LECTURE PRESENTATIONS

For CAMPBELL BIOLOGY, NINTH EDITION

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Chapter 54

Community Ecology

Lectures by
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Overview: Communities in Motion

- A biological **community** is an assemblage of populations of various species living close enough for potential interaction
  - For example, the “carrier crab” carries a sea urchin on its back for protection against predators

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Figure 54.1

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Concept 54.1: Community interactions are classified by whether they help, harm, or have no effect on the species involved

- Ecologists call relationships between species in a community **interspecific interactions**
- Examples are competition, predation, herbivory, symbiosis (parasitism, mutualism, and commensalism), and facilitation
- Interspecific interactions can affect the survival and reproduction of each species, and the effects can be summarized as positive (+), negative (–), or no effect (0)

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Competition

- **Interspecific competition** (–/– interaction) occurs when species compete for a resource in short supply

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Competitive Exclusion

- Strong competition can lead to **competitive exclusion**, local elimination of a competing species
- The competitive exclusion principle states that two species competing for the same limiting resources cannot coexist in the same place

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Ecological Niches and Natural Selection

- The total of a species' use of biotic and abiotic resources is called the species' **ecological niche**
- An ecological niche can also be thought of as an organism's ecological role
- Ecologically similar species can coexist in a community if there are one or more significant differences in their niches

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- **Resource partitioning** is differentiation of ecological niches, enabling similar species to coexist in a community

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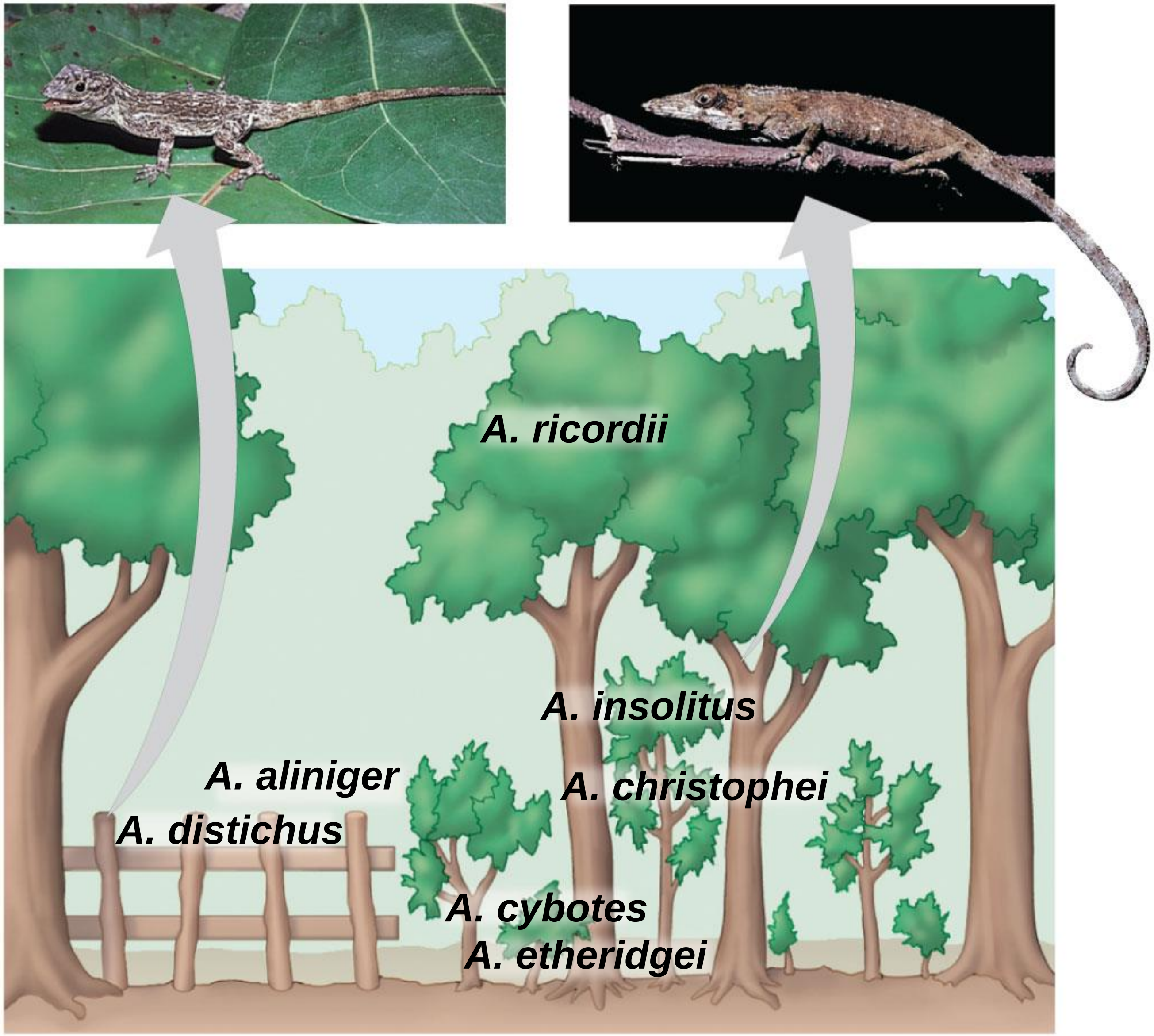
Figure 54.2

A. distichus **perches on fence posts and other sunny surfaces.**

A. insolitus **usually perches on shady branches.**



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- A species’ fundamental niche is the niche potentially occupied by that species
- A species’ realized niche is the niche actually occupied by that species
- As a result of competition, a species’ fundamental niche may differ from its realized niche
  - For example, the presence of one barnacle species limits the realized niche of another species

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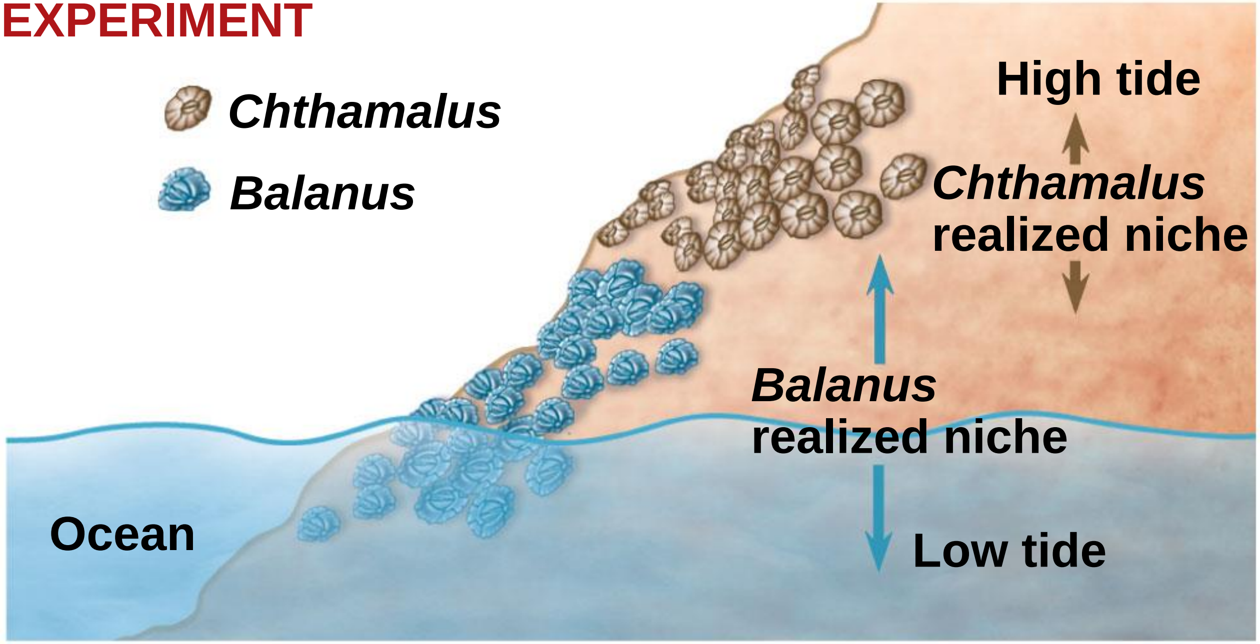
Figure 54.3

EXPERIMENT



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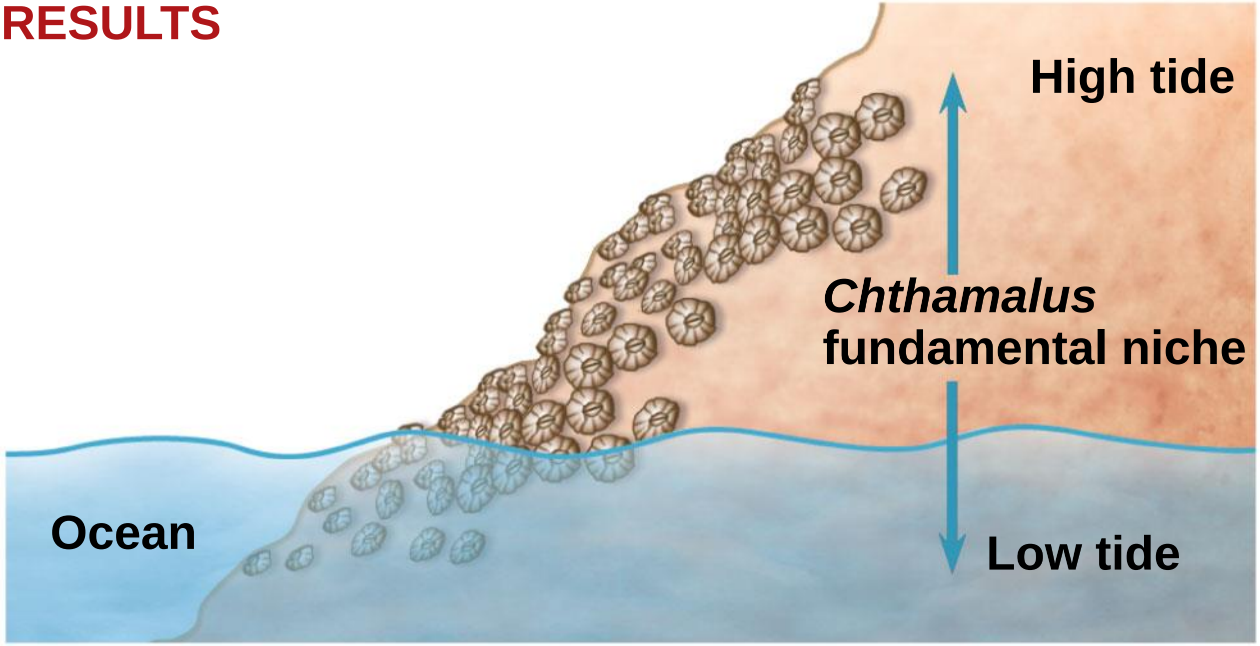

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- The common spiny mouse and the golden spiny mouse show temporal partitioning of their niches
- Both species are normally nocturnal (active during the night)
- Where they coexist, the golden spiny mouse becomes diurnal (active during the day)

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Character Displacement

- **Character displacement** is a tendency for characteristics to be more divergent in sympatric populations of two species than in allopatric populations of the same two species
- An example is variation in beak size between populations of two species of Galápagos finches

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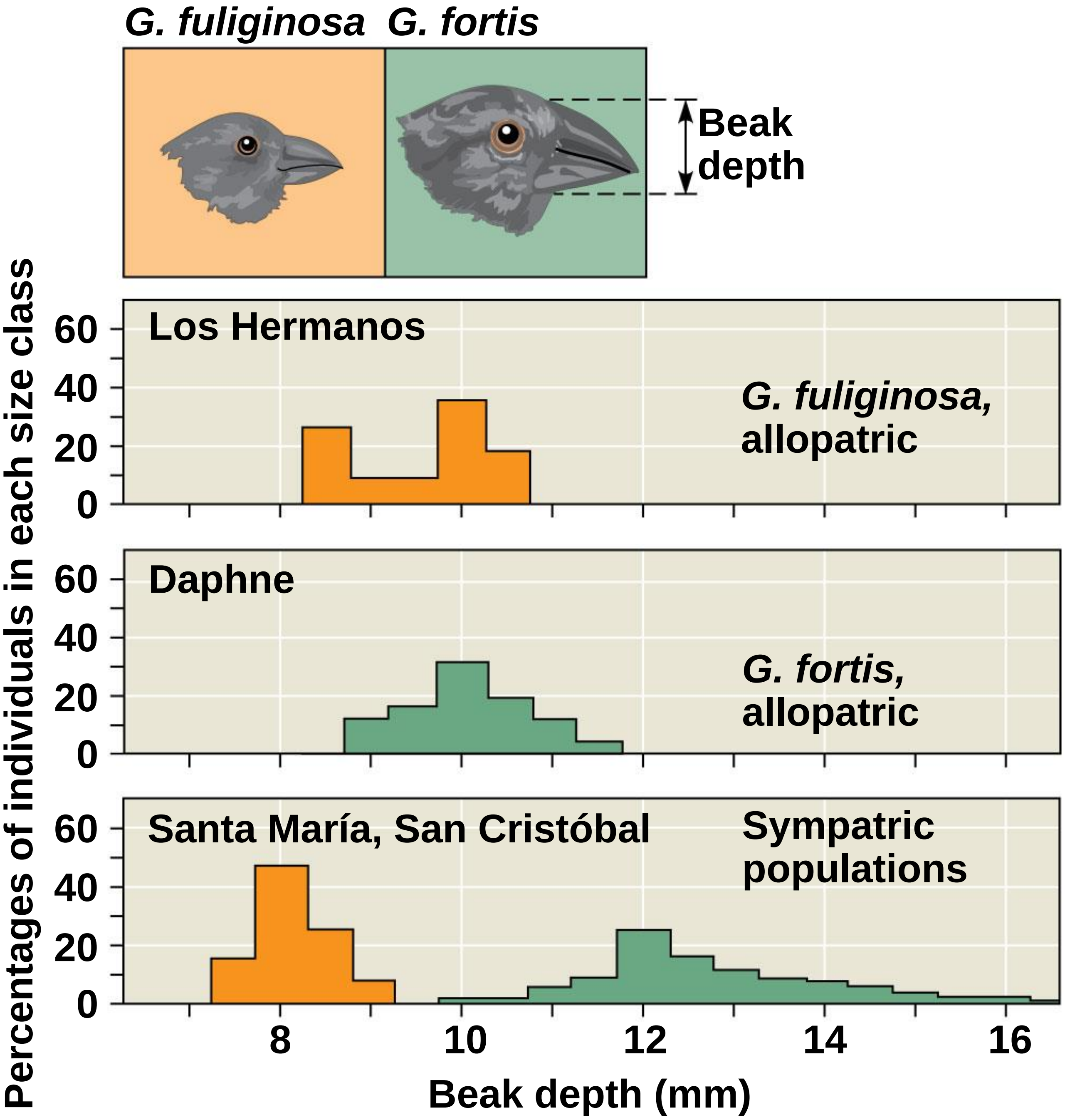
Figure 54.4



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Predation

- **Predation** (+/– interaction) refers to an interaction in which one species, the predator, kills and eats the other, the prey
- Some feeding adaptations of predators are claws, teeth, fangs, stingers, and poison

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- Prey display various defensive adaptations
- Behavioral defenses include hiding, fleeing, forming herds or schools, self-defense, and alarm calls
- Animals also have morphological and physiological defense adaptations
- **Cryptic coloration**, or camouflage, makes prey difficult to spot

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Figure 54.5

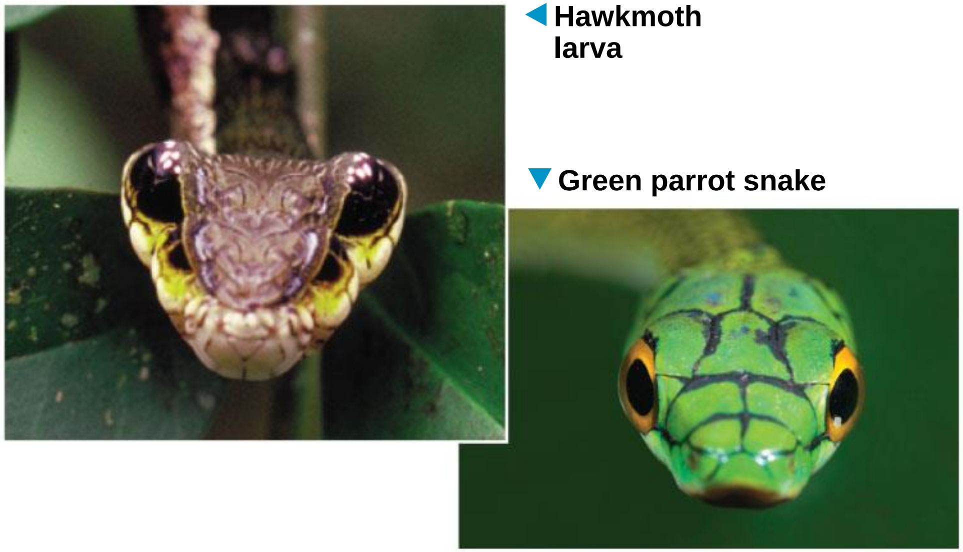
(a) Cryptic coloration

▶ **Canyon tree frog**

(b) Aposematic coloration

▶ **Poison dart frog**

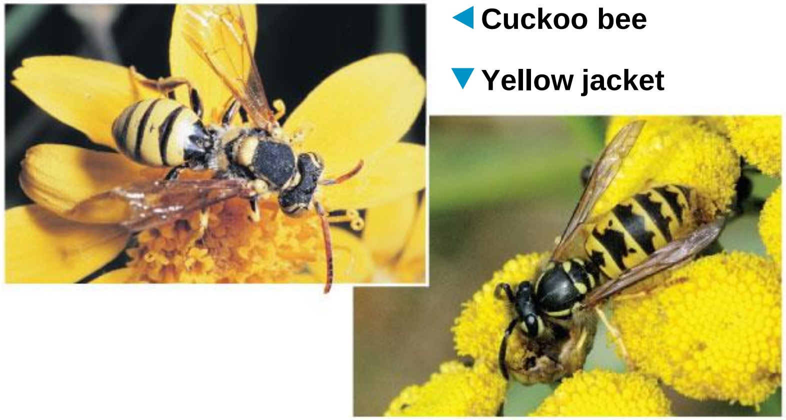
(c) Batesian mimicry: A harmless species mimics a harmful one.



◀ **Hawkmoth larva**

▼ **Green parrot snake**

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



◀ **Cuckoo bee**

▼ **Yellow jacket**

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- Animals with effective chemical defense often exhibit bright warning coloration, called **aposematic coloration**
- Predators are particularly cautious in dealing with prey that display such coloration

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- In some cases, a prey species may gain significant protection by mimicking the appearance of another species
- In **Batesian mimicry**, a palatable or harmless species mimics an unpalatable or harmful model

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- In **Müllerian mimicry**, two or more unpalatable species resemble each other

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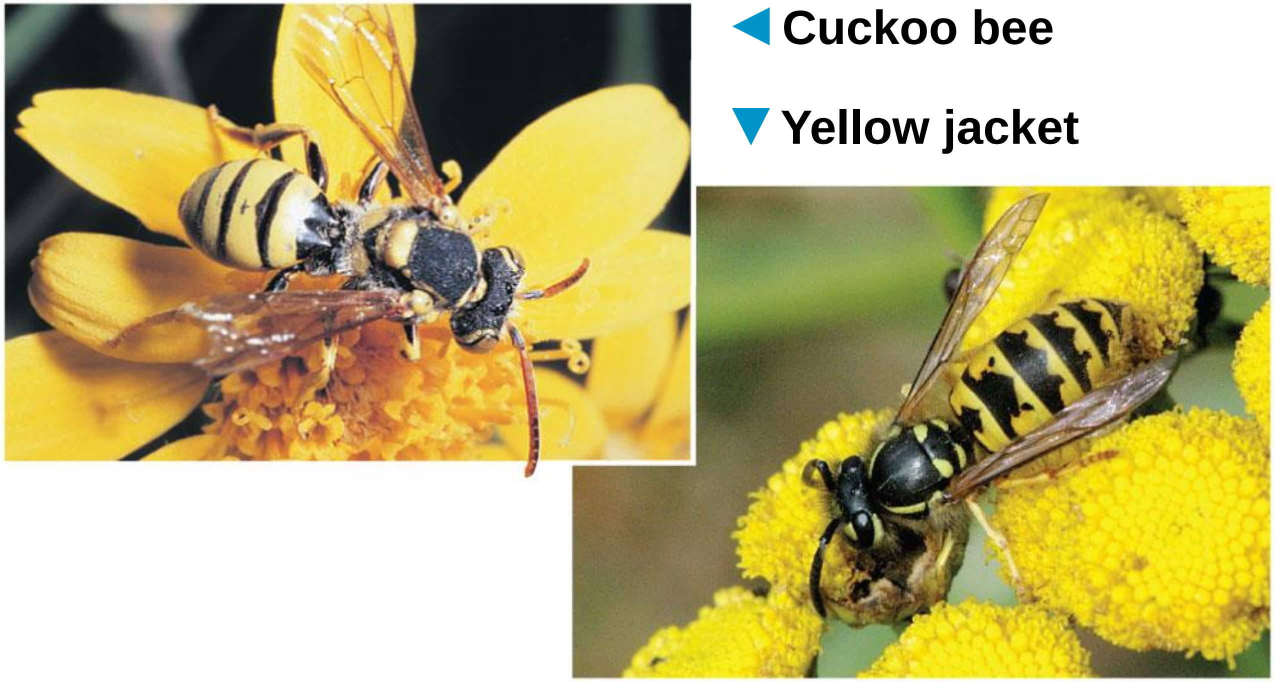
Figure 54.5d

