Chapter 5

Biodiversity, Species Interactions, and Population Control

In looking at nature, never forget that every single organic being around us may be said to be striving to increase its numbers.

- ***Charles Darwin***

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

- live in kelp forests
- eat sea urchins
- hunted in 1900s
- 1977 declared endangered
  - → Increased 300 to 2800
- keystone species
  - → protect kelp forest)

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**

What is Competition?

Competition – two species share a requirement for a limited resource → reduces fitness of one or both species

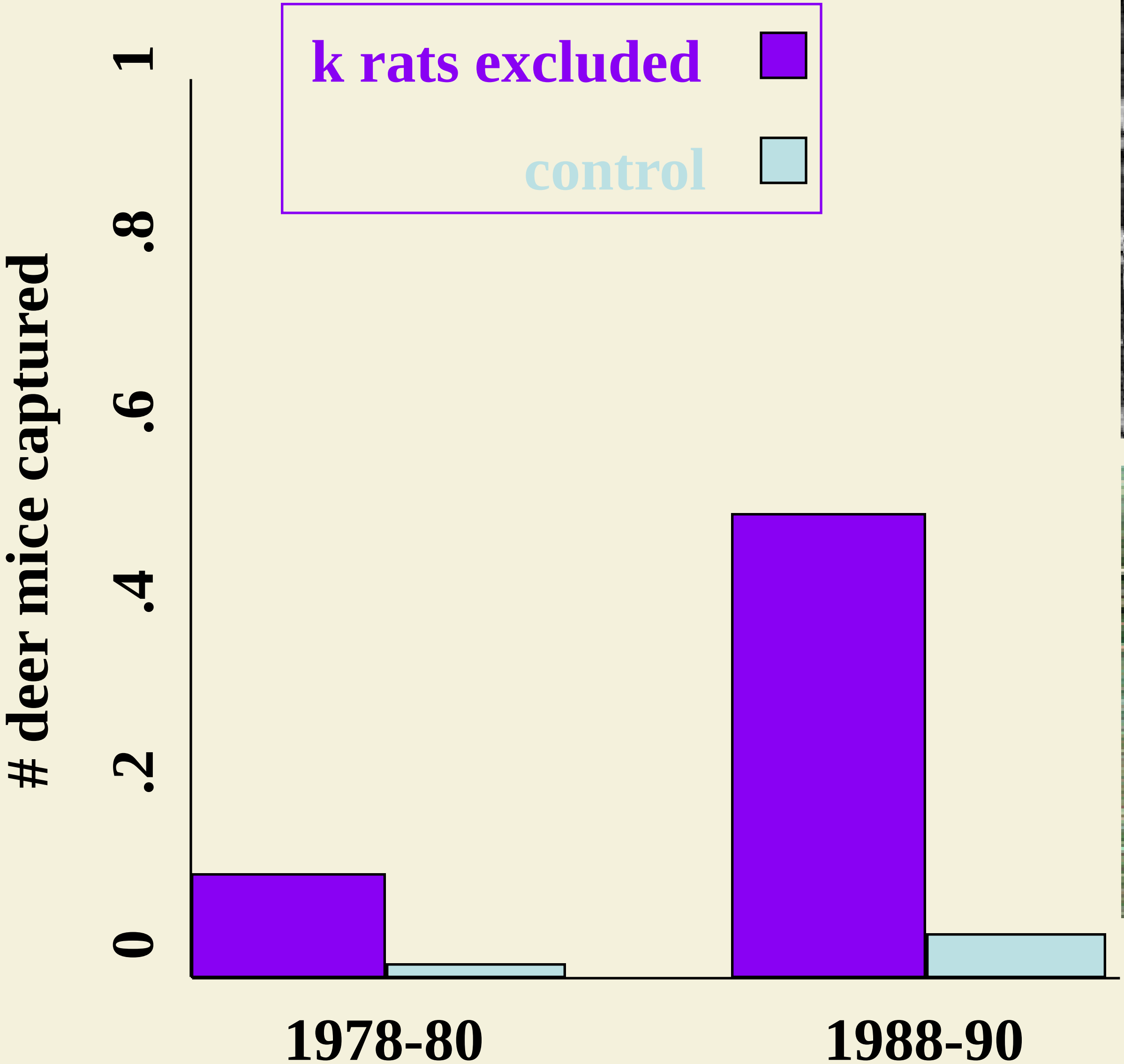
Types of Competition

Intraspecific competition – between individuals of the SAME species

contributes to K (carrying capacity)

Interspecific competition – between individuals of DIFFERENT species

How does interspecific competition affect N?



