all the various levels
  - Greatly simplified; leaves out the majority of species

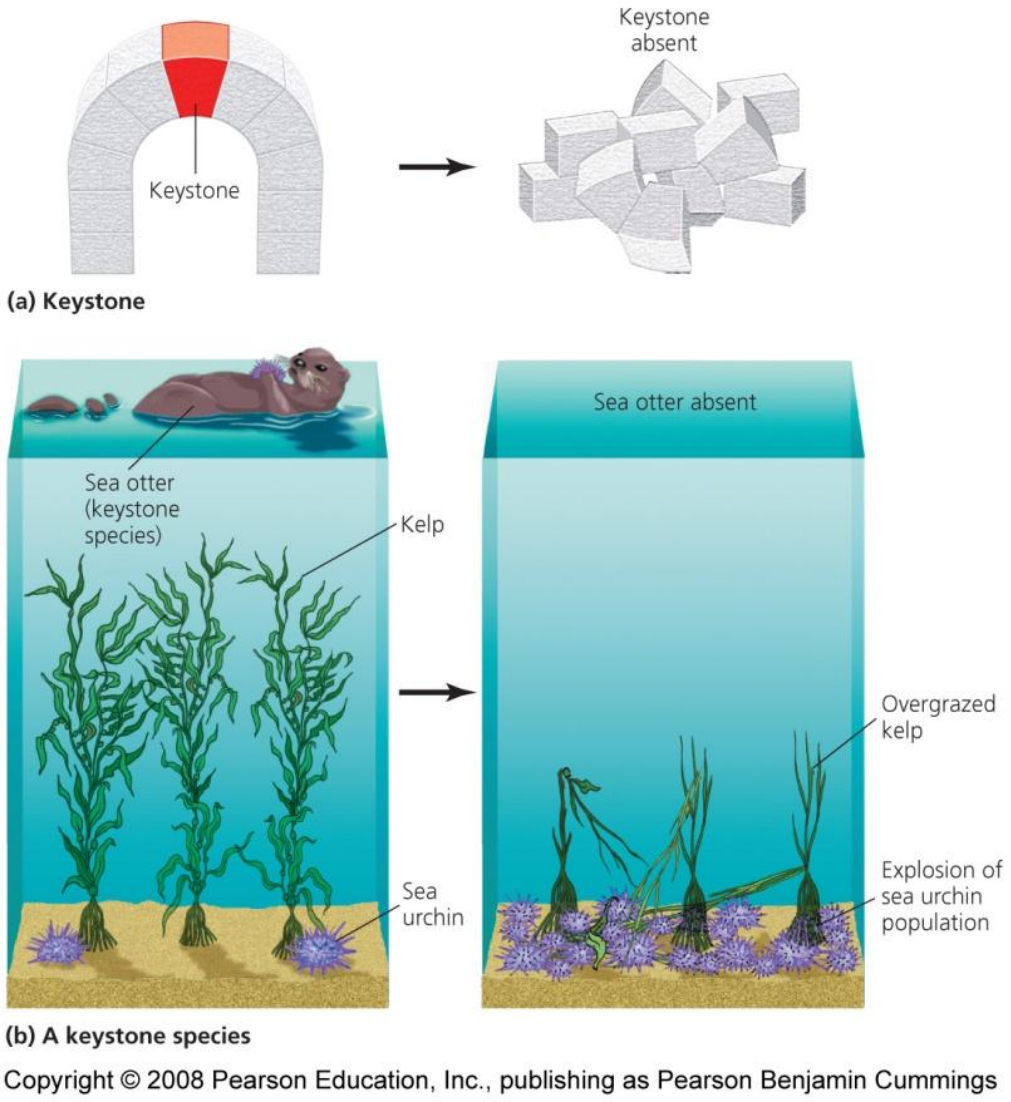


Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Some organisms play big roles

- **Keystone Species** = has a strong or wide-reaching impact far out of proportion to its abundance
- Removal of a keystone species has substantial ripple effects
  - Alters the food chain



Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Species can change communities

- **Trophic Cascade** = predators at *high trophic levels* can indirectly affect populations of organisms at *low trophic levels* by keeping species at *intermediate trophic* levels in check
  - Extermination of wolves led to increased deer populations, which led to overgrazed vegetation and changed forest structure
- Ecosystem engineers = physically modify the environment
  - Beaver dams, prairie dogs, fungi