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



◀ **Cuckoo bee**

▼ **Yellow jacket**

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Herbivory

- **Herbivory** (+/– interaction) refers to an interaction in which an herbivore eats parts of a plant or alga
- It has led to evolution of plant mechanical and chemical defenses and adaptations by herbivores

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Symbiosis

- **Symbiosis** is a relationship where two or more species live in direct and intimate contact with one another

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Parasitism

- In **parasitism** (+/– interaction), 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**

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- Many parasites have a complex life cycle involving a number of hosts
- Some parasites change the behavior of the host in a way that increases the parasites’ fitness

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Mutualism

- Mutualistic symbiosis, or **mutualism** (+/+ interaction), is an interspecific interaction that benefits both species
- A mutualism can be
  - Obligate, where one species cannot survive without the other
  - Facultative, where both species can survive alone

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Figure 54.7

(a) Acacia tree and ants (genus *Pseudomyrmex*)

(b) Area cleared by ants at the base of an acacia tree

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Figure 54.7b

(b) Area cleared by ants at the base of an acacia tree

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Commensalism

- In **commensalism** (+/0 interaction), one species benefits and the other is neither harmed nor helped
- Commensal interactions are hard to document in nature because any close association likely affects both species

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Figure 54.8

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Facilitation

- **Facilitation** (+/+ or 0/+) is an interaction in which one species has positive effects on another species without direct and intimate contact
  - For example, the black rush makes the soil more hospitable for other plant species

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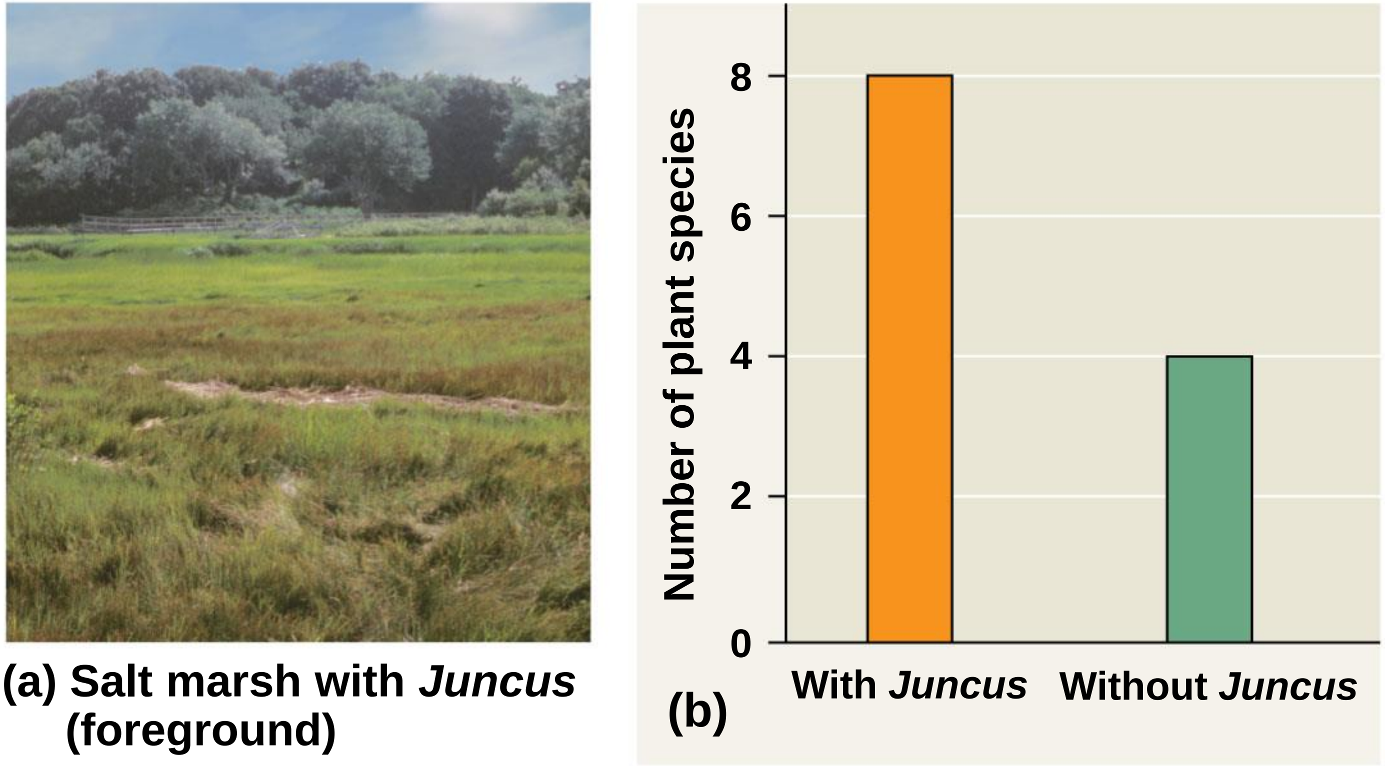
Figure 54.9



(a) Salt marsh with *Juncus* (foreground)

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Concept 54.2: Diversity and trophic structure characterize biological communities

- In general, a few species in a community exert strong control on that community's structure
- Two fundamental features of community structure are species diversity and feeding relationships

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Species Diversity

- **Species diversity** of a community is the variety of organisms that make up the community
- It has two components: species richness and relative abundance
  - **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

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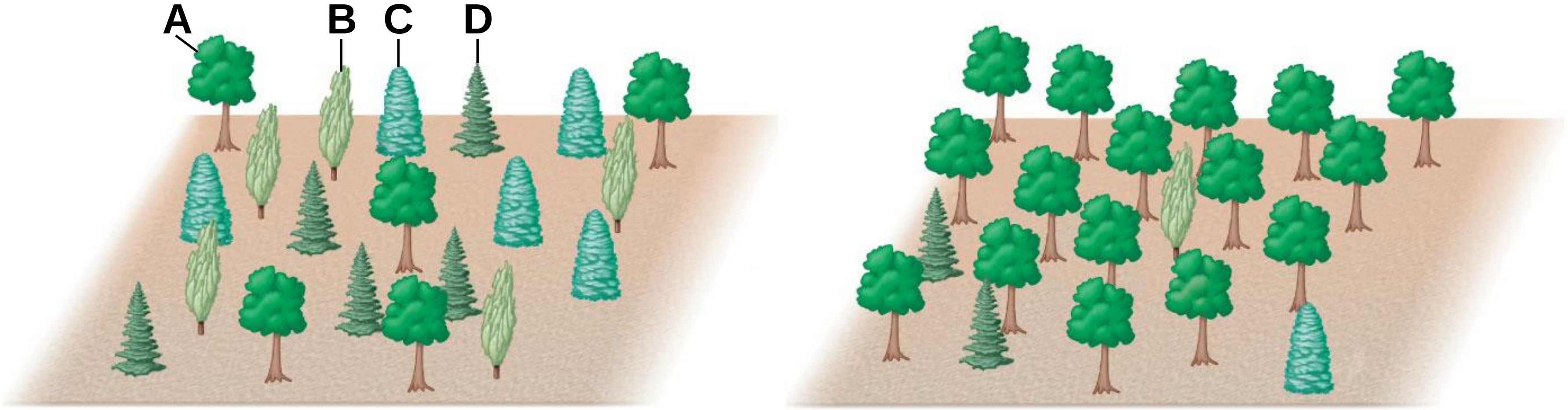
Figure 54.10



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

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

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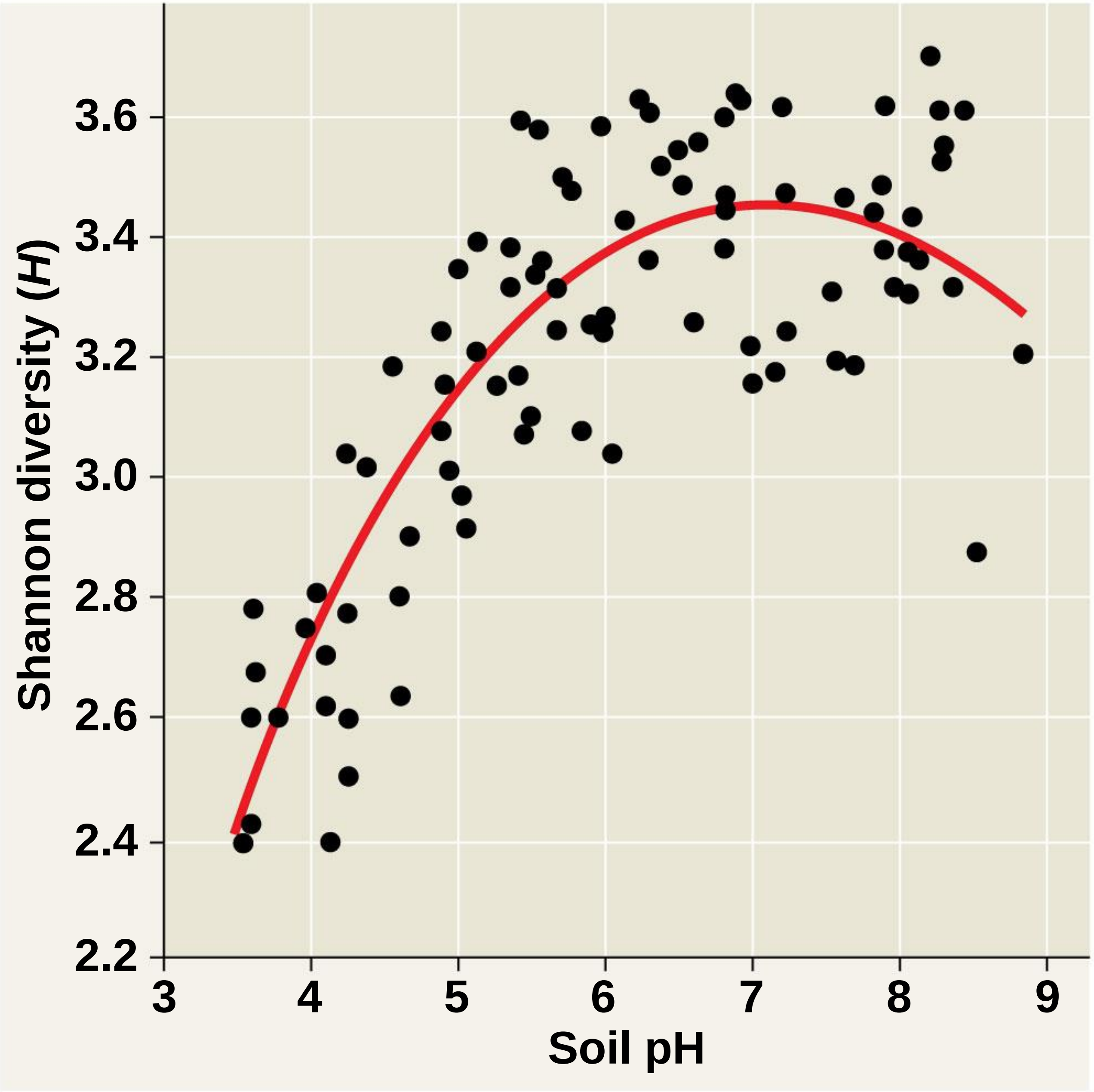
Figure 54.11

RESULTS



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- Communities with higher diversity are
  - More productive and more stable in their productivity
  - Better able to withstand and recover from environmental stresses
  - More resistant to **invasive species**, organisms that become established outside their native range

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Trophic Structure

- **Trophic structure** is the feeding relationships between organisms in a community
- It is a key factor in community dynamics
- **Food chains** link trophic levels from producers to top carnivores

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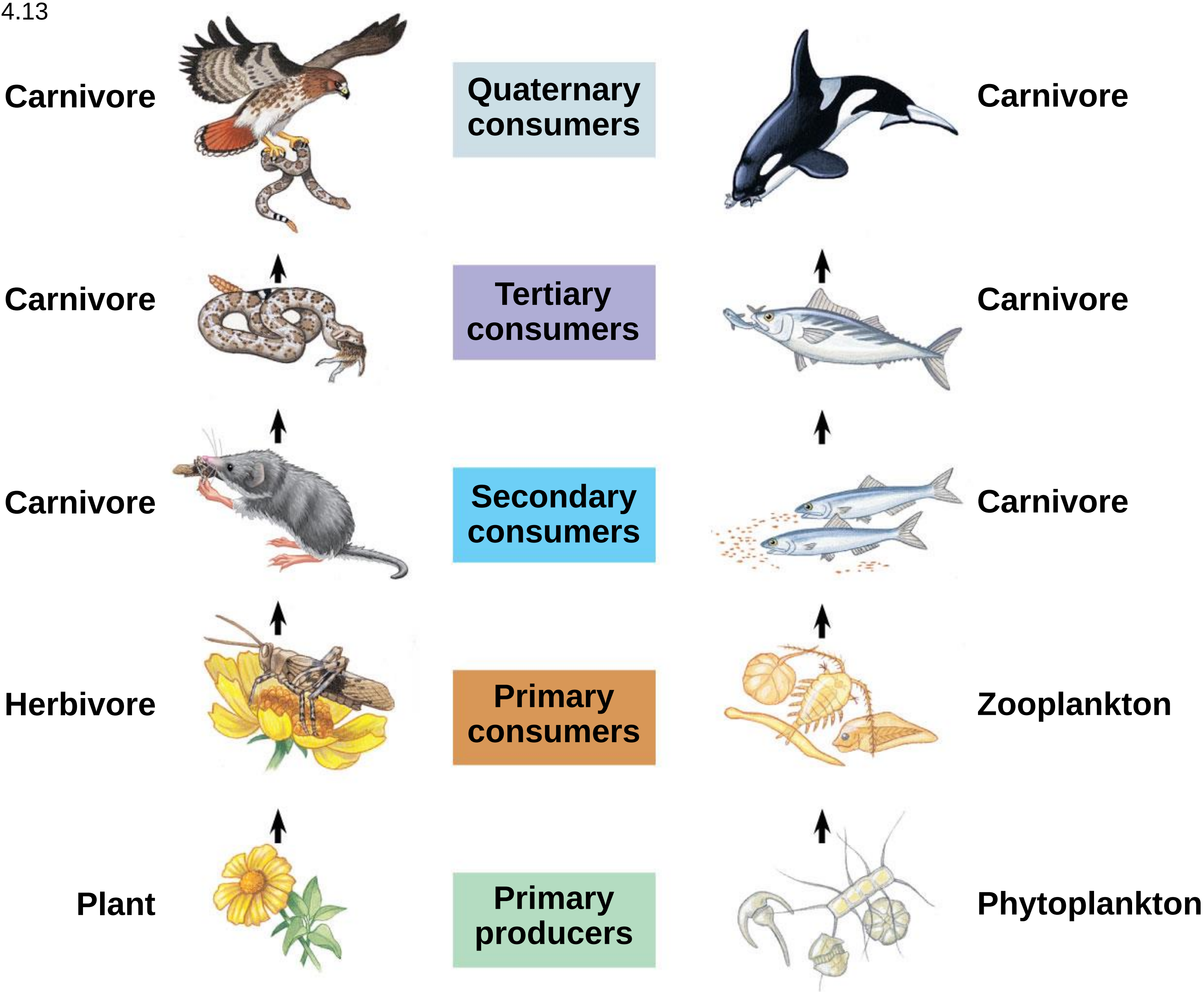
Figure 54.13



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

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Food Webs

- A **food web** is a branching food chain with complex trophic interactions

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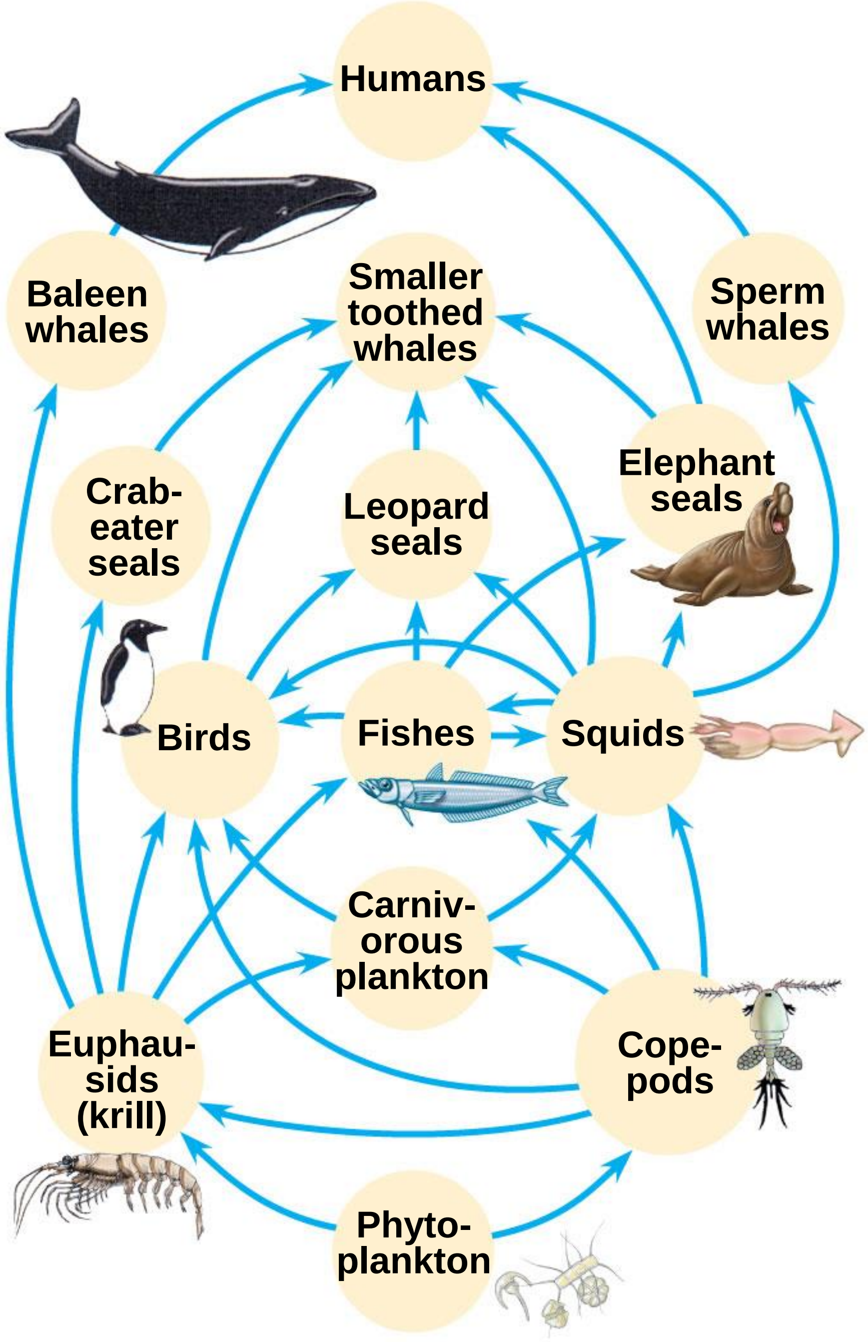
Figure 54.14



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- Species may play a role at more than one trophic level
- 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

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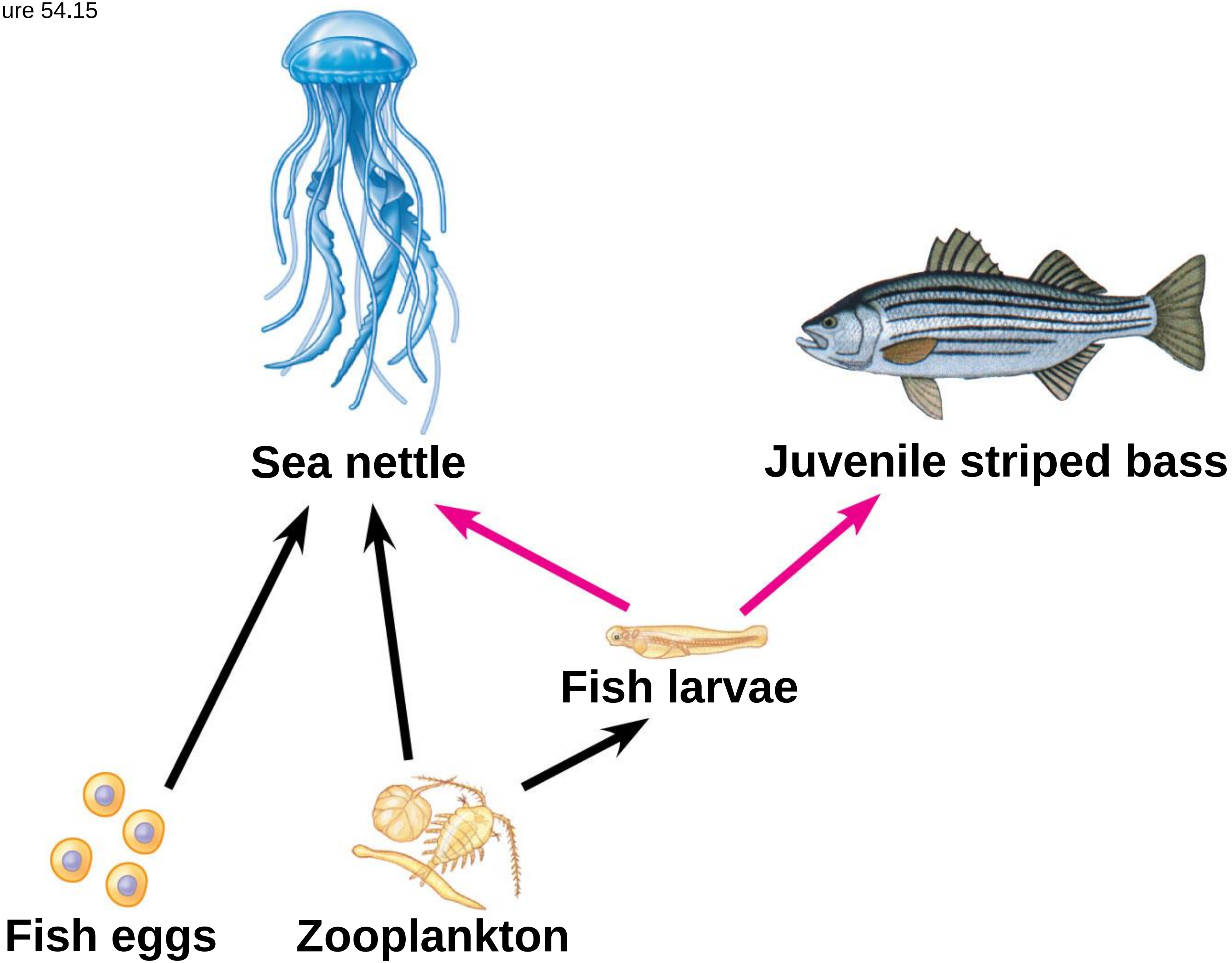
Figure 54.15



Sea nettle

Juvenile striped bass

Fish larvae

Fish eggs

Zooplankton

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Limits on Food Chain Length

- Each food chain in a food web is usually only a few links long
- Two hypotheses attempt to explain food chain length: the energetic hypothesis and the dynamic stability hypothesis

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- The **energetic hypothesis** suggests that length is limited by inefficient energy transfer
  - For example, a producer level consisting of 100 kg of plant material can support about 10 kg of herbivore **biomass** (the total mass of all individuals in a population)
- The **dynamic stability hypothesis** proposes that long food chains are less stable than short ones
- Most data support the energetic hypothesis

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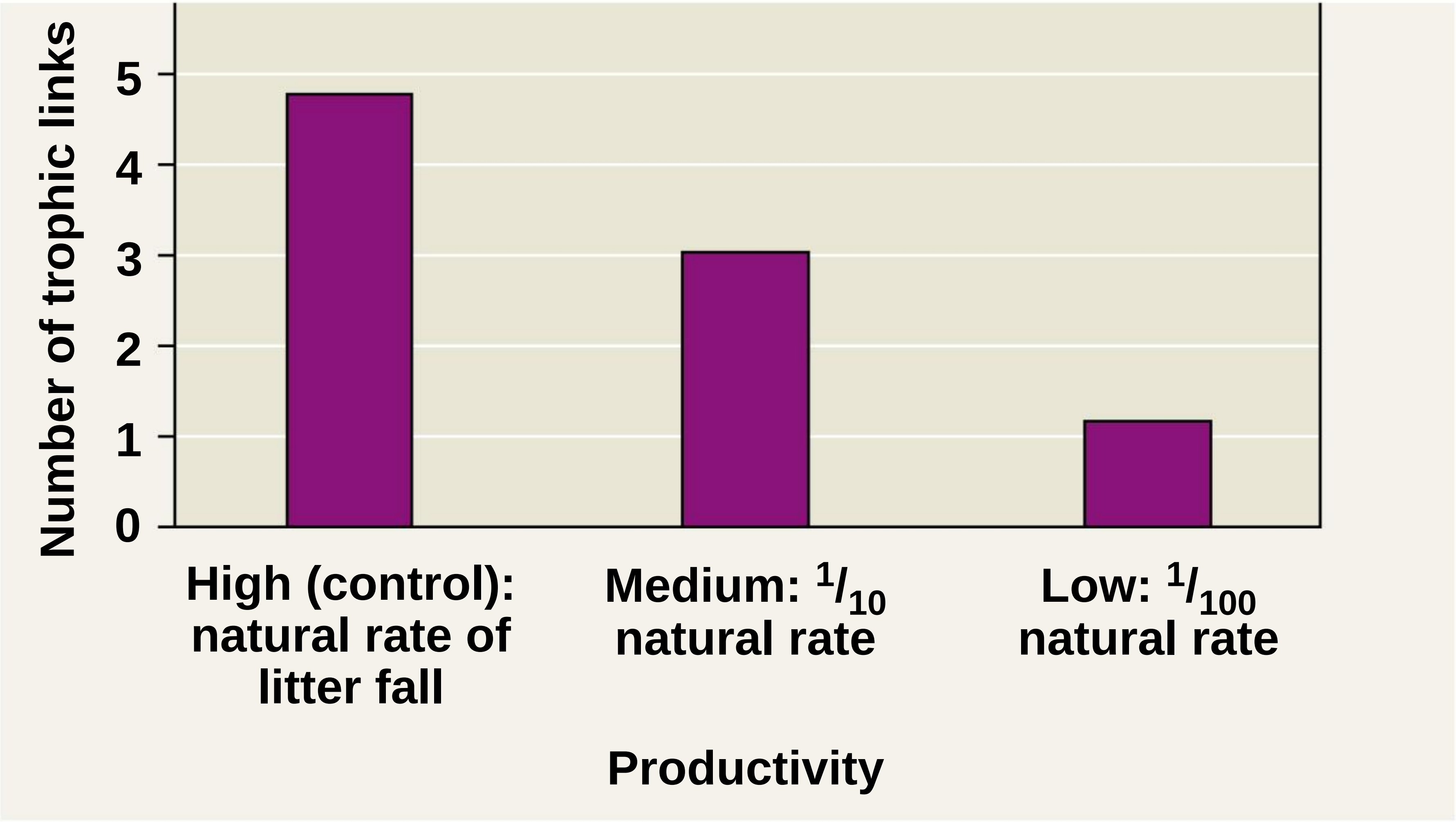
Figure 54.16



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Species with a Large Impact

- Certain species have a very large impact on community structure
- Such species are highly abundant or play a pivotal role in community dynamics

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Dominant Species

- **Dominant species** are those that are most abundant or have the highest biomass
- Dominant species exert powerful control over the occurrence and distribution of other species
  - For example, sugar maples have a major impact on shading and soil nutrient availability in eastern North America; this affects the distribution of other plant species

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- One hypothesis suggests that dominant species are most competitive in exploiting resources
- Another hypothesis is that they are most successful at avoiding predators
- Invasive species, typically introduced to a new environment by humans, often lack predators or disease

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Keystone Species and Ecosystem Engineers

- **Keystone species** exert strong control on a community by their ecological roles, or niches
- In contrast to dominant species, they are not necessarily abundant in a community
- Field studies of sea stars illustrate their role as a keystone species in intertidal communities

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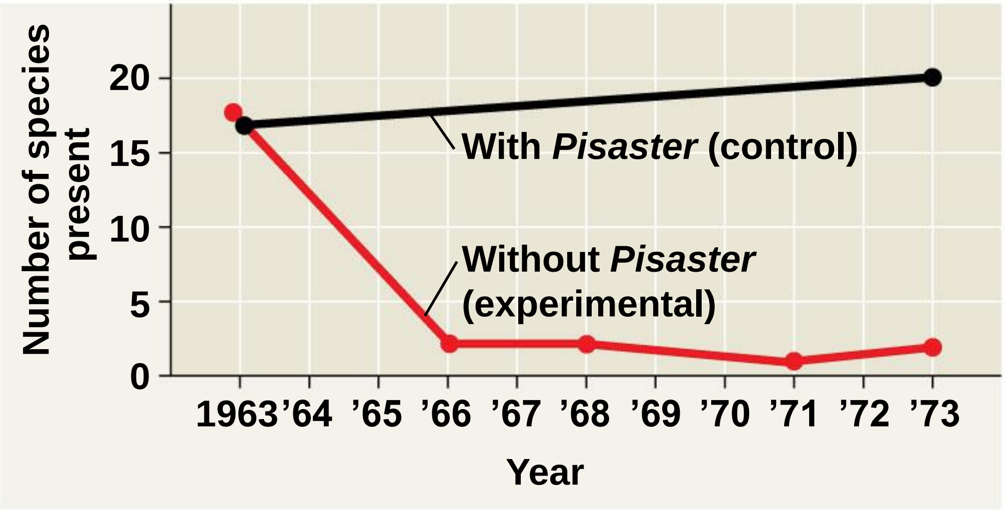
Figure 54.17

EXPERIMENT

RESULTS



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- Observation of sea otter populations and their predation shows how otters affect ocean communities

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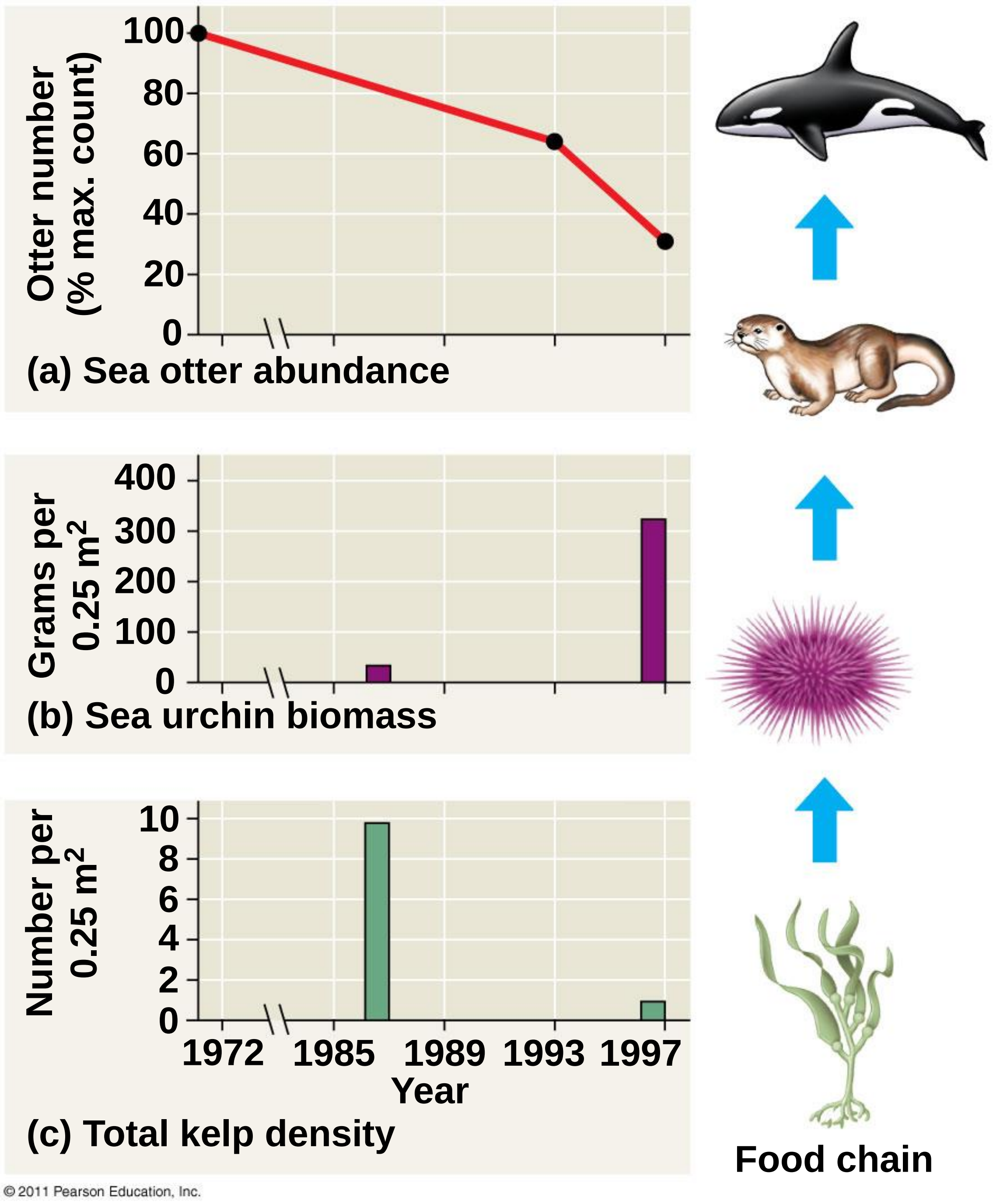
Figure 54.18



(a) Sea otter abundance

(b) Sea urchin biomass

(c) Total kelp density

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- **Ecosystem engineers** (or “foundation species”) cause physical changes in the environment that affect community structure
    - For example, beaver dams can transform landscapes on a very large scale

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Bottom-Up and Top-Down Controls

- The **bottom-up model** of community organization proposes a unidirectional influence from lower to higher trophic levels
- In this case, the presence or absence of mineral nutrients determines community structure, including the abundance of primary producers

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- The **top-down model**, also called the trophic cascade model, proposes that control comes from the trophic level above
- In this case, predators control herbivores, which in turn control primary producers

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- **Biomanipulation** can help restore polluted communities
- In a Finnish lake, blooms of cyanobacteria (primary producers) occurred when zooplankton (primary consumers) were eaten by large populations of roach fish (secondary consumers)
- The addition of pike perch (tertiary consumers) controlled roach populations, allowing zooplankton populations to increase and ending cyanobacterial blooms

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Concept 54.3: Disturbance influences species diversity and composition

- Decades ago, most ecologists favored the view that communities are in a state of equilibrium
- This view was supported by F. E. Clements, who suggested that species in a climax community function as a superorganism

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- Other ecologists, including A. G. Tansley and H. A. Gleason, challenged whether communities were at equilibrium
- Recent evidence of change has led to a **nonequilibrium model**, which describes communities as constantly changing after being buffeted by disturbances
- A **disturbance** is an event that changes a community, removes organisms from it, and alters resource availability

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Characterizing Disturbance

- Fire is a significant disturbance in most terrestrial ecosystems
- A high level of disturbance is the result of a high intensity and high frequency of disturbance

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

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- In a New Zealand study, the richness of invertebrate taxa was highest in streams with an intermediate intensity of flooding

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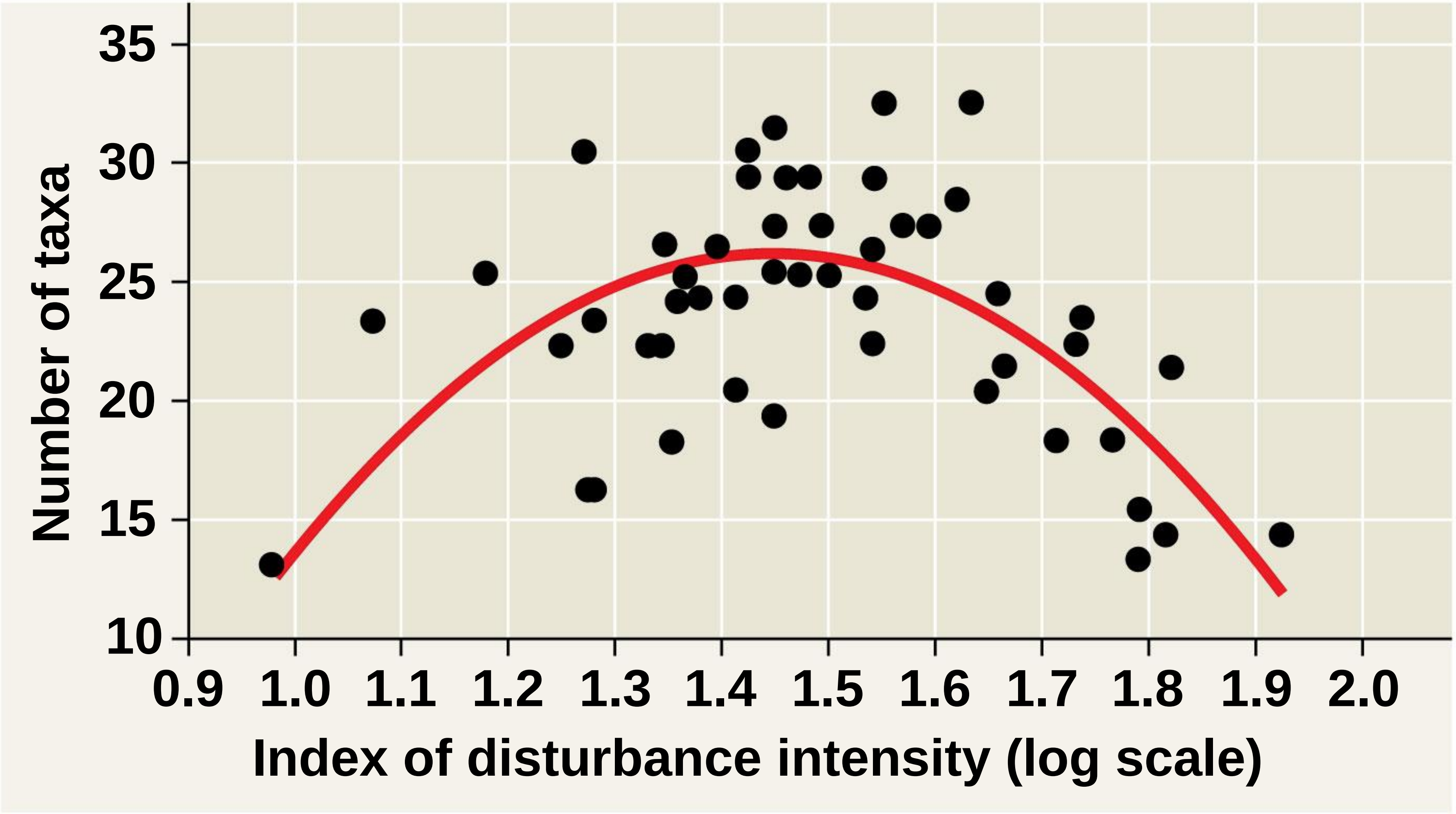
Figure 54.20



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- The large-scale fire in Yellowstone National Park in 1988 demonstrated that communities can often respond very rapidly to a massive disturbance
- The Yellowstone forest is an example of a nonequilibrium community

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Figure 54.21

(a) Soon after fire

(b) One year after fire

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Figure 54.21a

(a) Soon after fire

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(b) One year after fire

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Ecological Succession

- **Ecological succession** is the sequence of community and ecosystem changes after a disturbance
- **Primary succession** occurs where no soil exists when succession begins
- **Secondary succession** begins in an area where soil remains after a disturbance

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- 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 favorable
  - They may inhibit the establishment of later species
  - They may tolerate later species but have no impact on their establishment

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- Retreating glaciers provide a valuable field-research opportunity for observing succession
- Succession on the moraines in Glacier Bay, Alaska, follows a predictable pattern of change in vegetation and soil characteristics

1. The exposed moraine is colonized by pioneering plants, including liverworts, mosses, fireweed, *Dryas*, willows, and cottonwood

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4. Alder are overgrown by Sitka spruce, western hemlock, and mountain hemlock