(Heske, E. J., J. H. Brown, and S. Mistry 1994)

What is the effect of kangaroo rat competition on deer mice?

Competitive Exclusion Principle

If two species have the same niche, the stronger competitor will eliminate the other competitor.

"Complete competitors cannot coexist."

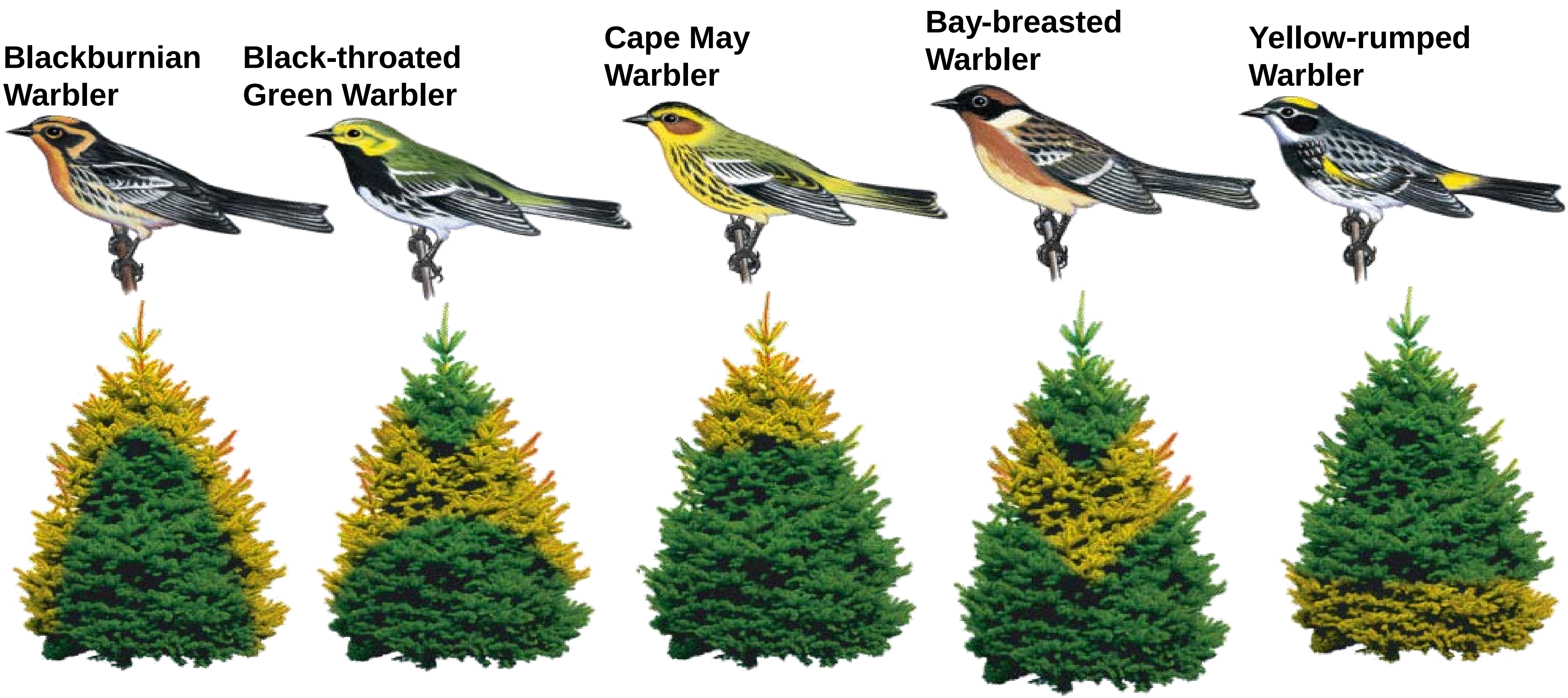
Most Species Compete with One Another for Certain Resources

- For limited resources
- Ecological niche for exploiting resources
- Some niches overlap

RESOURCE PARTIONING

Some Species Evolve Ways to Share Resources

- Using only parts of resource
- Using at different times
- Using in different ways