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

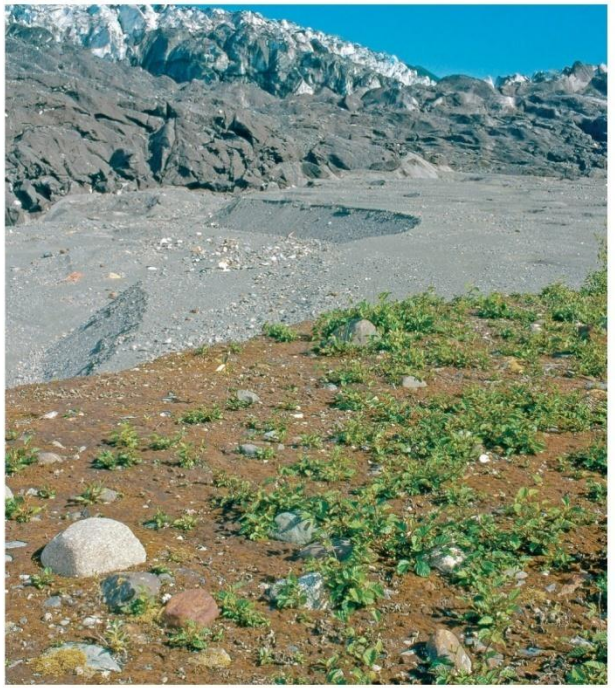
Communities respond to disturbances

- Communities experience many types of disturbance
  - Removal of keystone species, spread of invasive species, natural disturbances
  - Human impacts cause major changes
- **Resistance** = community of organisms resists change and remains stable despite the disturbance
- **Resilience** = a community changes in response to a disturbance, but later returns to its original state

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Primary succession

- **Succession** = the predictable series of changes in a community following a disturbance
- **Primary succession** = disturbance eliminates all vegetation and/or soil life
  - Glaciers, drying lakes, volcanic lava
- **Pioneer species** = the first species to arrive in a primary succession area (ex, lichens)

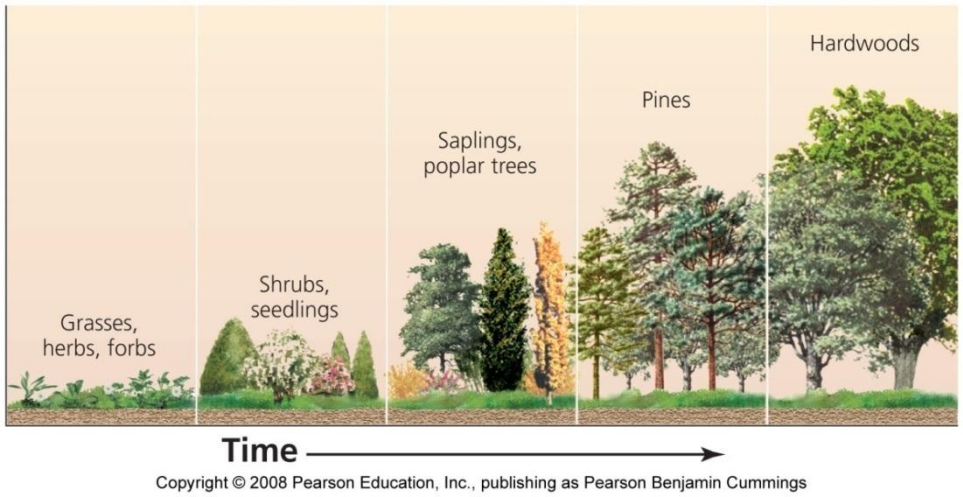


Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Secondary succession

- **Secondary succession** = a disturbance dramatically alters, but does not destroy, all local organisms
  - The remaining organisms form "building blocks" for the next population species
  - Fires, hurricanes, farming, logging
- **Climax community** = the community resulting from successful succession
  - Remains stable until another disturbance restarts succession



Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Community cohesion

- **Frederick Clements** = viewed communities as cohesive entities
  - Its members remain associated over space and time
  - The community shared similar limiting factors and evolutionary histories
- **Henry Gleason** = maintained that each species responds independently to its own limiting factors
  - Species can join or leave communities without greatly altering the community's composition
  - The most widely accepted view of ecologists today

