Biodiversity, Species Interactions, and Population Control

Chapter 5

Core Case Study: Southern Sea Otters: Are They Back from the Brink of Extinction?

- Habitat
- Hunted: early 1900s
- Partial recovery
- Why care about sea otters?
  - Ethics
  - Keystone species
  - Tourism dollars

Southern Sea Otter

Video: Coral spawning

PLAY

5-1 How Do Species Interact?

- ***Concept 5-1*** *Five types of species interactions —competition, predation, parasitism, mutualism, and commensalism—affect the resource use and population sizes of the species in an ecosystem.*

Species Interact in Five Major Ways

- Interspecific Competition
- Predation
- Parasitism
- Mutualism
- Commensalism

Most Species Compete with One Another for Certain Resources

- Competition
- Competitive exclusion principle

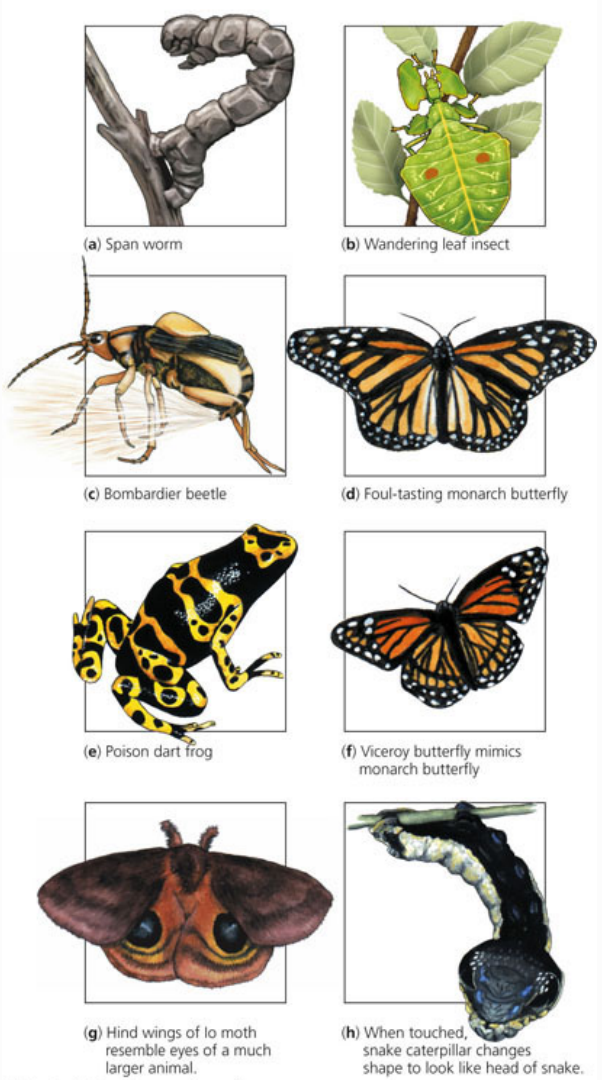
Most Consumer Species Feed on Live Organisms of Other Species (1)

- **Predators** may capture prey by
  - Walking
  - Swimming
  - Flying
  - Pursuit and ambush
  - Camouflage
  - Chemical warfare

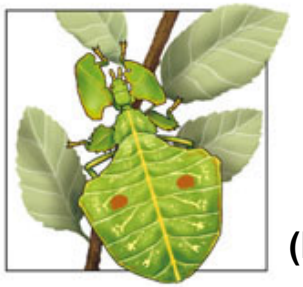
Most Consumer Species Feed on Live Organisms of Other Species (2)

- **Prey** may avoid capture by
  - Camouflage
  - Chemical warfare
  - Warning coloration
  - Mimicry
  - Deceptive looks
  - Deceptive behavior

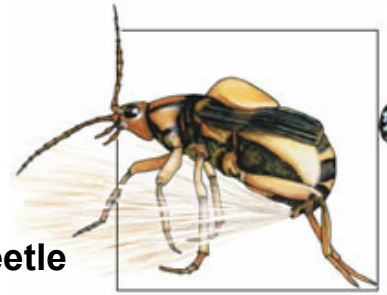
Some Ways Prey Species Avoid Their Predators



(a) Span worm



(b) Wandering leaf insect



(c) Bombardier beetle

(d) Foul-tasting monarch butterfly

(e) Poison dart frog

(f) Viceroy butterfly mimics monarch butterfly

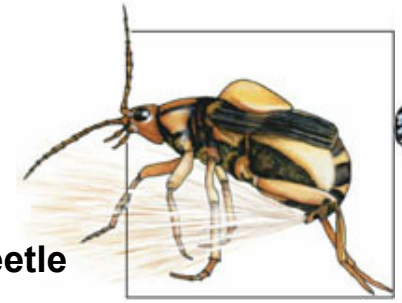
(g) Hind wings of lo moth resemble eyes of a much larger animal.

(h) When touched, snake caterpillar changes shape to look like head of snake.

Fig. 5-2, p. 103

(a) Span worm

(b) Wandering leaf insect



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(g) Hind wings of lo moth resemble eyes of a much larger animal.

(h) When touched, snake caterpillar changes shape to look like head of snake.

Stepped Art

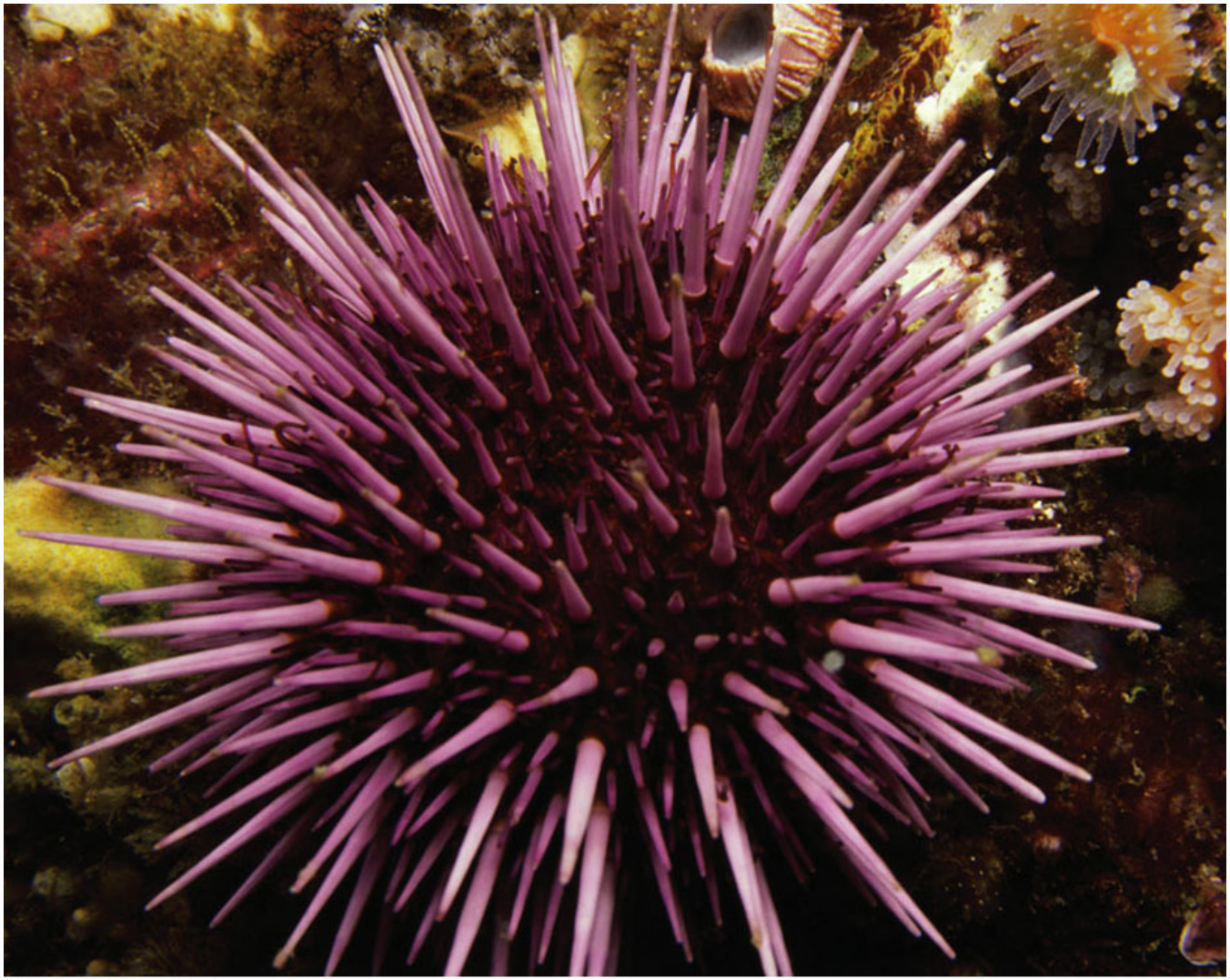
Fig. 5-2, p. 103

Science Focus: Why Should We Care about Kelp Forests?

- Kelp forests: biologically diverse marine habitat

- Major threats to kelp forests
  - Sea urchins
  - Pollution from water run-off
  - Global warming

Purple Sea Urchin



Predator and Prey Species Can Drive Each Other's Evolution

- Intense natural selection pressures between predator and prey populations

- **Coevolution**

Coevolution: A Langohrfledermaus Bat Hunting a Moth

Some Species Feed off Other Species by Living on or in Them

- **Parasitism**
- Parasite-host interaction may lead to coevolution

Parasitism: Tree with Parasitic Mistletoe, Trout with Blood-Sucking Sea Lampreys

In Some Interactions, Both Species Benefit

- **Mutualism**
- Nutrition and protection relationship
- Gut inhabitant mutualism

Mutualism: Oxpeckers Clean Rhinoceros; Anemones Protect and Feed Clownfish

(a) Oxpeckers and black rhinoceros

(b) Clownfish and sea anemone

(a) Oxpeckers and black rhinoceros

Fig. 5-5a, p. 106

(b) Clownfish and sea anemone

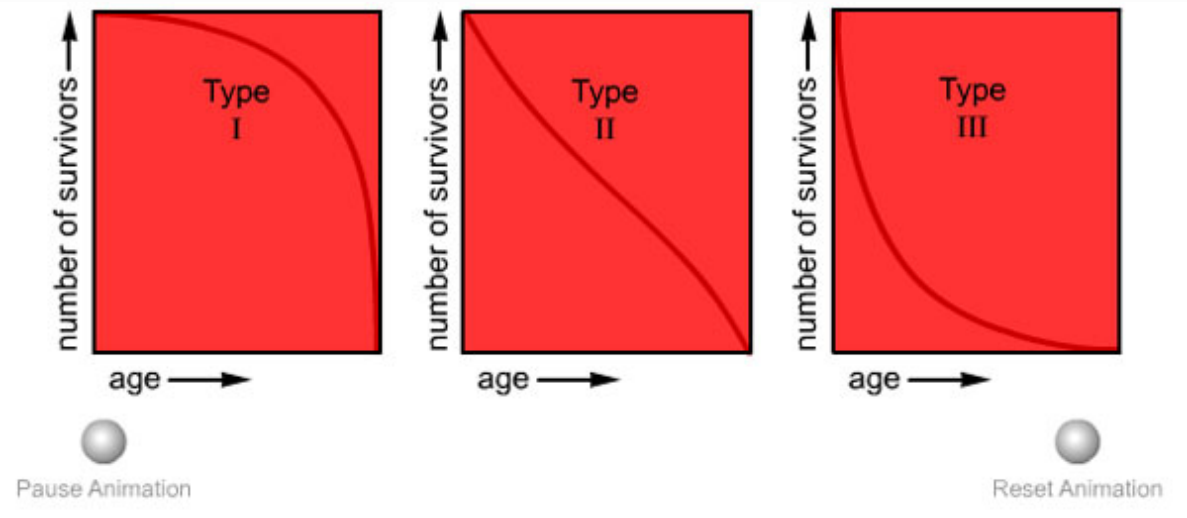
Fig. 5-5b, p. 106

In Some Interactions, One Species Benefits and the Other Is Not Harmed

- **Commensalism**
- Epiphytes
- Birds nesting in trees

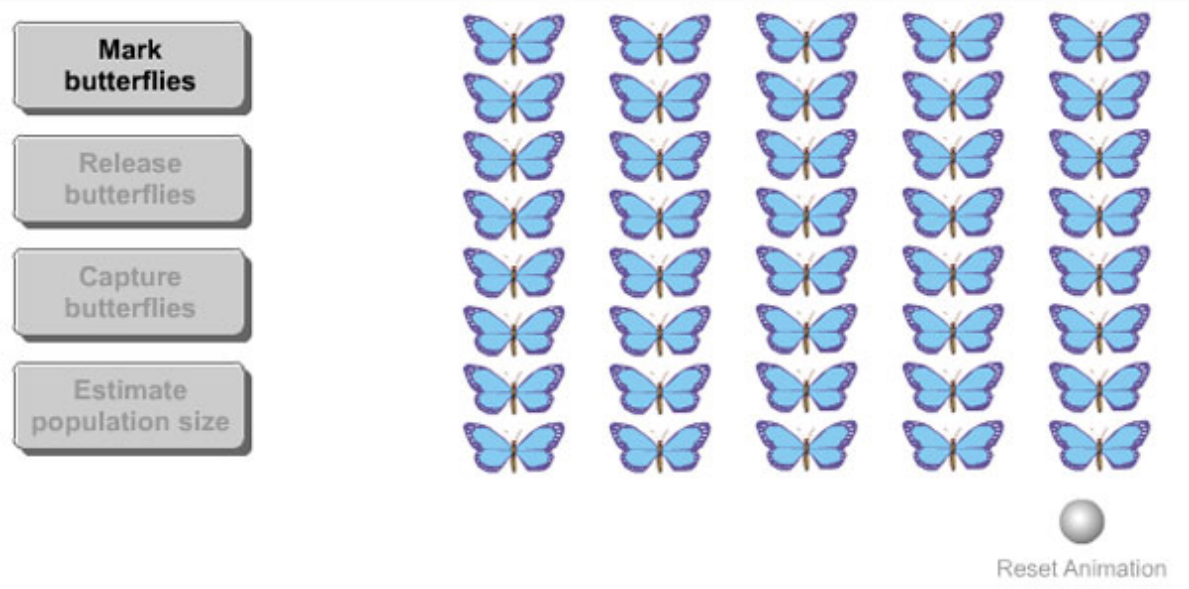
Commensalism: Bromiliad Roots on Tree Trunk Without Harming Tree

Animation: Life history patterns



PLAY

Animation: Capture-recapture method



PLAY

Video: Kelp forest (Channel Islands)

PLAY

Video: Otter feeding

PLAY

Video: Salmon swimming upstream

PLAY

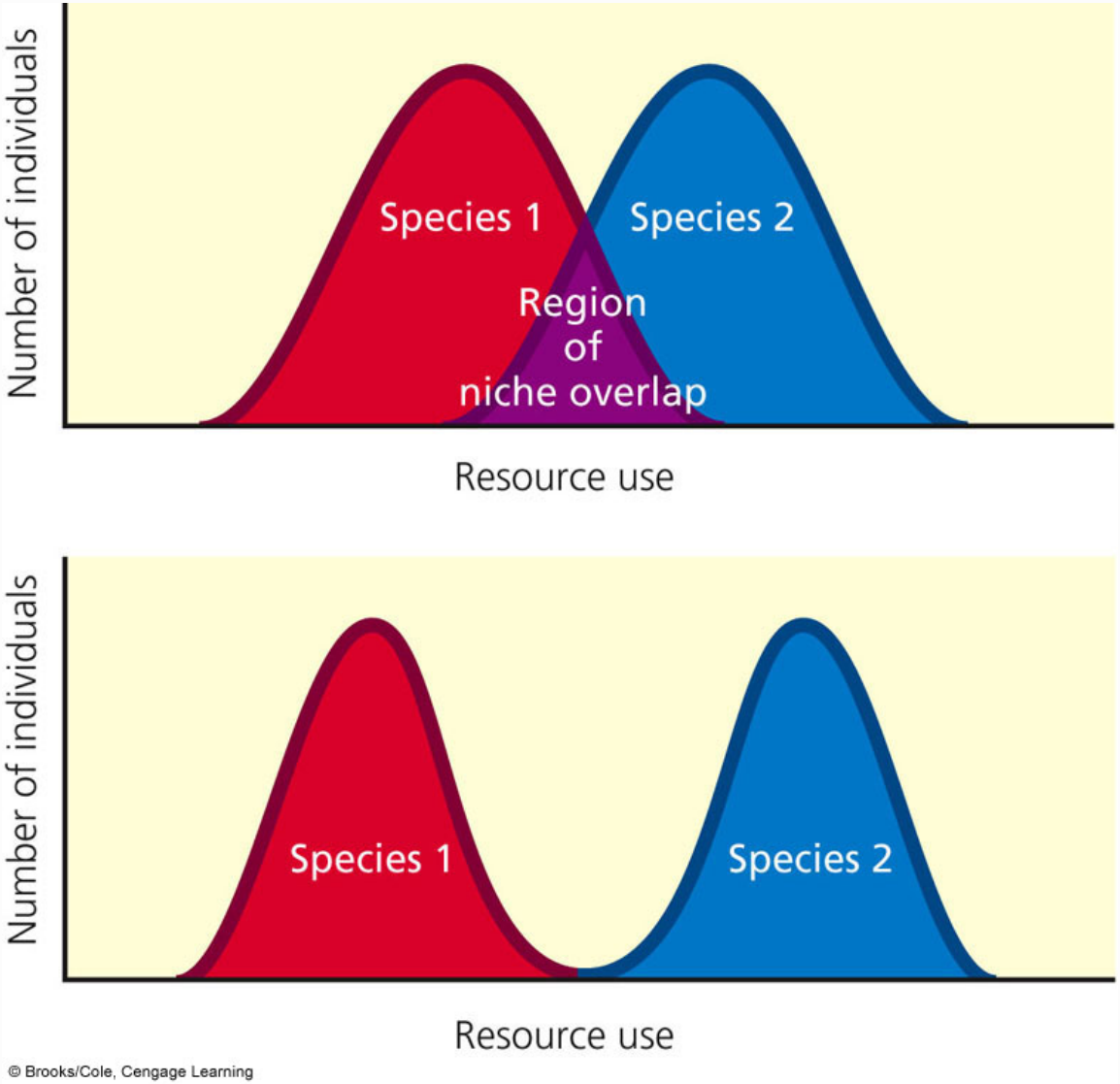
5-2 How Can Natural Selection Reduce Competition between Species?

- ***Concept 5-2*** *Some species develop adaptations that allow them to reduce or avoid competition with other species for resources.*

Some Species Evolve Ways to Share Resources

- **Resource partitioning**
- Reduce niche overlap
- Use shared resources at different
  - Times
  - Places
  - Ways

Competing Species Can Evolve to Reduce Niche Overlap



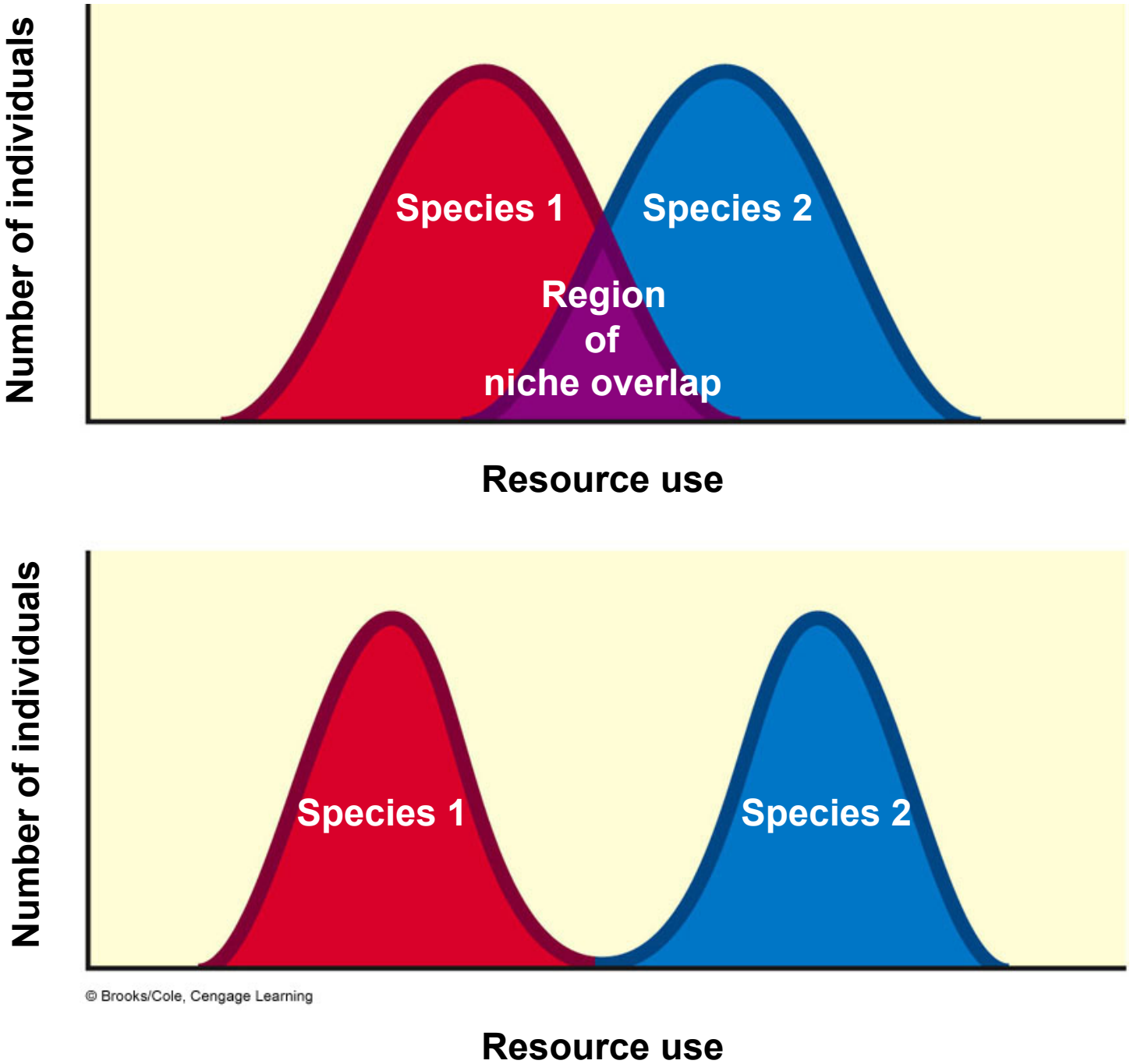


Fig. 5-7, p. 107

Sharing the Wealth: Resource Partitioning

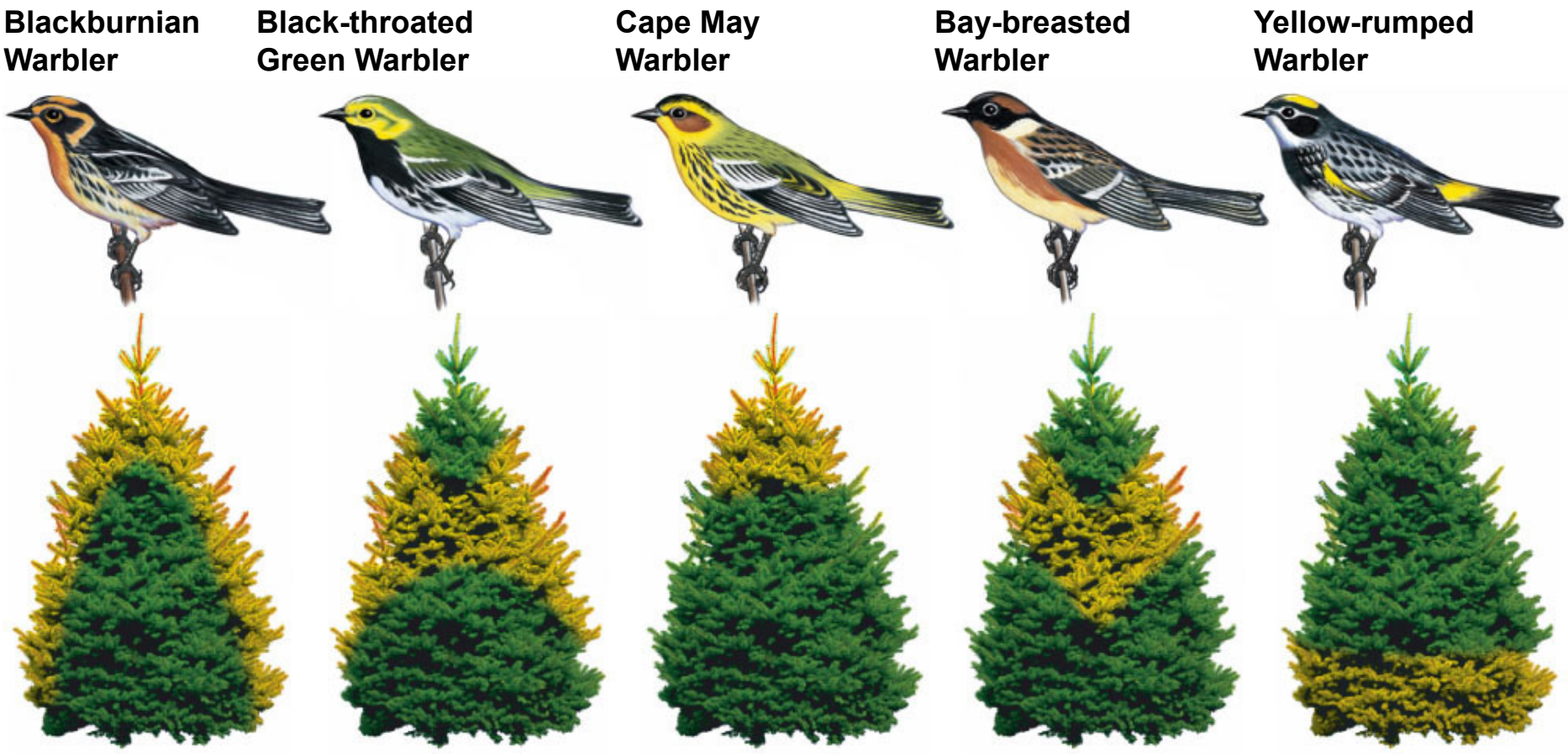
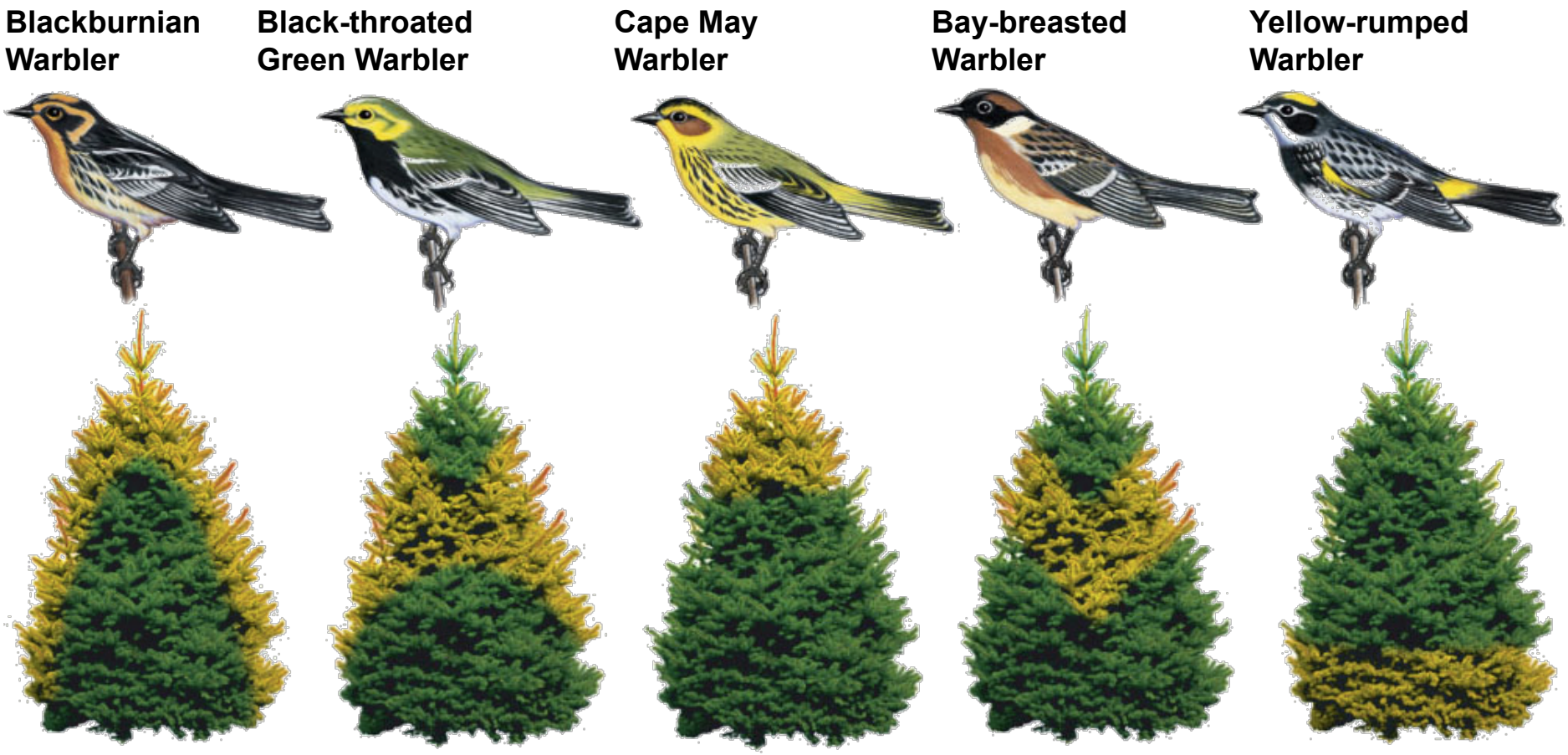


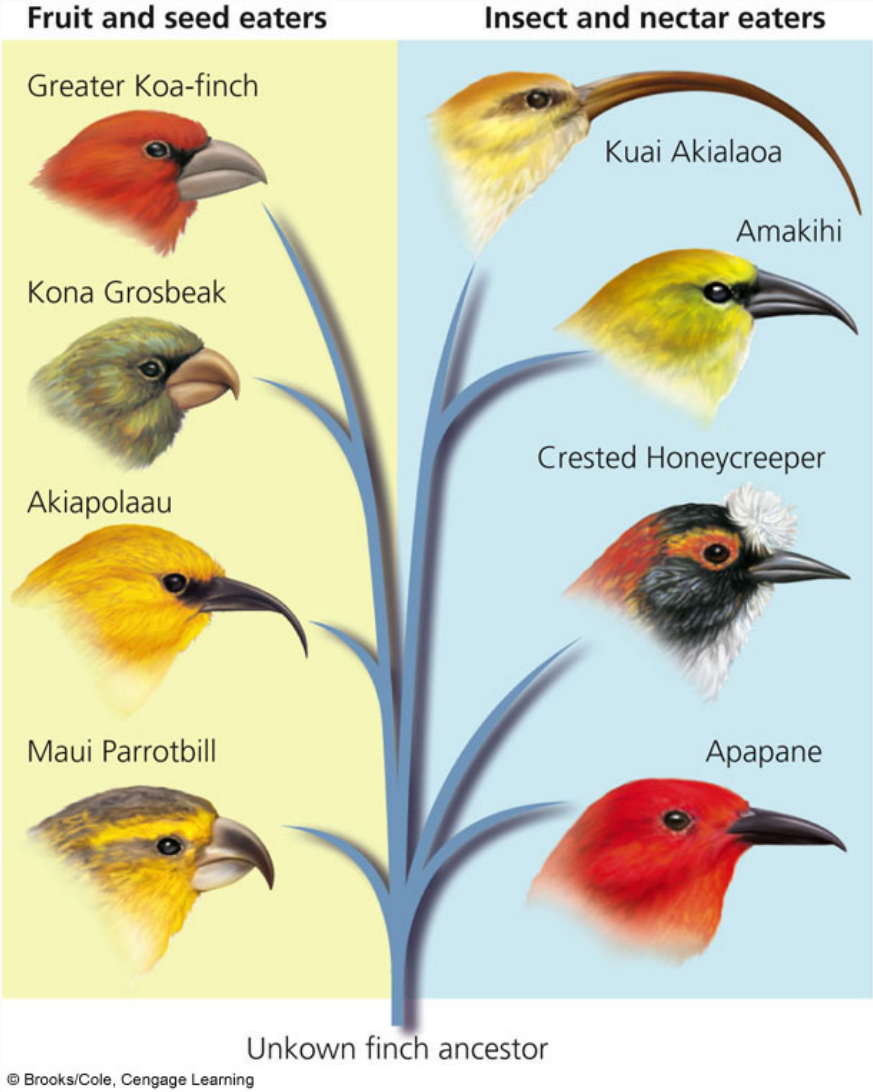
Fig. 5-8, p. 107



Stepped Art

Fig. 5-8, p. 107

Specialist Species of Honeycreepers



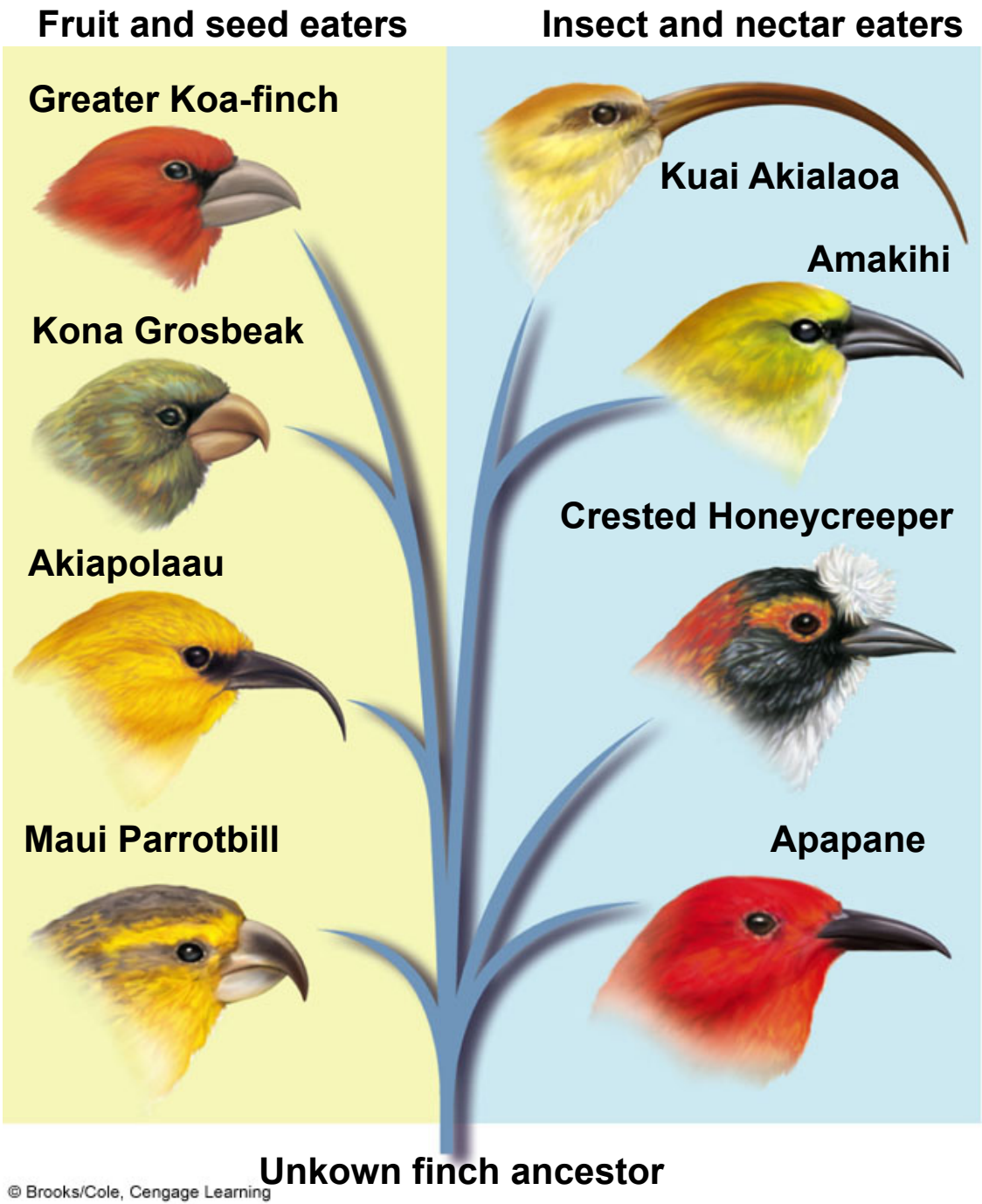


Fig. 5-9, p. 108

5-3 What Limits the Growth of Populations?

