Community Ecology

Questions to Ponder

- What determines the number of species in a community?
- How can we classify species according to their roles in a community?
- How do species interact with one another?
- How do communities respond to changes in environmental conditions?
- Does high species biodiversity increase the stability and sustainability of a community?

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

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

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

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

SPECIES INTERACTIONS: COMPETITION AND PREDATION

- Species called predators feed on other species called prey.
- Organisms use their senses their senses to locate objects and prey and to attract pollinators and mates.
- Some predators are fast enough to catch their prey, some hide and lie in wait, and some inject chemicals to paralyze their prey.

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

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
  - Species adjust to minimize competition by using only a part of the available resource

PREDATION

- Some prey escape their predators or have outer protection, some are camouflaged, and some use chemicals to repel predators.

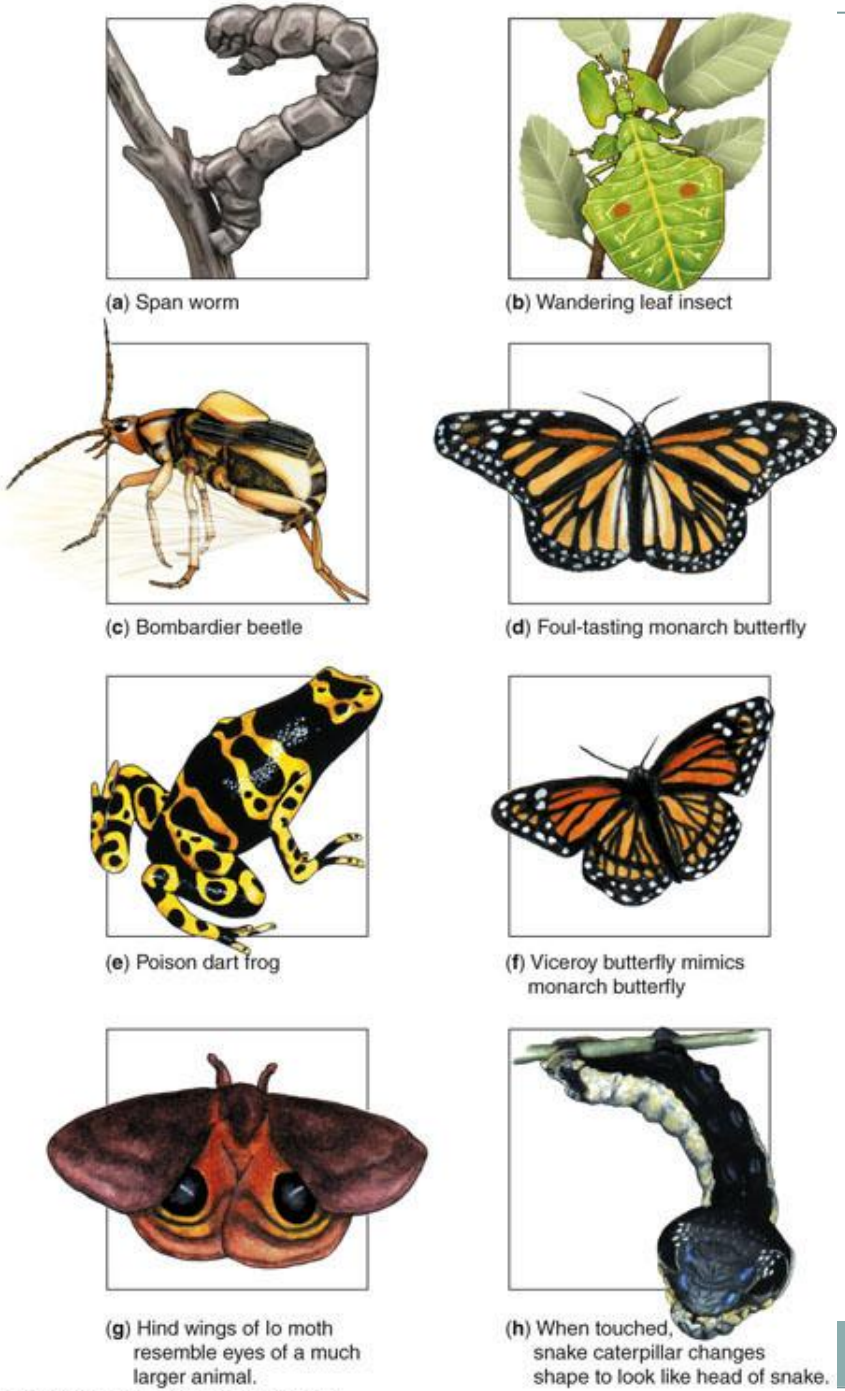


Figure 7-8

Predation

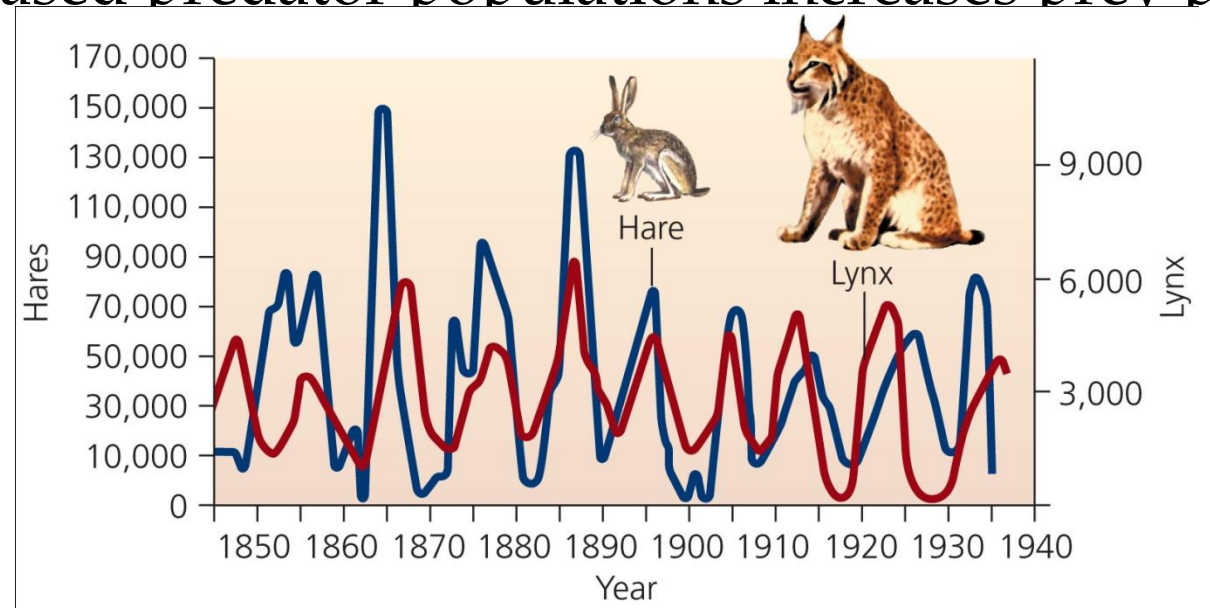
- **Exploitation** = one member exploits another for its own gain
  - Predation, parasitism, herbivory
- **Predation** = process by which individuals of one species (**predators**) capture, kill, and consume individuals of another species (**prey**)
  - Structures food webs