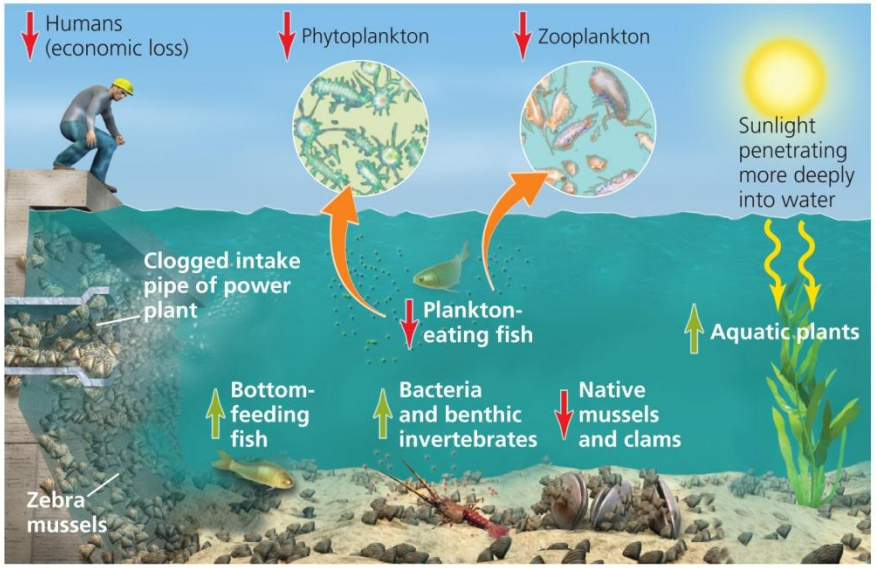
Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Invasive species

- **Invasive species** = non-native (exotic) organisms that spread widely and become dominant in a community
  - Growth-limiting factors (predators, disease, etc.) are removed or absent
  - They have major ecological effects
  - Chestnut blight, from Asia, wiped out American chestnut trees
- Some species help people (i.e., European honeybee)

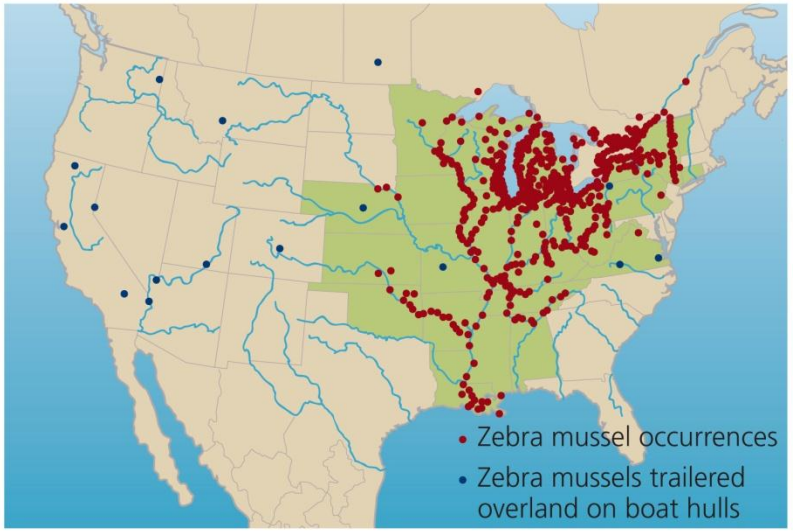
Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Two invasive mussels



(a) Impacts of zebra mussels on members of a Great Lakes nearshore community

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings



(b) Occurrence of zebra mussels in North America, 2005

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

(c) Occurrence of quagga mussels in North America, 2007

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Controlling invasive species

- Techniques to control invasive species
  - Remove manually
  - Toxic chemicals
  - Drying them out
  - Depriving of oxygen
  - Stressing them
    - Heat, sound, electricity, carbon dioxide, ultraviolet light

Prevention, rather than control, is the best policy

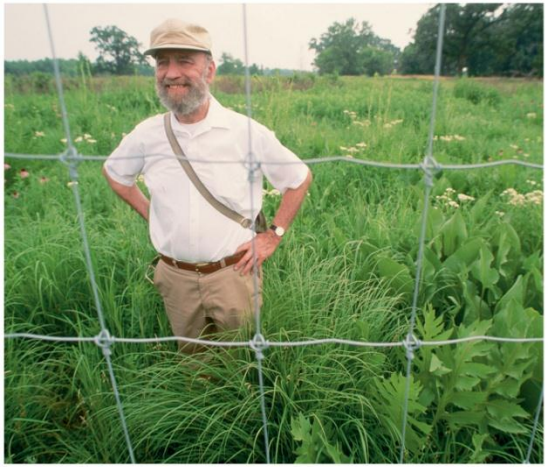
Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Changed communities need to be restored