- ***Concept 5-3*** *No population can continue to grow indefinitely because of limitations on resources and because of competition among species for those resources.*

Populations Have Certain Characteristics (1)

- Populations differ in
  - Distribution
  - Numbers
  - Age structure

- **Population dynamics**

Populations Have Certain Characteristics (2)

- Changes in population characteristics due to:
  - Temperature
  - Presence of disease organisms or harmful chemicals
  - Resource availability
  - Arrival or disappearance of competing species

Most Populations Live Together in Clumps or Patches (1)

- Population distribution
  - Clumping
  - Uniform dispersion
  - Random dispersion

Most Populations Live Together in Clumps or Patches (2)

- Why clumping?
  - Species tend to cluster where resources are available
  - Groups have a better chance of finding clumped resources
  - Protects some animals from predators
  - Packs allow some to get prey
  - Temporary groups for mating and caring for young

Populations Can Grow, Shrink, or Remain Stable (1)

- Population size governed by
  - Births
  - Deaths
  - Immigration
  - Emigration

- Population change =

  (births + immigration) – (deaths + emigration)

Populations Can Grow, Shrink, or Remain Stable (2)

- Age structure
  - Pre-reproductive age
  - Reproductive age
  - Post-reproductive age

No Population Can Grow Indefinitely: J-Curves and S-Curves (1)

- Biotic potential
  - Low
  - High
- **Intrinsic rate of increase (r)**
- Individuals in populations with high **r**
  - Reproduce early in life
  - Have short generation times
  - Can reproduce many times
  - Have many offspring each time they reproduce

No Population Can Grow Indefinitely: J-Curves and S-Curves (2)

- Size of populations limited by
  - Light
  - Water
  - Space
  - Nutrients
  - Exposure to too many competitors, predators or infectious diseases

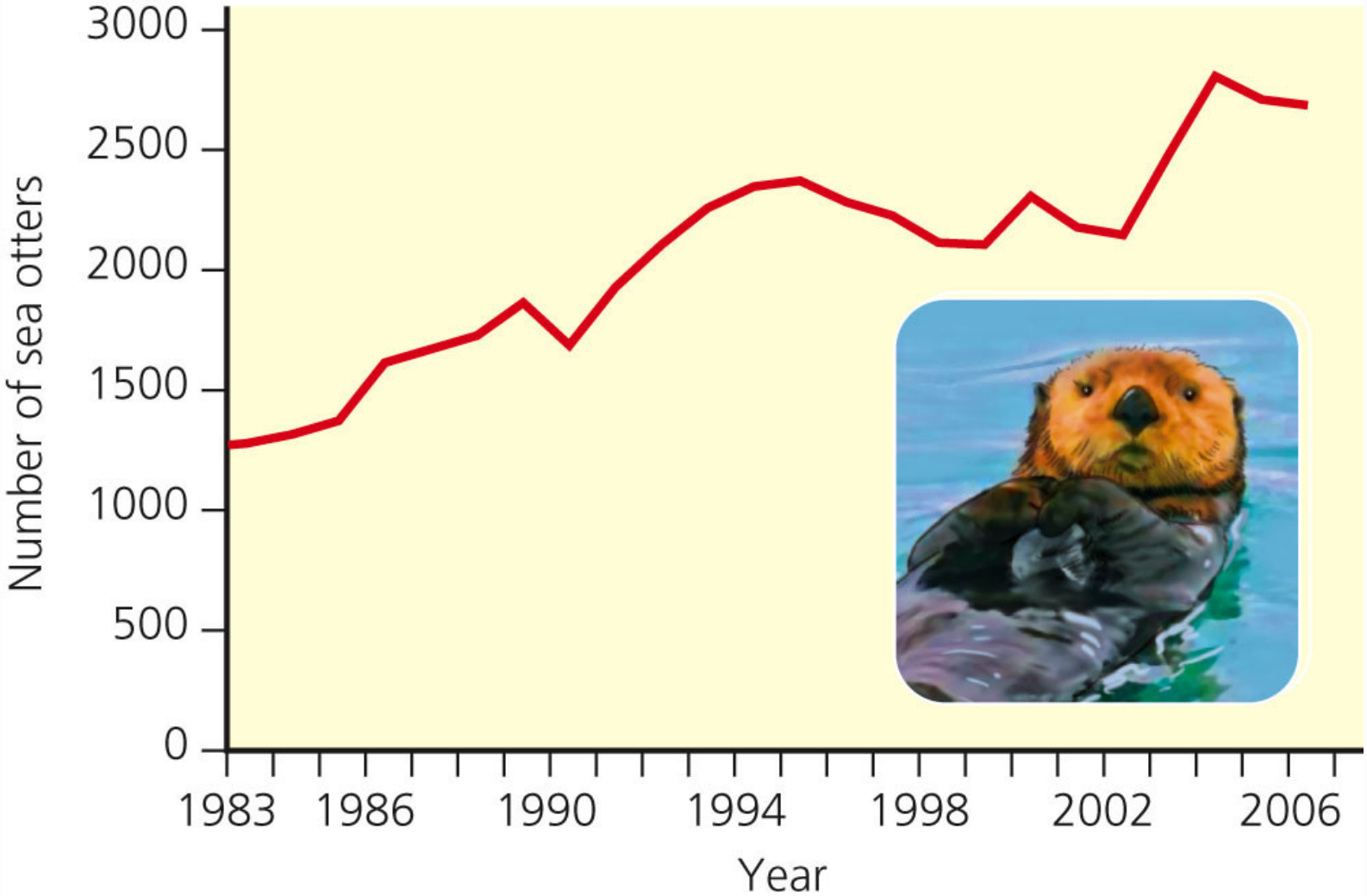
No Population Can Grow Indefinitely: J-Curves and S-Curves (3)

- Environmental resistance
- Carrying capacity (K)
- Exponential growth
- Logistic growth

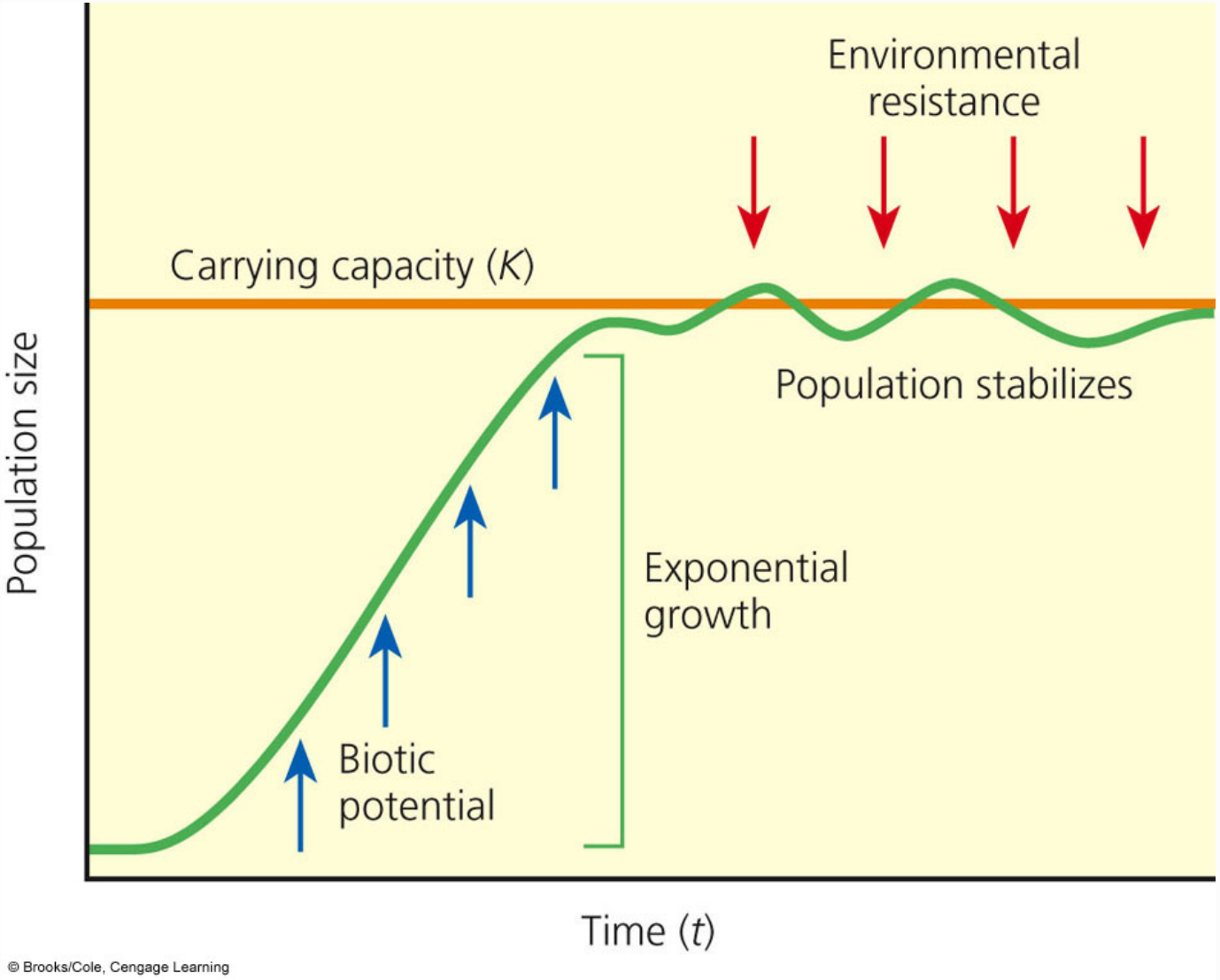
Science Focus: Why Are Protected Sea Otters Making a Slow Comeback?

- Low biotic potential
- Prey for orcas
- Cat parasites
- Thorny-headed worms
- Toxic algae blooms
- PCBs and other toxins
- Oil spills

Population Size of Southern Sea Otters Off the Coast of So. California (U.S.)