  - Influences community composition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

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

Effects of predation on populations

- 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



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

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

SPECIES INTERACTIONS: PARASITISM, MUTUALISM, AND COMMENSALIM

- Parasitism occurs when one species feeds on part of another organism.
- In mutualism, two species interact in a way that benefits both.
- Commensalism is an interaction that benefits one species but has little, if any, effect on the other species.

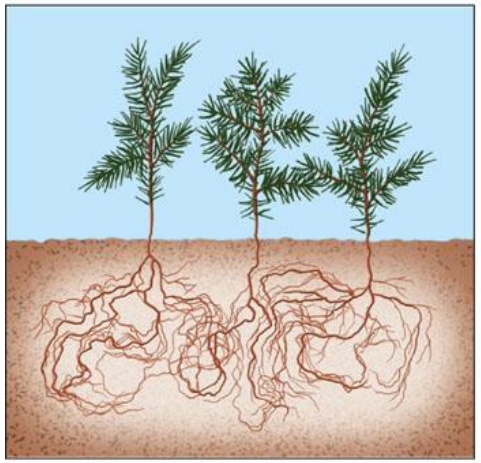
Parasites: Sponging Off of Others

- Although parasites can harm their hosts, they can promote community biodiversity.
  - Some parasites live in host (micororganisms, tapeworms).
  - Some parasites live outside host (fleas, ticks, mistletoe plants, sea lampreys).
  - Some have little contact with host (dump-nesting birds like cowbirds, some duck species)

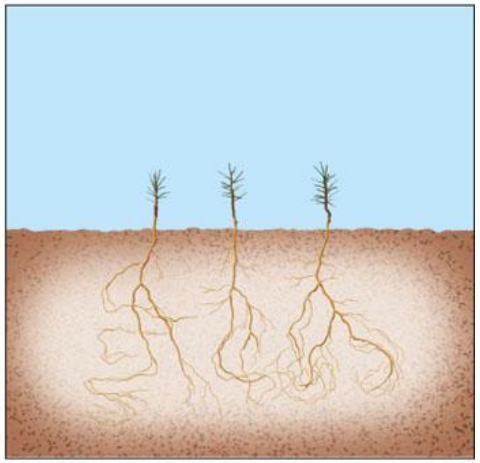
Mutualism: Win-Win Relationship

(a) Oxpeckers and black rhinoceros

(b) Clownfish and sea anemone



(c) Mycorrhizal fungi on juniper seedlings in normal soil



(d) Lack of mycorrhizal fungi on juniper seedlings in sterilized soil

- Two species can interact in ways that benefit both of them.

Figure 7-9

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 = bees, bats, birds and others transfer pollen from one flower to another, fertilizing its eggs

Commensalism: Using without Harming

- Some species interact in a way that helps one species but has little or no effect on the other.