- **Ecological restoration** = returning an area to unchanged conditions
  - Informed by restoration ecology = the science of restoring an area to the condition that existed before humans changed it
  - It is difficult, time-consuming, expensive
  - Best to protect natural systems from degradation in the first place

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Restoration efforts

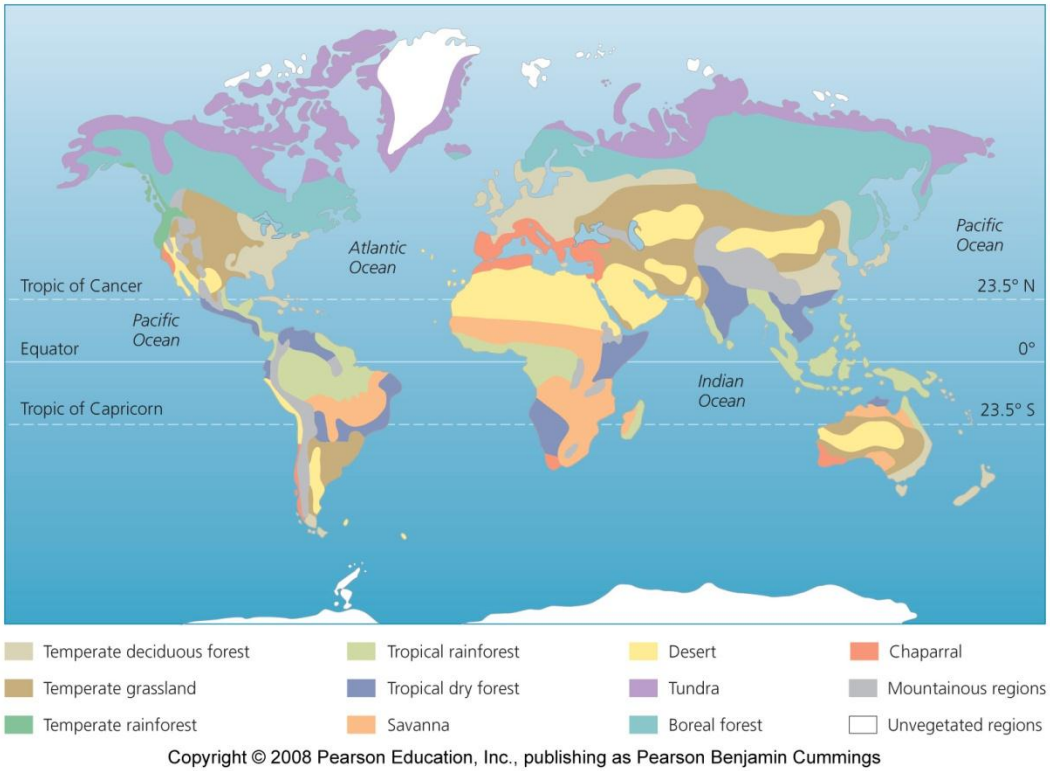

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

- Prairie Restoration
  - Native species replanted and invasive species controlled
- The world's largest project: Florida Everglades
  - Depletion caused by flood control practices and irrigation
  - Populations of wading birds dropped 90-95%
  - It will take 30 years, and billions of dollars

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Widely separated regions share similarities

- Biome = major regional complex of similar communities recognized by
  - Plant type
  - Vegetation structure

