Chapter 54

Community Ecology

PowerPoint® Lecture Presentations for

Biology

Eighth Edition

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Key concepts

1. Community ecology concerns interactions among species, and factors influence diversity of a community.

Overview: A Sense of Community

- A biological **community** is an assemblage of populations of various species living close enough for potential interaction

Fig. 54-1


How many interactions between species
are occurring in this scene?

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, and symbiosis (parasitism, mutualism, and commensalism)

Competition

- **Interspecific competition** (–/– interaction) occurs when species compete for a resource in short supply
- The competitive exclusion principle states that two species competing for the same limiting resources cannot coexist in the same place

Ecological Niches

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

Fig. 54-2

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

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

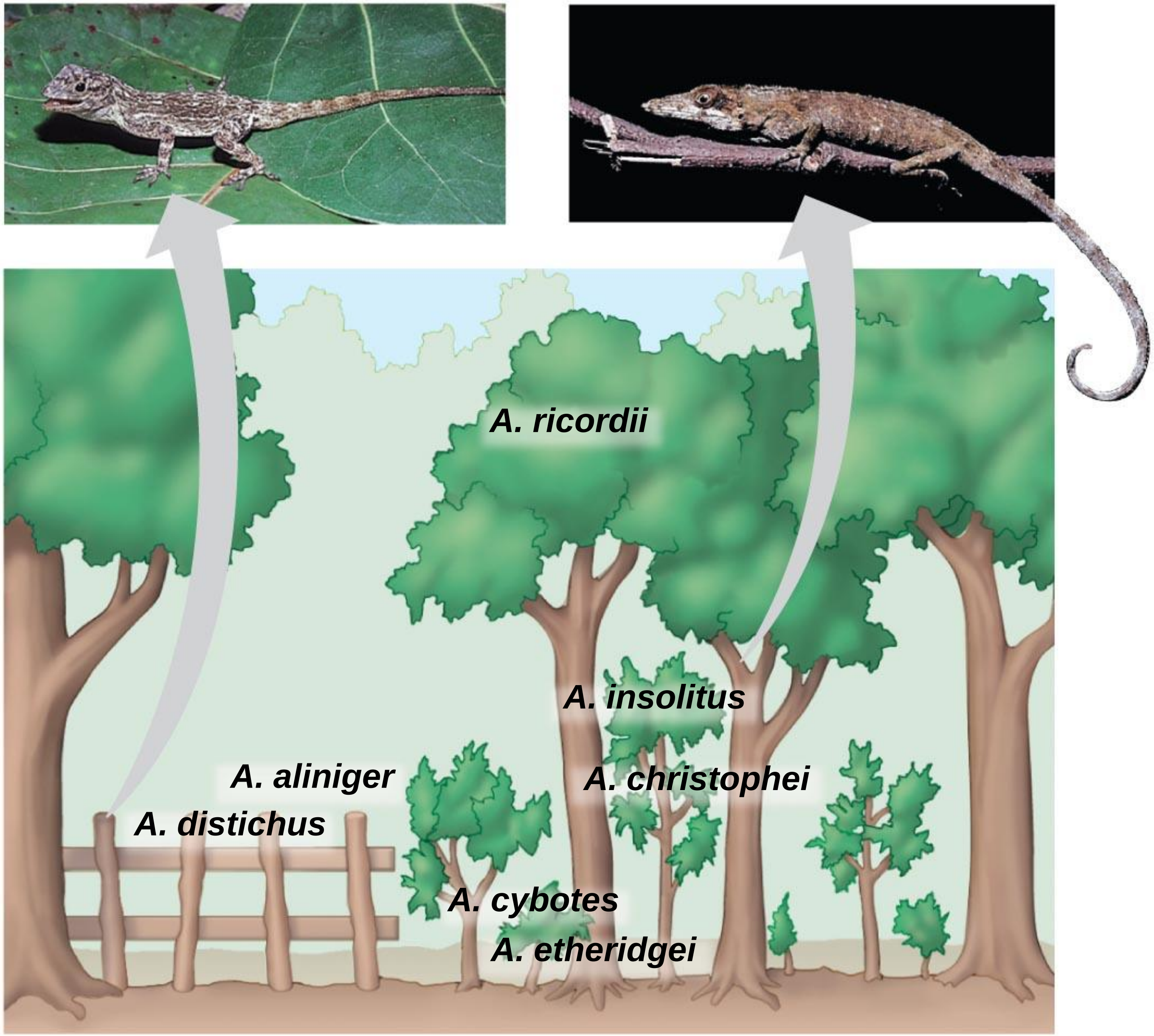
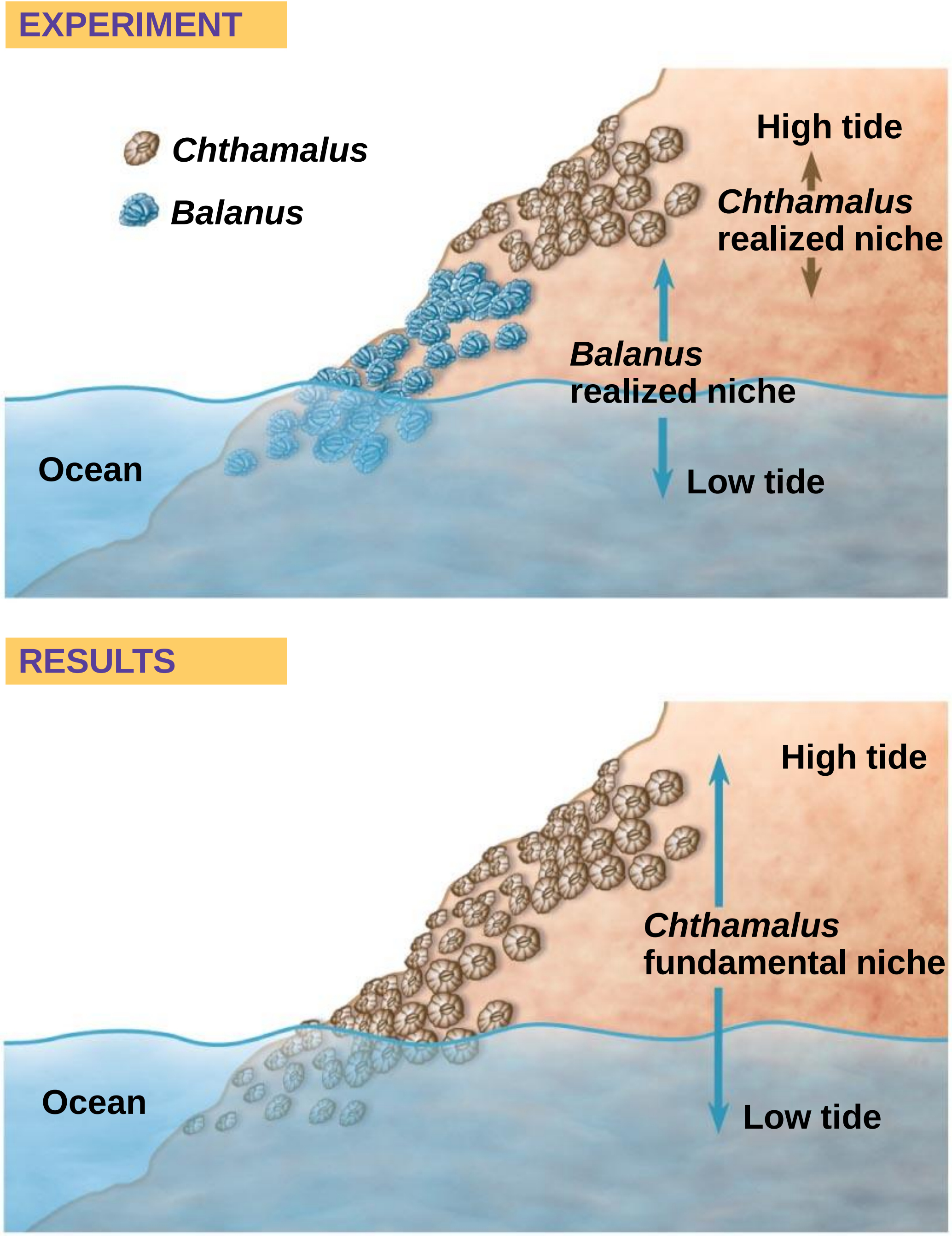
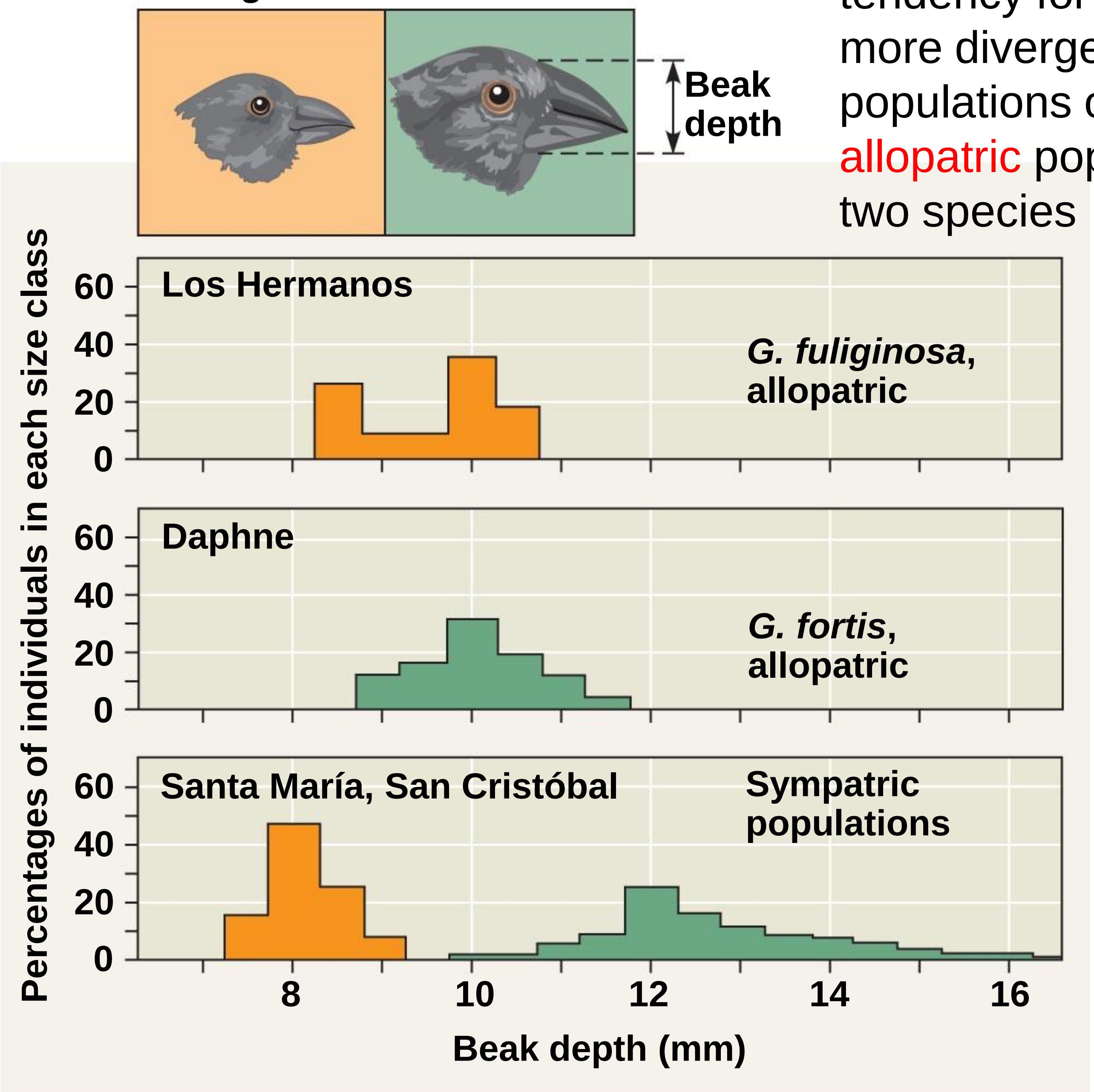


Fig. 54-3



As a result of competition, a species' fundamental niche may differ from its realized niche

Fig. 54-4



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

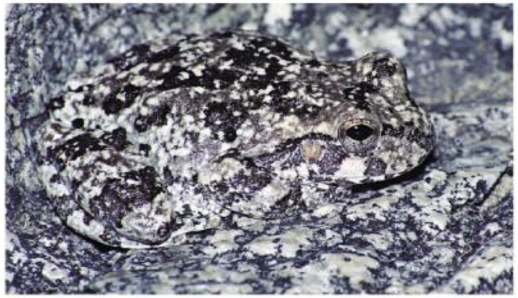
Predation

- **Predation** (+/– interaction) refers to interaction where one species, the predator, kills and eats the other, the prey
- Behavioral defenses include hiding, fleeing, forming herds or schools, self-defense, and alarm calls
- **Cryptic coloration**, or camouflage, makes prey difficult to spot

Fig. 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

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

Fig. 54-6

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**

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

Fig. 54-7

Mutualism between acacia trees and ants

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

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

Commensalism

- In **commensalism** (+/0 interaction), one species benefits and the other is apparently unaffected
- Commensal interactions are hard to document in nature because any close association likely affects both species

Fig. 54-8

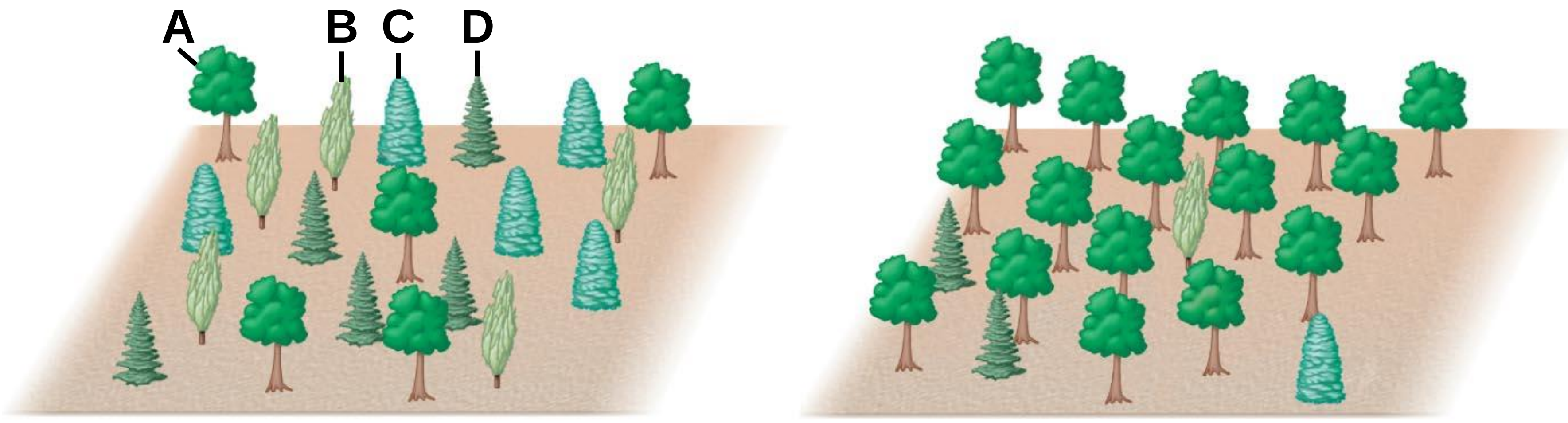

A possible example of commensalism
between cattle egrets and water buffalo

Species Diversity

- **Species diversity** of a community is the variety of organisms that make up the community
- **Species richness** is the total number of different species in the community
- **Relative abundance** is the proportion each species represents of the total individuals in the community

Fig. 54-9

Which forest is more diverse?



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

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

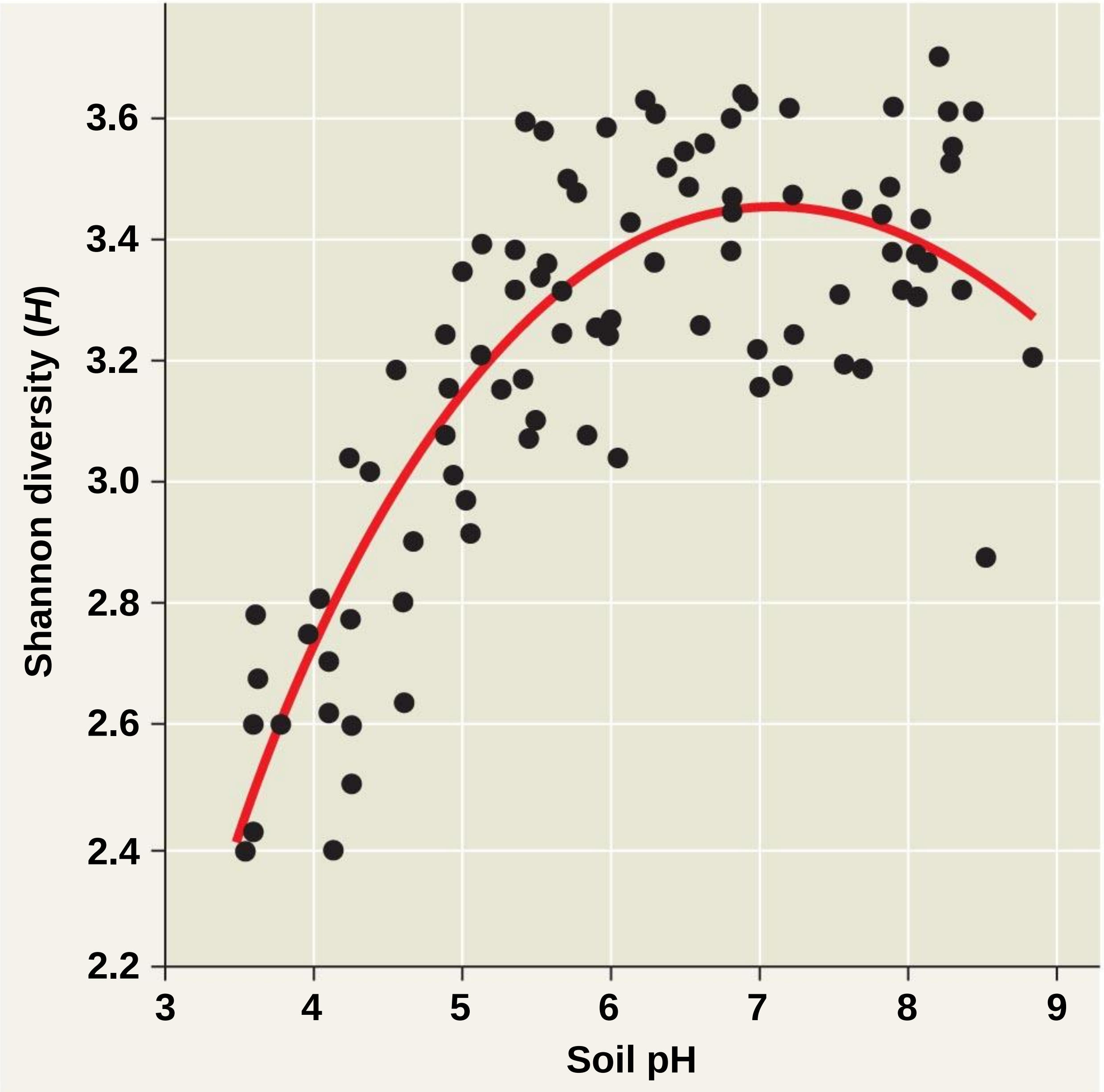
- Two communities can have the same species richness but a different relative abundance
- Diversity can be compared using a diversity index
  - **Shannon diversity** index (H):

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

Fig. 54-10

RESULTS

Determining microbial diversity using molecular tools



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

Fig. 54-11

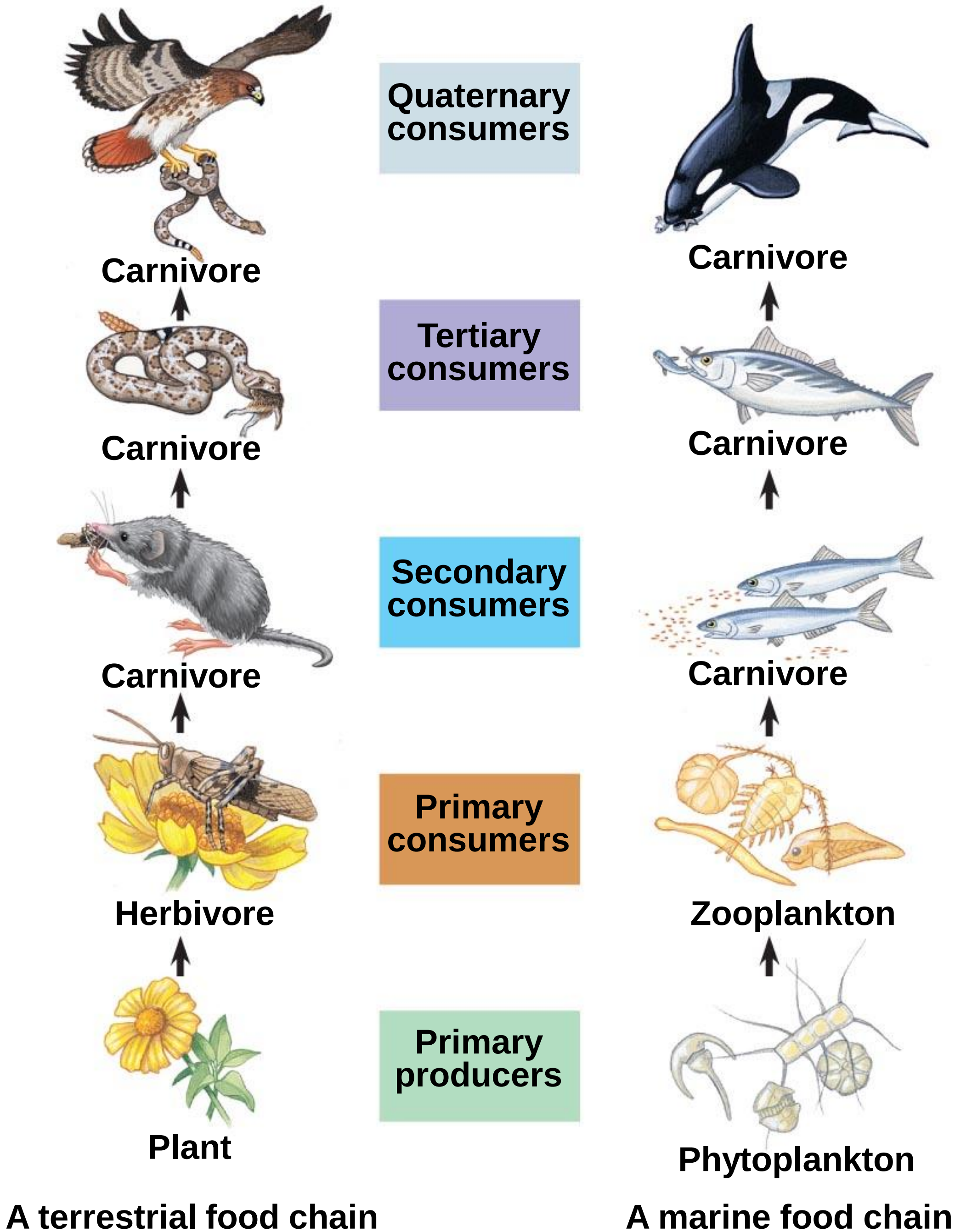

Quaternary consumers
Tertiary consumers
Secondary consumers
Primary consumers
Primary producers
Carnivore
Carnivore
Carnivore
Herbivore
Plant
Carnivore
Carnivore
Carnivore
Zooplankton
Phytoplankton
A terrestrial food chain
A marine food chain

Fig. 54-12

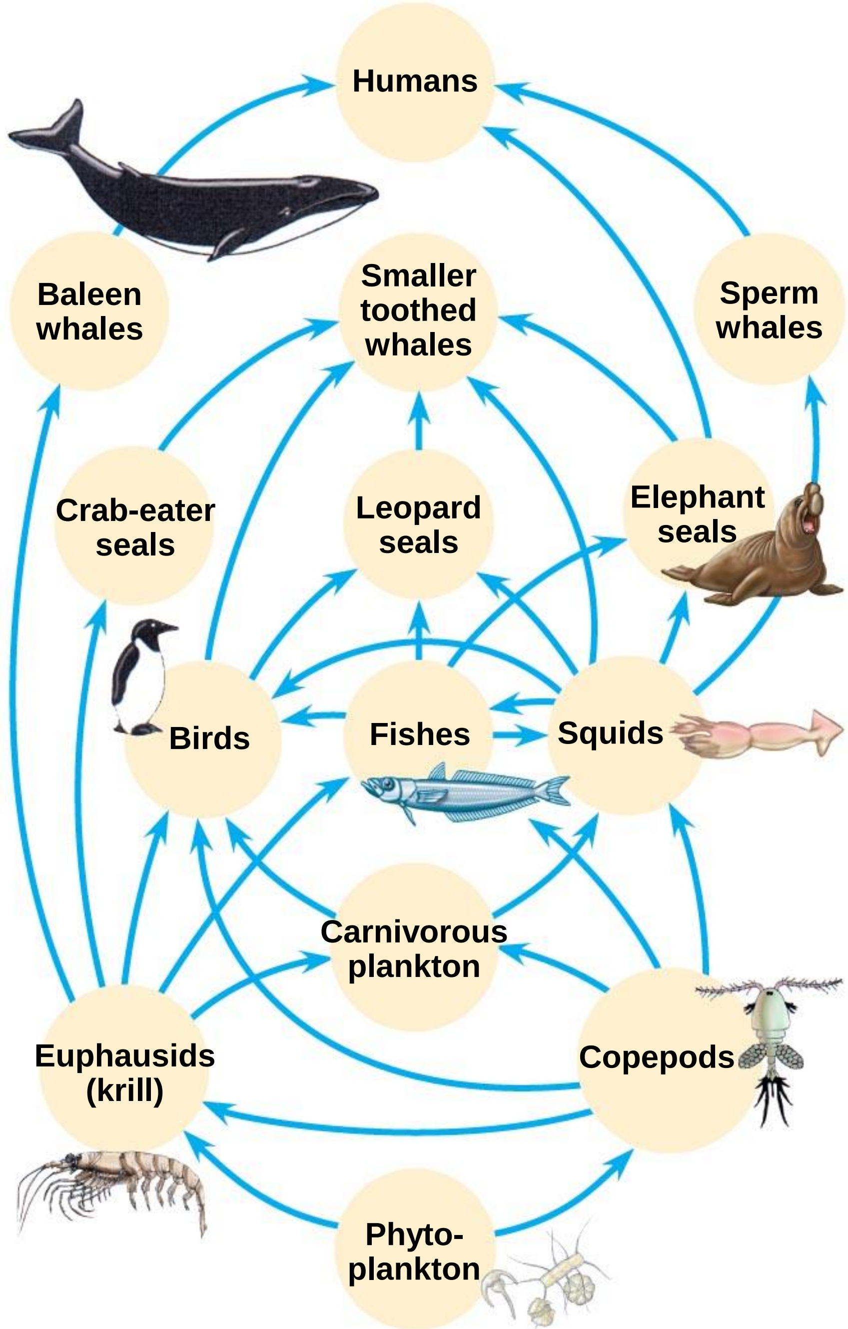
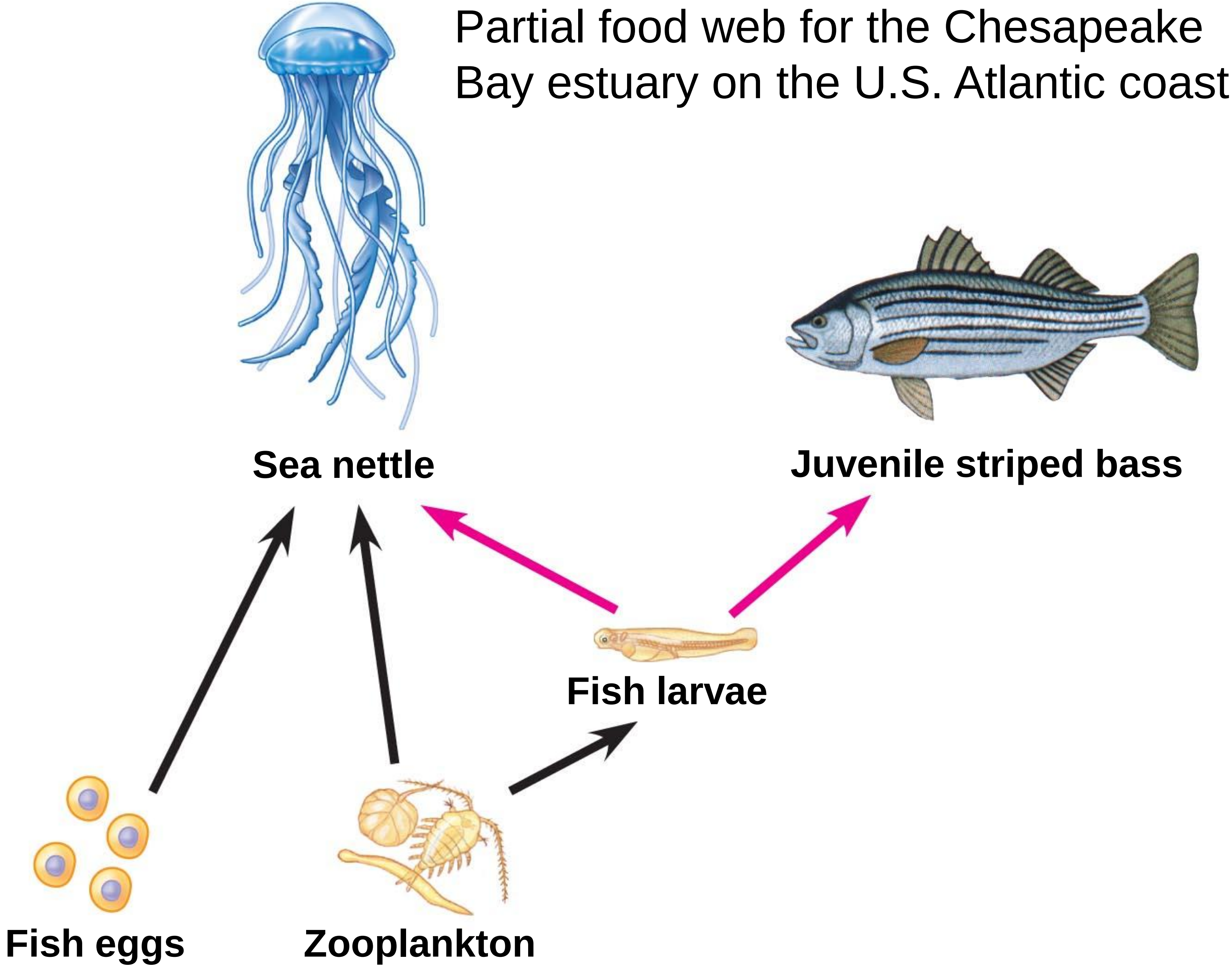

Humans
Baleen whales
Smaller toothed whales
Sperm whales
Crab-eater seals
Leopard seals
Elephant seals
Birds
Fishes
Squids
Carnivorous plankton
Euphausids (krill)
Copepods
Phyto-plankton

Fig. 54-13

Partial food web for the Chesapeake Bay estuary on the U.S. Atlantic coast

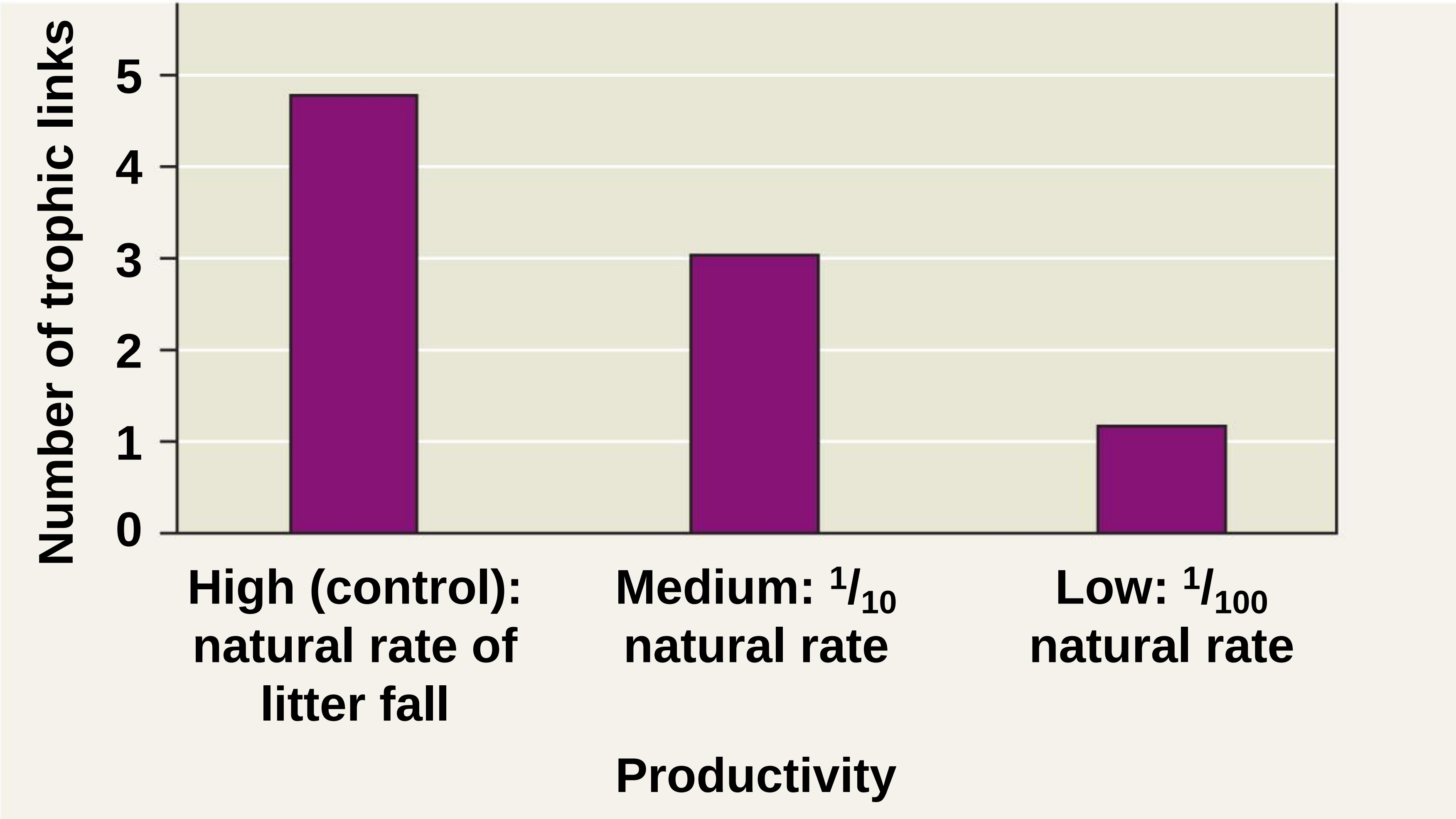


Limits on Food Chain Length

- Each food chain in a food web is usually only a few links long
- The **energetic hypothesis** suggests that length is limited by inefficient energy transfer
- The **dynamic stability hypothesis** proposes that long food chains are less stable than short ones
- Most data support the energetic hypothesis

Fig. 54-14

Test of the energetic hypothesis for the restriction of food chain length



Dominant Species

- **Dominant species** are those that are most abundant or have the highest biomass
- 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

Keystone Species

- **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

Fig. 54-15

EXPERIMENT

Field studies of sea stars exhibit their role as a keystone species in intertidal communities

RESULTS

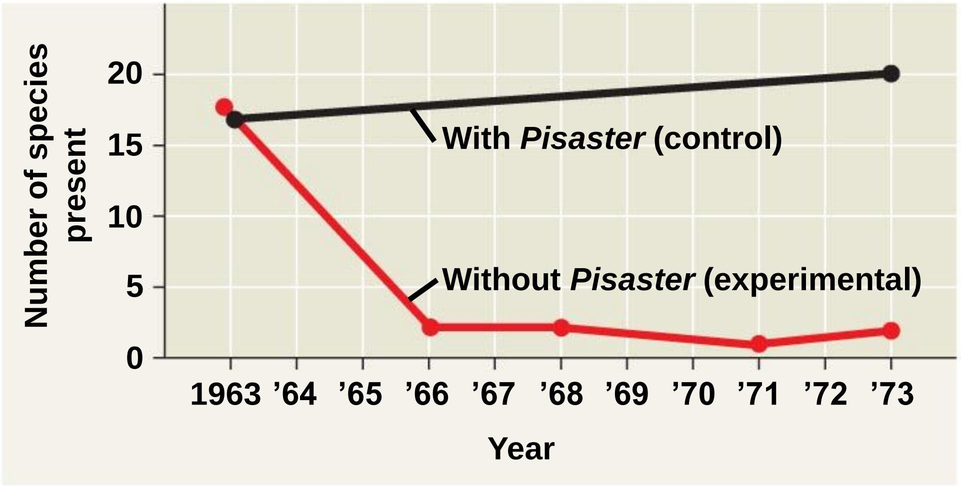
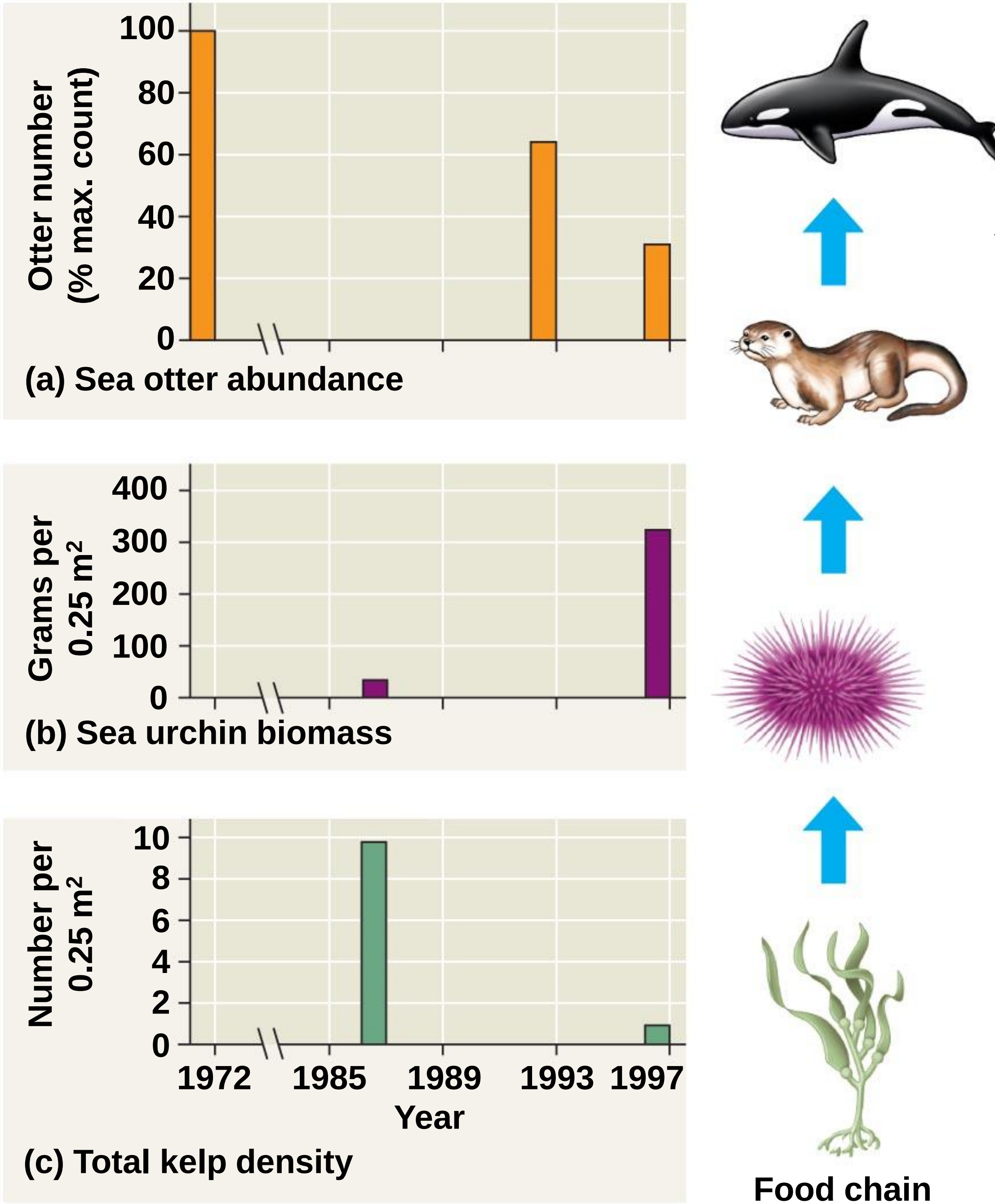


Fig. 54-16



Sea otters as keystone predators in the North Pacific

Foundation Species (Ecosystem "Engineers")

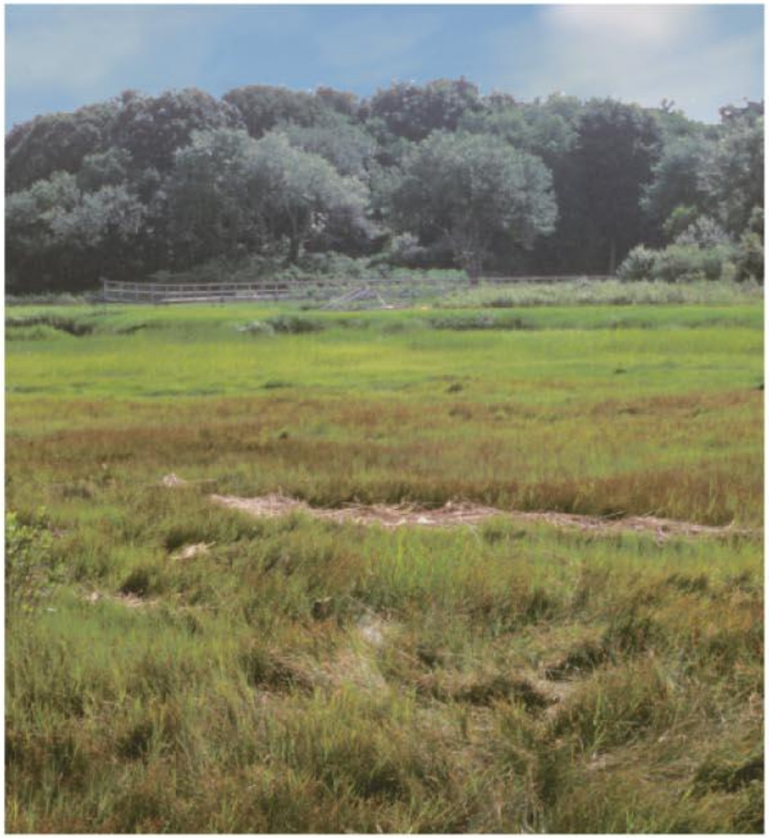
- **Foundation species** (ecosystem "engineers") cause physical changes in the environment that affect community structure

Fig. 54-17

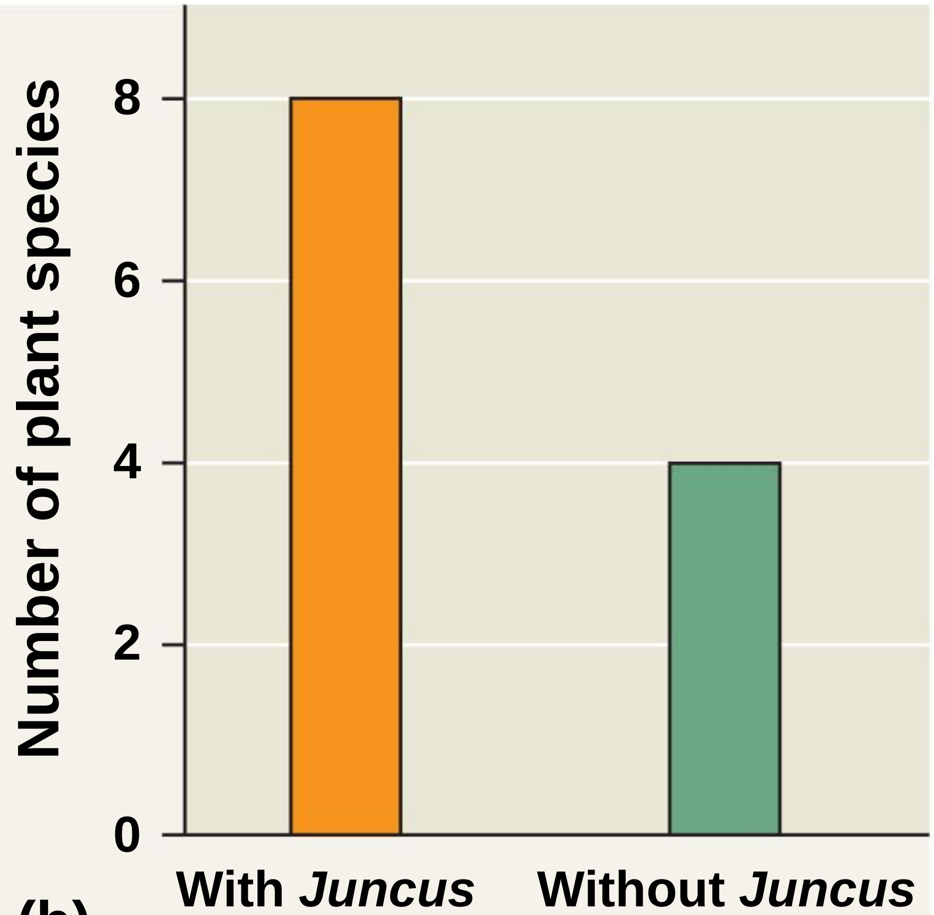
Beaver dams can transform landscapes on a very large scale

Fig. 54-18

Some foundation species act as **facilitators** that have positive effects on survival and reproduction of some other species in the community



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



(b)

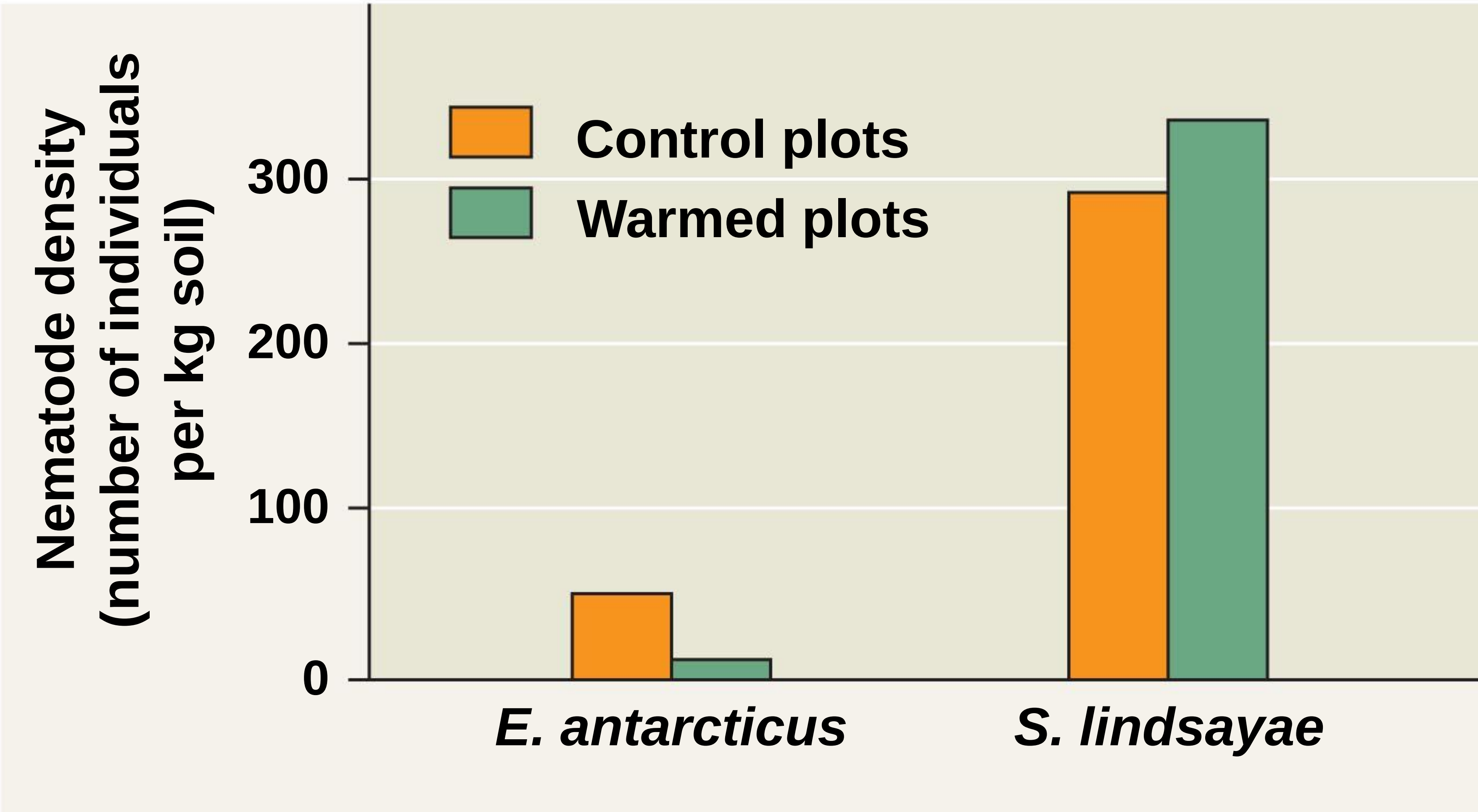
Bottom-Up and Top-Down Controls

- The **bottom-up model** of community organization proposes a unidirectional influence from lower to higher trophic levels
- The **top-down model**, also called the trophic cascade model, proposes that control comes from the trophic level above

Fig. 54-19

Soil nematode communities in Antarctica are controlled by top-down factors

RESULTS



Biomanipulation can help restore polluted communities

	Polluted State	Restored State
Fish	Abundant	Rare
Zooplankton	Rare	Abundant
Algae	Abundant	Rare

Concept 54.3: Disturbance influences species diversity and composition

- Decades ago, most ecologists favored the view that communities are in a state of equilibrium
- Recent evidence of change has led to a **nonequilibrium model**, which describes communities as constantly changing after being buffeted by **disturbances**

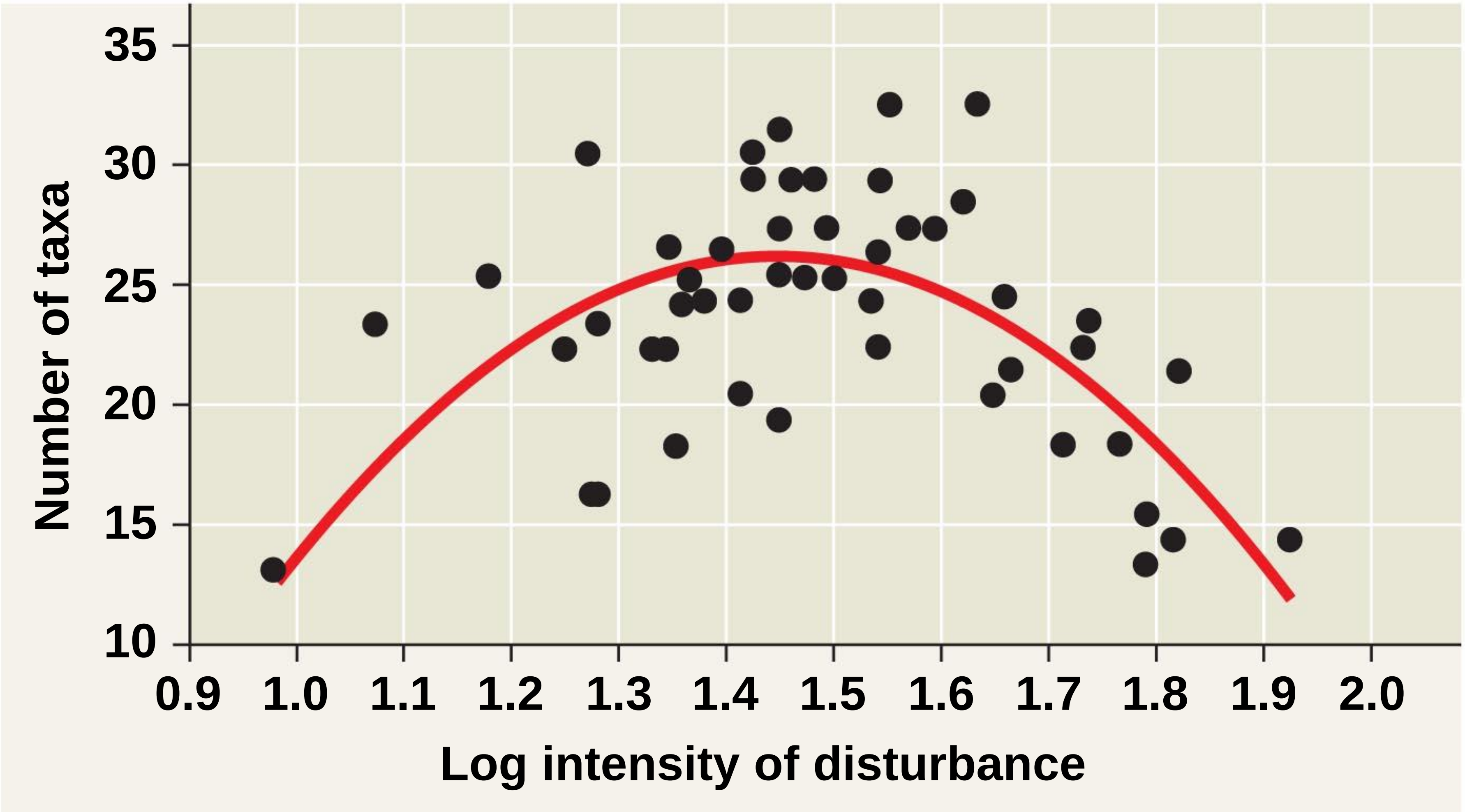
- The **intermediate disturbance hypothesis** suggests that moderate levels of disturbance can foster greater diversity than either high or low levels of disturbance

- High levels of disturbance exclude many slow-growing species

- Low levels of disturbance allow dominant species to exclude less competitive species

Fig. 54-20

Testing the intermediate disturbance hypothesis



The large-scale fire in Yellowstone National Park in 1988 demonstrated that communities can often respond very rapidly to a massive disturbance

(a) Soon after fire

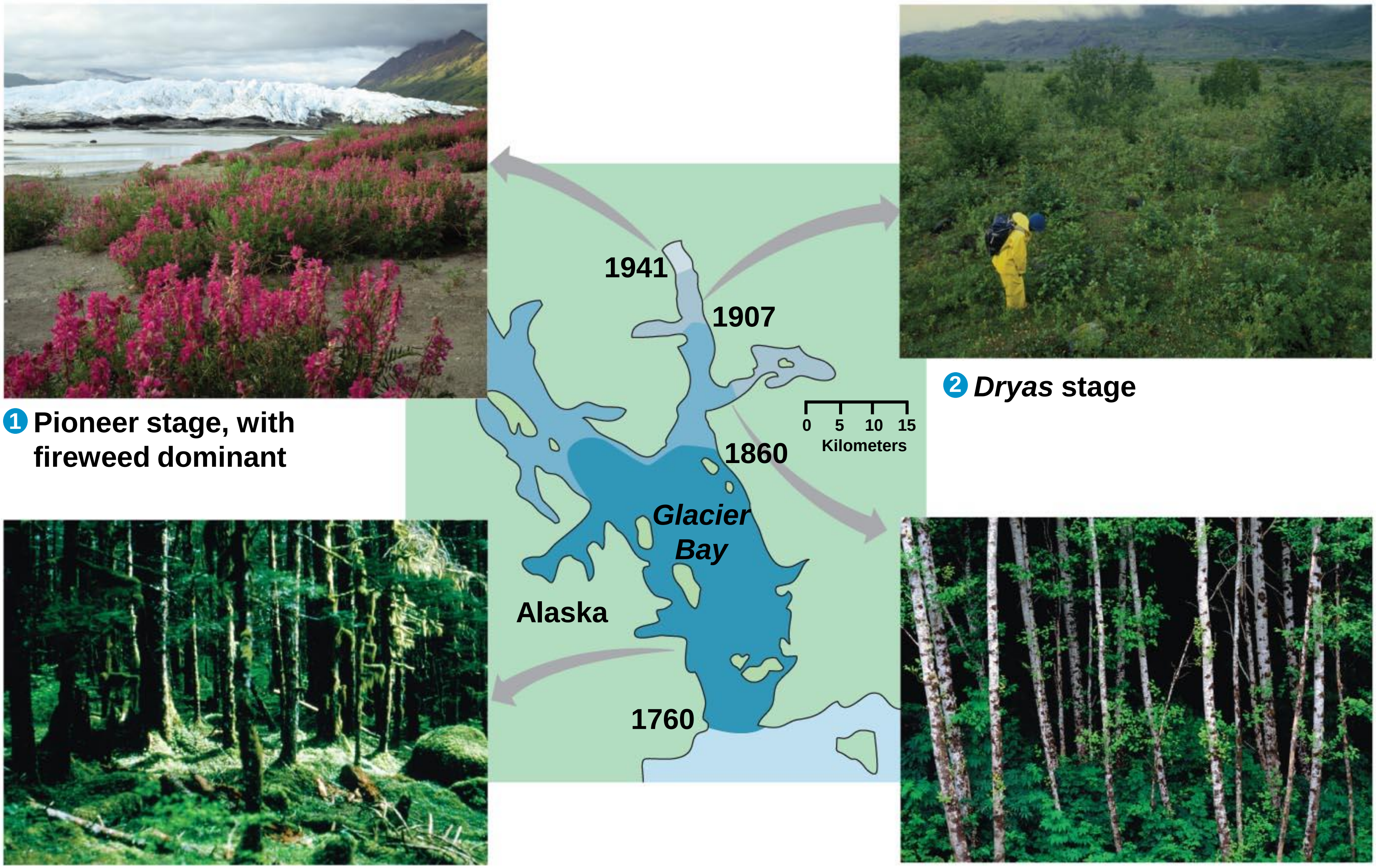
(b) One year after fire

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

Fig. 54-22-4

Glacial retreat and primary succession at Glacier Bay, Alaska



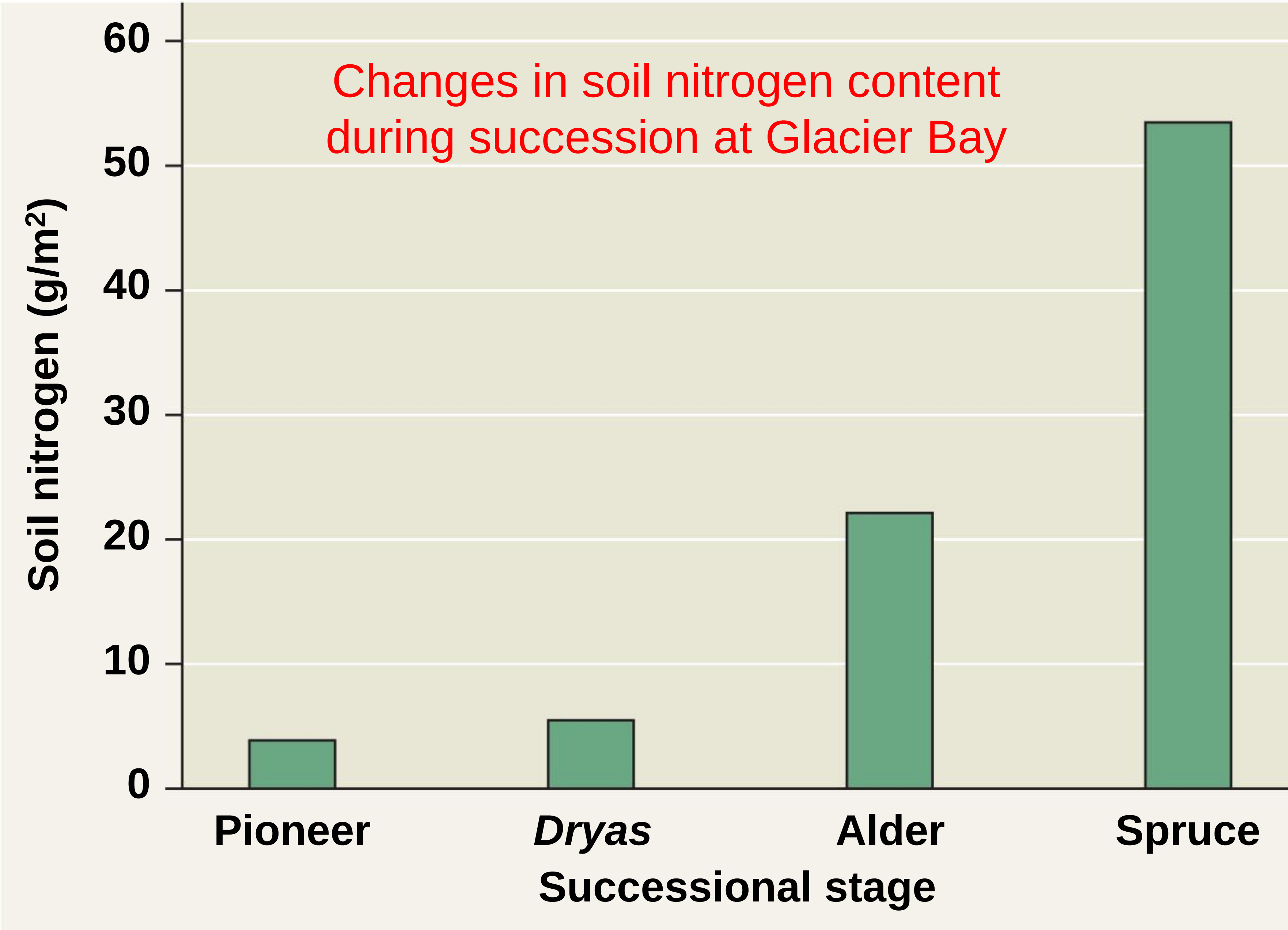
1 **Pioneer stage, with fireweed dominant**

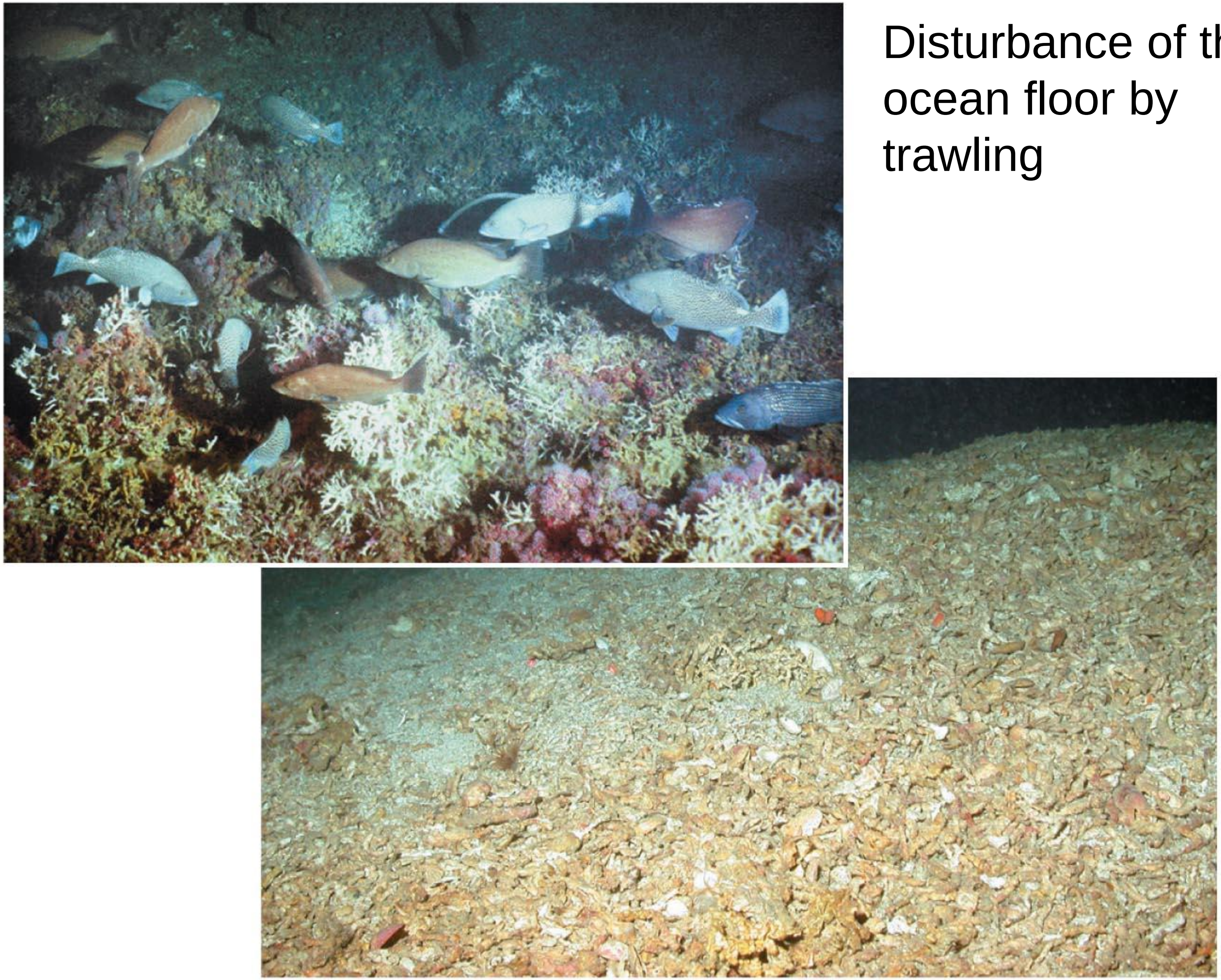
2 ***Dryas* stage**

3 **Alder stage**

4 **Spruce stage**

Fig. 54-23


Changes in soil nitrogen content
during succession at Glacier Bay
Soil nitrogen (g/m²)
60
50
40
30
20
10
0
Pioneer
Dryas
Alder
Spruce
Successional stage

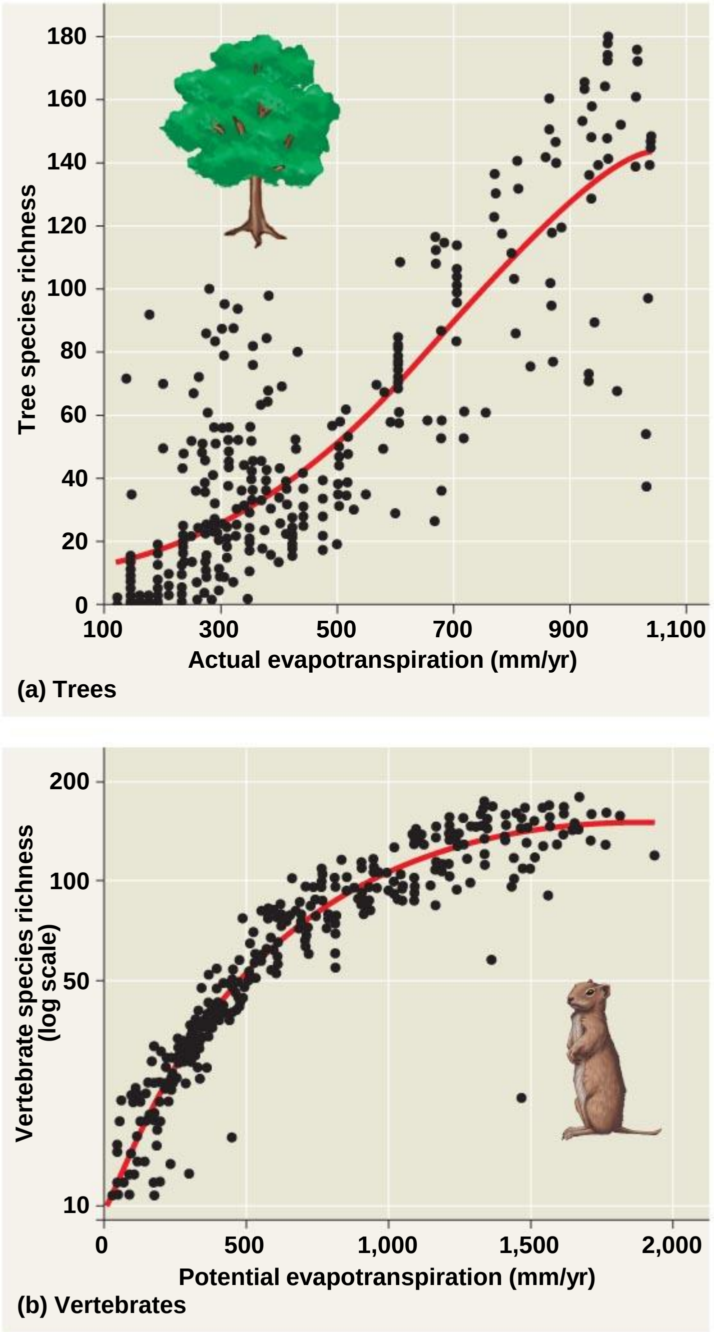


Disturbance of the ocean floor by trawling

Latitudinal Gradients

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

Fig. 54-25



Two main climatic factors correlated with biodiversity are solar energy and water availability

Evapotranspiration is evaporation of water from soil plus transpiration of water from plants

Fig. 54-26

The **species-area curve** quantifies the idea that, all other factors being equal, a larger geographic area has more species

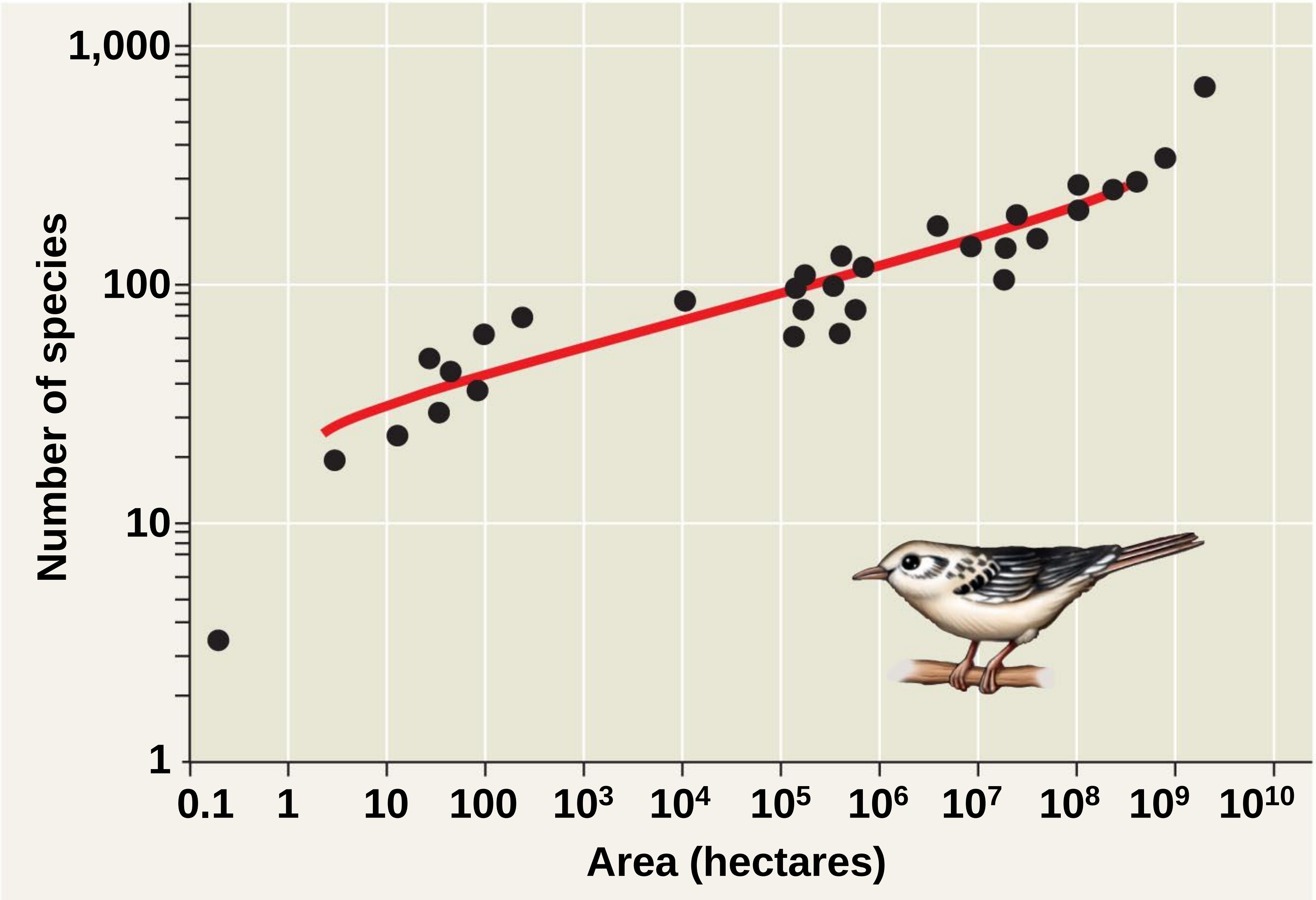
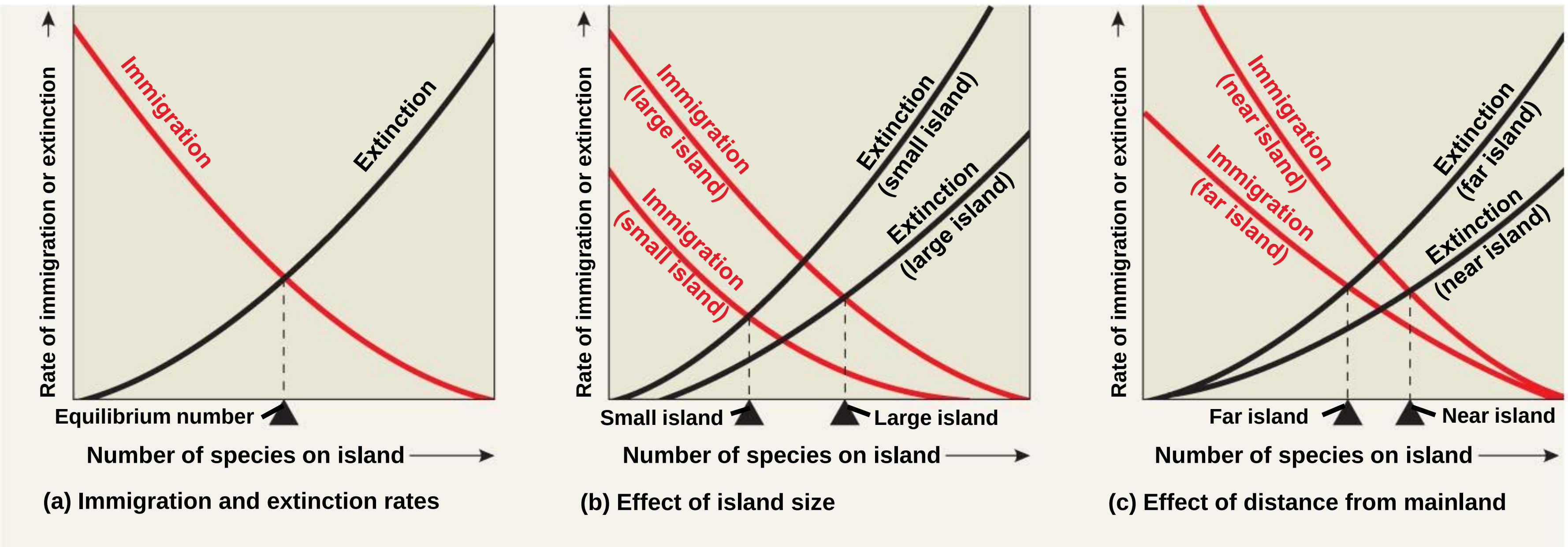


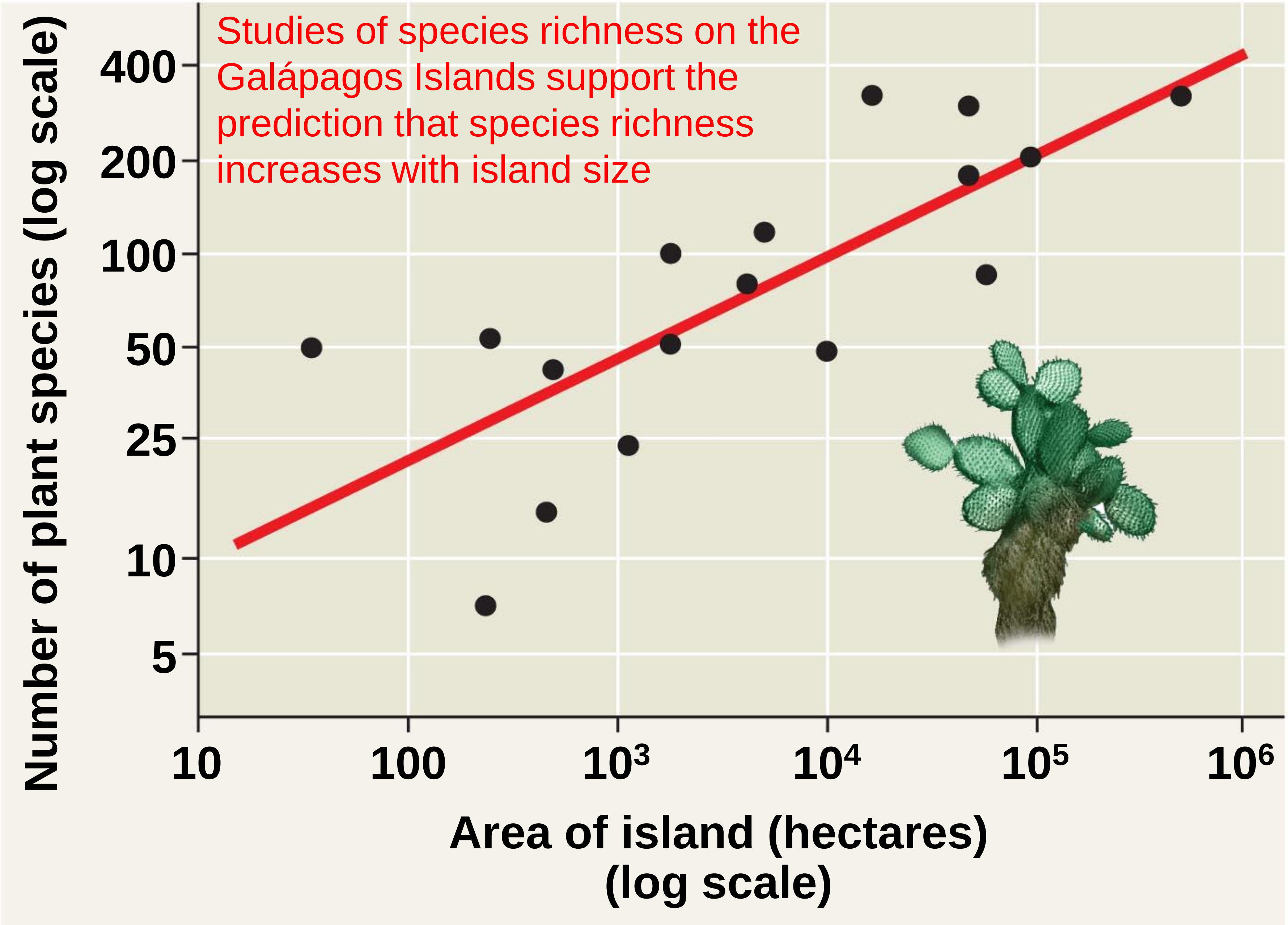
Fig. 54-27

Species richness on islands depends on island size, distance from the mainland, immigration, and extinction



The equilibrium model of island biogeography

Fig. 54-28


Studies of species richness on the Galápagos Islands support the prediction that species richness increases with island size
Number of plant species (log scale)
400
200
100
50
25
10
5
10
100
10³
10⁴
10⁵
10⁶
Area of island (hectares) (log scale)

Concept 54.5: Community ecology is useful for understanding pathogen life cycles and controlling human disease

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

Fig. 54-29

Coral reef communities are being decimated by white-band disease

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

You should now be able to:

1. Distinguish between the following sets of terms: competition, predation, herbivory, symbiosis; fundamental and realized niche; cryptic and aposematic coloration; Batesian mimicry and Müllerian mimicry; parasitism, mutualism, and commensalism; endoparasites and ectoparasites; species richness and relative abundance; food chain and food web; primary and secondary succession

2. Define an ecological niche and explain the competitive exclusion principle in terms of the niche concept
3. Explain how dominant and keystone species exert strong control on community structure
4. Distinguish between bottom-up and top-down community organization
5. Describe and explain the intermediate disturbance hypothesis

6. Explain why species richness declines along an equatorial-polar gradient
7. Define zoonotic pathogens and explain, with an example, how they may be controlled