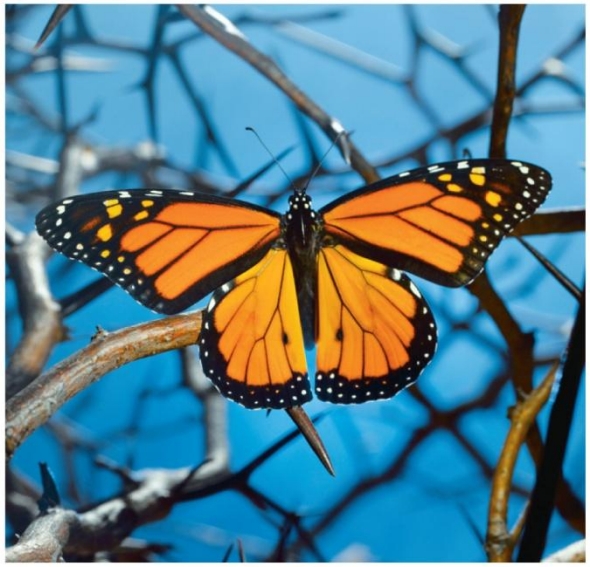
Figure 7-10

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

Organisms evolve defenses against being eaten

(a) Cryptic coloration



(b) Warning coloration

(c) Mimicry

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

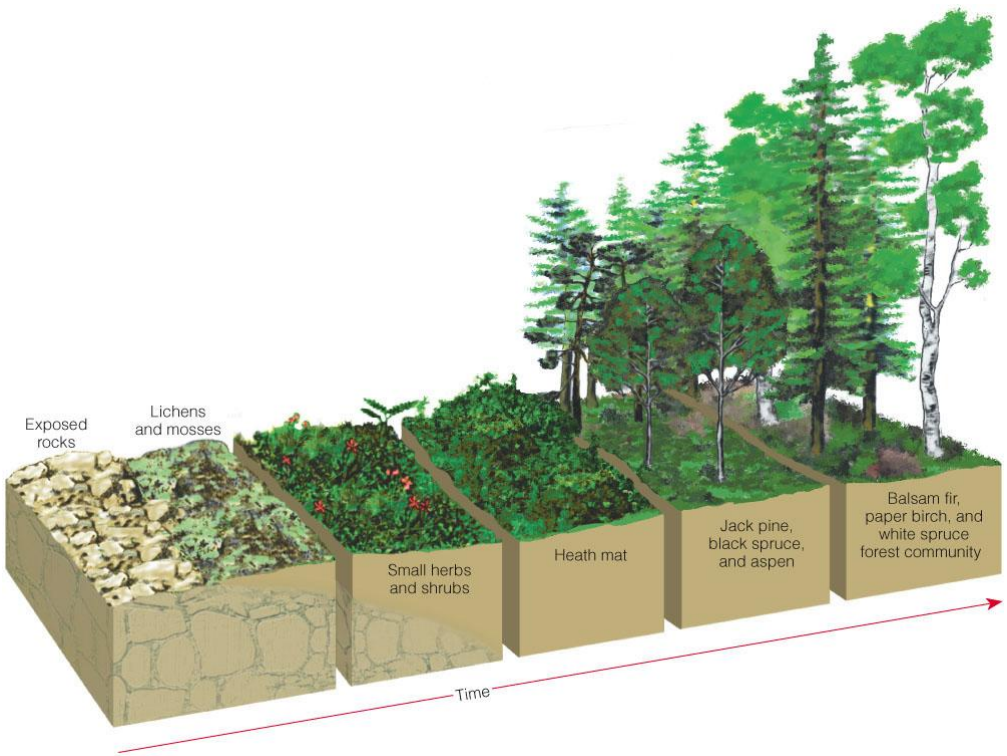
Coevolution

- **Coevolution** = hosts and parasites 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

ECOLOGICAL SUCCESSION: COMMUNITIES IN TRANSITION

- New environmental conditions allow one group of species in a community to replace other groups.
- ***Ecological succession***: the gradual change in species composition of a given area
  - ***Primary succession***: the gradual establishment of biotic communities in lifeless areas where there is no soil or sediment.
  - ***Secondary succession***: series of communities develop in places containing soil or sediment.

Primary Succession: Starting from Scratch

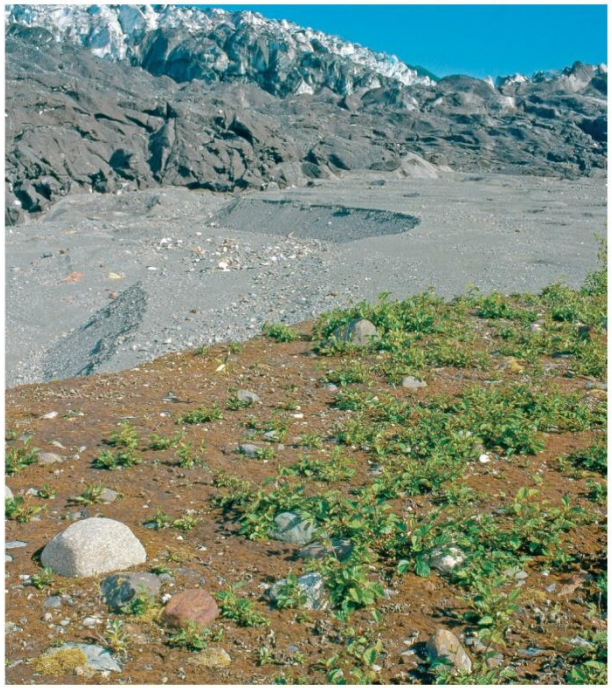


- Primary succession begins with an essentially lifeless are where there is no soil in a terrestrial ecosystem

Figure 7-11

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)