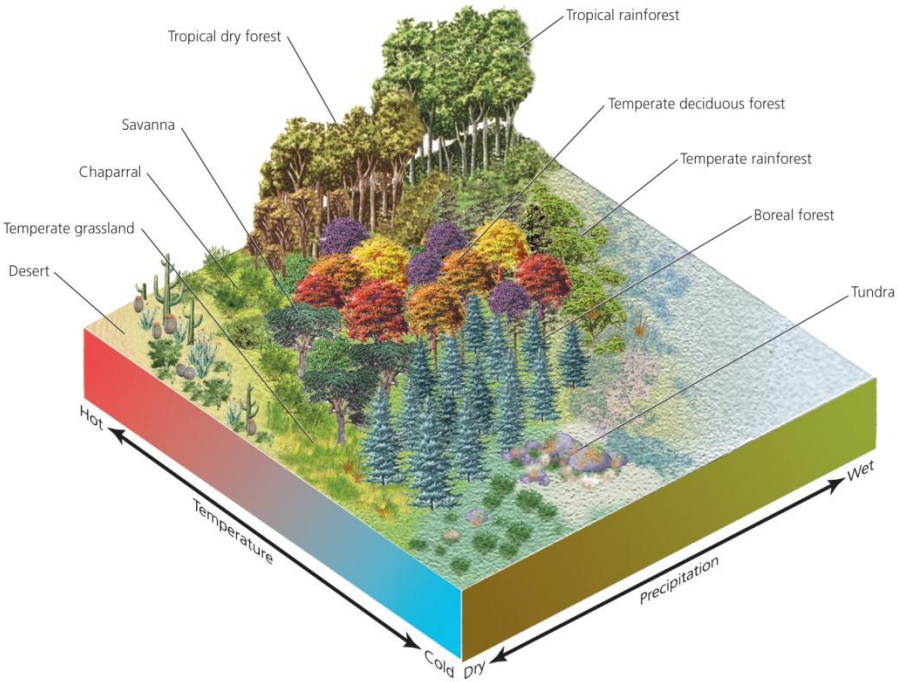


Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

A variety of factors determine the biome

- The biome in an area depends on a variety of abiotic factors
  - Temperature, precipitation, atmospheric circulation, soil
- **Climatographs=**
  - A climate diagram showing an area's mean monthly temperature and precipitation
  - Similar biomes occupy similar latitudes



Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

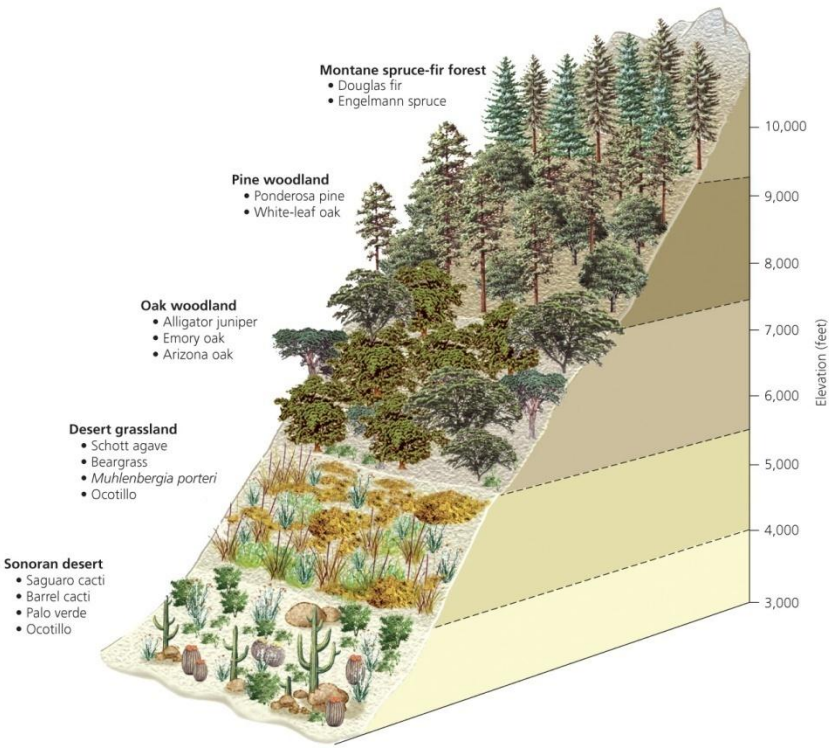
Aquatic systems have biome-like patterns

- Various aquatic systems comprise distinct communities
  - Coastlines, continental shelves
  - Open ocean, deep sea
  - Coral reefs, kelp forests
- Aquatic systems are shaped by
  - Water temperature, salinity, and dissolved nutrients
  - Wave action, currents, depth
  - Substrate type, and animal and plant life

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Altitudes create patterns

- Vegetative communities change along mountain slopes
  - In the Andes, a mountain climber would begin in the tropics and end up in a glacier



Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings

Hiking up a mountain in the southwest U.S. is analogous to walking from Mexico to Canada

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings