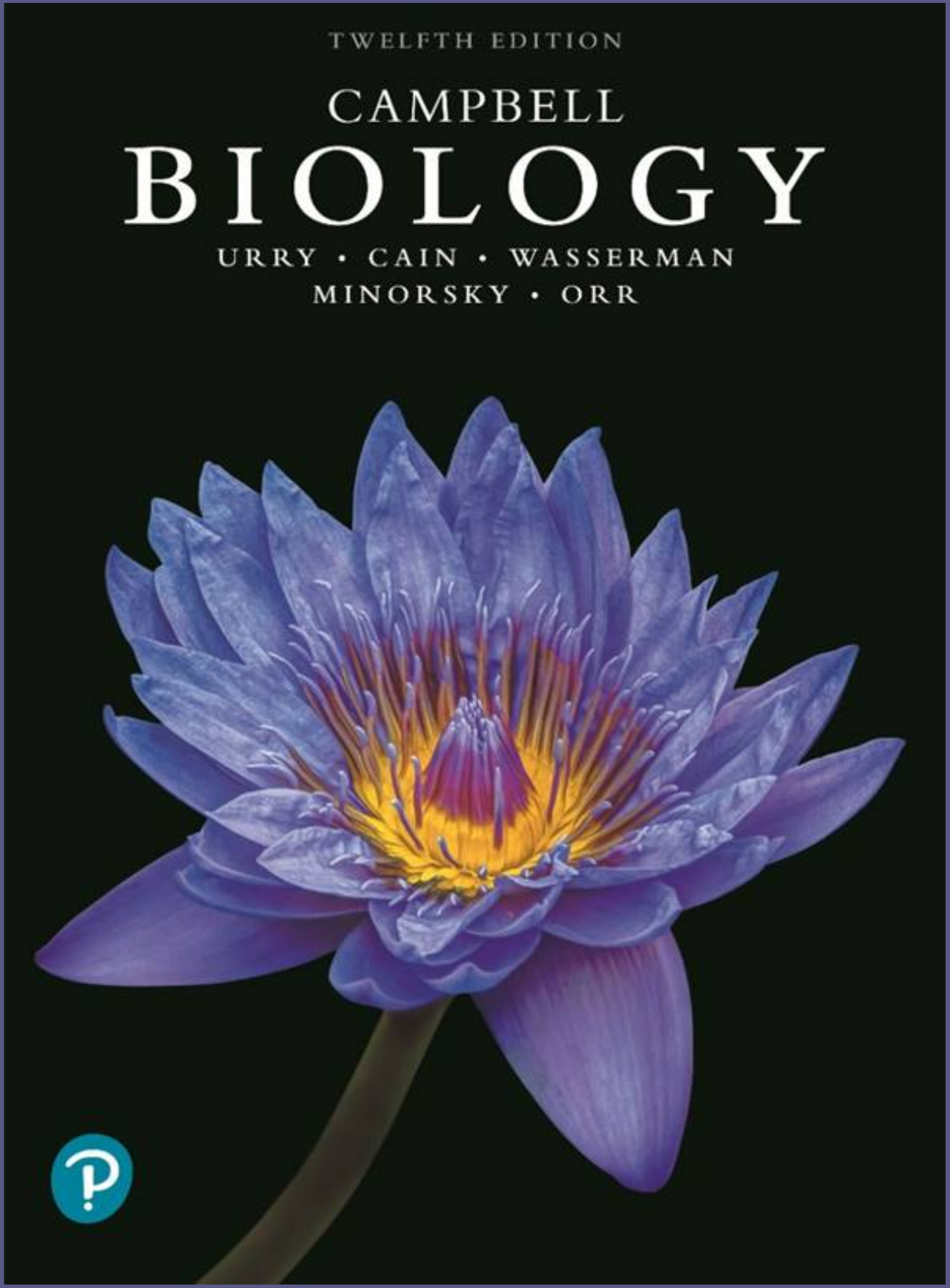


Chapter 54

Community Ecology

Lecture Presentations by
Nicole Tunbridge and
Kathleen Fitzpatrick

What are some factors that influence the structure of a community?

- Within a community, members of different species participate in a number of ecological interactions
  - For example, a cleaner wrasse feeds on the parasites that live inside the mouth of a moray eel; members of both species benefit from this interaction

Figure 54.1a

Figure 54.1b

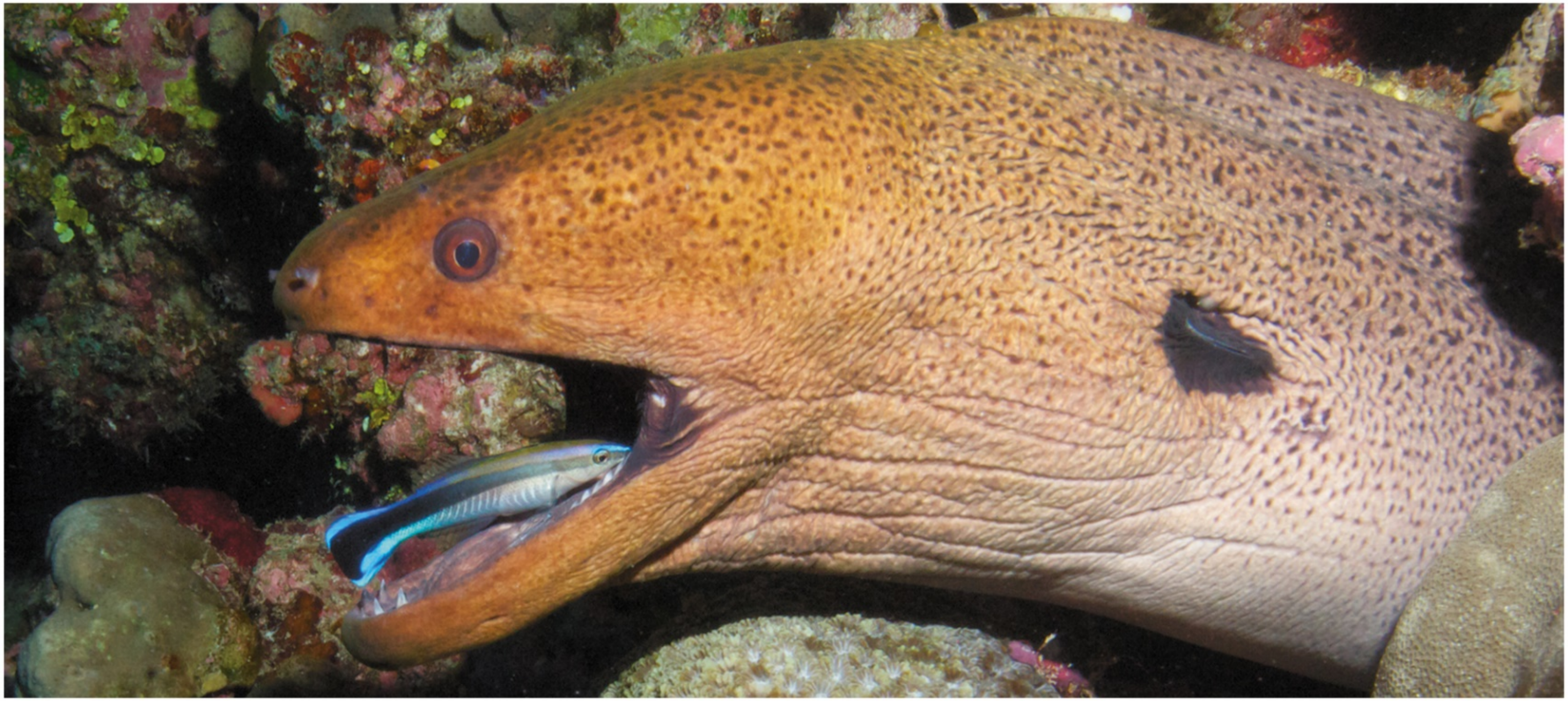


Figure 54.1c

What are some factors that influence the structure of a community?

Foundation species

Species that are large or abundant may affect community structure by providing habitat and food for other organisms.

Interactions between species

Predation and other interactions affect the number of species and the particular species that are present.

Disturbances

Marine heat waves, storms, human activities, and other disturbances can remove organisms or alter resource availability.

- **Community structure** is affected by the number, composition, and relative abundance of different species within a community

CONCEPT 54.1: Interactions between species can help, harm, or have no effect on the individuals involved

- **Interspecific interactions** are any interactions that occur between individuals of different species
- These interactions include competition, predation, herbivory, parasitism, mutualism, and commensalism

- Interspecific interactions can have positive (+), negative (–), or no effect (0) on the survival and reproduction of individuals involved
- There are three broad categories of ecological interactions: competition (–/–), exploitation (+/–), and positive interactions (+/+ or +/0)

Competition

- **Competition** (–/–) occurs when individuals of different species use a resource that limits survival and reproduction of both individuals
  – For example, garden weeds compete with garden plants for soil nutrients and water
- Species do not compete for resources that are not in short supply

Competitive Exclusion

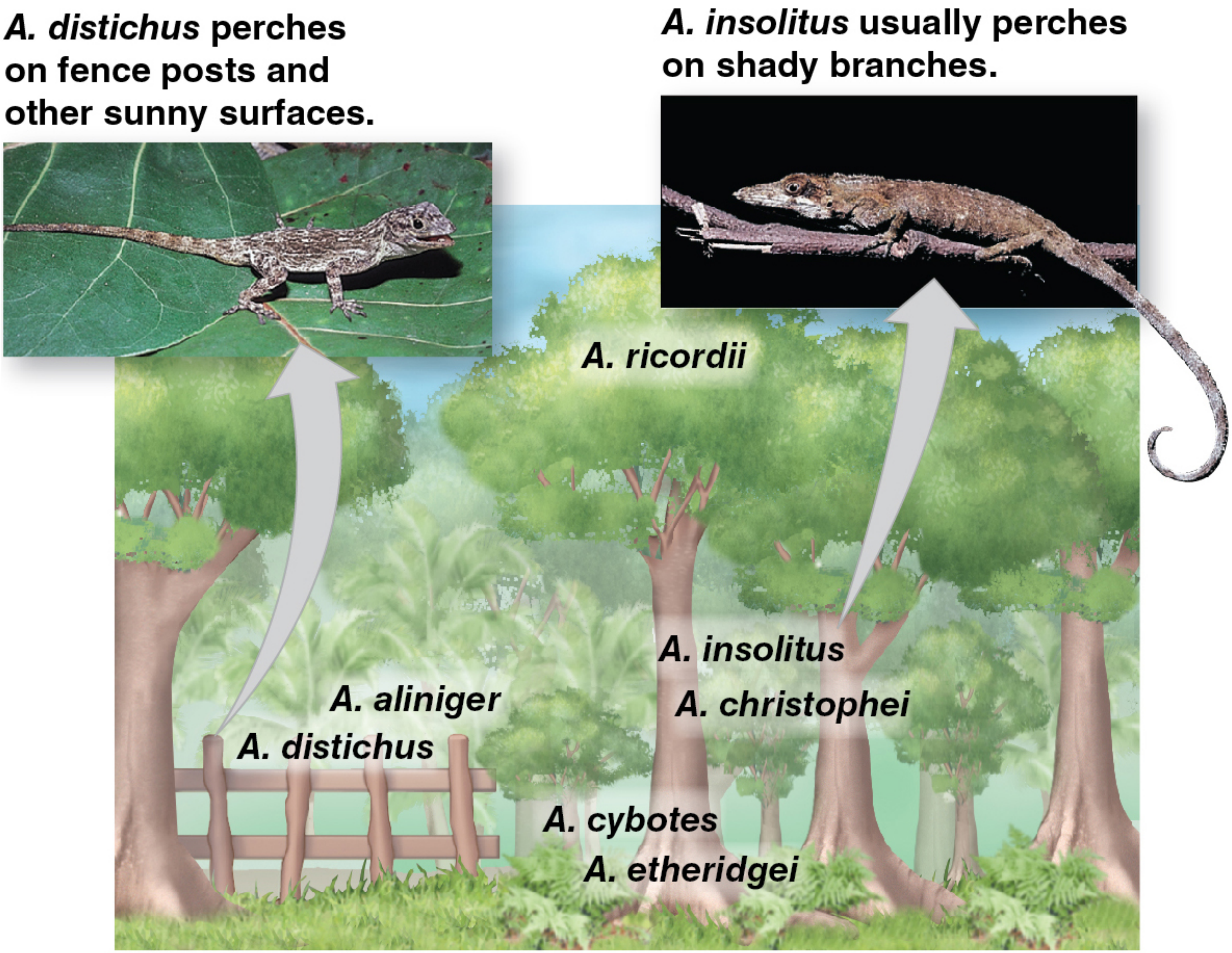
- **Competitive exclusion**—local elimination of the inferior competitor—can result when two species use the same limited resources
  - For example, when *Paramecium aurelia* and *Paramecium caudatum* compete for resources in culture, *P. caudatum* is driven to extinction
  - Both species survive when cultured alone
  - Based on this result, G.F. Gause concluded that two species competing for the same limiting resources cannot coexist permanently in the same place

Ecological Niches and Natural Selection

- An organism's **ecological niche** is the specific set of biotic and abiotic environmental resources it uses
  - For example, the niche of a tropical tree lizard includes the temperature range it tolerates, the size of branches it perches on, the time it is active, and the size and kind of insects it eats

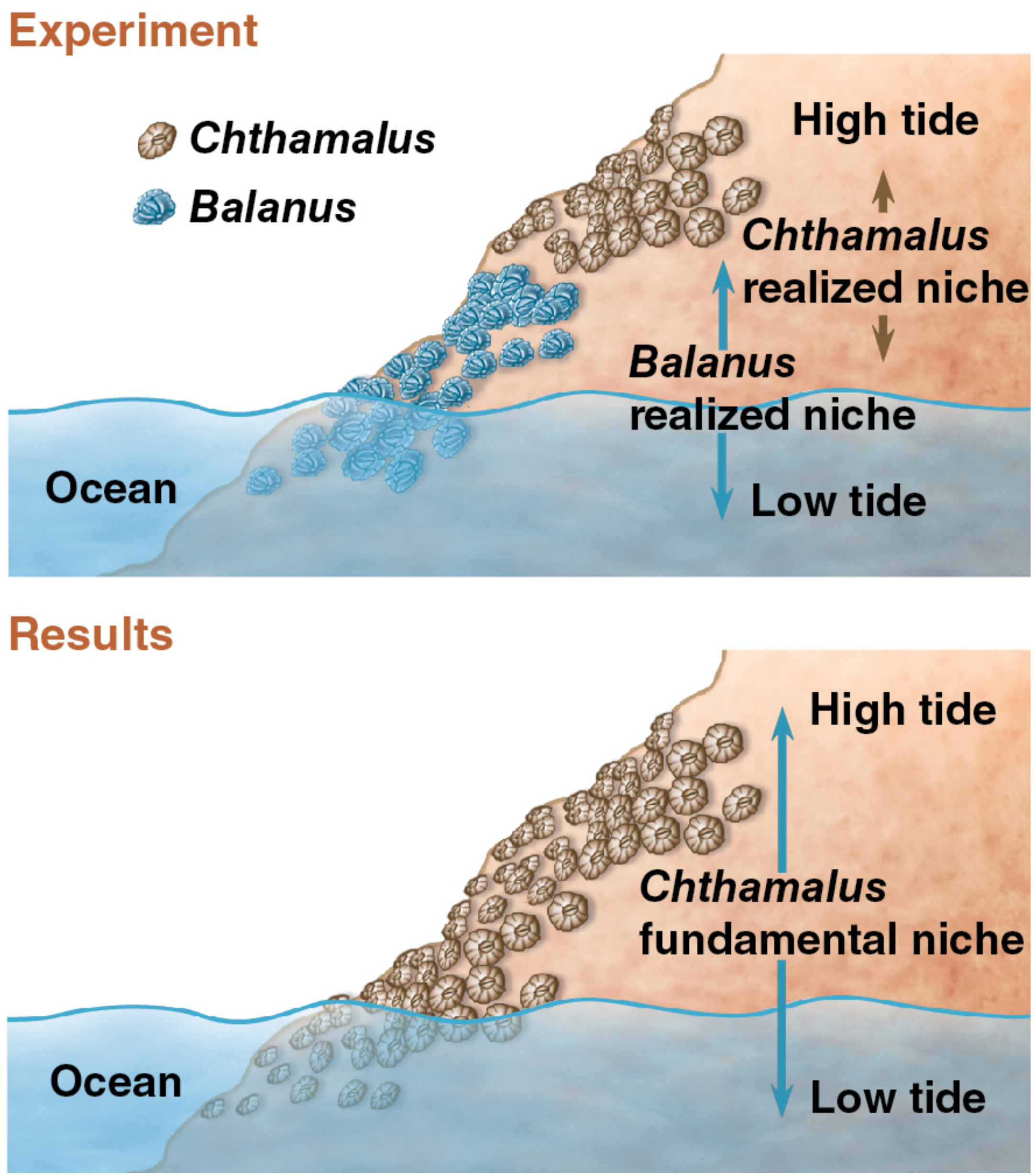
- The niche concept can be used to restate the principle of competitive exclusion:
  - Two species cannot coexist permanently in a community if their niches are identical
  - Ecologically similar species can coexist if one or more significant differences in their niches arise
- **Resource partitioning** is the differentiation of niches that enables similar species to coexist in a community

Figure 54.2


A. distichus perches on fence posts and other sunny surfaces.
A. insolitus usually perches on shady branches.
A. ricordii
A. insolitus
A. christophei
A. aliniger
A. distichus
A. cybotes
A. etheridgei

- A species' fundamental niche is the niche potentially occupied by that species
- A species' realized niche is the portion of the fundamental niche actually occupied by that species
- As a result of competition, a species' fundamental niche may differ from its realized niche

Figure 54.3


Experiment
Chthamalus
Balanus
High tide
Chthamalus
realized niche
Balanus
realized niche
Ocean
Low tide
Results
High tide
Chthamalus
fundamental niche
Ocean
Low tide

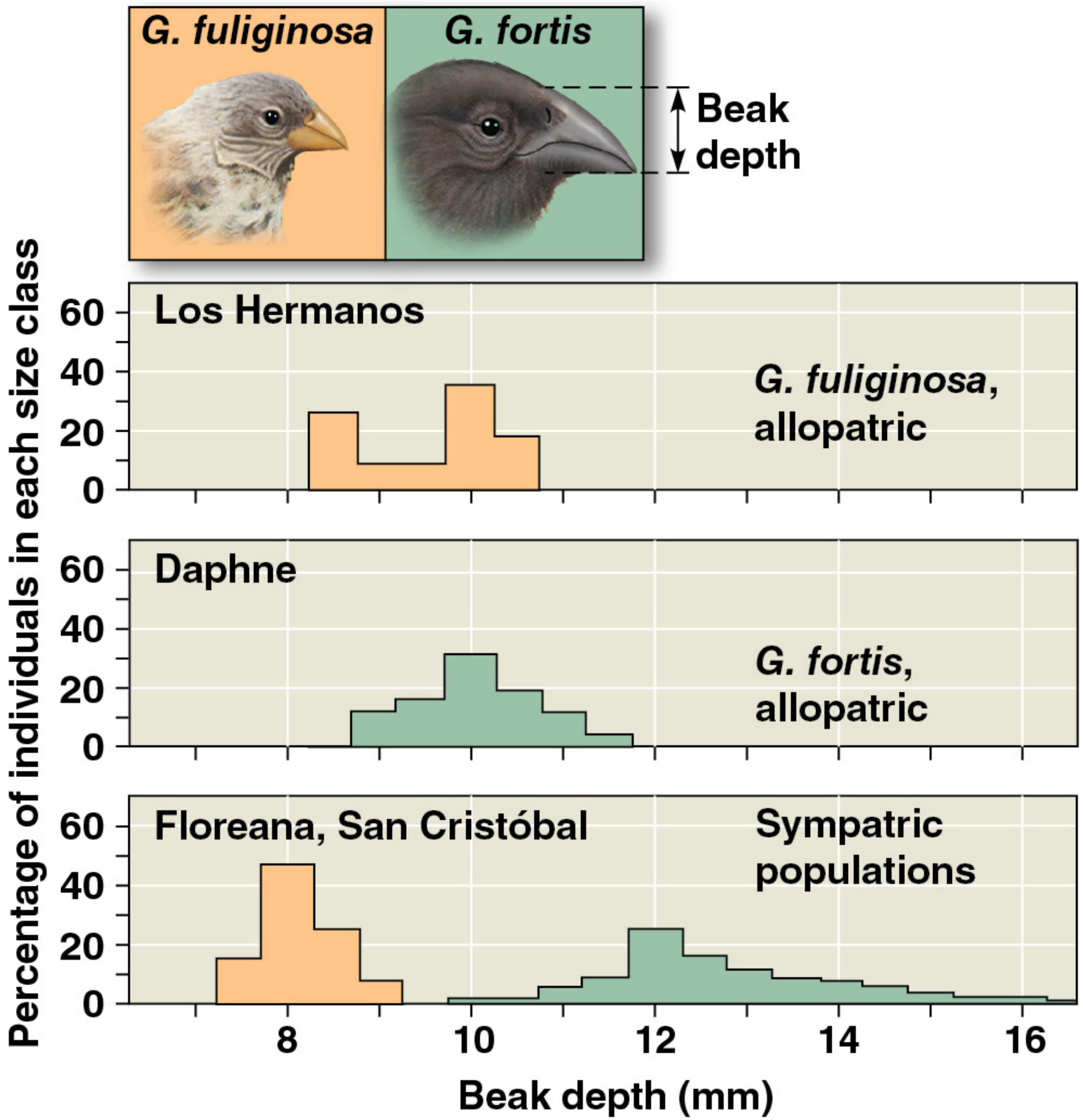
- Species can partition their niches in time, as well as space
  - For example, the common spiny mouse and the golden spiny mouse are both normally nocturnal (active during the night)
  - Where they coexist, the golden spiny mouse becomes diurnal (active during the day)

Figure 54.4

Character Displacement

- The tendency for characteristics to diverge more in sympatric than in allopatric populations of two species is called **character displacement**
  - For example, beak depth is similar between allopatric populations of two species of Galapagos finches, but has diverged considerably in sympatric populations

Figure 54.5


G. fuliginosa
G. fortis
Beak depth
Percentage of individuals in each size class
Los Hermanos
G. fuliginosa, allopatric
Daphne
G. fortis, allopatric
Floreana, San Cristóbal
Sympatric populations
60
40
20
0
8
10
12
14
16
Beak depth (mm)

Exploitation

- **Exploitation** refers to any +/– interaction in which individuals of one species benefit by feeding on individuals of the other species (which are harmed)
- Exploitative interactions include predation, herbivory, and parasitism

Predation

- **Predation** (+/–) refers to an interaction in which an individual of one species—the predator—kills and eats an individual of another species—the prey
- Most predators have acute senses that enable them to find and identify potential prey
  - For example, pit vipers find their prey with a pair of heat-sensing organs located on the head

- Many predators have adaptations such as claws, fangs, or poison to help catch and subdue their prey
- Predators that pursue their prey are fast and agile; those that lie in ambush are generally disguised in their environments

- Prey species may have behavioral defenses including hiding, fleeing, and forming herds or schools
- Animals also have a variety of morphological and physiological defense adaptations
- Some species are protected by mechanical or chemical defenses

(a) Mechanical defense

Porcupine

Figure 54.6b

(b) Chemical defense

Skunk

- Some animals can synthesize toxins, while others accumulate them from the plants that they eat
- Animals with chemical defenses often exhibit bright warning coloration, called **aposematic coloration**
- Predators tend to avoid brightly colored prey

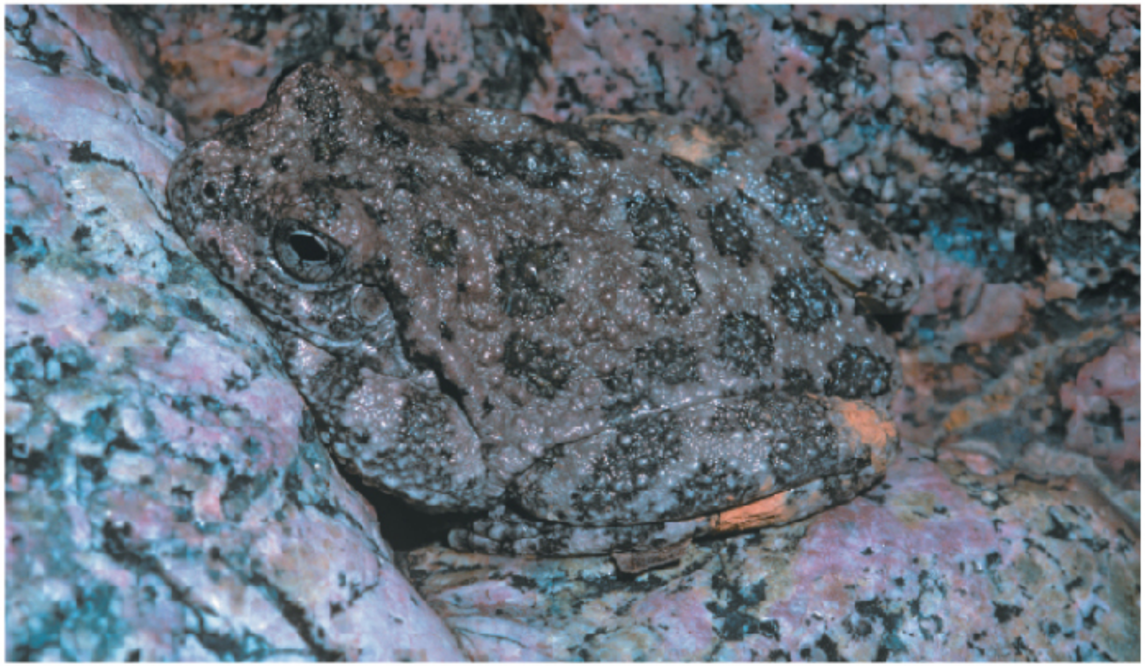
(c) Aposematic coloration: warning coloration

Poison dart frog

- **Cryptic coloration**, or camouflage, makes prey difficult to see in their environment

Figure 54.6d

(d) Cryptic coloration: camouflage



Canyon tree frog

Video: Seahorse Camouflage

- Some prey species are protected by their resemblance to other species
- In **Batesian mimicry**, a palatable or harmless species mimics an unpalatable or harmful model
- Harmless individuals that resemble members of a harmful species are avoided by predators that have learned not to eat the harmful ones

(e) Batesian mimicry: A harmless species mimics a harmful one.

▲ Venomous green parrot snake

▲ Nonvenomous hawkmoth larva

- In **Müllerian mimicry**, two or more unpalatable species resemble each other
- Predators can learn to avoid unpalatable prey faster when they encounter more of them with a similar appearance

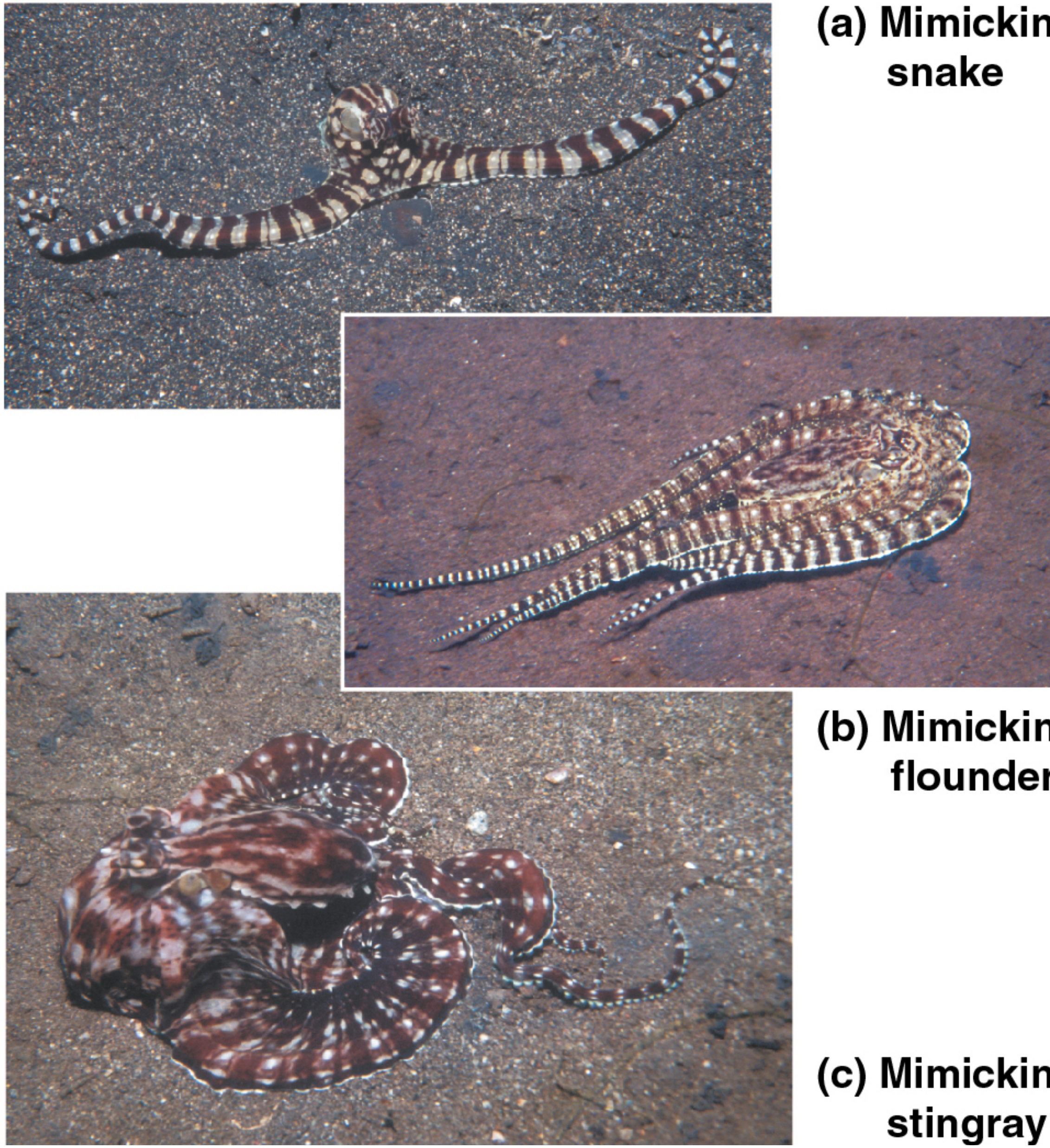
(f) Müllerian mimicry: Two unpalatable species mimic each other.

▲Yellow jacket

▲Cuckoo bee

- Mimicry has also evolved in many predators to enable them to approach prey
  - For example, the mimic octopus can take on the appearance and movement of more than a dozen marine animals

Figure 54.7



(a) Mimicking a sea snake

(b) Mimicking a flounder

(c) Mimicking a stingray

Herbivory

- **Herbivory** (+/–) refers to an interaction in which an herbivore eats parts of a plant or alga
- Herbivores harm, but do not usually kill the plants and algae that they feed on
- Large mammals are the most familiar herbivores, but most herbivores are invertebrates

Figure 54.8

- Herbivores have many specialized adaptations
  - For example, many herbivorous insects have chemical sensors that enable them to distinguish toxicity or nutritional value of plants
  - Many herbivores have specialized teeth or digestive systems for processing vegetation

- Plants often have mechanical defenses, such as spines or thorns, or chemical defenses, such as toxins, to deter herbivores
- Non-toxic chemical defenses may cause abnormal development of herbivores or be distasteful to them

Parasitism

- In **parasitism** (+/–), one organism, the **parasite**, derives nourishment from another organism, its host, which is harmed in the process
- Parasites that live within the body of their host are called **endoparasites**
- Parasites that live on the external surface of a host are **ectoparasites**

- Many parasites have complex life cycles that involve multiple hosts
- Some parasites change the behavior of the host in a way that increases the likelihood that the parasite will be transmitted to the next host
  - For example, crustaceans parasitized by acanthocephalan worms move into the open, increasing the chance of being eaten by birds

- Parasites can significantly affect the survival, reproduction, and density of their host population, both directly and indirectly
  - For example, ticks withdraw blood and cause hair loss in their moose hosts; parasitized moose are more likely to die from cold stress or predation

Positive Interactions

- Ecological communities are heavily influenced by **positive interactions**, where at least one species benefits and neither is harmed
- Mutualism (+/+) and commensalism (+/0) are positive interactions

Mutualism

- **Mutualism** (+/+) is a common interspecific interaction that benefits individuals of both species
- In some mutualisms, each species depends on the other for their survival and reproduction; in others, both species can survive alone

Figure 54.9

(a) Acacia trees house stinging ants which feed on the trees' nectar and protein-rich swellings (yellow)

(b) Area cleared by ants around an acacia tree

Video: Clownfish and Anemone

- Typically, both partners in a mutualism incur costs as well as benefits
- The benefits to each partner must exceed the costs, or else the mutualism may break down
  - For example, in some mycorrhizae, the plant stops supplying carbohydrates to the fungus when soil nutrients are plentiful

Commensalism

- **Commensalism** (+/0) is an interaction in which individuals of one species benefits while members of the other species is neither harmed nor helped
  - For example, shade-tolerant wildflowers depend on the shade provided by forest trees, but the trees are not affected by the wildflowers

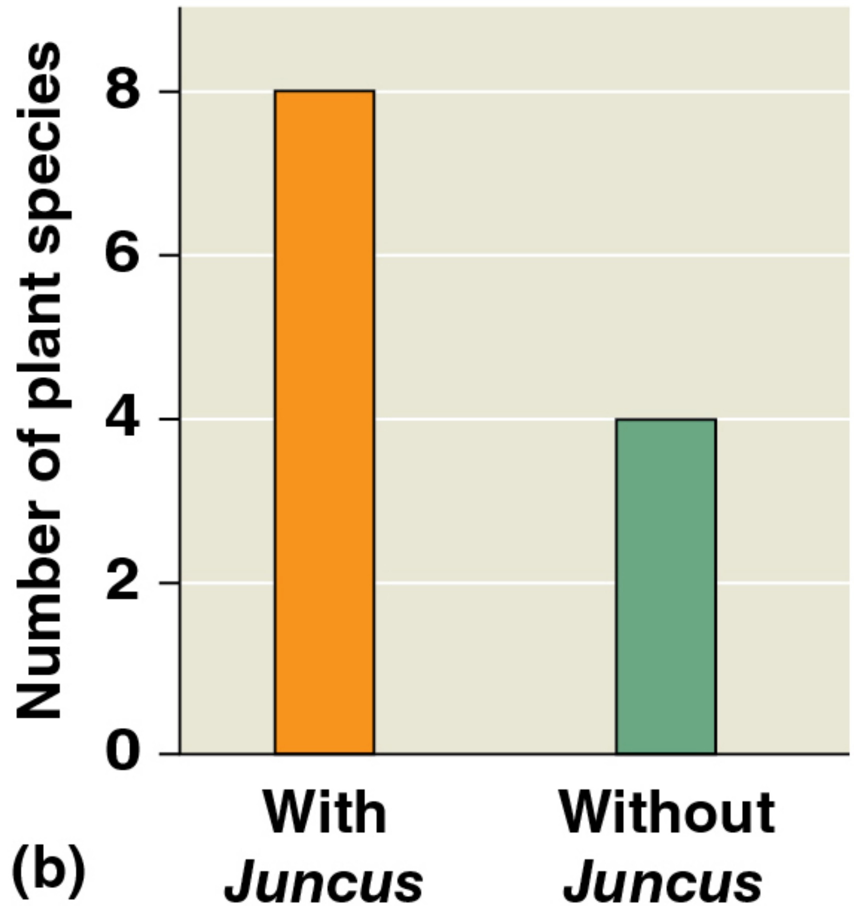
- Some interactions that are typically commensal may at times become mutualistic
  - For example, cattle egrets benefit from the insects flushed out of the grass by grazing herbivores; egrets typically have no effect on the herbivores
  - Sometimes, the egrets provide a benefit to the herbivore by eating ectoparasites that live on its skin

Figure 54.10

- Positive interactions can have significant influence on the structure of ecological communities
  - For example, the black rush affects community diversity in New England salt marshes by making the soil more hospitable for other plant species

Figure 54.11

(a) Salt marsh with *Juncus*



(b)

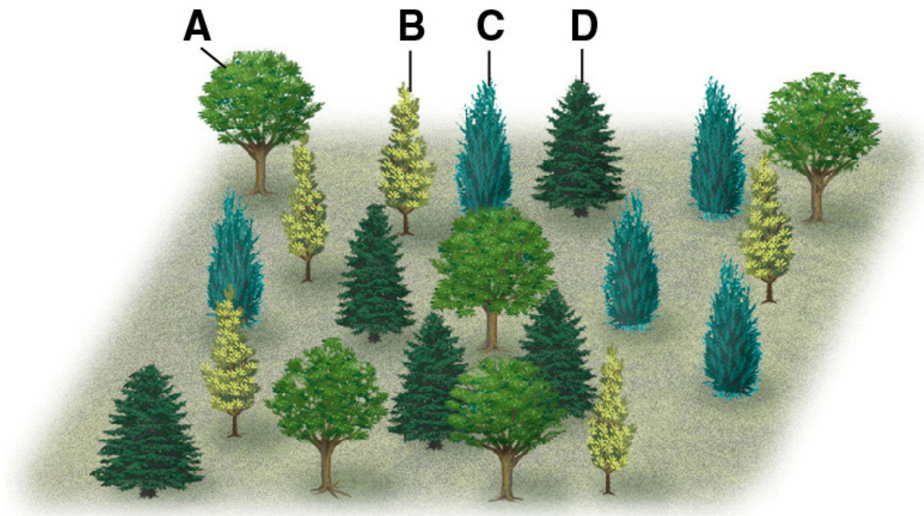
CONCEPT 54.2: Diversity and trophic structure characterize biological communities

- Ecological communities can be characterized by general attributes, such as diversity and feeding relationships of their species
- In some cases, a few species in a community exert strong control on that community's structure

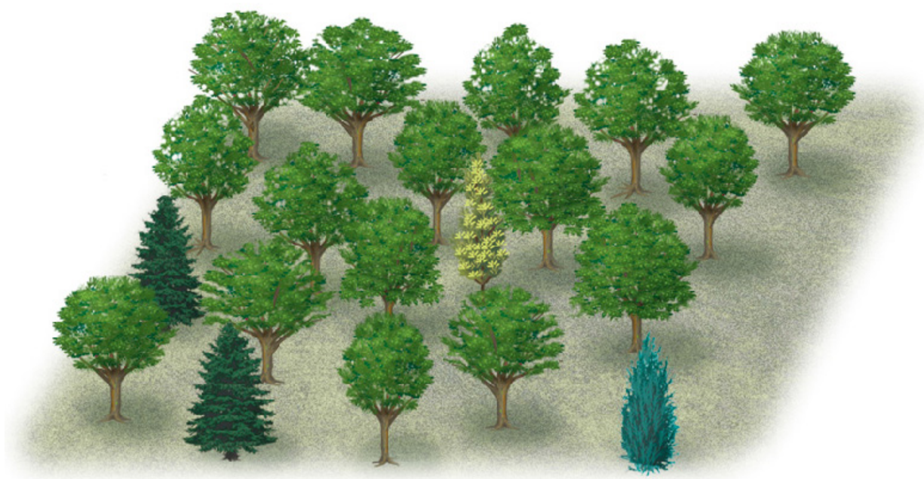
Species Diversity

- The **species diversity** of a community—the variety of organisms it includes—has two components:
  - **Species richness** is the number of different species in the community
  - **Relative abundance** is the proportion each species represents of all individuals in the community
- Two communities can have the same species richness but a different relative abundance

Figure 54.12



Community 1
A: 25% B: 25% C: 25% D: 25%



Community 2
A: 80% B: 5% C: 5% D: 10%

- Diversity can be compared between communities using a diversity index
- The **Shannon diversity** index (*H*) is widely used by ecologists

$$H = -(p_A \ln p_A + p_B \ln p_B + p_C \ln p_C + \ldots)$$

  - A, B, C . . . represent the species in the community
  - p is the relative abundance of each species
  - ln is the natural logarithm

- We can calculate the Shannon diversity index for the two communities discussed in the text
  - For community 1, *p* = 0.25 for each species, so

$$H = -4\left(0.25 \ln 0.25\right) = 1.39$$

  - For community 2,

$$H = -\left[0.8 \ln 0.8 + 2\left(0.05 \ln 0.05\right) + 0.1 \ln 0.1\right] = 0.71$$

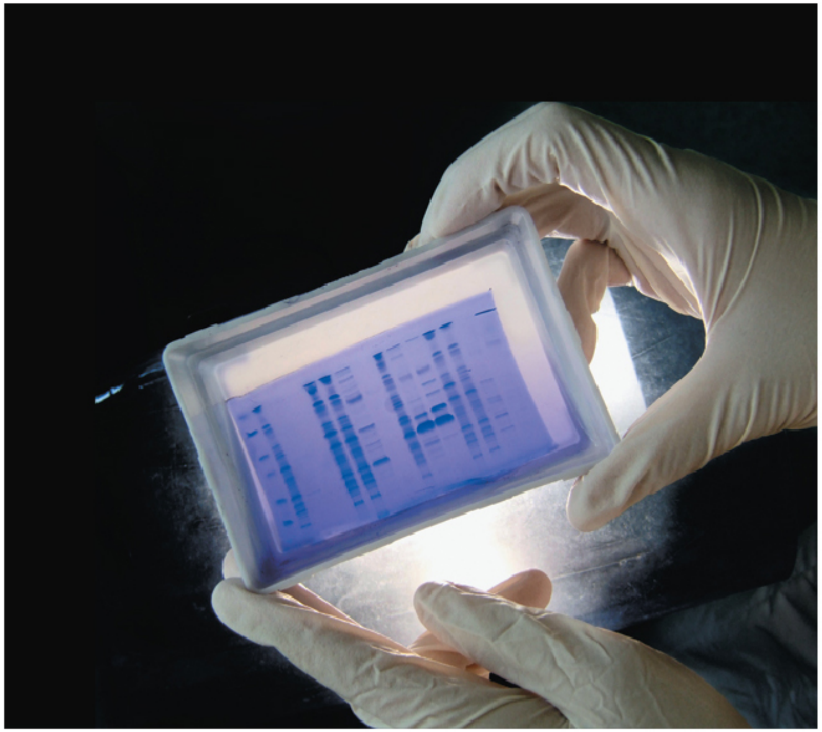
- Determining the number and abundance of species that are rare, hard to identify, highly mobile, or less visible presents challenges
- Species can be identified by comparing their sequences of a short standardized section of DNA—a *DNA “barcode”*—to a reference database

Figure 54.13

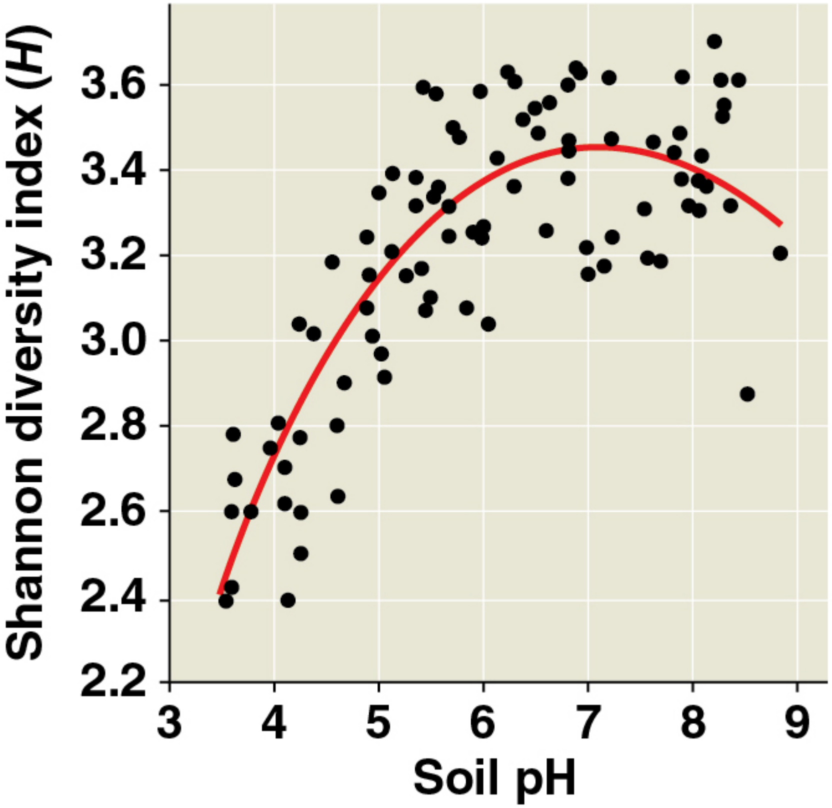
- Ecologists can also use molecular tools to census highly mobile or less visible members of communities, such as microorganisms

Figure 54.14

Technique



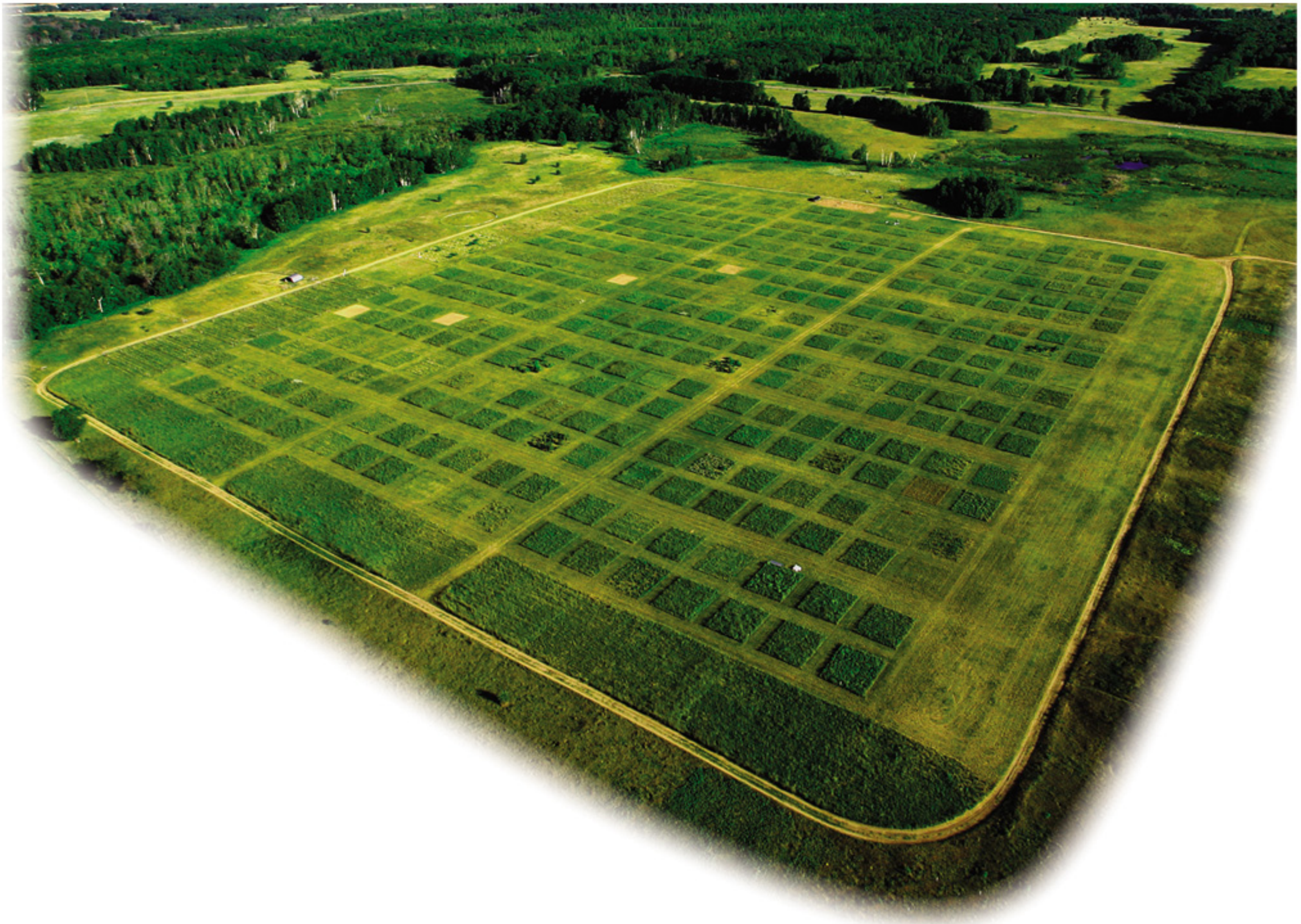
Results



Diversity and Community Stability

- Ecologists manipulate diversity to study its effects on experimental communities
  - For example, plant diversity has been manipulated at Cedar Creek Ecosystem Science Reserve in Minnesota for more than three decades
  - In one decade-long experiment, researchers created 168 plots, each containing 1, 2, 4, 8, or 16 perennial grassland species

Figure 54.15



- Results from the experiment indicate that higher-diversity plant communities are generally
  - more productive; they produce more **biomass** (the total mass of all organisms) per year
  - more stable year to year in their productivity
  - better able to withstand and recover from environmental stresses

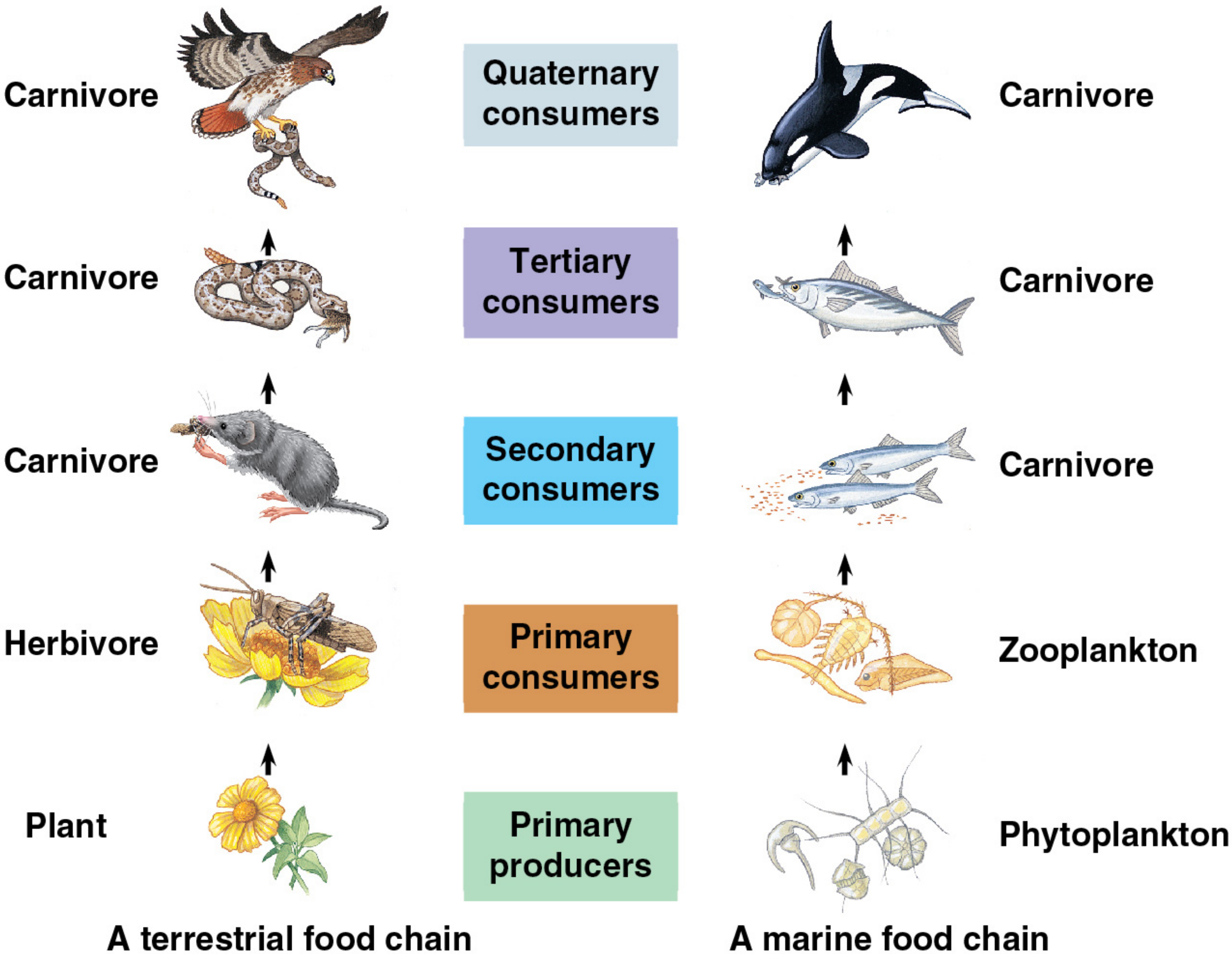
- Higher-diversity communities are often more resistant to introduced species—organisms that humans have moved outside their native range
  - For example, a research experiment off the coast of Connecticut manipulated diversity of marine invertebrate communities
  - An introduced tunicate was four times more likely to survive in lower-diversity communities

Trophic Structure

- **Trophic structure**—the feeding relationships between organisms in a community—is a key factor affecting community structure and dynamics

- Energy is transferred from autotrophs (primary producers) through herbivores (primary consumers) to carnivores (secondary and higher consumers)
- Decomposers are the final link in this chain, which is referred to as a **food chain**
- The position an organism occupies in a food chain is called its **trophic level**

Figure 54.16

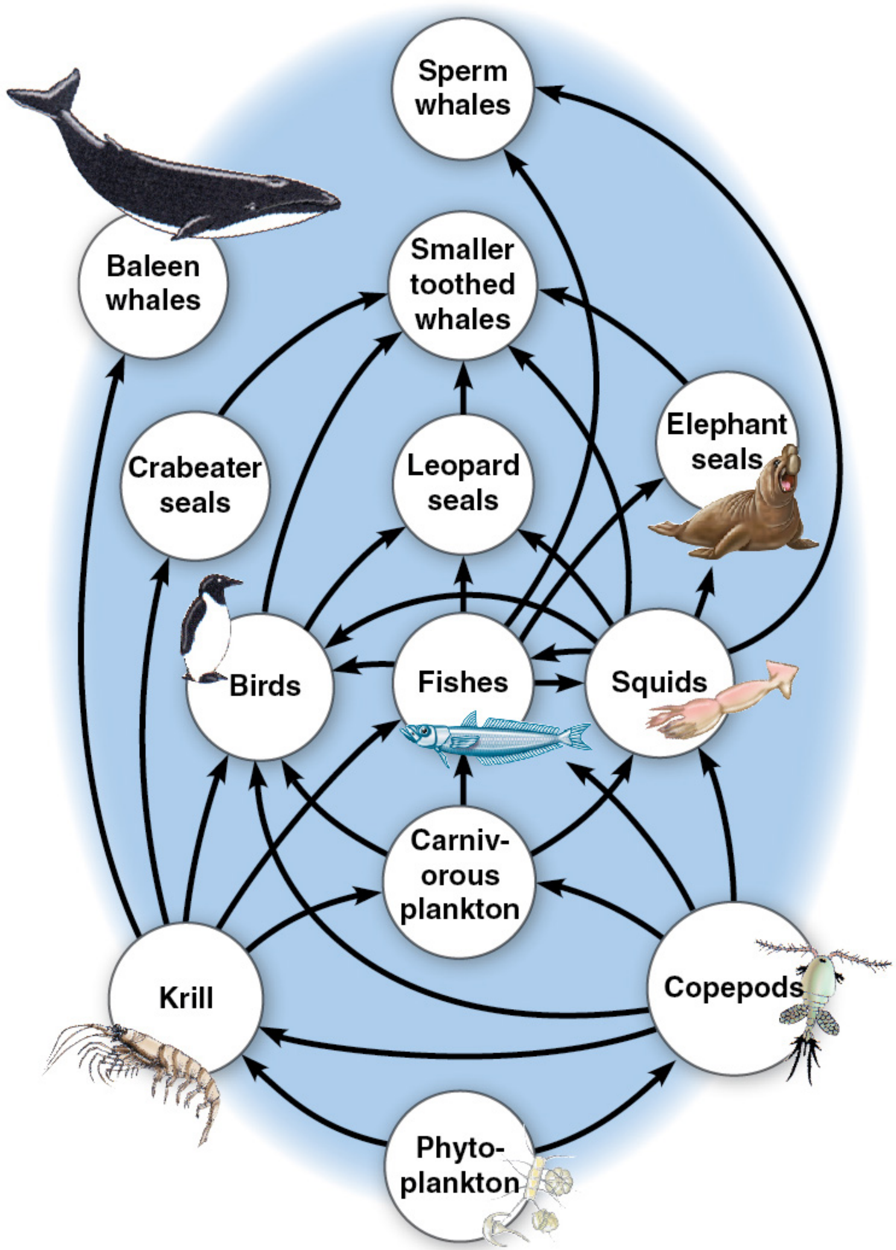

Carnivore
Quaternary consumers
Carnivore
Carnivore
Tertiary consumers
Carnivore
Carnivore
Secondary consumers
Carnivore
Herbivore
Primary consumers
Zooplankton
Plant
Primary producers
Phytoplankton
A terrestrial food chain
A marine food chain

Video: Shark Eating a Seal

Food Webs

- A **food web** is a group of food chains linked together forming complex trophic interactions
- Arrows link species in the food web according to who eats whom

Figure 54.17

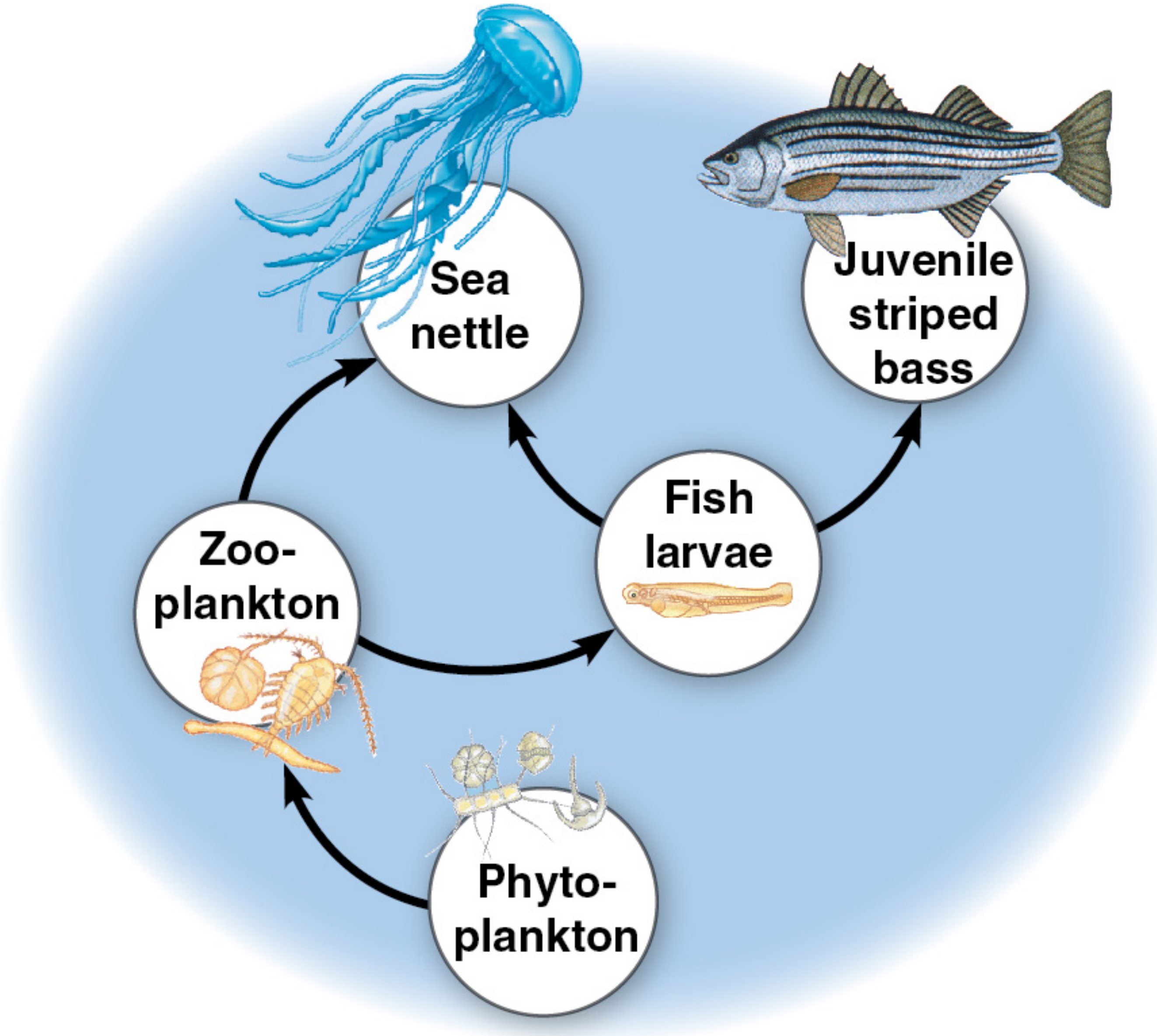


Sperm whales
Baleen whales
Smaller toothed whales
Crabeater seals
Leopard seals
Elephant seals
Birds
Fishes
Squids
Carniv-orous plankton
Krill
Copepods
Phyto-plankton

- A species may play a role at more than one trophic level in a food web
  - For example, foxes are omnivores whose diet includes plant materials, herbivores, and other predators

- Complicated food webs can be simplified by
  - Grouping species with similar trophic relationships into broad functional groups
  - Isolating a portion of a community that interacts very little with the rest of the community

Figure 54.18



Sea nettle
Juvenile striped bass
Fish larvae
Zoo-plankton
Phyto-plankton

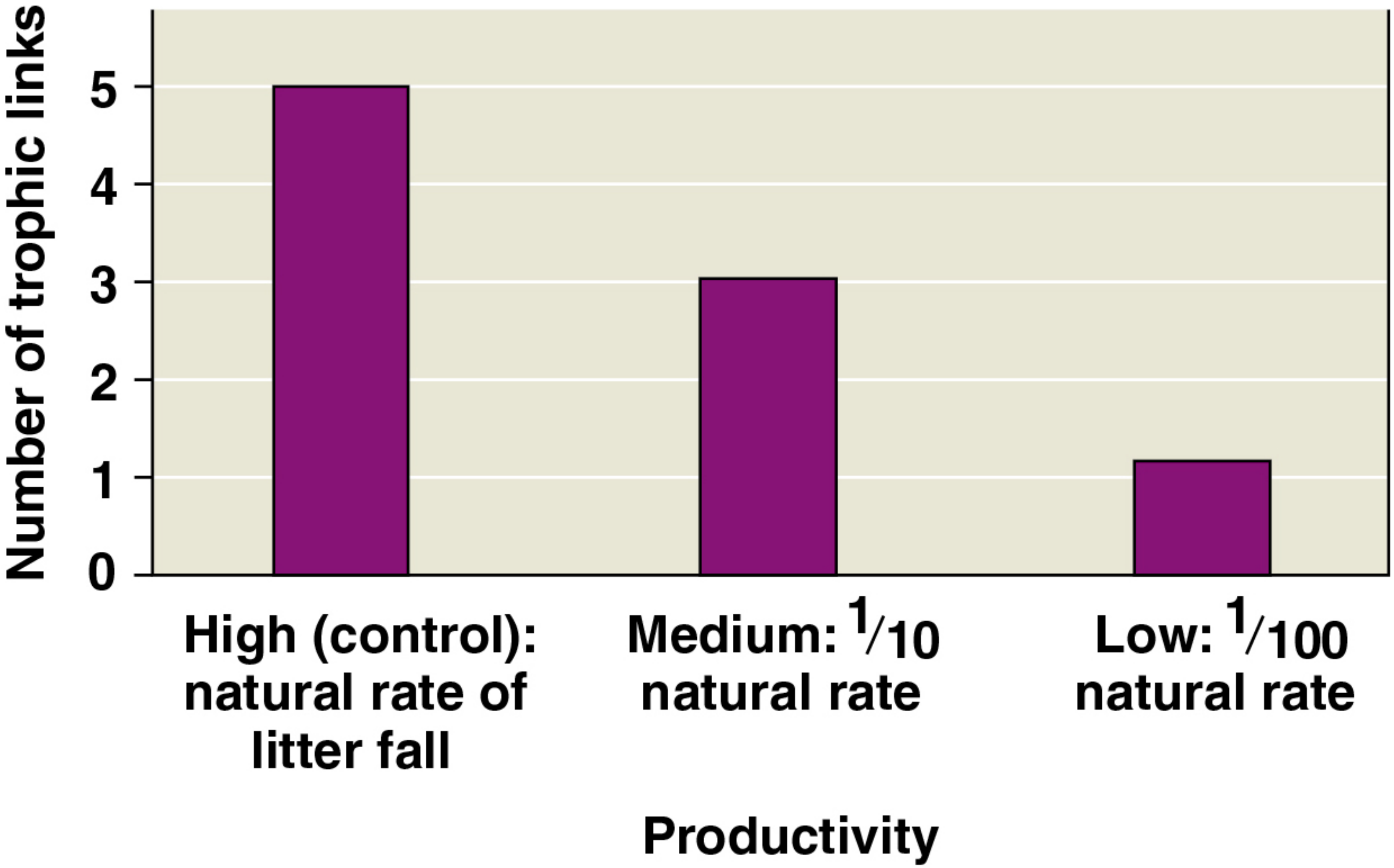
Limits on Food Chain Length

- Each food chain in a food web is usually only a few links long; most studies to date have chains with five or fewer links

- The **energetic hypothesis** suggests that length is limited by inefficient energy transfer
- Only about 10% of the energy stored in organic matter at each trophic level is converted to organic matter at the next trophic level
  – For example, a producer level consisting of 100 kg of plant material can support about 10 kg of herbivore biomass and 1 kg of carnivore biomass

- The energetic hypothesis predicts that food chains should be longer in habitats with higher production
- This hypothesis can be tested by manipulating community productivity
  - For example, researchers found a relationship between the amount of leaf litter available in tree-hole communities and food chain length

Figure 54.19



Number of trophic links
5
4
3
2
1
0
High (control): natural rate of litter fall
Medium: 1/10 natural rate
Low: 1/100 natural rate
Productivity

- Another factor limiting food chain length is that carnivores tend to be larger at higher trophic levels
- Large carnivores cannot obtain enough food from their small prey in a given time to meet their metabolic needs

Species with a Large Impact

- Certain species have a very large impact on community structure due to their abundance or pivotal role in community dynamics

- **Foundation species** have strong effects due to their large size or high abundance
- They often have community-wide effects because they provide habitat or food
- They may be competitively dominant—superior in exploiting key resources such as space, water, nutrients, or light

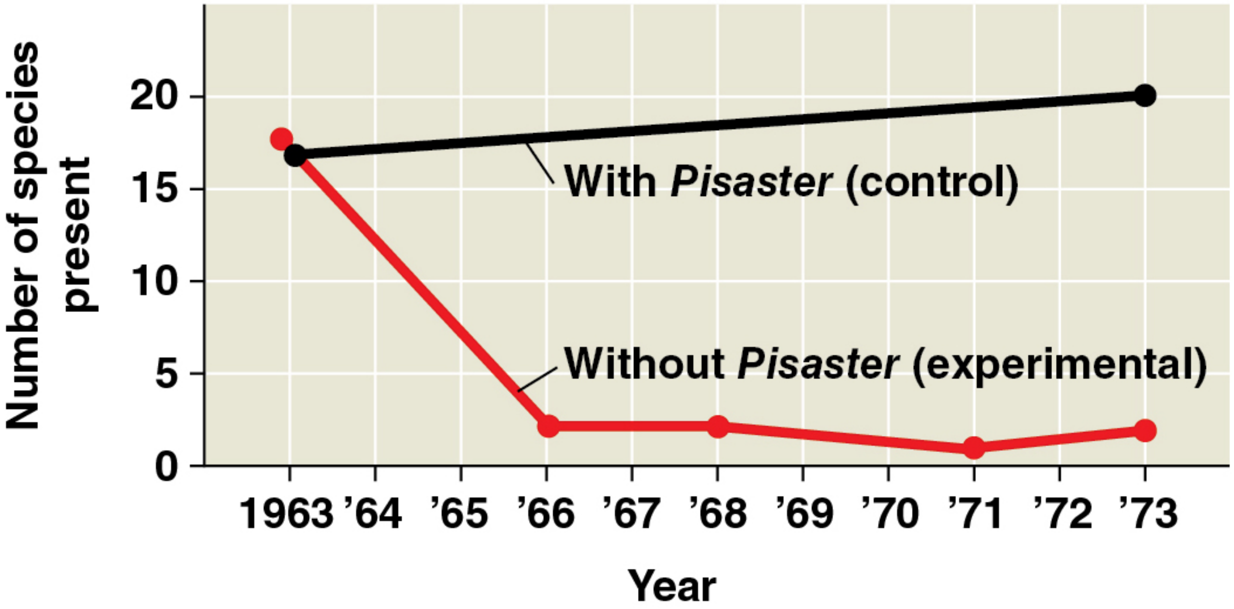
- One way to discover the impact of a foundation species is to remove it from the community
  - For example, introduction of chestnut blight to eastern North America killed most of the dominant American chestnut trees
  - Removal of the dominant species had a small impact on some species and severe effects on others

- **Keystone species** exert strong control on a community by their pivotal ecological roles
- In contrast to foundation species, they are not usually abundant in a community
  - For example, a sea star affects its community by feeding on and limiting the abundance of a competitively dominant species, a mussel

Figure 54.20

Experiment

Results



- **Ecosystem engineers** create or dramatically alter their physical environment
  - For example, beavers build dams that can transform landscapes on a very large scale
- Some foundation species, such as trees, are considered ecosystem engineers because their presence creates habitat for other species

Figure 54.21

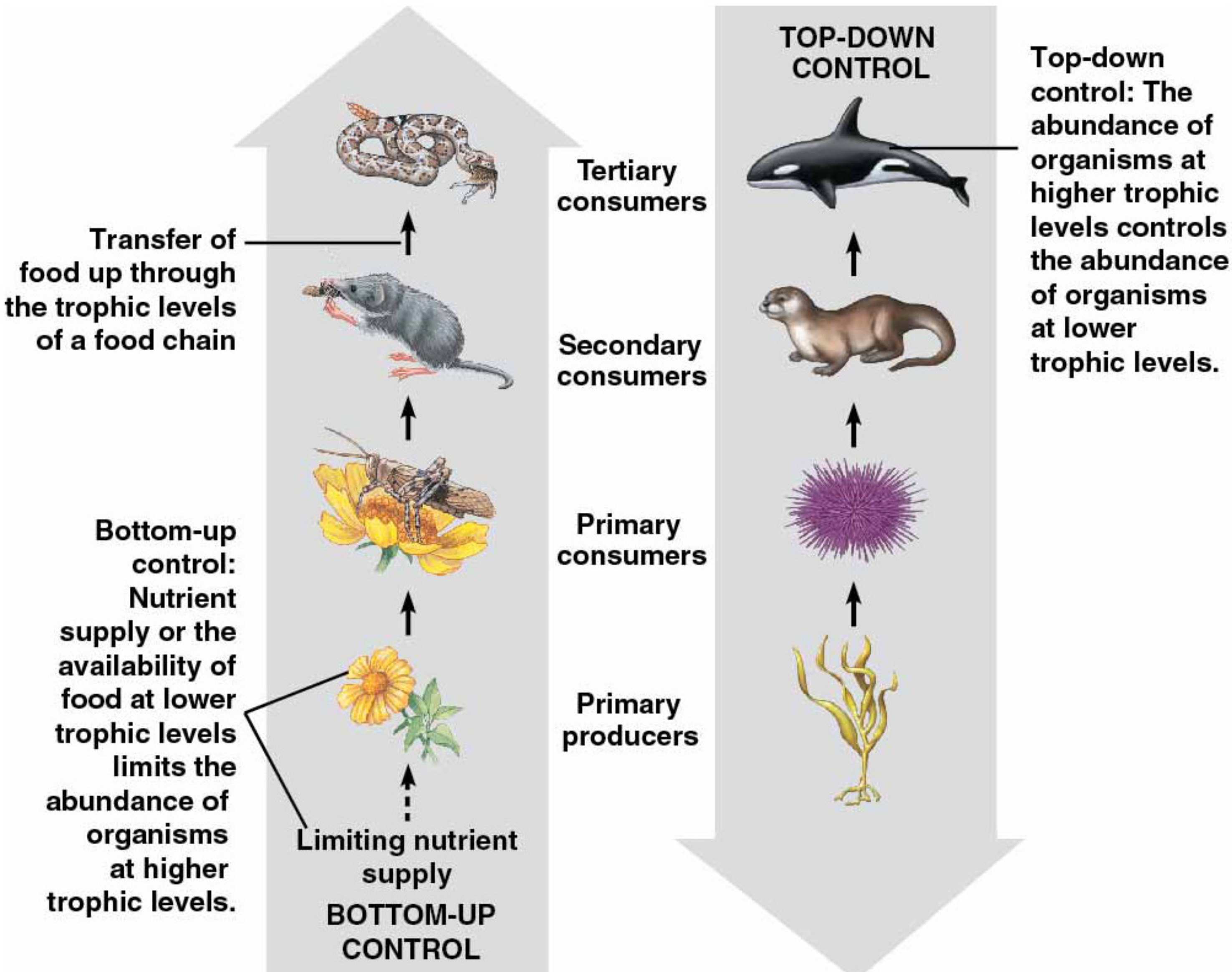
Bottom-Up and Top-Down Controls

- Adjacent trophic levels can affect one another in two general ways:
  - Organisms can be controlled by what they eat ("bottom-up" control)
  - Organisms can be controlled by what eats them ("top-down" control)

- In **bottom-up control**, the abundance of organisms at each trophic level is limited by nutrient supply or food availability at lower levels
- In this case, the biomass or abundance of organisms at lower trophic levels would have to be altered to change community structure

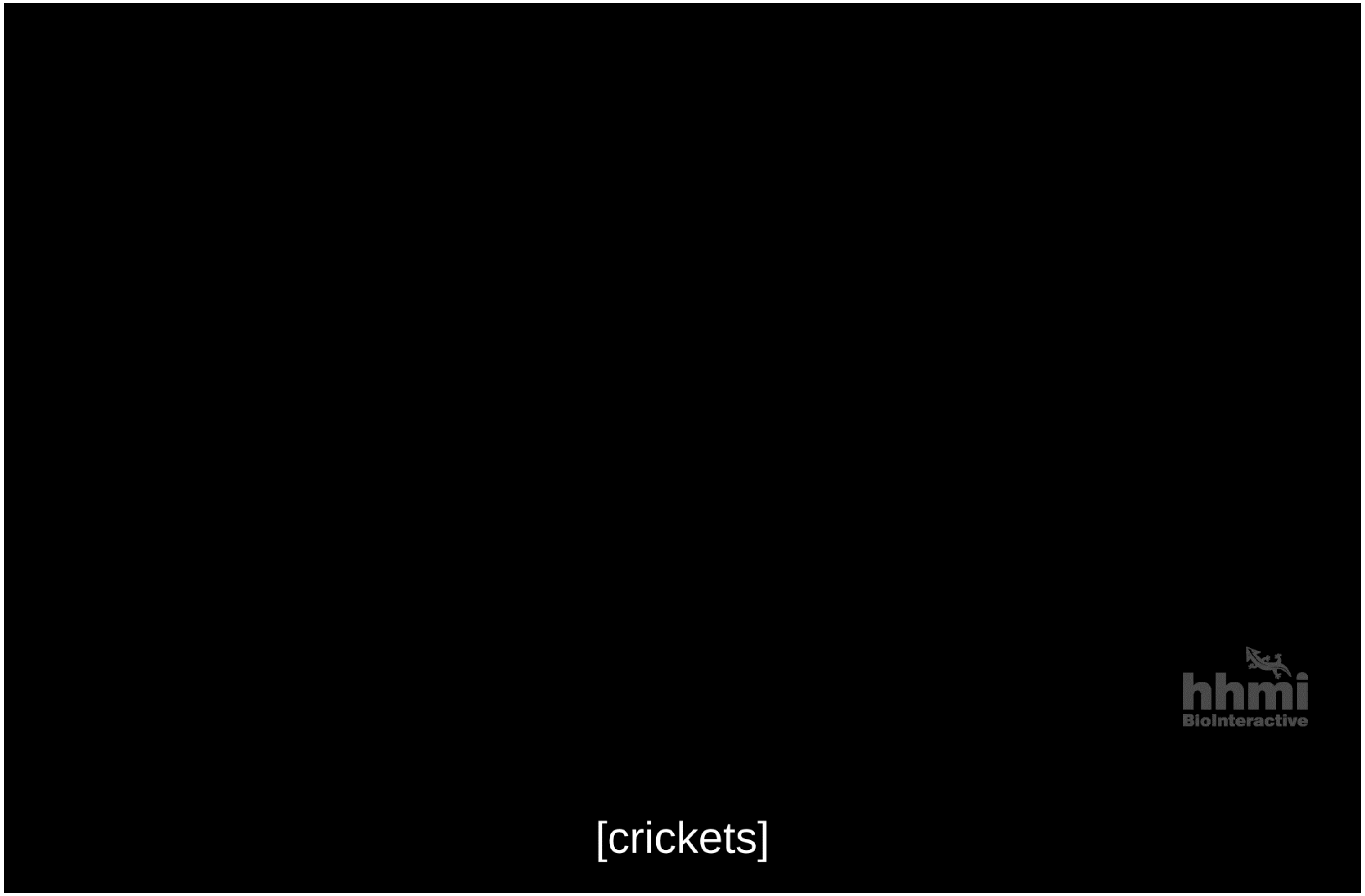
- In **top-down control**, the abundance of organisms at each trophic level is controlled by the abundance of consumers at higher trophic levels
- The effects of removing top level carnivores move down the trophic structure as alternating +/– effects

Figure 54.22



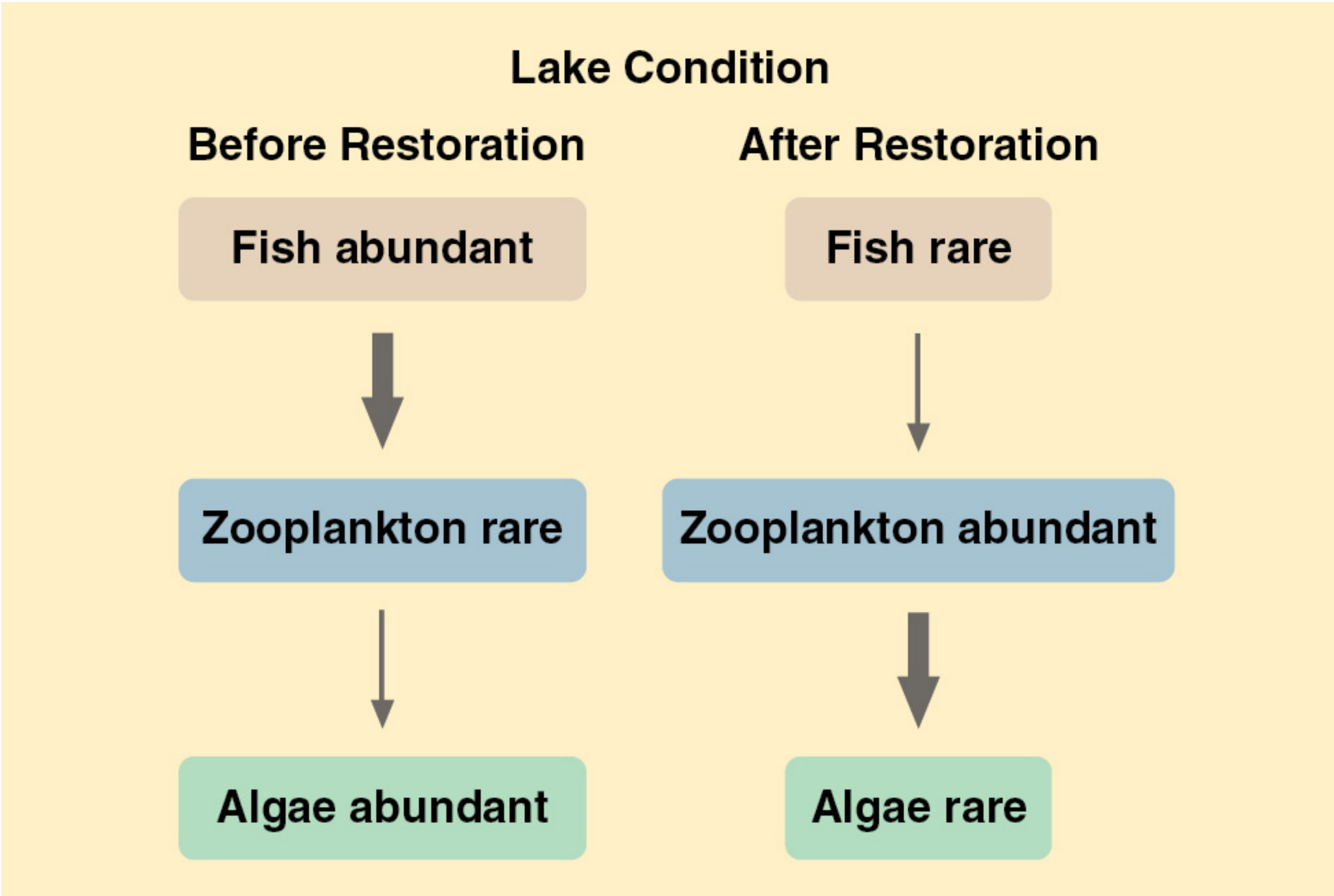
TOP-DOWN CONTROL
Top-down control: The abundance of organisms at higher trophic levels controls the abundance of organisms at lower trophic levels.
Tertiary consumers
Secondary consumers
Primary consumers
Primary producers
Transfer of food up through the trophic levels of a food chain
Bottom-up control: Nutrient supply or the availability of food at lower trophic levels limits the abundance of organisms at higher trophic levels.
Limiting nutrient supply
BOTTOM-UP CONTROL

Video: Some Animals Are More Equal Than Others: Keystone Species and Trophic Cascades



- Ecologists can apply top-down control to improve water quality in lakes with a high abundance of algae
  - For example, in lakes with three trophic levels, removing fish improves water quality by increasing the density of zooplankton, which decreases algal density
  - In those with four trophic levels, adding top predators should have the same effect

Figure 54.23



Lake Condition
Before Restoration
After Restoration
Fish abundant
Zooplankton rare
Algae abundant
Fish rare
Zooplankton abundant
Algae rare

CONCEPT 54.3: Disturbance influences species diversity and composition

- Decades ago, most ecologists favored the view that biological communities are at equilibrium, unless seriously disturbed by human activities
- This view focused on competition as a key factor determining composition and stability of communities

- Proponents of this view thought that plant communities had only one state of equilibrium, a climax community controlled solely by climate
- They argued that biotic interactions caused species in the community to function as an integrated unit—a superorganism

- Other ecologists challenged the concept of a single climax community
- Differences in soils, topography, and other factors could create many possible stable communities
- Communities were viewed as chance assemblages of species with similar abiotic requirements

- Disturbance keeps many communities from reaching equilibrium
- A **disturbance** is an event that changes a community by removing organisms from it or altering resource availability
- The **nonequilibrium model** describes communities as constantly changing after disturbance

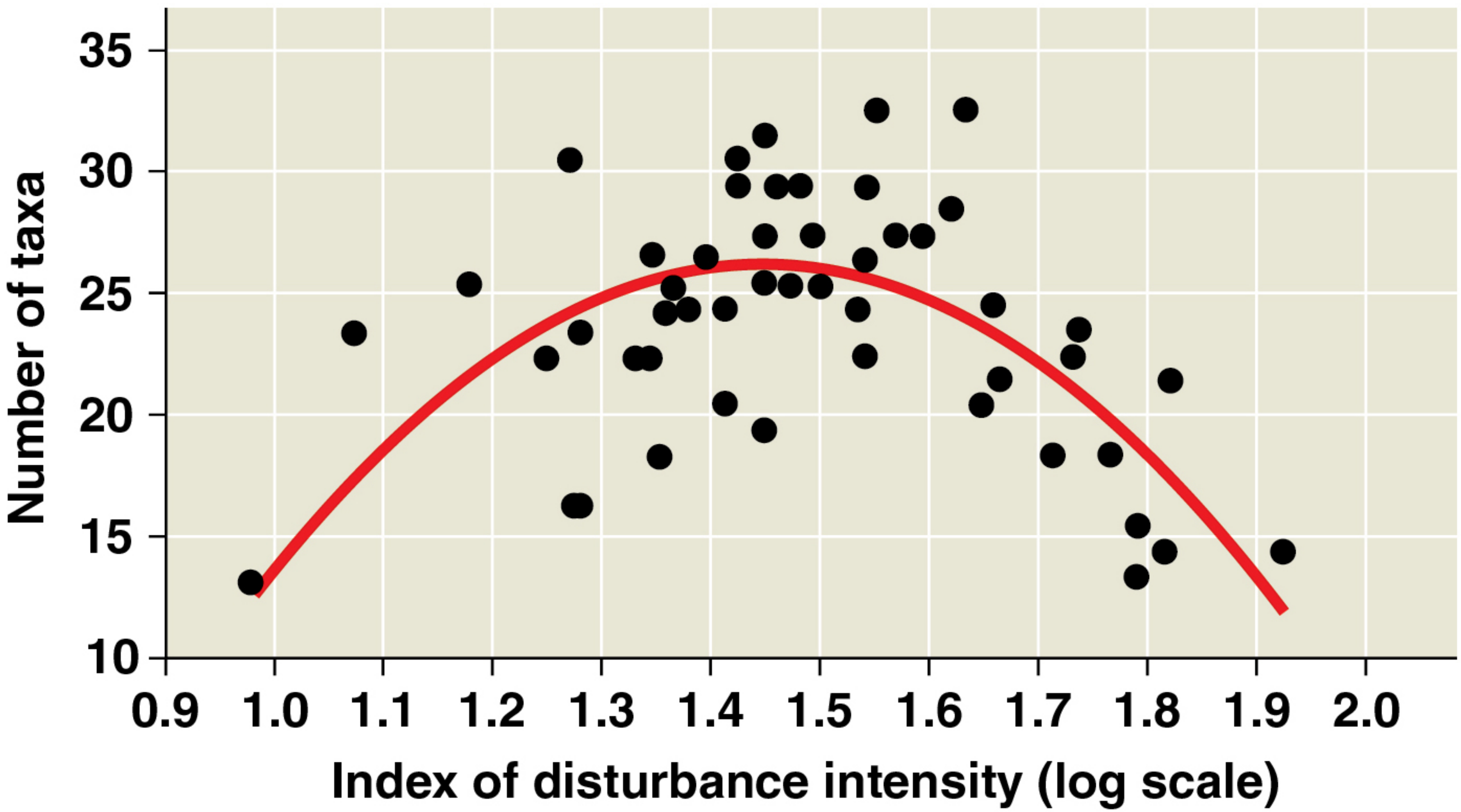
Characterizing Disturbance

- The types of disturbances and their frequency and severity vary among communities
- Storms, fire, and seasonal flooding are significant sources of disturbance in many communities
- A high level of disturbance is the result of frequent and intense disturbance
- Low levels of disturbance can result from low frequency or low intensity of disturbance

- The **intermediate disturbance hypothesis** states that moderate levels of disturbance foster greater diversity than do high or low levels of disturbance
- High levels of disturbance exclude many slow-growing species
- Low levels of disturbance allow competitively dominant species to exclude less competitive ones

- The intermediate disturbance hypothesis is supported by many terrestrial and aquatic studies
  - For example, one study compared the richness of invertebrates in stream beds exposed to different frequencies and intensities of flooding
  - Species richness was highest in streams with an intermediate frequency or intensity of flooding

Figure 54.24



35
30
25
20
15
10
Number of taxa
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
Index of disturbance intensity (log scale)

- Small and large disturbances can also have important effects on community structure
  - For example, communities dominated by lodgepole pine forest, such as that found in much of Yellowstone National Park, recover rapidly after large-scale fires

Figure 54.25

(a) Soon after fire

(b) One year after fire

Ecological Succession

- **Ecological succession** refers to the pattern of colonization and species replacement that occurs in a community following a severe disturbance
- When this process begins in a virtually lifeless area, such as a new volcanic island, it is called **primary succession**

- During primary succession, prokaryotes and protists are the only life forms initially present
- Lichens and mosses arrive first, soil gradually develops as rocks weather, and organic matter accumulates as early colonizers decompose
- The plant community establishes after soil develops

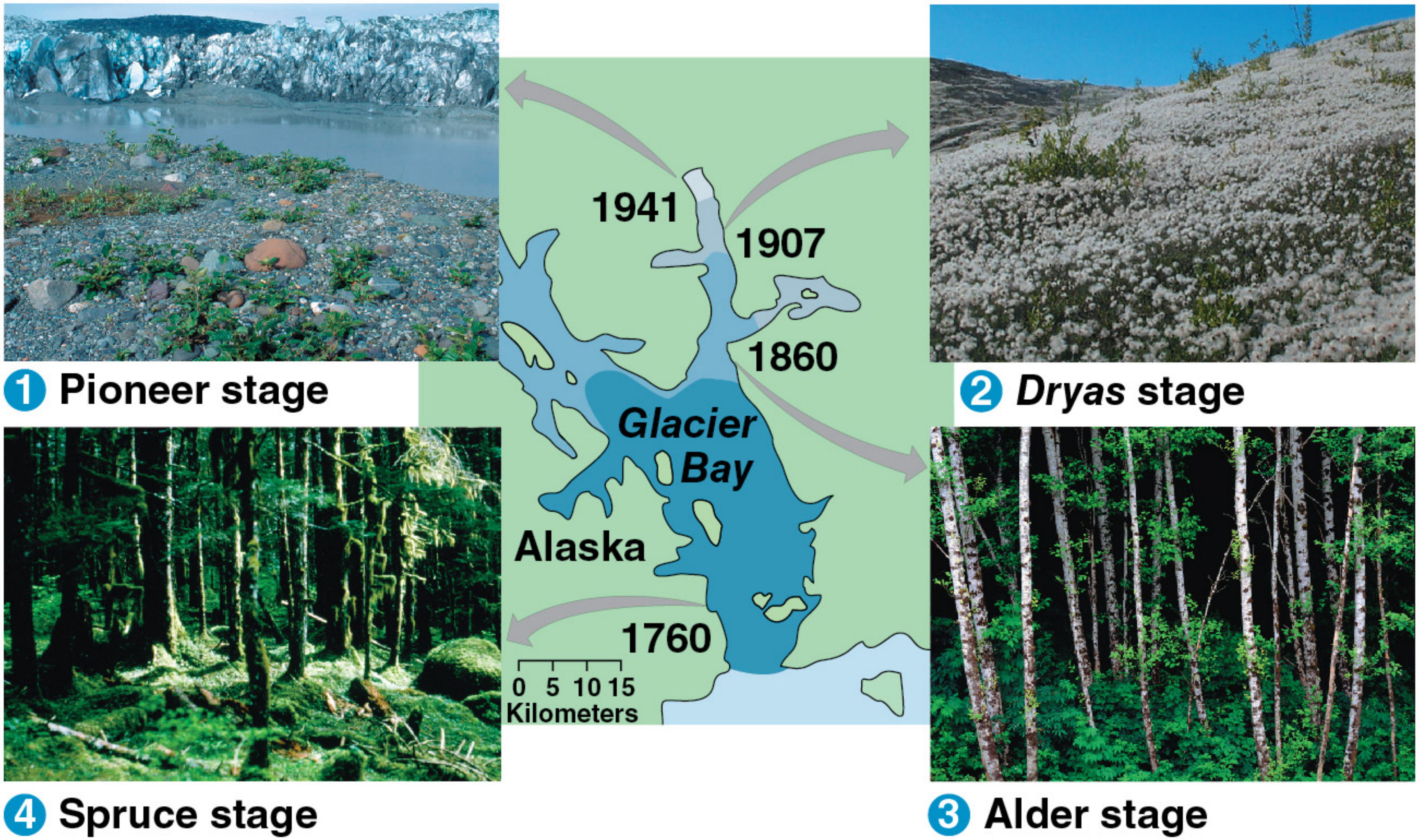
- Early-arriving species and later-arriving species may be linked in one of three processes
  - Early arrivals may facilitate the appearance of later species by making the environment more favorable
  - They may inhibit the establishment of later species
  - They may have no affect on the establishment of later species, which tolerate conditions of early succession but are neither helped or hindered by early species

- Extensive research on primary succession has been conducted at Glacier Bay in Alaska, where glaciers have retreated more than 100 km since 1760
- The oldest exposed areas are closest to the mouth of the bay; more recently exposed ones are farthest
- Researchers study succession at locations of varying distance from the mouth of the bay

- The following sequence of events occurred as the glaciers retreated

1. The exposed land is colonized first by pioneering species, including liverworts, mosses, fireweed, *Dryas* (a mat-forming shrub), and willows
2. *Dryas* dominates the plant community
3. Alder invades and forms dense thickets
4. Alder are overgrown first by Sitka spruce and later by western hemlock and mountain hemlock

Figure 54.26

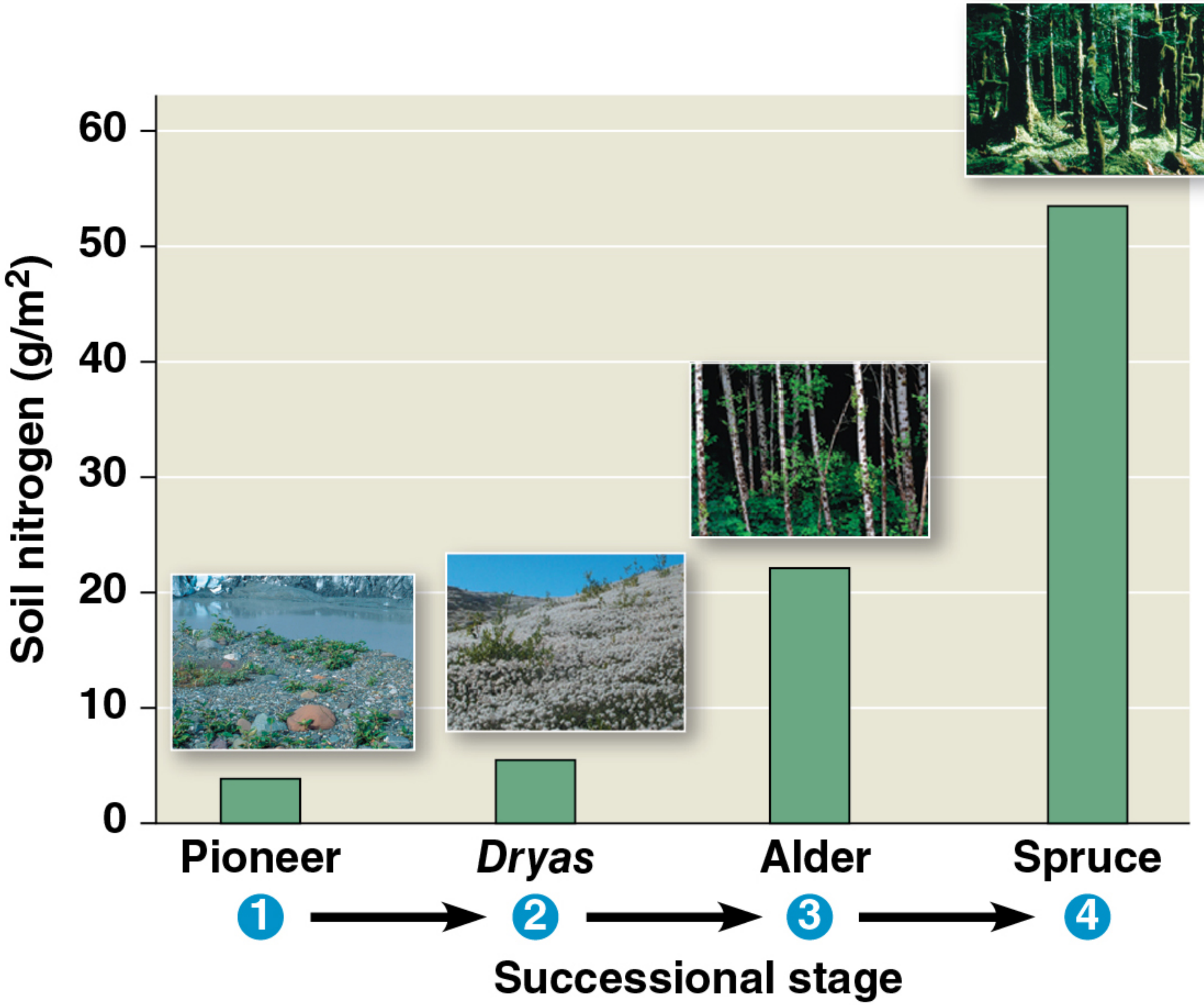


1 Pioneer stage
1941
1907
1860
Glacier Bay
Alaska
1760
0 5 10 15
Kilometers
2 Dryas stage
4 Spruce stage
3 Alder stage

- Sphagnum invades in areas of poor drainage, transforming them into bog ecosystems
- By 300 years after glacial retreat, vegetation consists of sphagnum bogs in poorly drained flats and spruce-hemlock forest on well-drained slopes

- Almost all early arriving plants at Glacier Bay begin with poor growth due to nutrient-poor conditions
- *Dryas* and alder host symbiotic bacteria in their roots that help increase soil nitrogen, facilitating colonization by new plant species

Figure 54.27

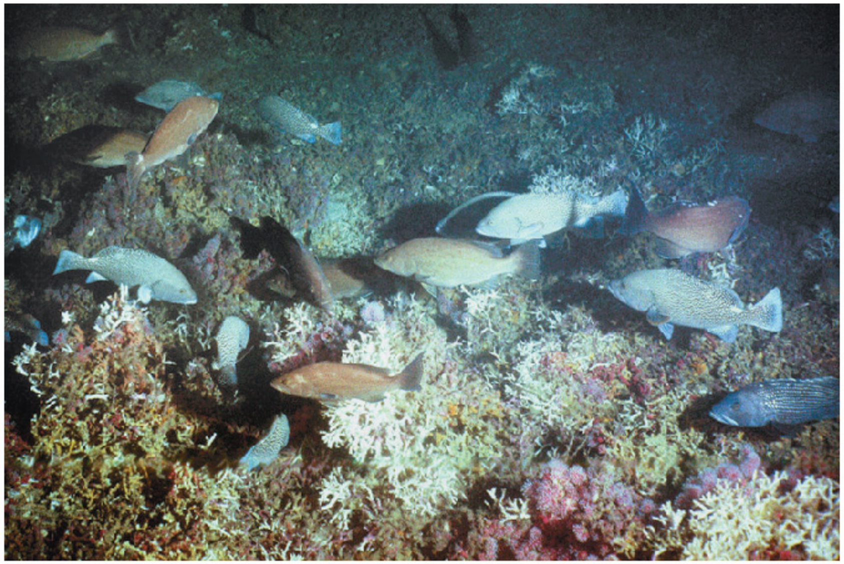


Soil nitrogen (g/m²)
60
50
40
30
20
10
0
Pioneer
Dryas
Alder
Spruce
1
2
3
4
Successional stage

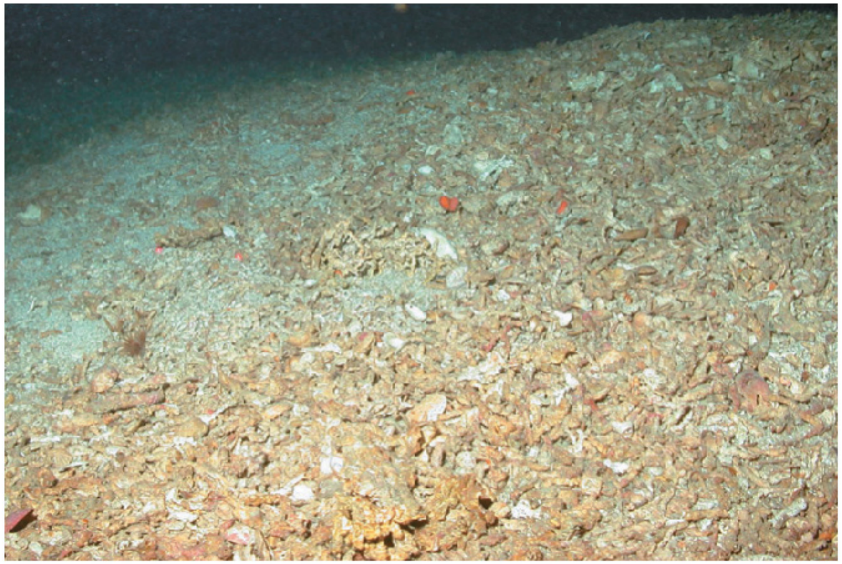
- **Secondary succession** involves the recolonization of an area after a major disturbance has removed most but not all of the organisms
  - For example, abandoned agricultural land may return to its original state through secondary succession

Human Disturbance

- Humans have the greatest impact on biological communities worldwide
- Both terrestrial and marine ecosystems are subject to human disturbance
- Human disturbance to communities usually reduces species diversity



Before trawling



After trawling

CONCEPT 54.4: Biogeographic factors affect community diversity

- Latitude and area are two key biogeographic factors that affect the species diversity of biological communities

Latitudinal Gradients

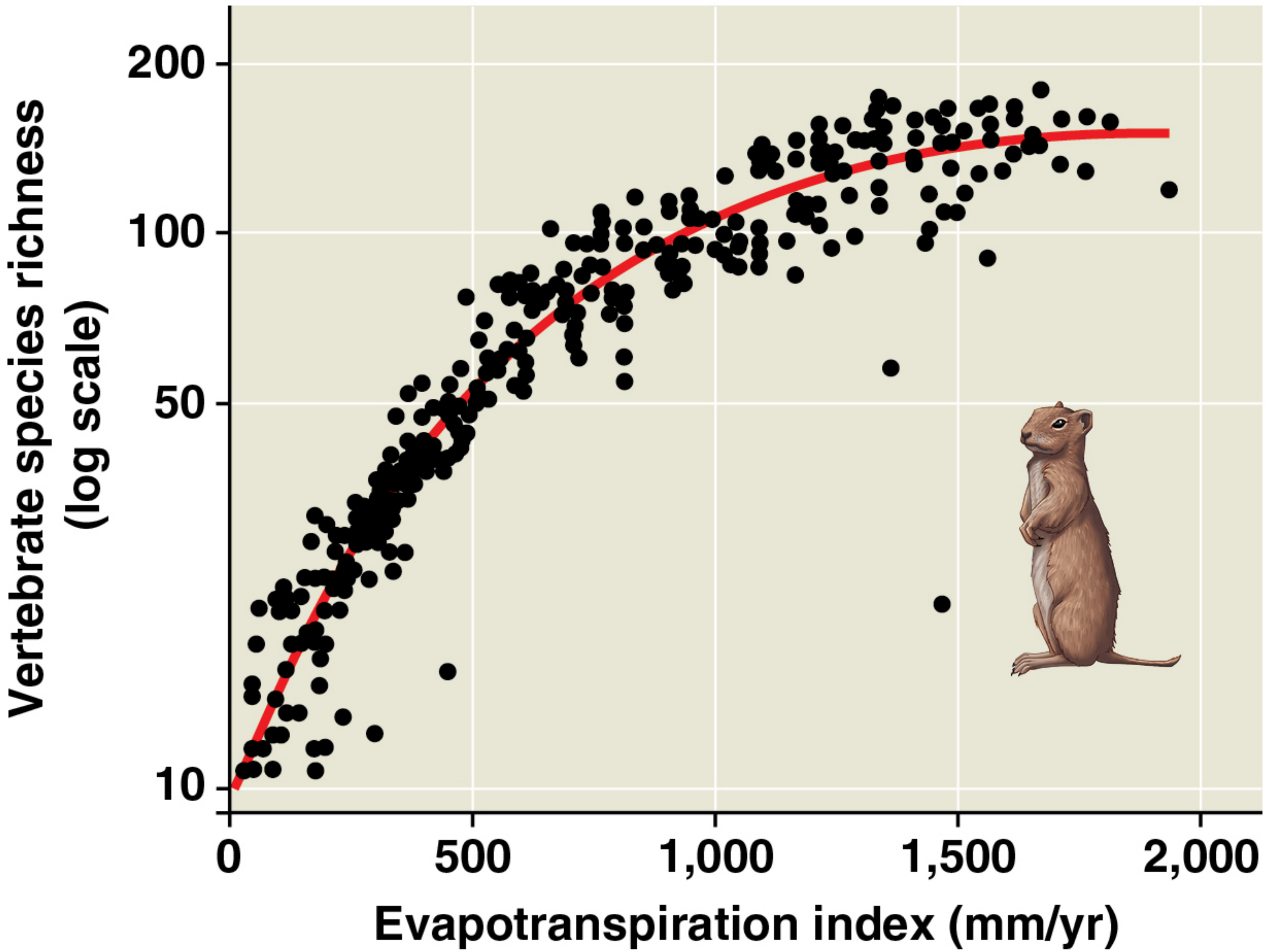
- Species richness is especially great in the tropics and generally declines in a gradient toward the poles
- Two key factors affecting latitudinal gradients of species richness are evolutionary history and climate

- Temperate and polar communities have "started over" repeatedly following major disturbances such as glaciations
- Tropical communities are older and have had more time for speciation to occur

- Climate is another key factor affecting latitudinal gradients of richness and diversity
- Sunlight and precipitation are two important climatic factors correlated with biodiversity in terrestrial communities

- **Evapotranspiration** is the evaporation of water from soil plus transpiration of water from plants
- It is much higher when temperature is hot and rainfall is abundant
- Species richness of plants and animals correlates with measures of evapotranspiration

Figure 54.29



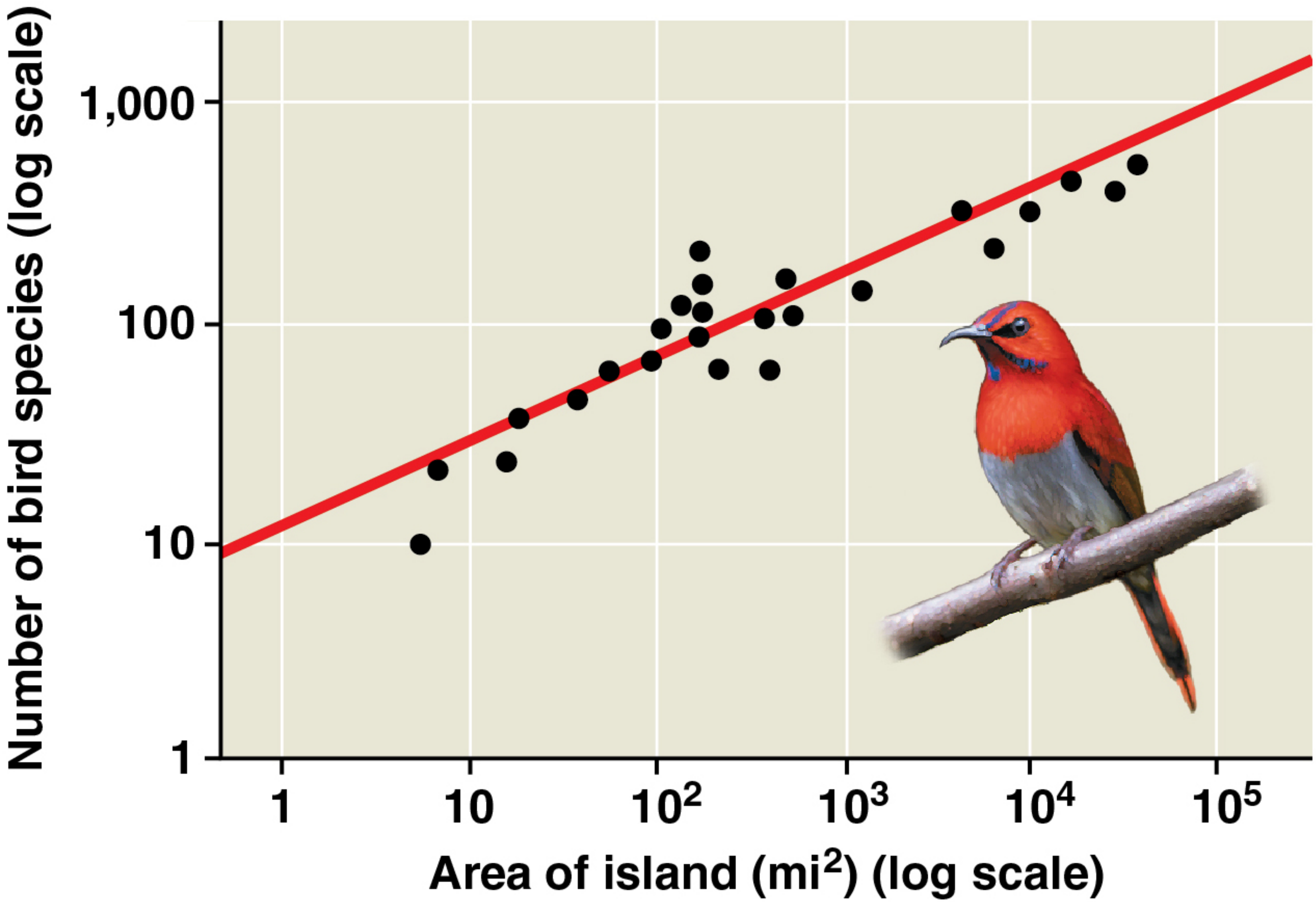
Vertebrate species richness
(log scale)
200
100
50
10
0
500
1,000
1,500
2,000
Evapotranspiration index (mm/yr)

Area Effects

- The **species-area curve** quantifies the idea that, all other factors being equal, a larger geographic area has more species
- Larger areas have a greater diversity of habitats and microhabitats

- Predictions of the species-area relationship have been tested by examining the number of species in many different regions
  - For example, in the Sunda Islands of Malaysia, the number of bird species increased with island size

Figure 54.30



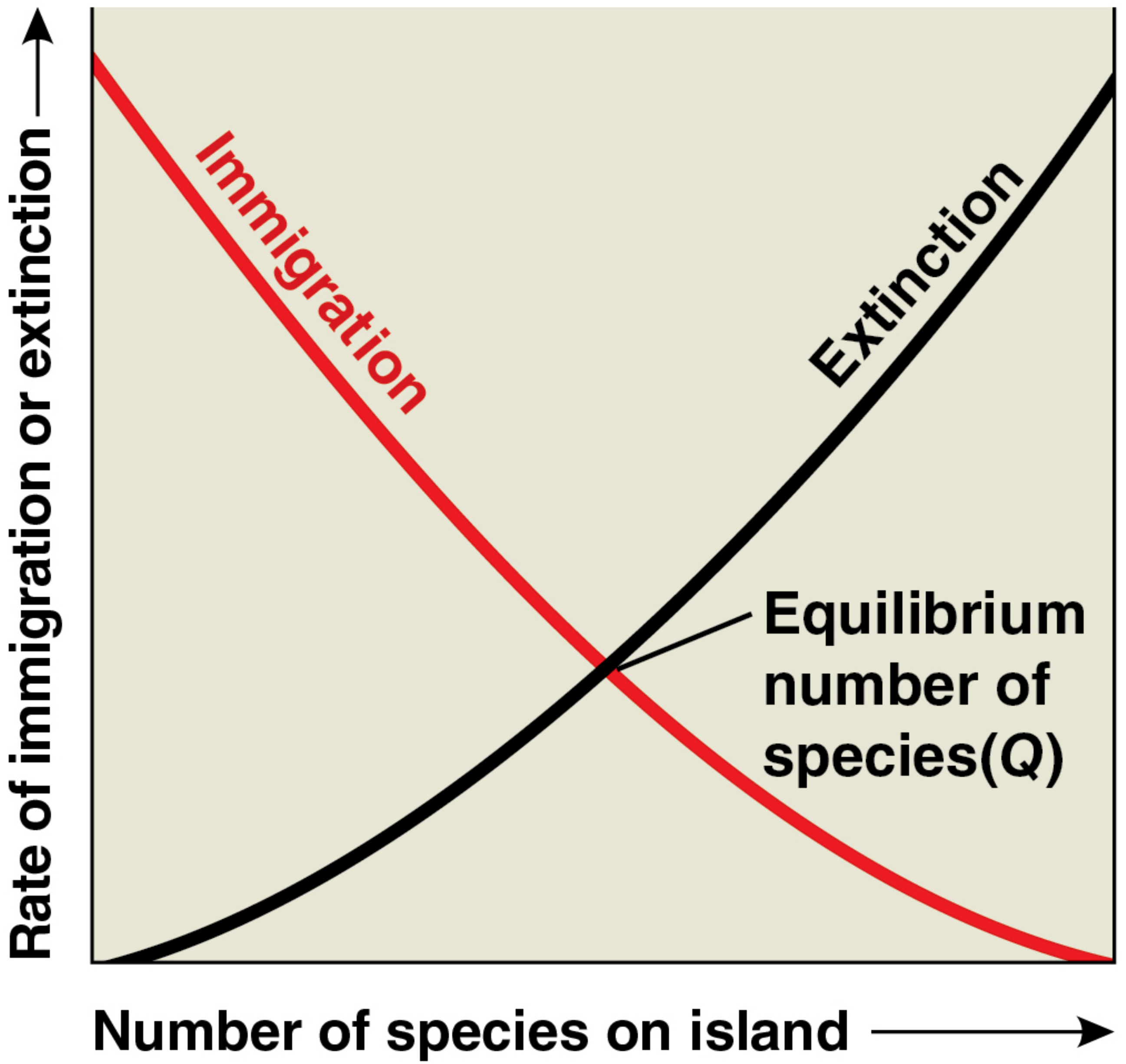
Number of bird species (log scale)
1,000
100
10
1
1
10
10^2
10^3
10^4
10^5
Area of island (mi^2) (log scale)

Island Equilibrium Model

- Robert MacArthur and E.O. Wilson developed the island equilibrium modal, a method for predicting species diversity on islands
- In this model, species richness on islands represents a balance between immigration of new species and extinction of established species
- As the number of species on an island increases, immigration decreases and extinction increases

- Immigration and extinction are affected by both island size and distance from the mainland
  - Smaller islands have lower immigration rates and higher extinction rates than larger islands
  - Islands closer to the mainland have higher immigration rates and lower extinction rates than more distant islands
- An equilibrium will be reached where the rate of immigration is equal to the rate of extinction

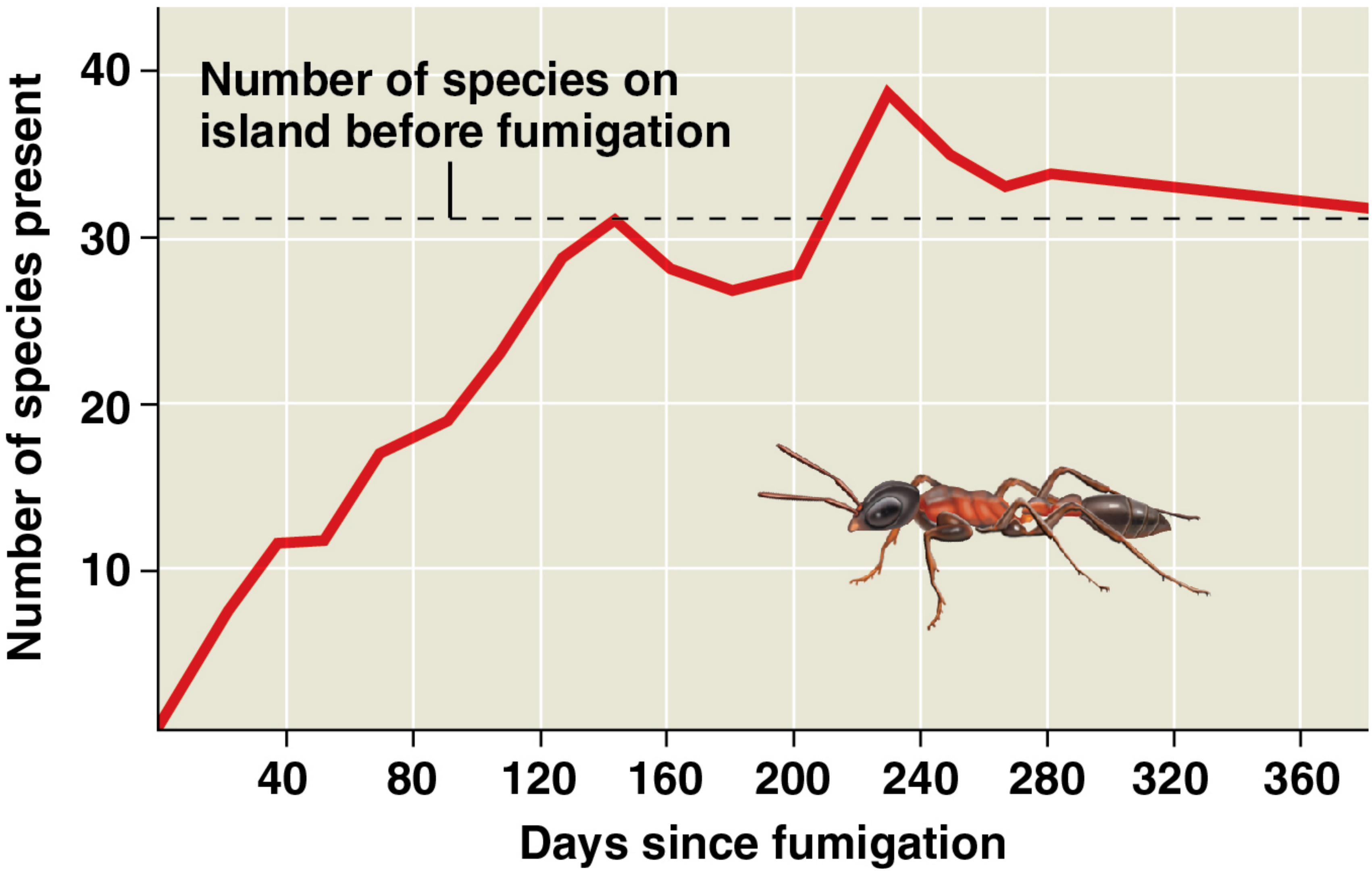
Figure 54.31


Immigration
Extinction
Equilibrium number of species(Q)
Rate of immigration or extinction
Number of species on island

- Researchers tested the island equilibrium model by counting all arthropod species on six small mangrove islands in the Florida Keys
- As predicted, species richness increased with island size and proximity to the mainland
- After fumigating four of the islands, the number of species increased over time to pre-fumigation values

Figure 54.32

Figure 54.33


Number of species on island before fumigation
Number of species present
40
30
20
10
40
80
120
160
200
240
280
320
360
Days since fumigation

Animation: Exploring Island Biogeography

CONCEPT 54.5: Pathogens alter community structure locally and globally

- **Pathogens**—disease-causing microorganisms, viruses, viroids, and prions—have strong effects on ecological communities
- Pathogens can be particularly virulent new habitats because new host populations lack resistance

Effects on Community Structure

- Pathogens can have dramatic effects on aquatic and terrestrial communities
  - For example, white-band disease has decimated coral populations in the Caribbean, removing key habitat for lobsters, snappers, and other fish
  - For example, a protist causing sudden oak death has killed millions of oak trees, indirectly resulting in decreased abundance of at least five bird species

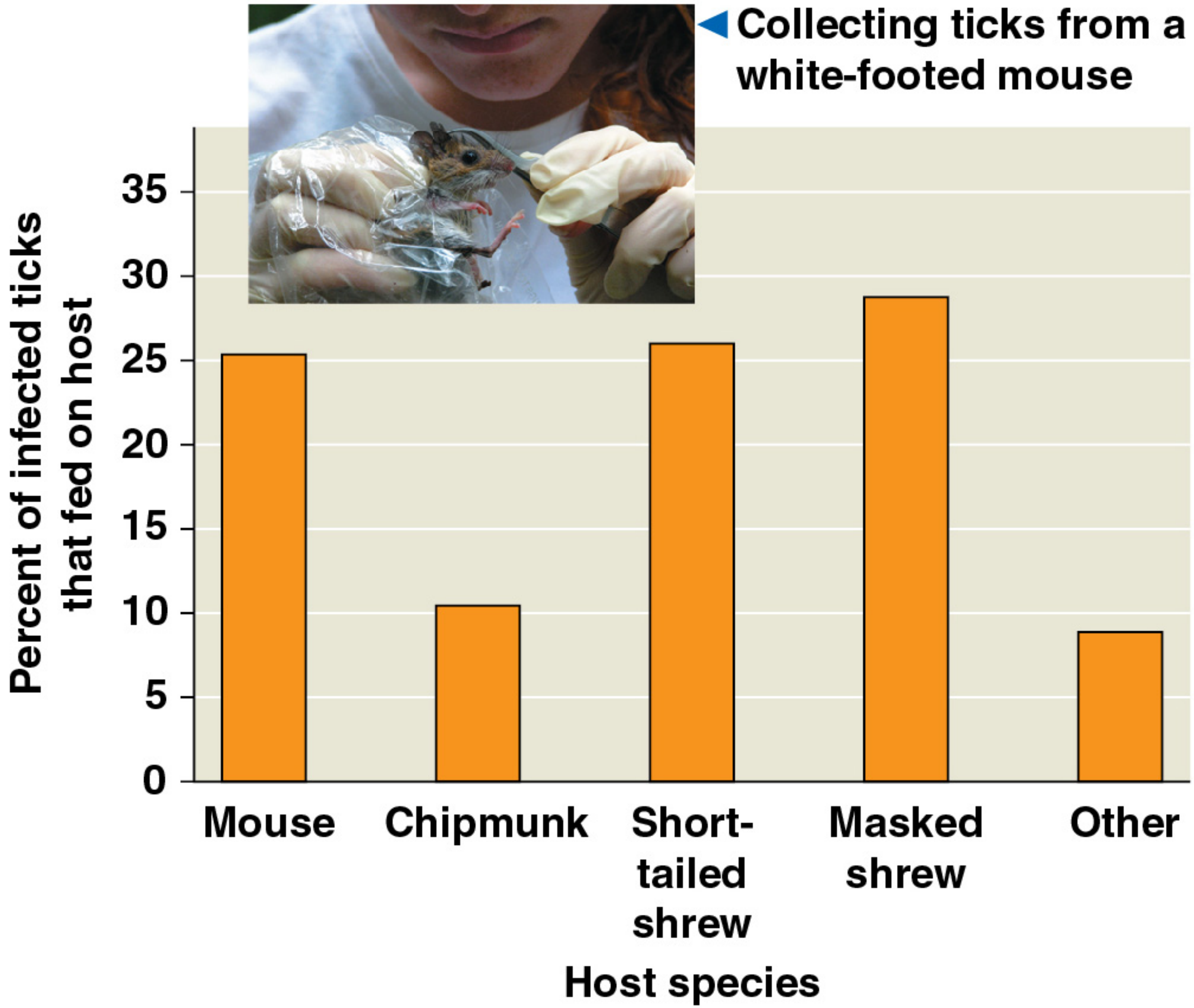
- Human activities are transporting pathogens around the world at unprecedented rates
  - For example, H1N1, the virus that causes “swine flu,” spread around the world from Veracruz, Mexico, causing more than 18,000 deaths within two years

Community Ecology and Zoonotic Diseases

- Three-quarters of emerging human diseases are caused by **zoonotic pathogens**—those that are transferred to humans from other animals
- The transfer of pathogens can be through direct contact or an intermediate species called a **vector**

- Identifying the community of hosts and vectors for a pathogen can help prevent the spread of disease
  - For example, recent studies identified two species of shrew as the primary hosts of the pathogen for Lyme disease

Figure 54.34


Collecting ticks from a white-footed mouse
Percent of infected ticks that fed on host
35
30
25
20
15
10
5
0
Mouse
Chipmunk
Short-tailed shrew
Masked shrew
Other
Host species

- Avian flu is a highly contagious virus of birds
- Since 2003, the H5N1 strain has killed hundreds of millions of poultry and more than 400 people
- Ecologists study the potential spread of the virus from Asia to North America by trapping and testing migrating and resident birds in Alaska

Figure 54.35

Figure 54.UN01

Type of Prey Offered	% of Snakes from Each Area That Ate Each Type of Prey	
	Area with Cane Toads Present for 40–60 Years	Area with No Cane Toads
Native frog	100	100
Cane toad	0	50

Figure 54.UN02

Number of Years Cane Toads Had Been Present in the Area	5	10	10	20	50	60	60	60	60	60
% Reduction in Snake Swimming Speed	52	19	30	30	5	5	9	11	12	22

Data from B. L. Phillips and R. Shine, An invasive species induces rapid adaptive change in a native predator: cane toads and black snakes in Australia, *Proceedings of the Royal Society B* 273:1545–1550 (2006).

Figure 54.UN03

Figure 54.UN04

Interaction	Description
Competition (–/–)	Individuals of different species each use a limited resource, reducing the survival or reproduction of both individuals.
Exploitation (+/–)	Members of one species benefit by feeding upon (and thereby harming) members of the other species. Exploitation includes the following:
Predation	An individual of one species, the predator, kills and eats an individual of the other, the prey.
Herbivory	An herbivore eats part of a plant or alga.
Parasitism	The parasite derives its nourishment from a second organism, its host.
Positive interactions (+/+ or 0/+)	Members of one species benefit, while members of the other benefit or are not harmed. Positive interactions include the following:
Mutualism (+/+)	Members of both species benefit from the interaction.
Commensalism (+/0)	Members of one species benefit, while members of the other are not affected.

Figure 54.UN05