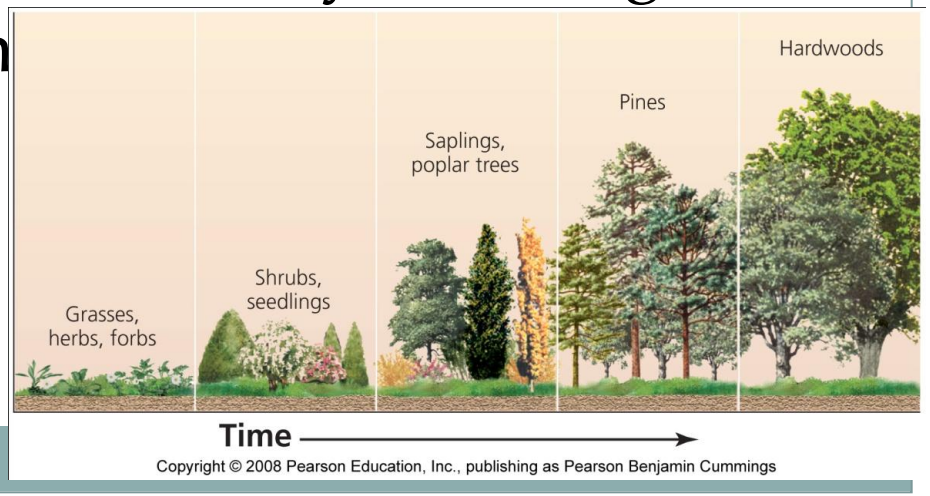
Secondary Succession: Starting Over with Some Help

- Secondary succession begins in an area where the natural community has been disturbed.

Figure 7-12

Secondary succession

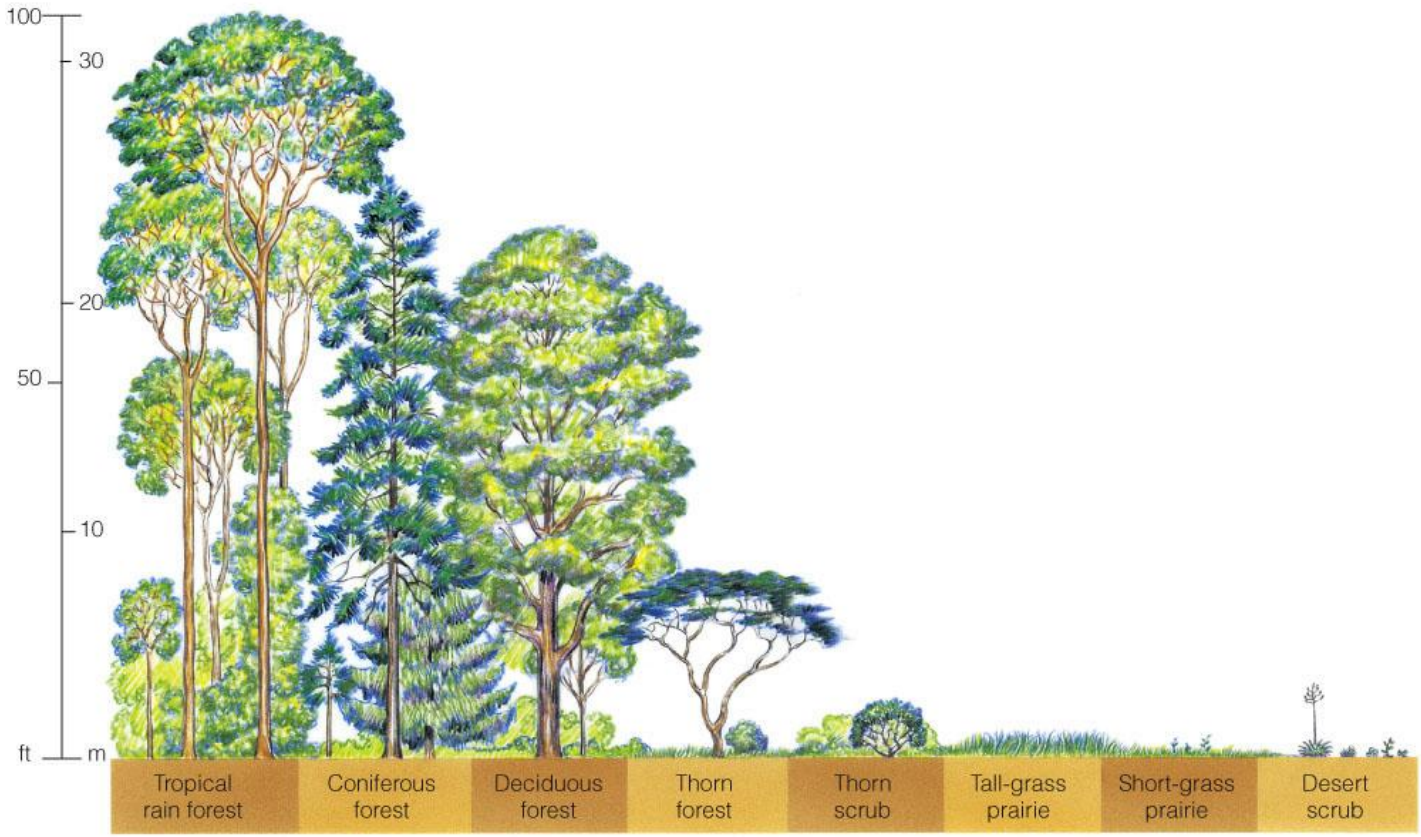
- **Secondary succession** = a disturbance dramatically alters, but does not destroy, all local organisms
  - The remaining organisms form "building blocks" for the next population species
  - Fires, hurricanes, farming, logging
- **Climax community** = the community resulting from successful succession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



Can We Predict the Path of Succession, and is Nature in Balance?