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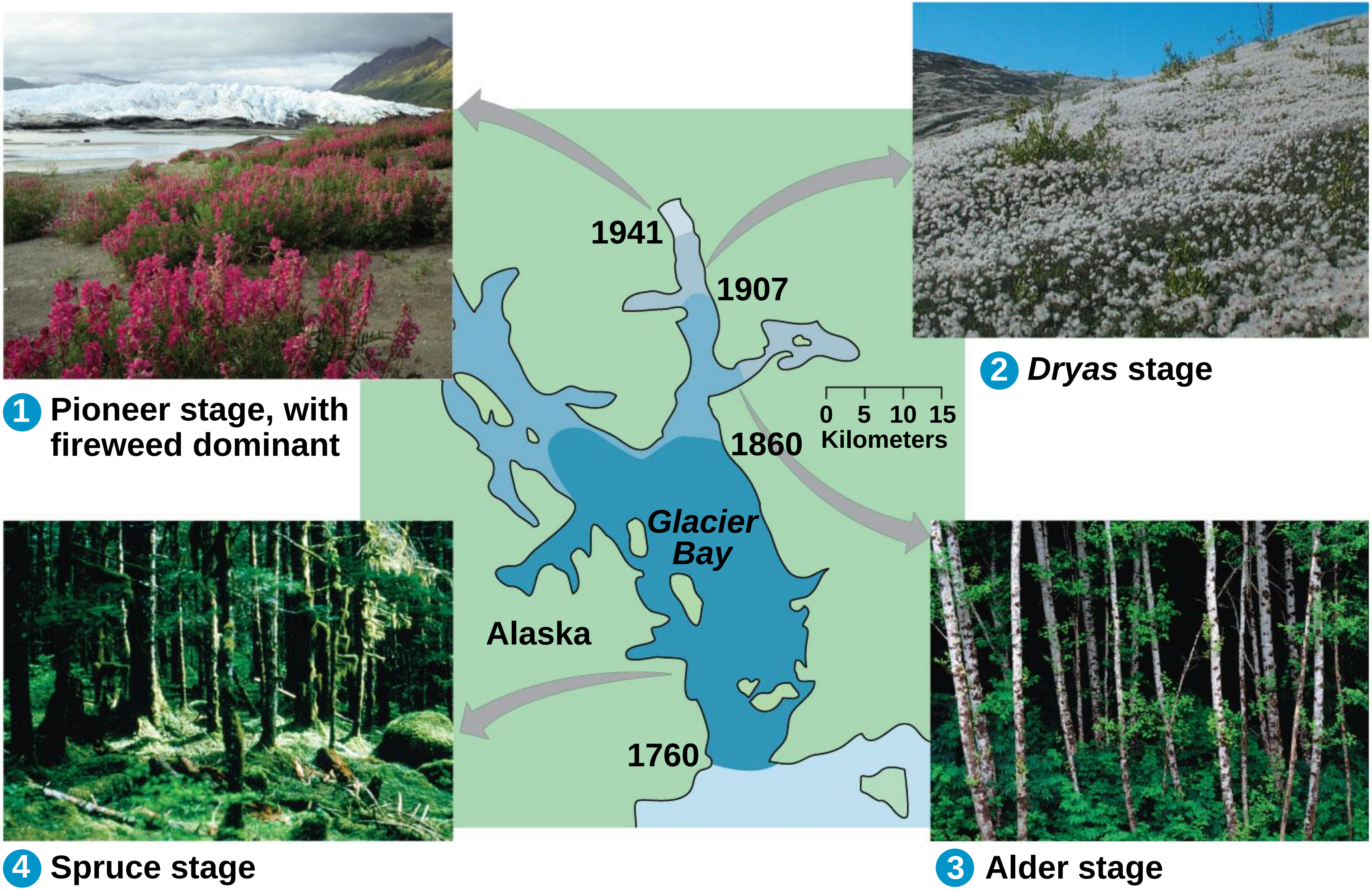
Figure 54.22-4



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- Succession is the result of changes induced by the vegetation itself
- On the glacial moraines, vegetation lowers the soil pH and increases soil nitrogen content

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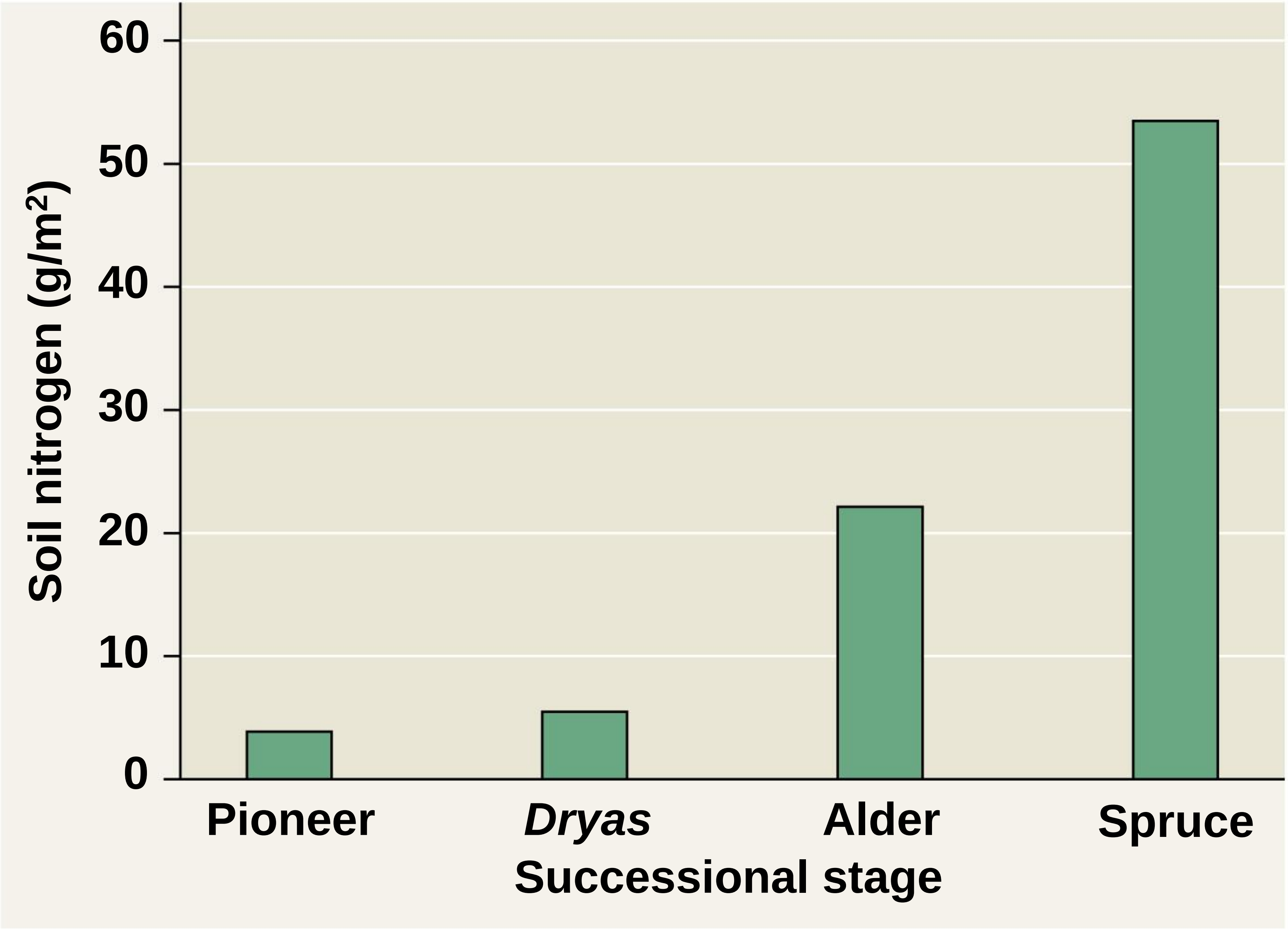
Figure 54.23



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Human Disturbance

- Humans have the greatest impact on biological communities worldwide
- Human disturbance to communities usually reduces species diversity

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Concept 54.4: Biogeographic factors affect community diversity

- Latitude and area are two key factors that affect a community’s species diversity

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Latitudinal Gradients

- Species richness is especially great in the tropics and generally declines along an equatorial-polar gradient
- Two key factors in equatorial-polar gradients of species richness are probably evolutionary history and climate

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- Temperate and polar communities have started over repeatedly following glaciations
- The greater age of tropical environments may account for their greater species richness
- In the tropics, the growing season is longer, so biological time runs faster

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- Climate is likely the primary cause of the latitudinal gradient in biodiversity
- Two main climatic factors correlated with biodiversity are solar energy and water availability
- They can be considered together by measuring a community’s rate of evapotranspiration
- **Evapotranspiration** is evaporation of water from soil plus transpiration of water from plants

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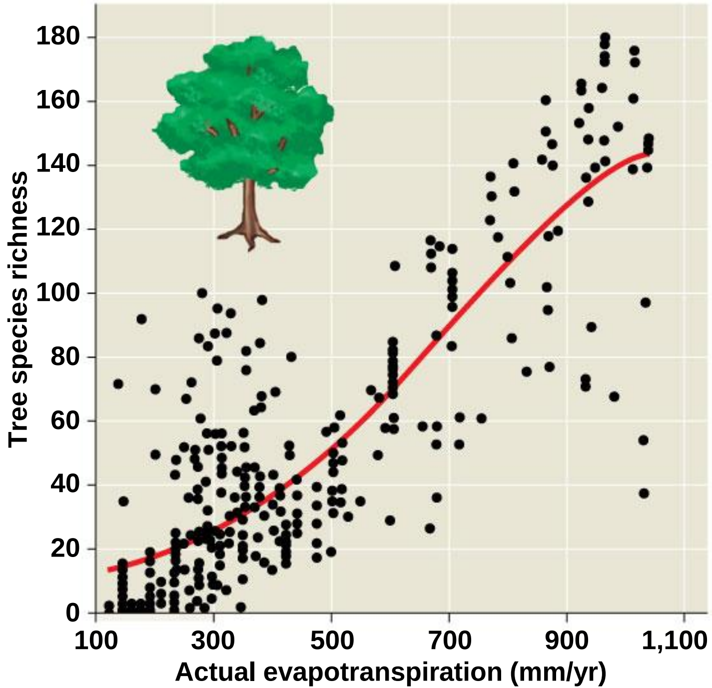
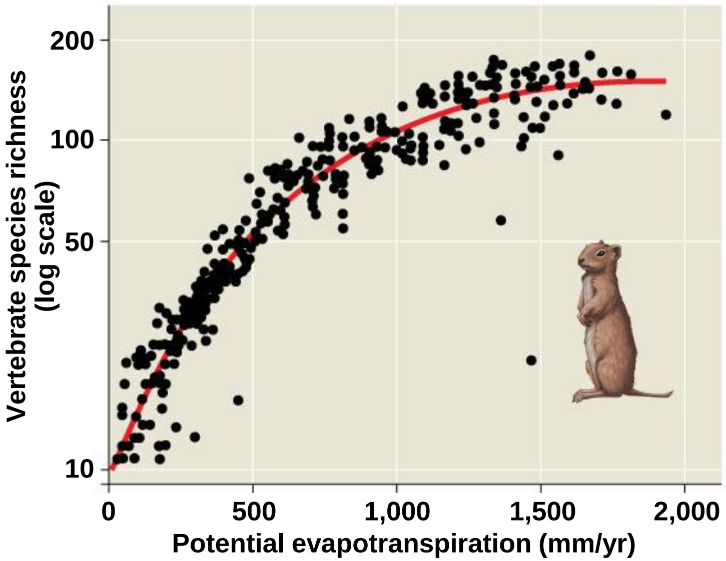
Figure 54.25