No Population Can Continue to Increase in Size Indefinitely



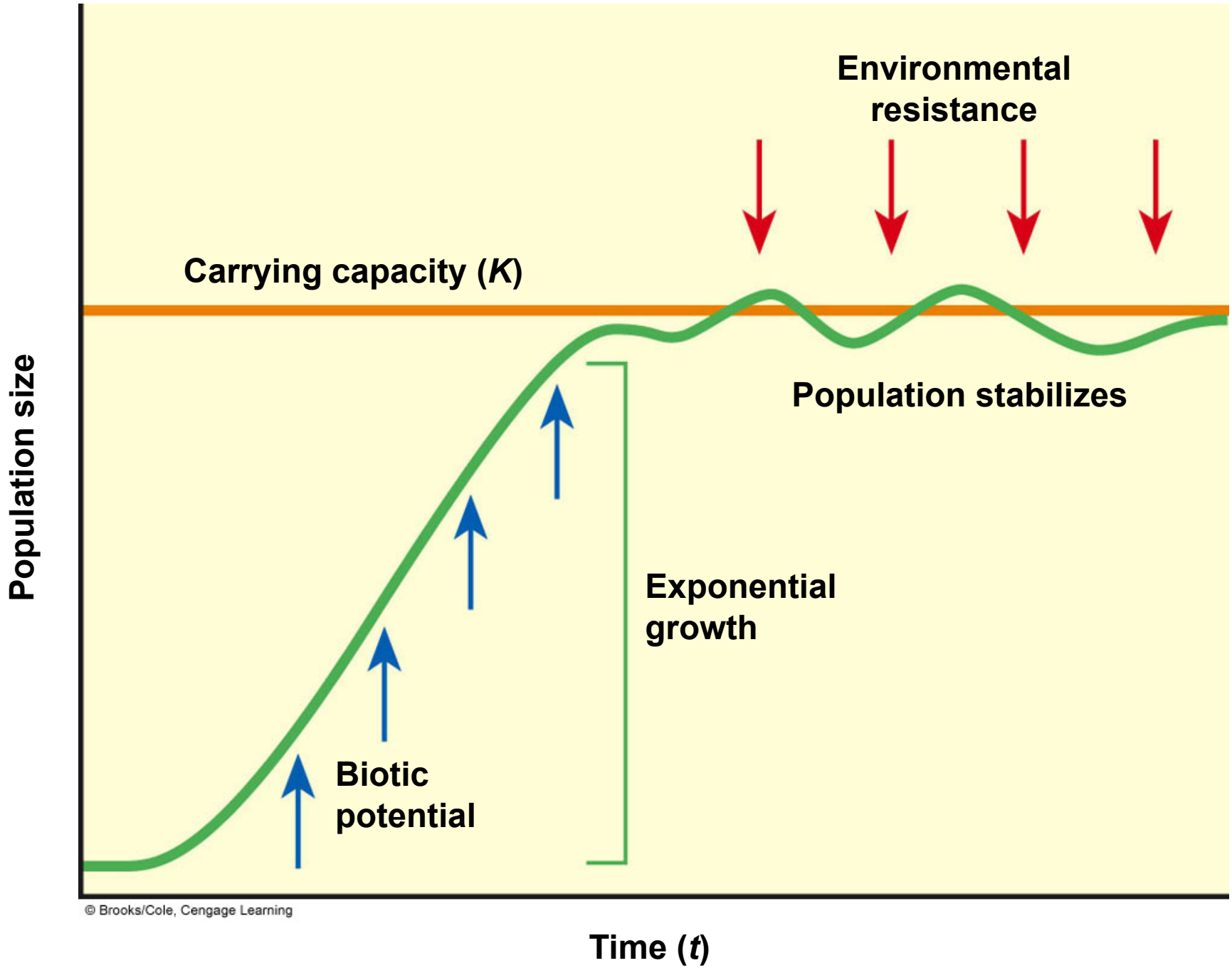
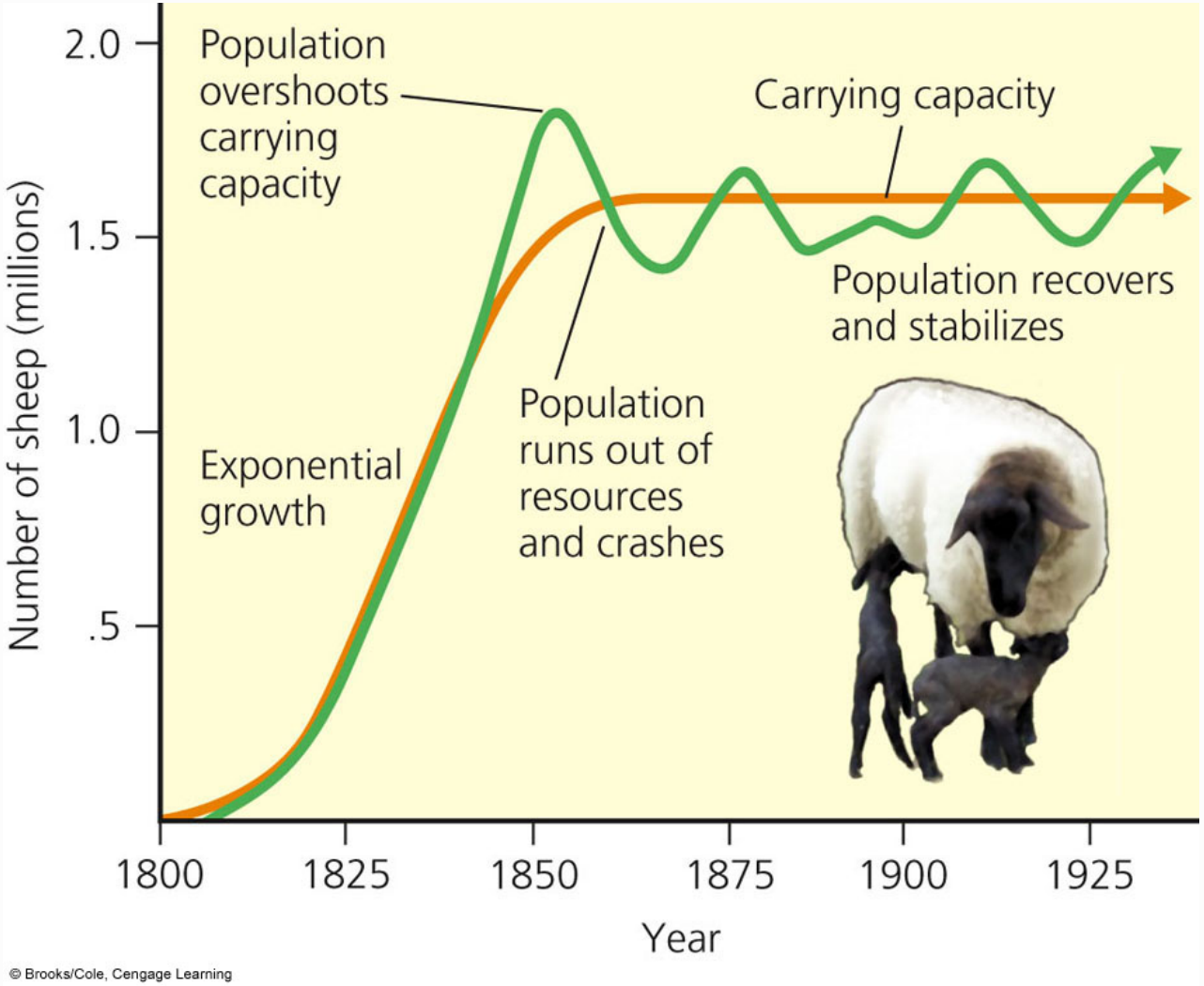

Environmental resistance
Carrying capacity (K)
Population stabilizes
Population size
Exponential growth
Biotic potential
© Brooks/Cole, Cengage Learning
Time (t)

Fig. 5-11, p. 111

Logistic Growth of a Sheep Population on the island of Tasmania, 1800–1925



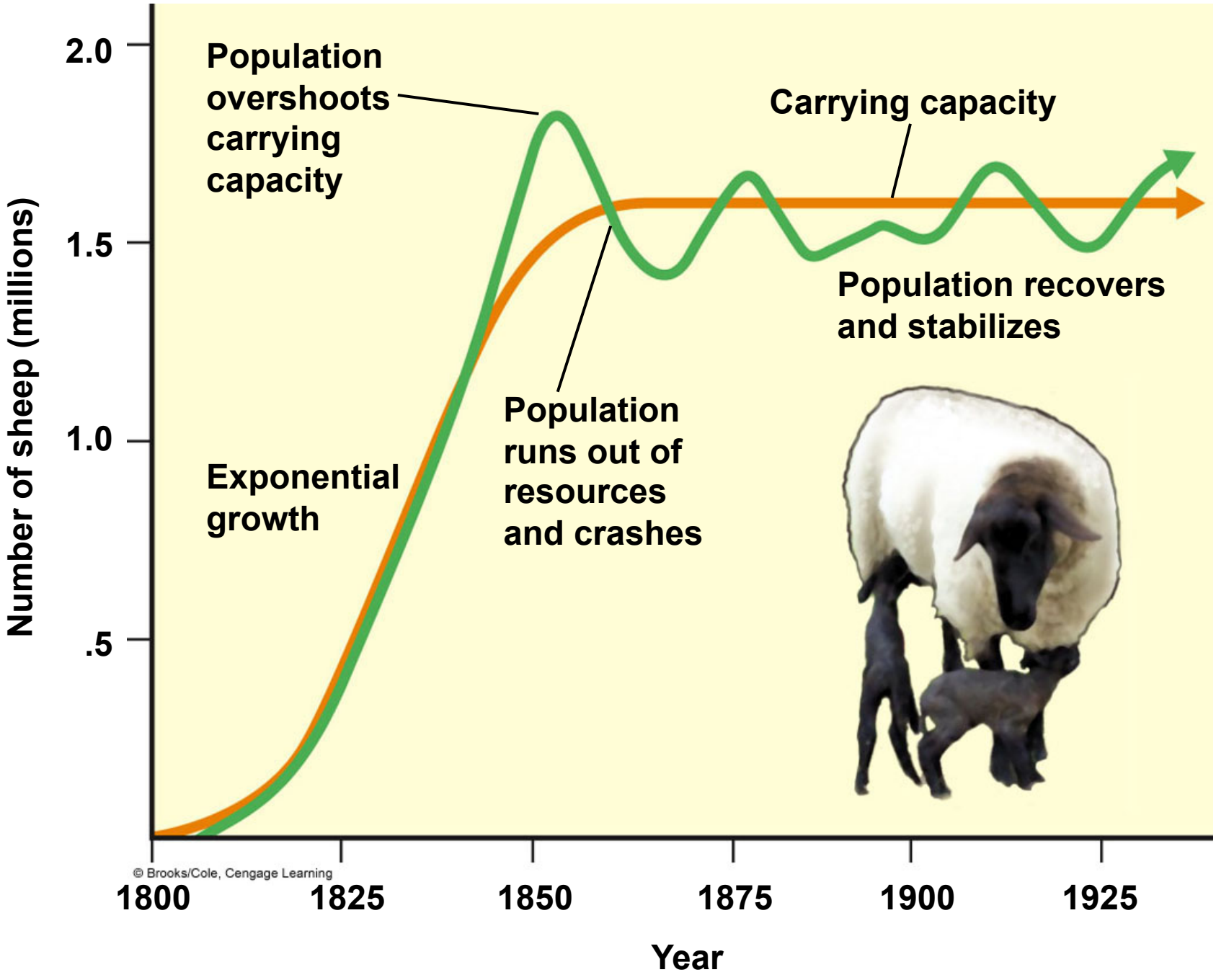
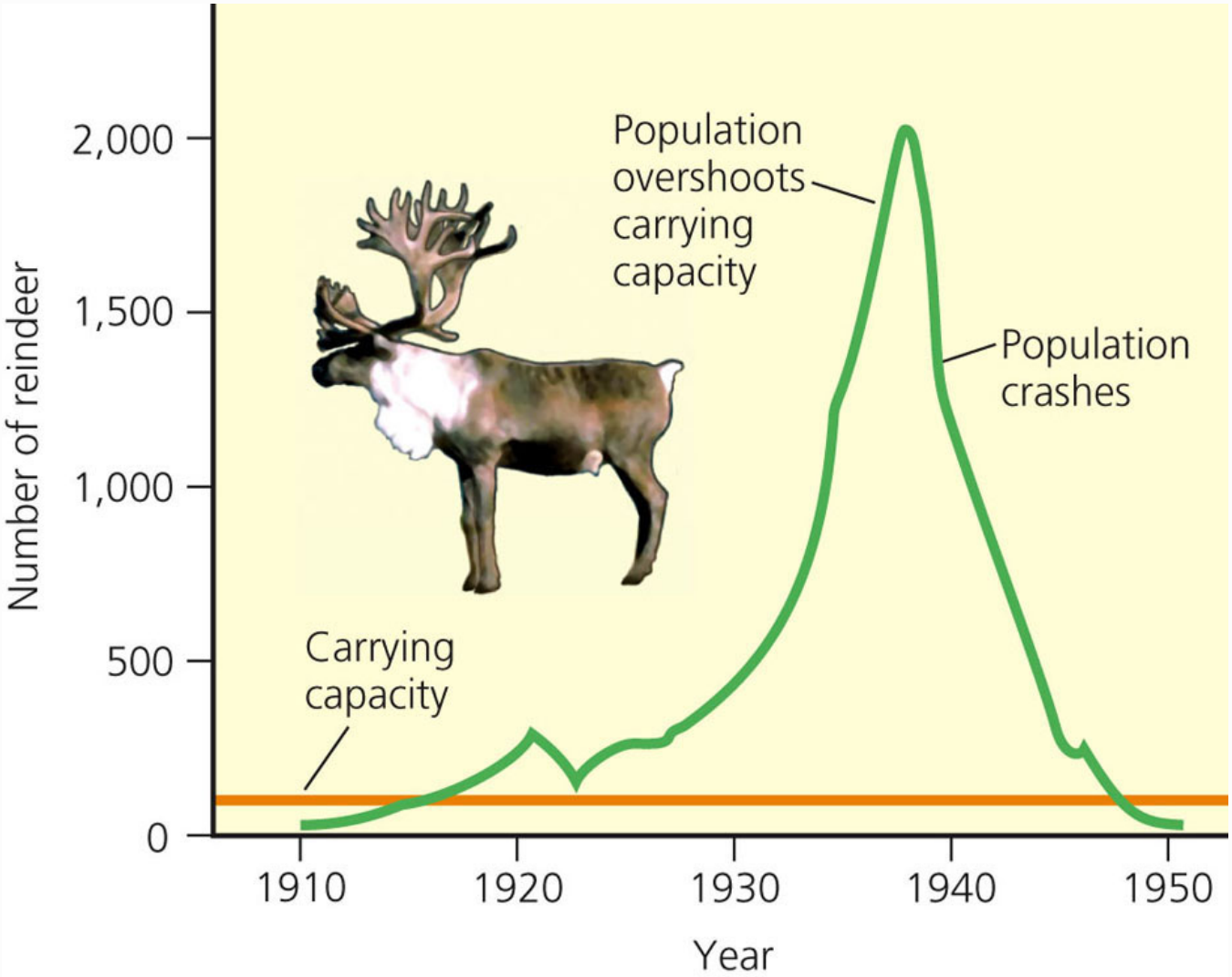

Population overshoots carrying capacity
Carrying capacity
Population recovers and stabilizes
Population runs out of resources and crashes
Exponential growth
Number of sheep (millions)
2.0
1.5
1.0
.5
1800
1825
1850
1875
1900
1925
Year
© Brooks/Cole, Cengage Learning

Fig. 5-12, p. 111

When a Population Exceeds Its Habitat's Carrying Capacity, Its Population Can Crash

- Carrying capacity: not fixed
- **Reproductive time lag** may lead to **overshoot**
  - **Dieback (crash)**
- Damage may reduce area's carrying capacity

Exponential Growth, Overshoot, and Population Crash of a Reindeer



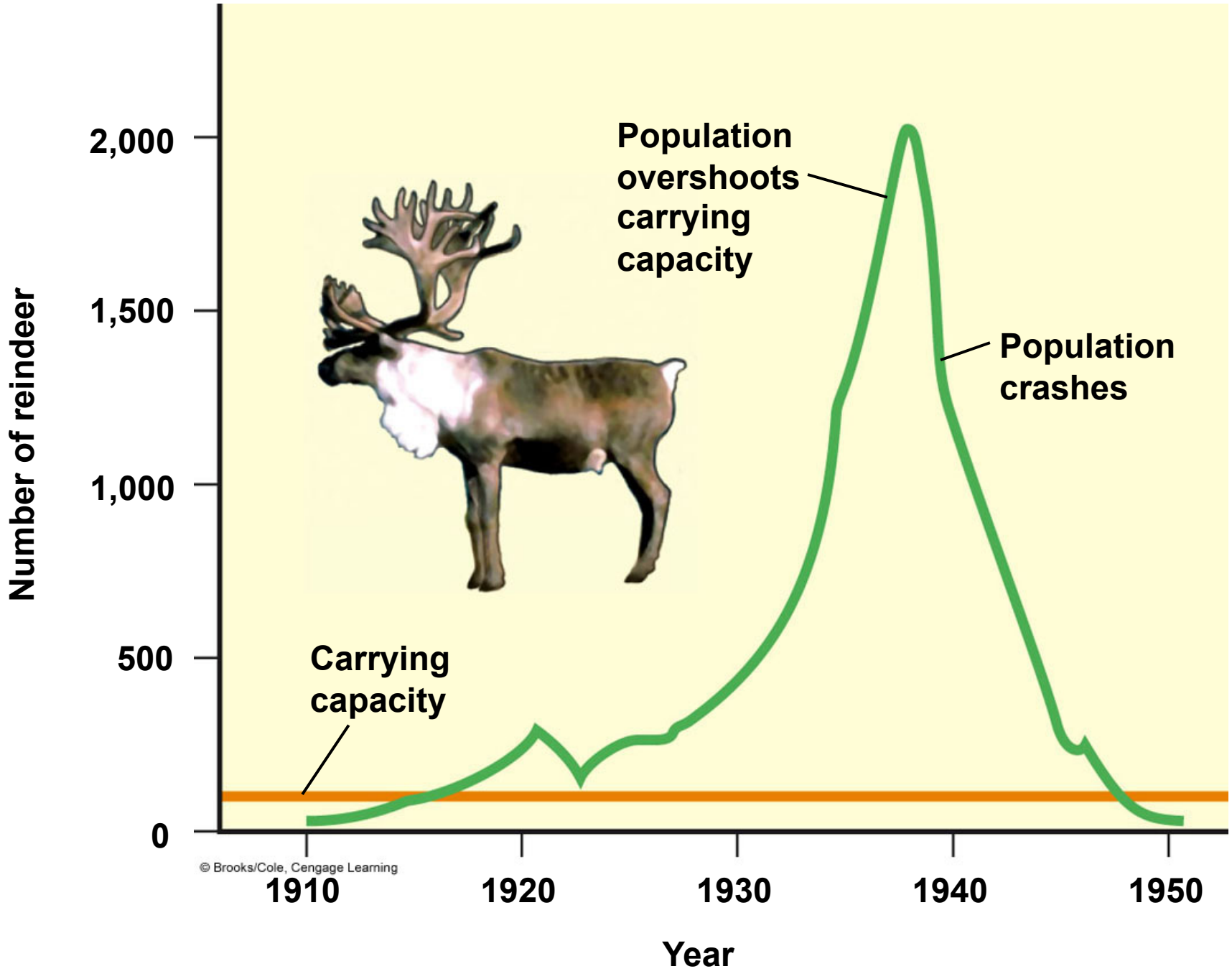
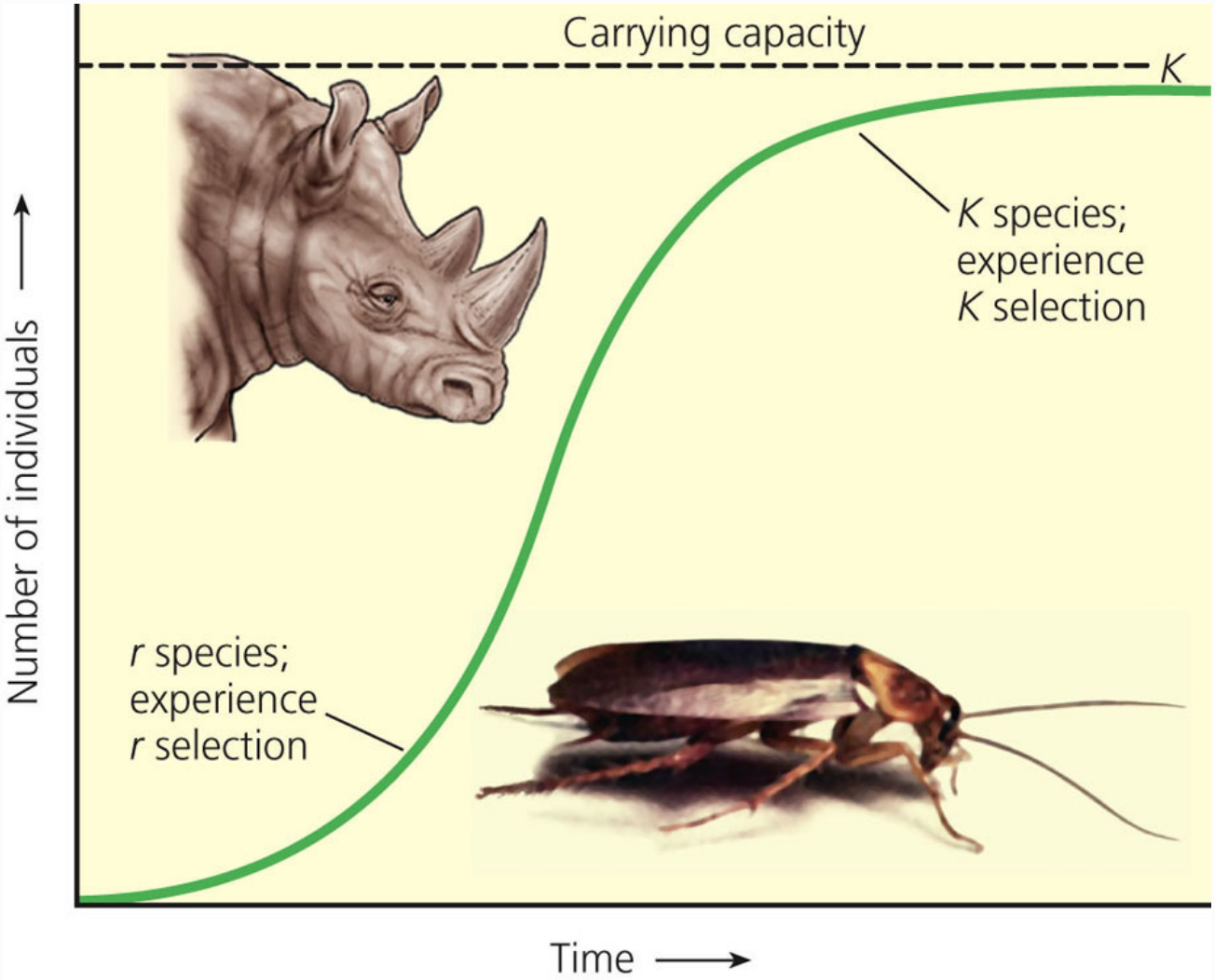

Number of reindeer
2,000
1,500
1,000
500
0
Population overshoots carrying capacity
Population crashes
Carrying capacity
© Brooks/Cole, Cengage Learning
1910
1920
1930
1940
1950
Year

Fig. 5-13, p. 112

Species Have Different Reproductive Patterns

- r-Selected species, opportunists
- K-selected species, competitors

Positions of r- and K-Selected Species on the S-Shaped Population Growth Curve



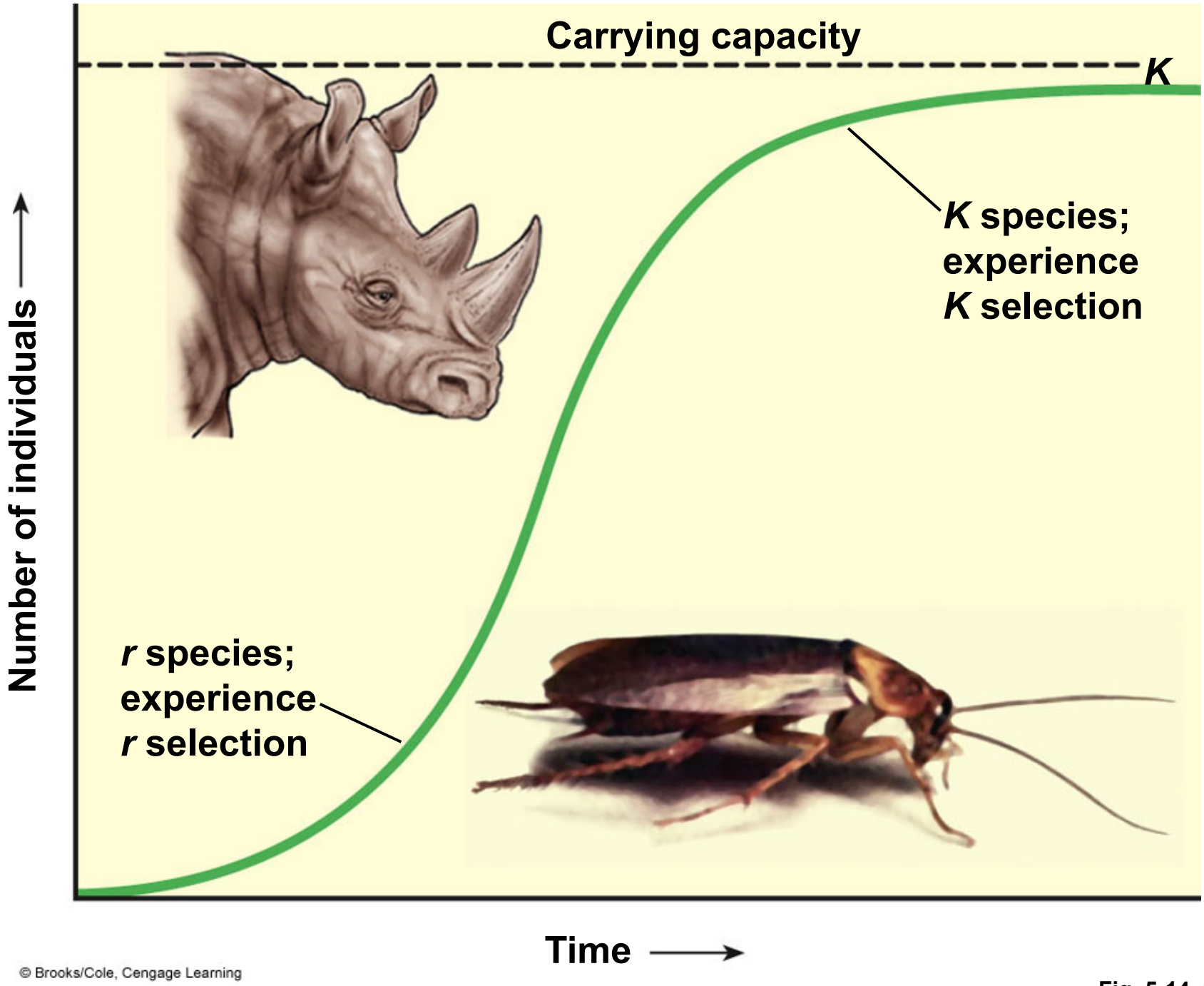


Fig. 5-14, p. 112

Genetic Diversity Can Affect the Size of Small Populations

- Founder effect
- Demographic bottleneck
- Genetic drift
- Inbreeding
- Minimum viable population size

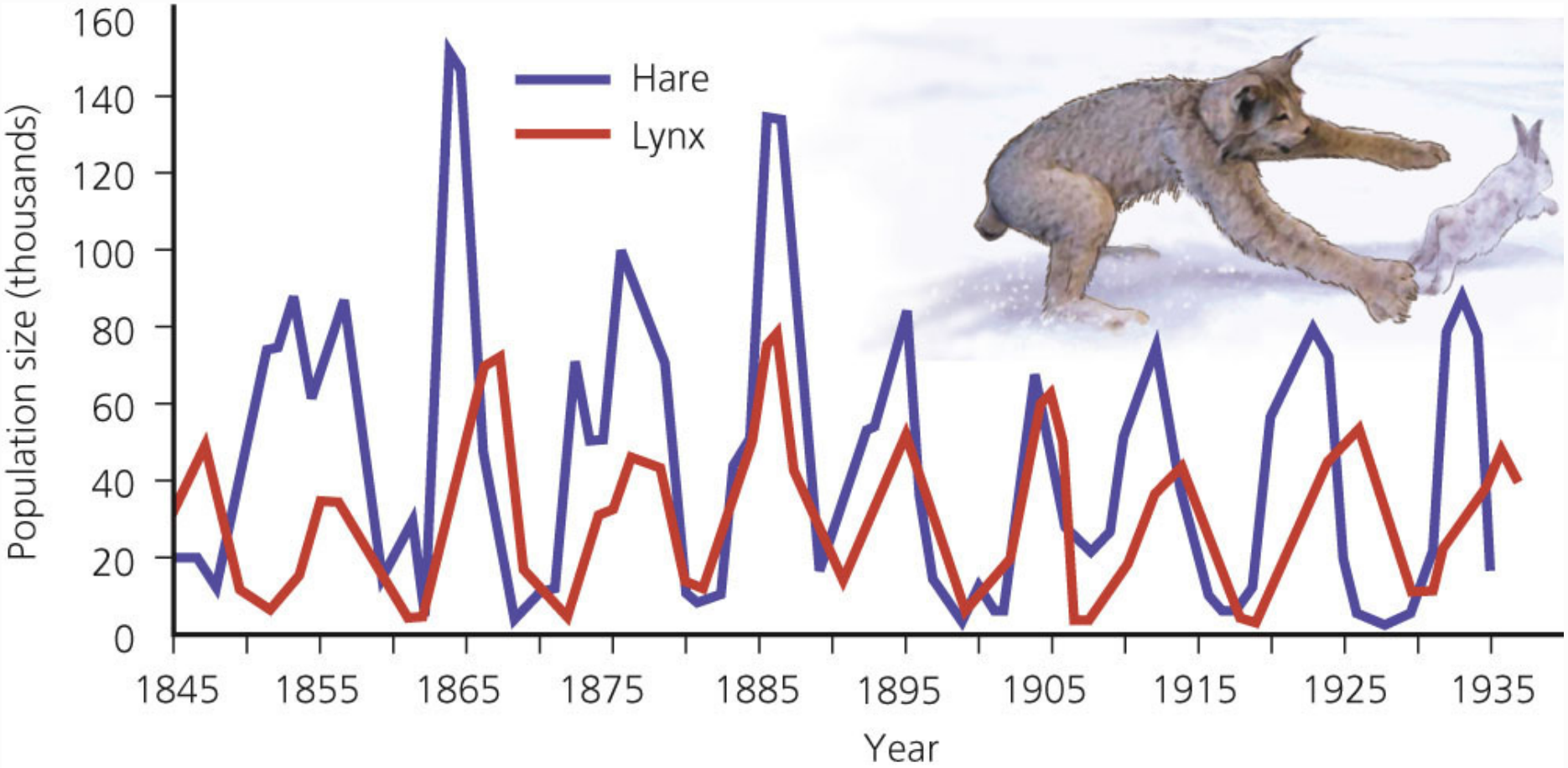
Under Some Circumstances Population Density Affects Population Size

- **Density-dependent population controls**
  - Predation
  - Parasitism
  - Infectious disease
  - Competition for resources

Several Different Types of Population Change Occur in Nature

- **Stable**
- **Irruptive**
- **Cyclic fluctuations, boom-and-bust cycles**
  - Top-down population regulation
  - Bottom-up population regulation
- **Irregular**

Population Cycles for the Snowshoe Hare and Canada Lynx



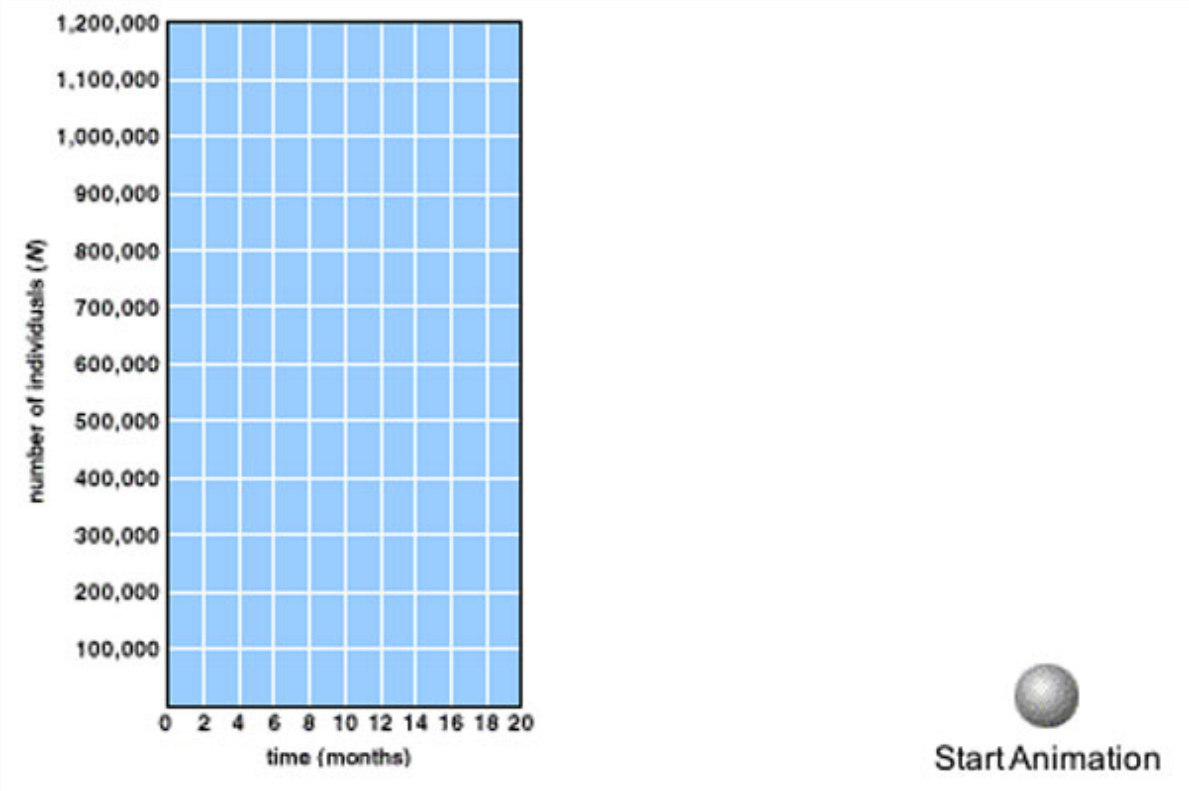
Humans Are Not Exempt from Nature's Population Controls

- Ireland
  - Potato crop in 1845
- Bubonic plague
  - Fourteenth century
- AIDS
  - Global epidemic

Case Study: Exploding White-Tailed Deer Population in the U.S.

- 1900: deer habitat destruction and uncontrolled hunting
- 1920s–1930s: laws to protect the deer
- Current population explosion for deer
  - Lyme disease
  - Deer-vehicle accidents
  - Eating garden plants and shrubs
- Ways to control the deer population

Active Figure: Exponential growth



PLAY

Animation: Logistic growth

PLAY

5-4 How Do Communities and Ecosystems Respond to Changing Environmental Conditions?

- ***Concept 5-4*** *The structure and species composition of communities and ecosystems change in response to changing environmental conditions through a process called ecological succession.*

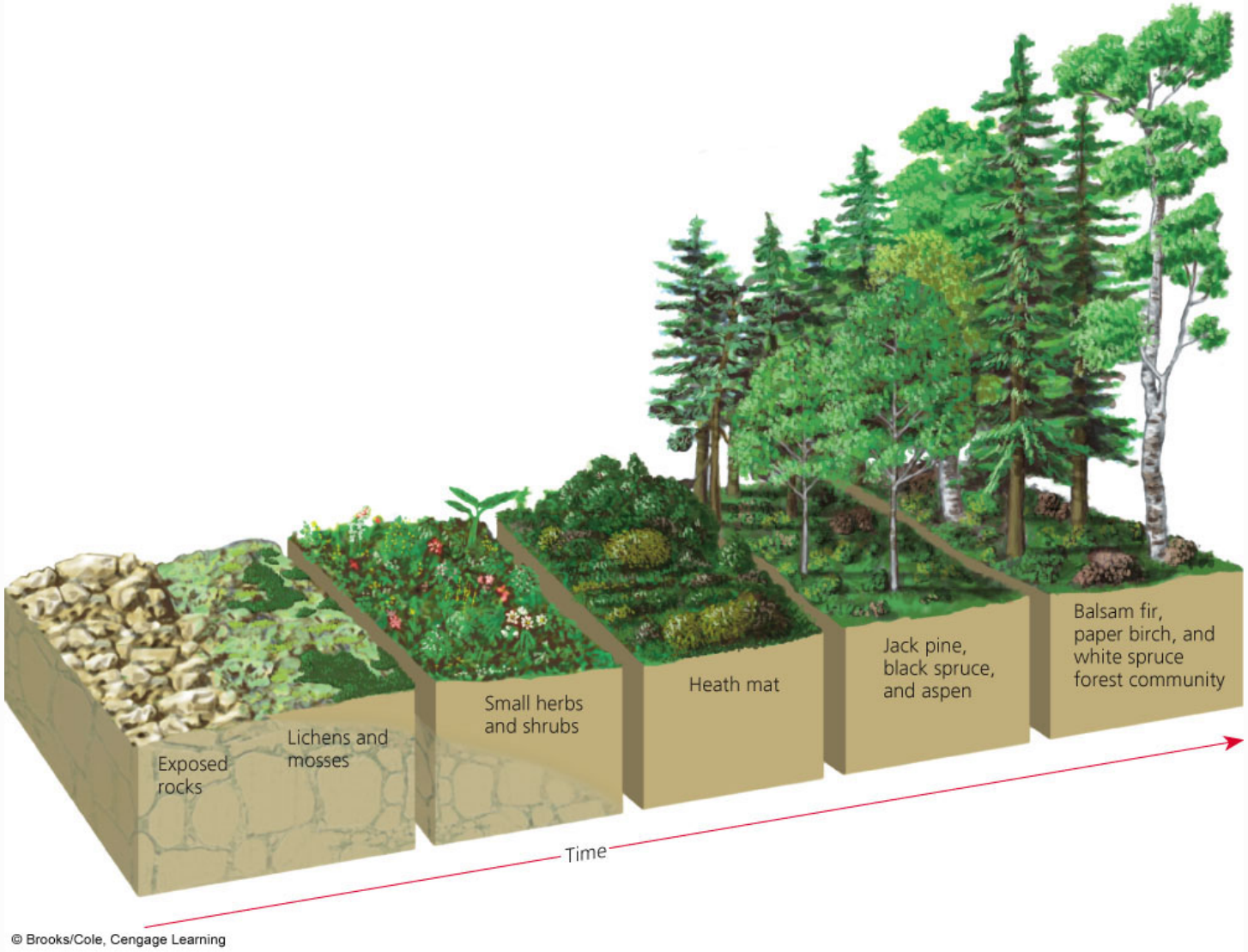
Communities and Ecosystems Change over Time: Ecological Succession

- Natural ecological restoration
  - Primary succession
  - Secondary succession

Some Ecosystems Start from Scratch: Primary Succession

- No soil in a terrestrial system
- No bottom sediment in an aquatic system
- **Early successional plant species, pioneer**
- **Midsuccessional plant species**
- **Late successional plant species**