- The course of succession cannot be precisely predicted.
- Previously thought that a stable climax community will always be achieved.
- Succession involves species competing for enough light, nutrients and space which will influence it's trajectory.

COMMUNITY STRUCTURE AND SPECIES DIVERSITY



- Biological communities differ in their structure and physical appearance.

Figure 7-2

Species Diversity and Niche Structure: Different Species Playing Different Roles

- Biological communities differ in the types and numbers of species they contain and the ecological roles those species play.
  - ***Species diversity***: the number of different species it contains (***species richness***) combined with the abundance of individuals within each of those species (***species evenness***).

Species Diversity and Niche Structure

- Niche structure: how many potential ecological niches occur, how they resemble or differ, and how the species occupying different niches interact.
- Geographic location: species diversity is highest in the tropics and declines as we move from the equator toward the poles.

SPECIES INTERACTIONS: COMPETITION AND PREDATION

- Species can interact through competition, predation, parasitism, mutualism, and commensalism.
- Some species evolve adaptations that allow them to reduce or avoid competition for resources with other species (resource partitioning).

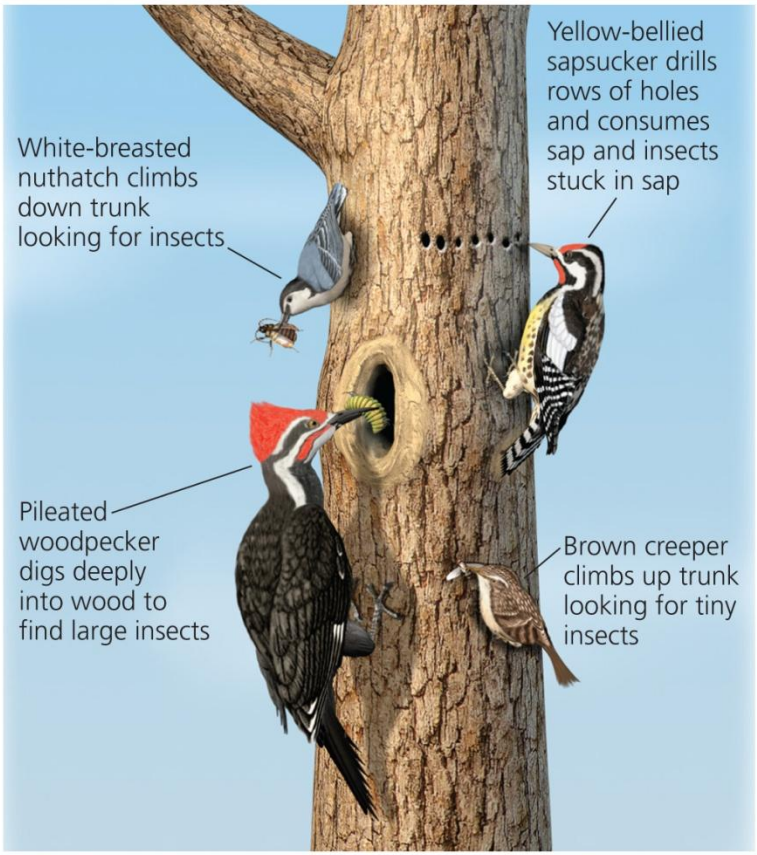
Resource Partitioning

- Each species minimizes competition with the others for food by spending at least half its feeding time in a distinct portion of the spruce tree and by consuming somewhat different insect species.

Figure 7-7

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



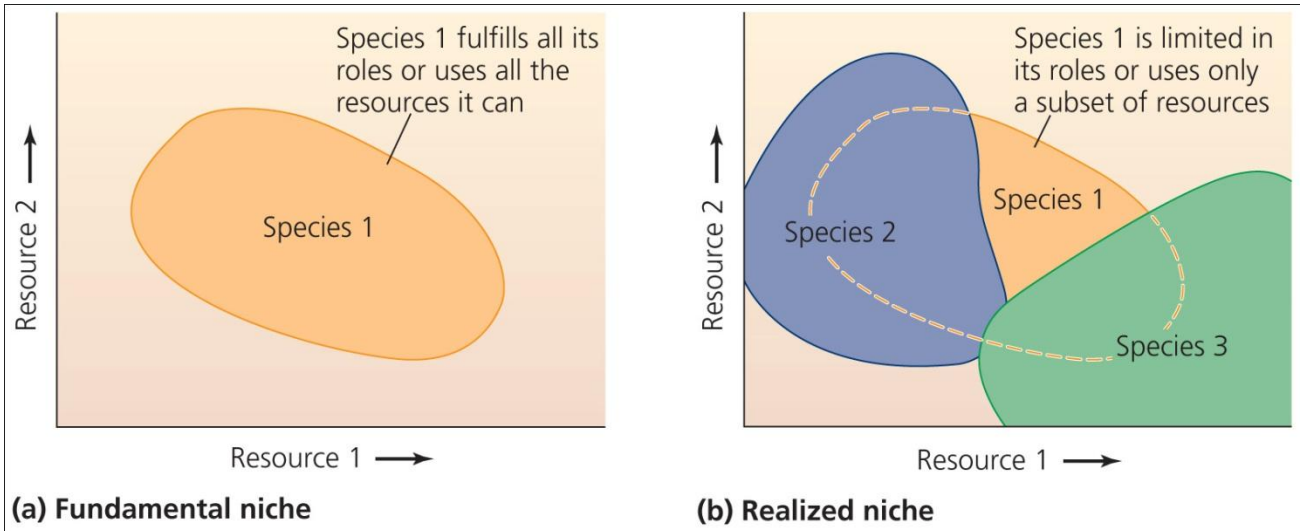
Effects of resource partitioning

- **Character displacement** = competing species evolve physical characteristics that reflect their reliance on the portion of the resource they use
  - Ex: birds that eat larger seeds evolve larger bills
  - Ex: birds that eat smaller seeds evolve smaller bills

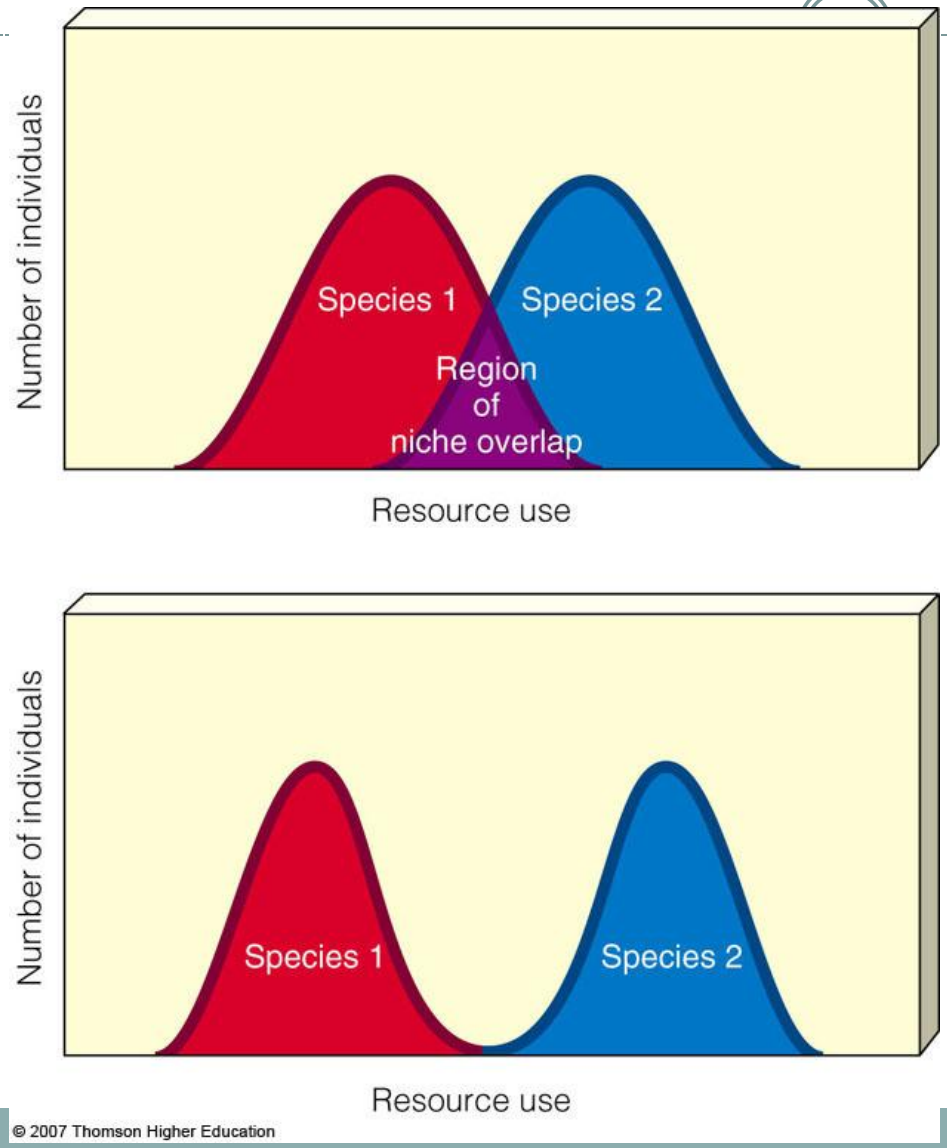
Competition is reduced when two species become more different

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



Niche Specialization



- Niches become separated to avoid competition for resources.

Figure 7-6

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

Case Study: Species Diversity on Islands

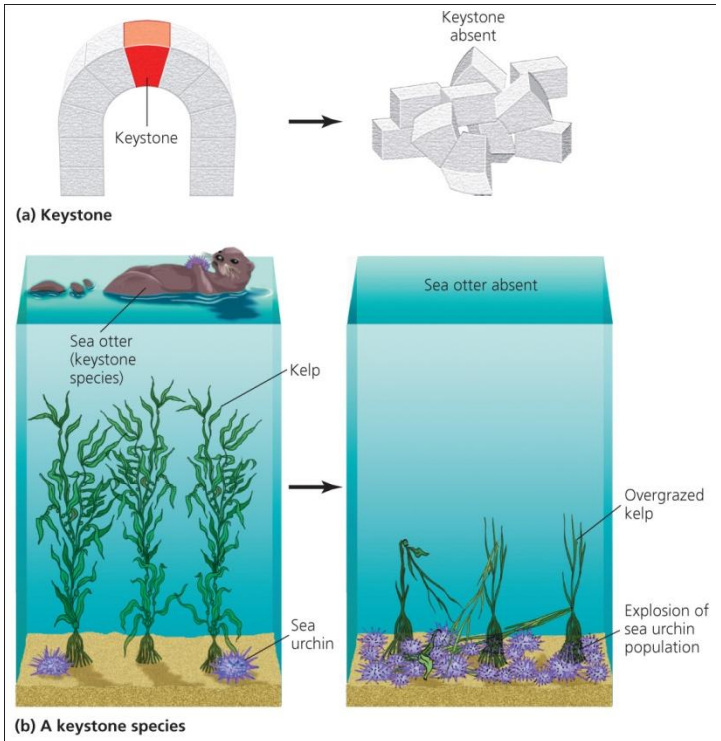
- MacArthur and Wilson proposed the species equilibrium model or theory of island biogeography in the 1960's.
- Model projects that at some point the rates of immigration and extinction should reach an equilibrium based on:
  - Island size
  - Distance to nearest mainland

TYPES OF SPECIES

- Native, nonnative, indicator, keystone, and foundation species play different ecological roles in communities.
  - Native: those that normally live and thrive in a particular community.
  - Nonnative species: those that migrate, deliberately or accidentally introduced into a community.

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



Keystone Species: Major Players

- Keystone species help determine the types and numbers of other species in a community thereby helping to sustain it.

Figures 7-4 and 7-5

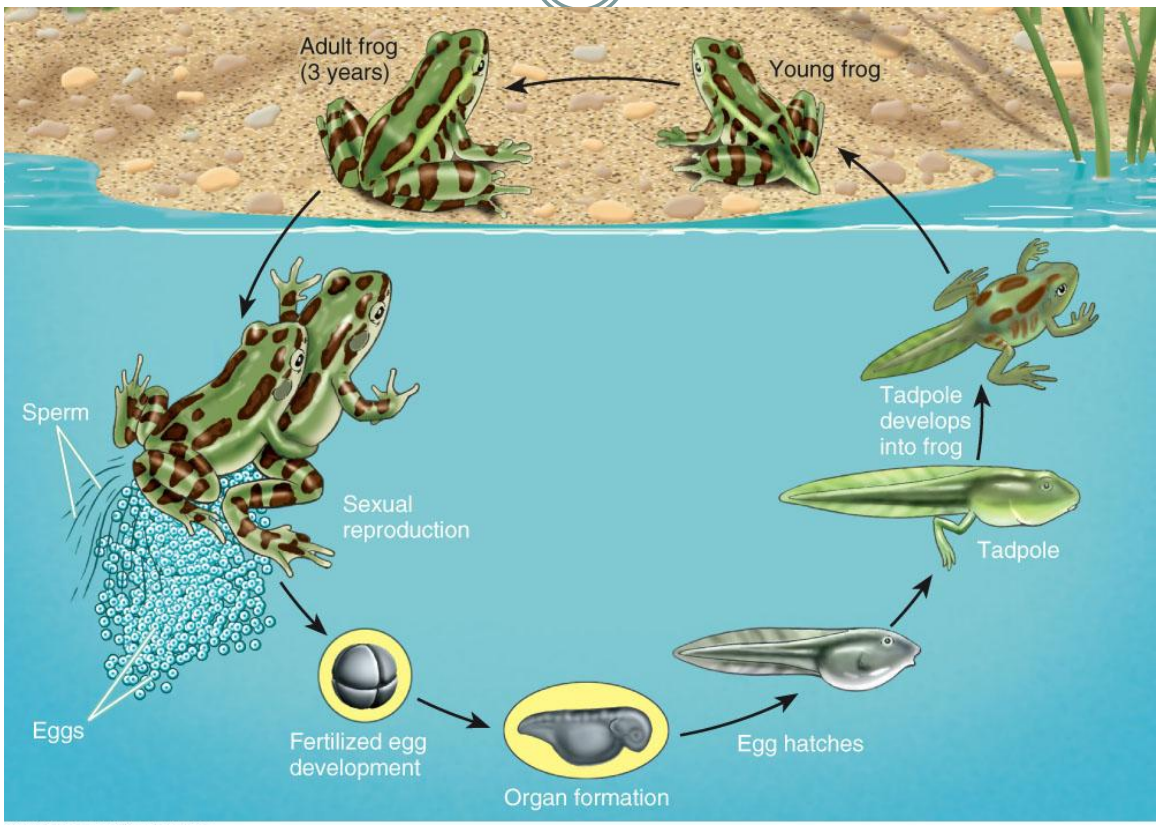
Foundation Species: Other Major Players

- Expansion of keystone species category.
- Foundation species can create and enhance habitats that can benefit other species in a community.
  - Elephants push over, break, or uproot trees, creating forest openings promoting grass growth for other species to utilize.

Indicator Species: Biological Smoke Alarms

- Species that serve as early warnings of damage to a community or an ecosystem.
  - Presence or absence of trout species because they are sensitive to temperature and oxygen levels.

Case Study: Why are Amphibians Vanishing?



- Frogs serve as indicator species because different parts of their life cycles can be easily disturbed.

Figure 7-3

Case Study: Why are Amphibians Vanishing?

- Habitat loss and fragmentation.
- Prolonged drought.
- Pollution.
- Increases in ultraviolet radiation.
- Parasites.
- Viral and Fungal diseases.
- Overhunting.
- Natural immigration or deliberate introduction of nonnative predators and competitors.