(a) Trees



(b) Vertebrates

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Area Effects

- The **species-area curve** quantifies the idea that, all other factors being equal, a larger geographic area has more species
- A species-area curve of North American breeding birds supports this idea

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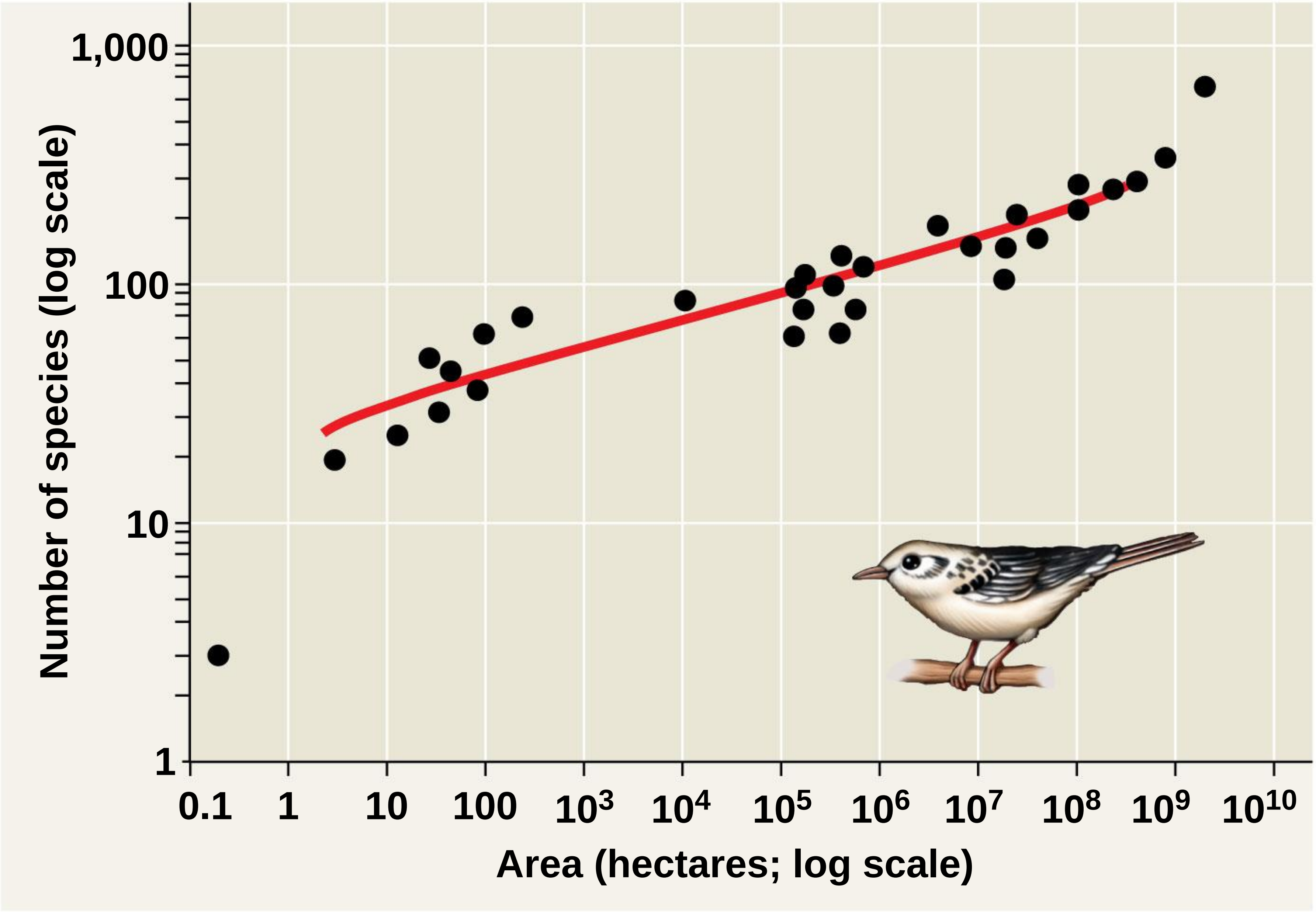
Figure 54.26



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Island Equilibrium Model

- Species richness on islands depends on island size, distance from the mainland, immigration, and extinction
- The equilibrium model of island biogeography maintains that species richness on an ecological island levels off at a dynamic equilibrium point

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- Studies of species richness on the Galápagos Islands support the prediction that species richness increases with island size

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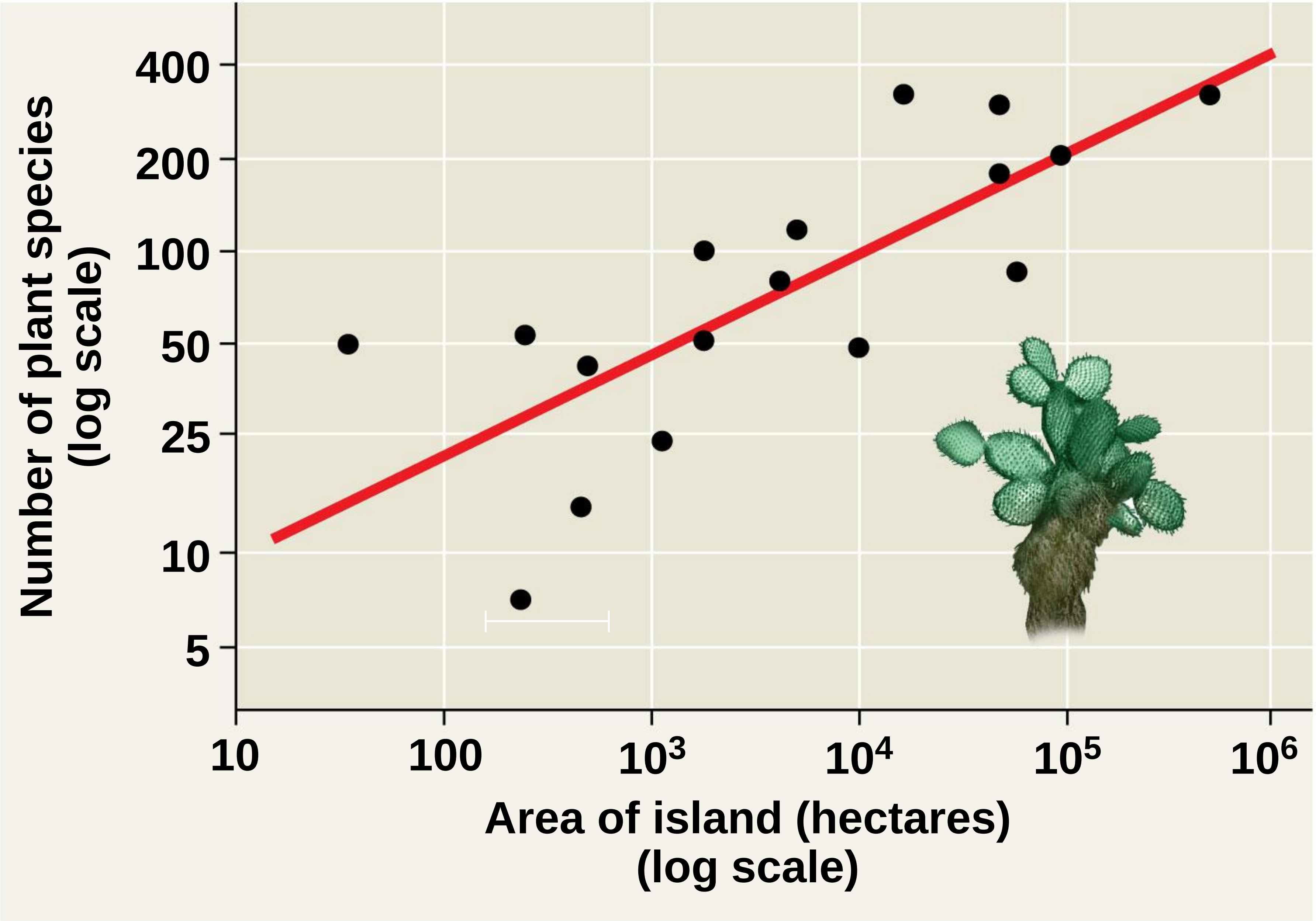
Figure 54.28

RESULTS



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Concept 54.5: Pathogens alter community structure locally and globally

- Ecological communities are universally affected by **pathogens**, which include disease-causing microorganisms, viruses, viroids, and prions
- Pathogens can alter community structure quickly and extensively

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Pathogens and Community Structure

- Pathogens can have dramatic effects on communities
  - For example, coral reef communities are being decimated by white-band disease

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- Human activities are transporting pathogens around the world at unprecedented rates
- Community ecology is needed to help study and combat pathogens

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Community Ecology and Zoonotic Diseases

- **Zoonotic pathogens** have been transferred from other animals to humans
- The transfer of pathogens can be direct or through an intermediate species called a **vector**
- Many of today’s emerging human diseases are zoonotic

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

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- Avian flu is a highly contagious virus of birds
- Ecologists are studying the potential spread of the virus from Asia to North America through migrating birds

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Figure 54.UN03

Interspecific Interaction	Description
Competition (–/–)	Two or more species compete for a resource that is in short supply.
Predation (+/–)	One species, the predator, kills and eats the other, the prey. Predation has led to diverse adaptations, including mimicry.
Herbivory (+/–)	An herbivore eats part of a plant or alga. Plants have various chemical and mechanical defenses against herbivory, and herbivores have specialized adaptations for feeding.
Symbiosis	Individuals of two or more species live in close contact with one another. Symbiosis includes parasitism, mutualism, and commensalism.
Parasitism (+/–)	The parasite derives its nourishment from a second organism, its host, which is harmed.
Mutualism (+/+)	Both species benefit from the interaction.
Commensalism (+/0)	One species benefits from the interaction, while the other is unaffected by it.
Facilitation (+/+ or 0/+)	Species have positive effects on the survival and reproduction of other species without the intimate contact of a symbiosis.

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