Primary Ecological Succession



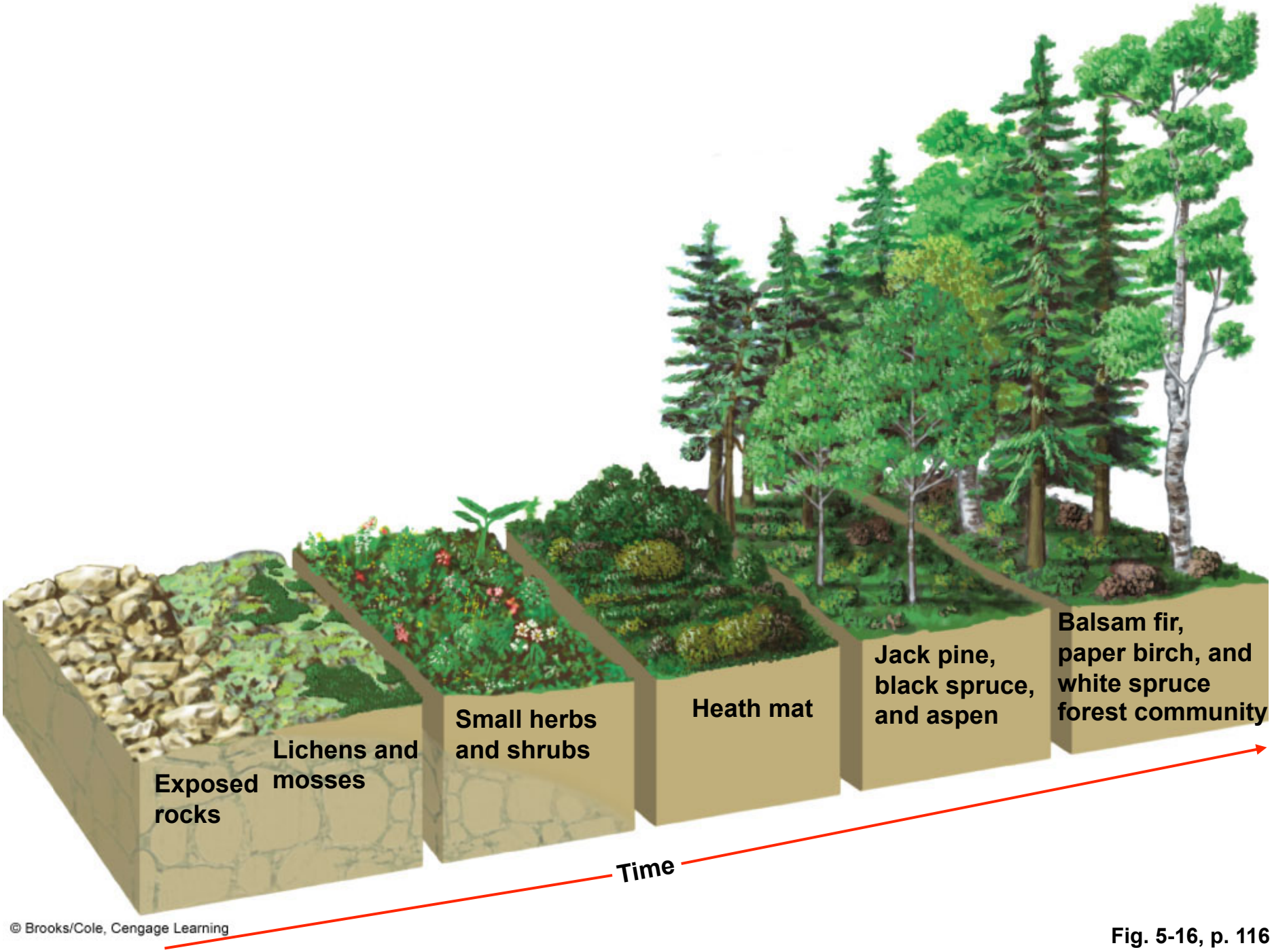
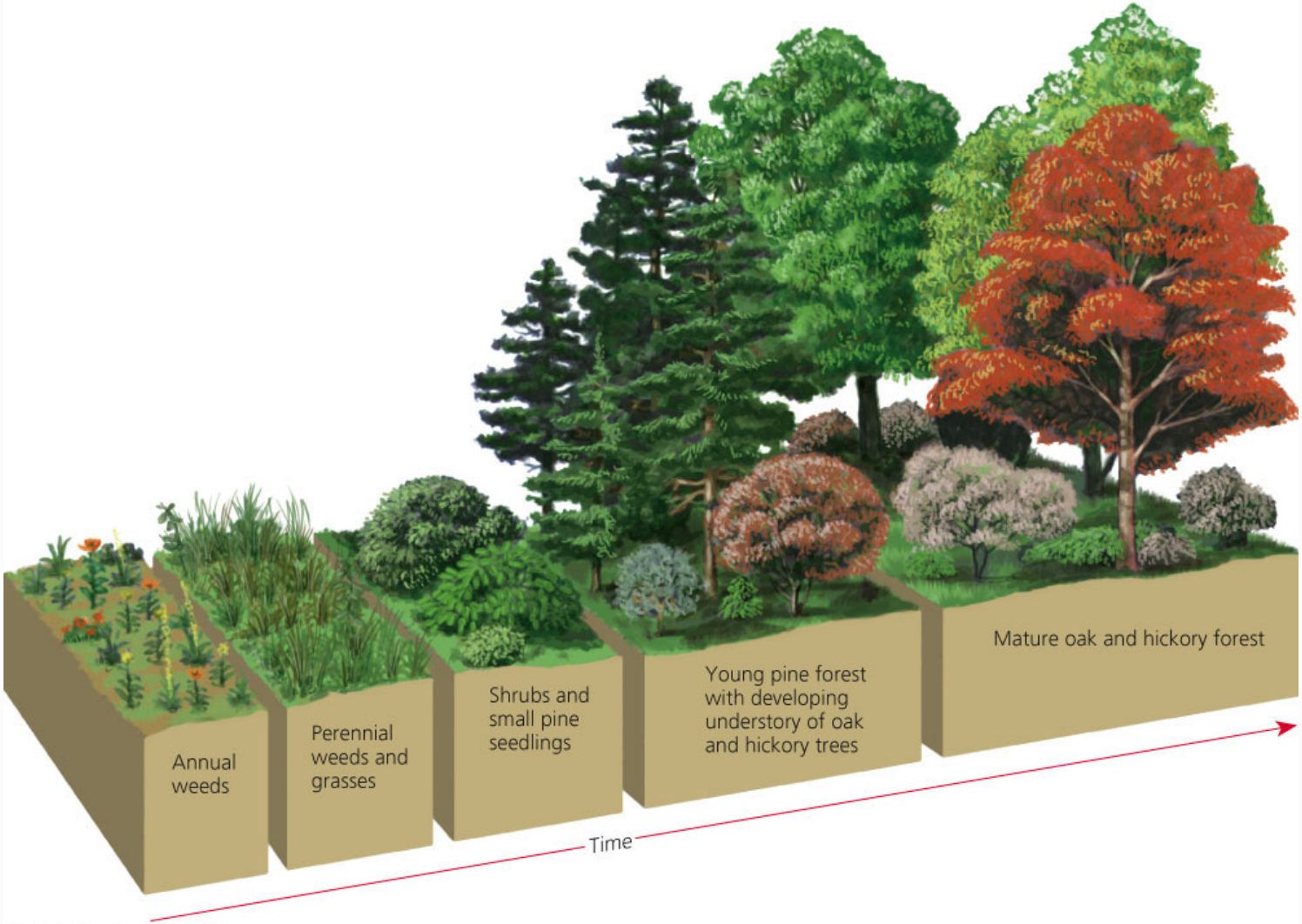


Fig. 5-16, p. 116

Some Ecosystems Do Not Have to Start from Scratch: Secondary Succession (1)

- Some soil remains in a terrestrial system
- Some bottom sediment remains in an aquatic system
- Ecosystem has been
  - Disturbed
  - Removed
  - Destroyed

Natural Ecological Restoration of Disturbed Land



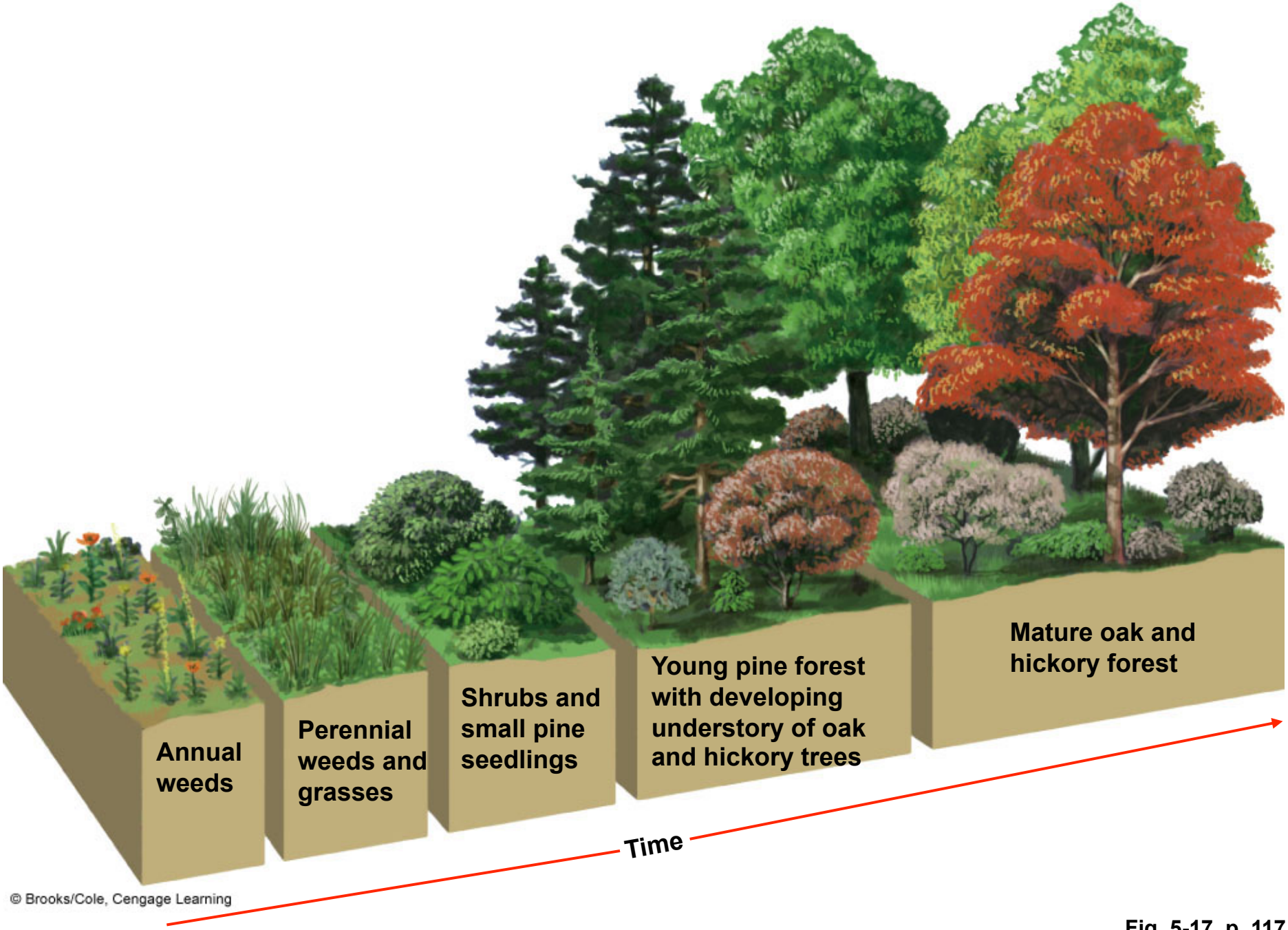


Fig. 5-17, p. 117

Some Ecosystems Do Not Have to Start from Scratch: Secondary Succession (2)

- Primary and secondary succession
  - Tend to increase biodiversity
  - Increase species richness and interactions among species
- Primary and secondary succession can be interrupted by
  - Fires
  - Hurricanes
  - Clear-cutting of forests
  - Plowing of grasslands
  - Invasion by nonnative species

Science Focus: How Do Species Replace One Another in Ecological Succession?

- **Facilitation**
- **Inhibition**
- **Tolerance**

Succession Doesn't Follow a Predictable Path

- Traditional view
  - Balance of nature and a climax community
- Current view
  - Ever-changing mosaic of patches of vegetation
  - Mature late-successional ecosystems
    - State of continual disturbance and change

Living Systems Are Sustained through Constant Change

- **Inertia, persistence**
  - Ability of a living system to survive moderate disturbances
- **Resilience**
  - Ability of a living system to be restored through secondary succession after a moderate disturbance
- **Tipping point**