Frogs: The Thin Green Line

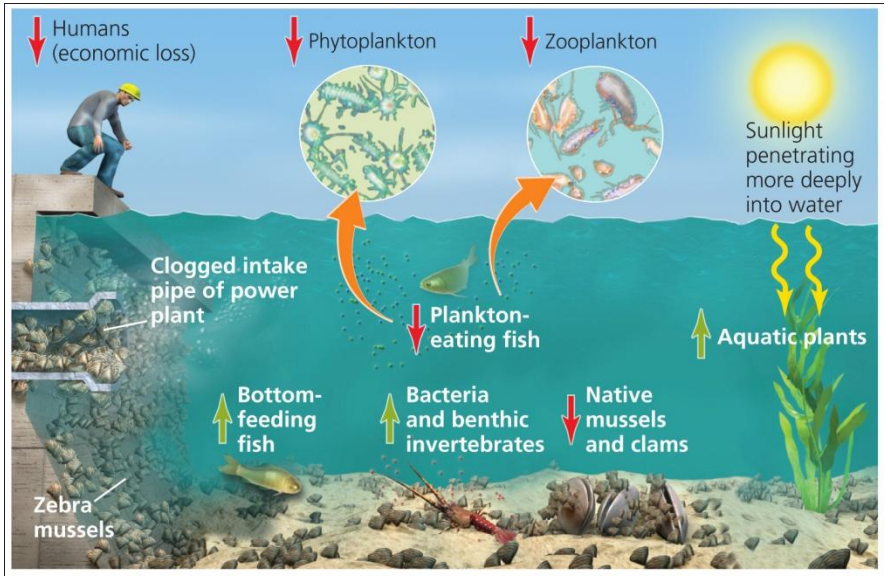
PLAY
VIDEO

- From Nature, PBS Video Online

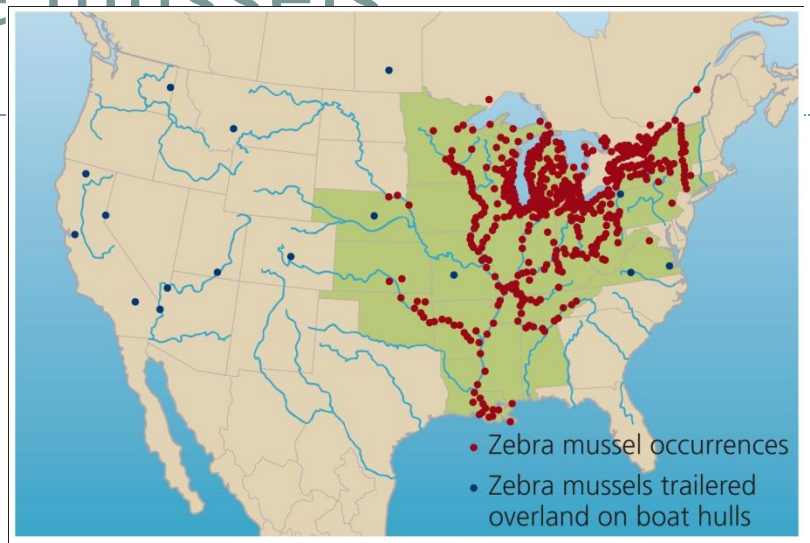
Invasive species

- **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)

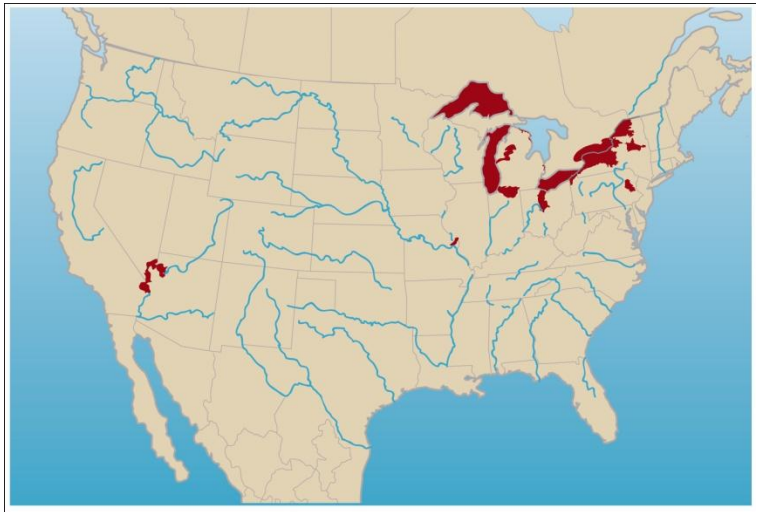
Two invasive mussels



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



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



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

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

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

ECOLOGICAL STABILITY AND SUSTAINABILITY

- Living systems maintain some degree of stability through constant change in response to environmental conditions through:
  - Inertia (persistence): the ability of a living system to resist being disturbed or altered.
  - Constancy: the ability of a living system to keep its numbers within the limits imposed by available resources.
  - Resilience: the ability of a living system to bounce back and repair damage after (a not too drastic) disturbance.

ECOLOGICAL STABILITY AND SUSTAINABILITY

- Having many different species appears to increase the sustainability of many communities.
- Human activities are disrupting ecosystem services that support and sustain all life and all economies.

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

Restoration efforts

- 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
- The U.S. is trying to restore Iraq marshes