Stepped Art

Fig. 5-2, p. 106

Specialist Species of Honeycreepers

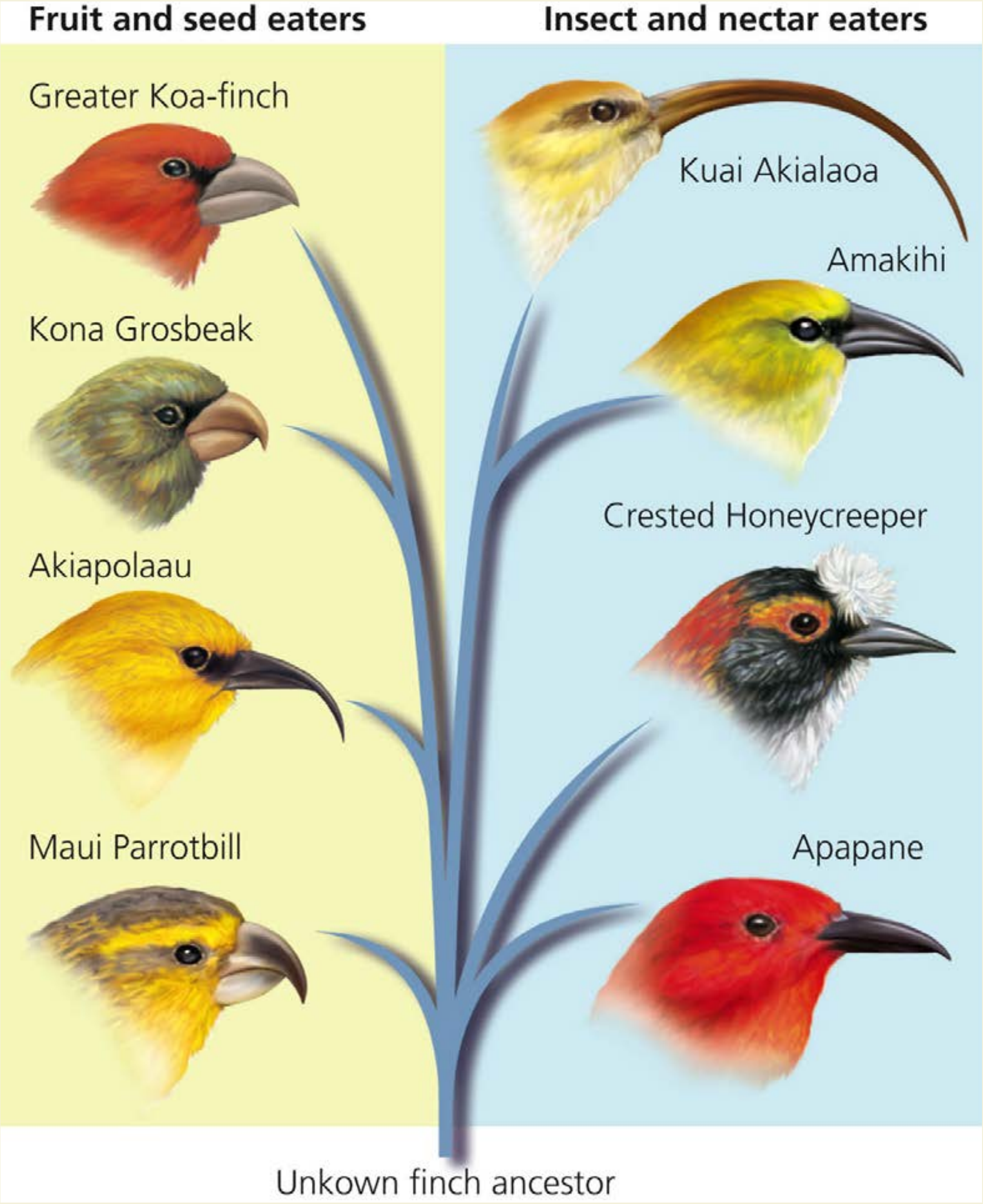


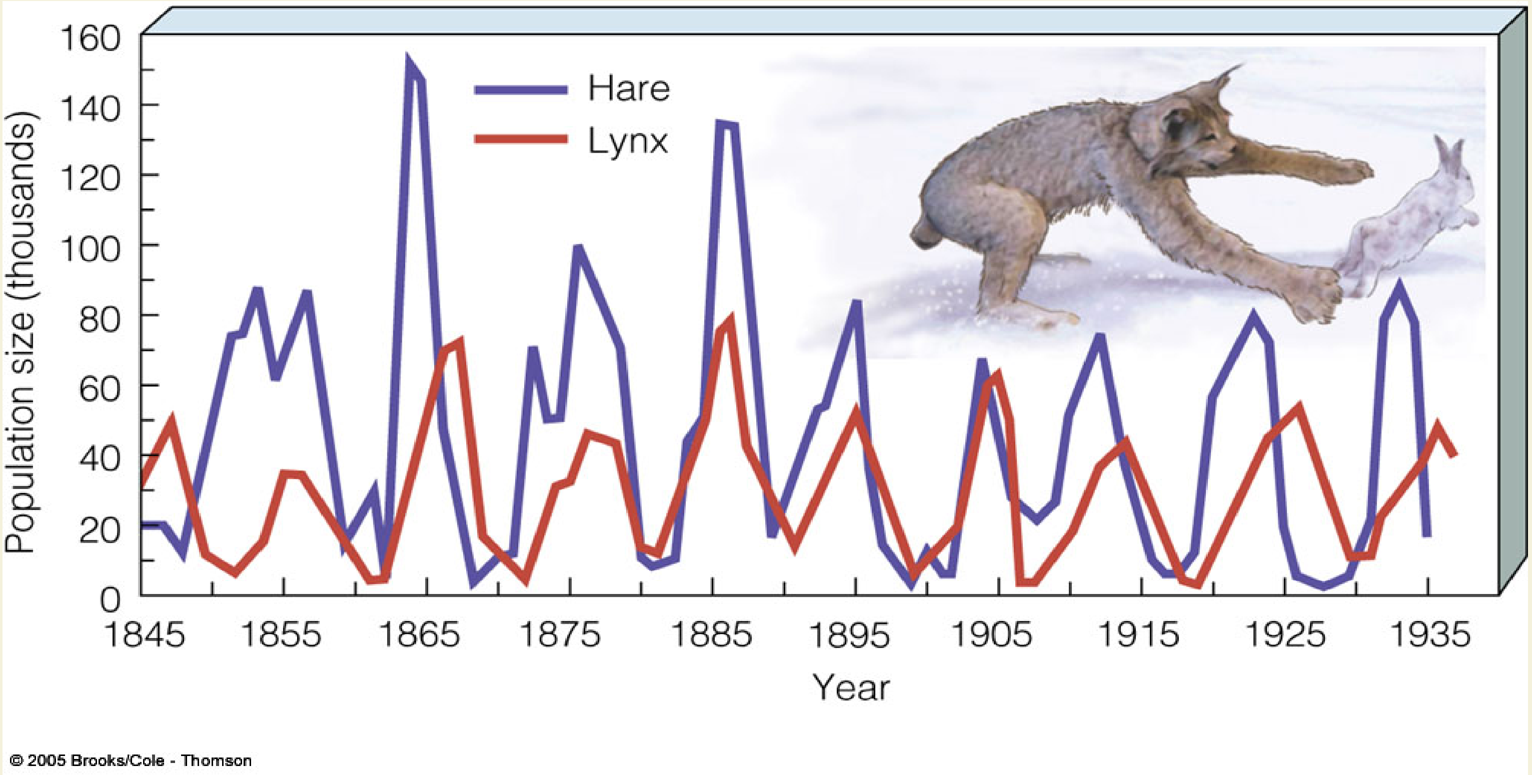
Fig. 5-3, p. 107

Predator-Prey Relationships

Fig. 5-4, p. 107

The Role of Predation in Controlling Population Size

- **Top-down control**
  - lynx preying on hares periodically reduce the hare pop.
- **Bottom-up control**
  - the hare pop. may cause changes in lynx pop.



Most Consumer Species Feed on Live Organisms of Other Species

Predators may capture prey by

1. Walking
2. Swimming
3. Flying
4. Pursuit and ambush
5. Camouflage
6. Chemical warfare

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

- **Prey** may avoid capture by
  1. Run, swim, fly
  2. Protection: shells, bark, thorns
  3. Camouflage
  4. Chemical warfare
  5. Warning coloration
  6. Mimicry
  7. Deceptive looks
  8. Deceptive behavior

Some Ways Prey Species Avoid Their Predators

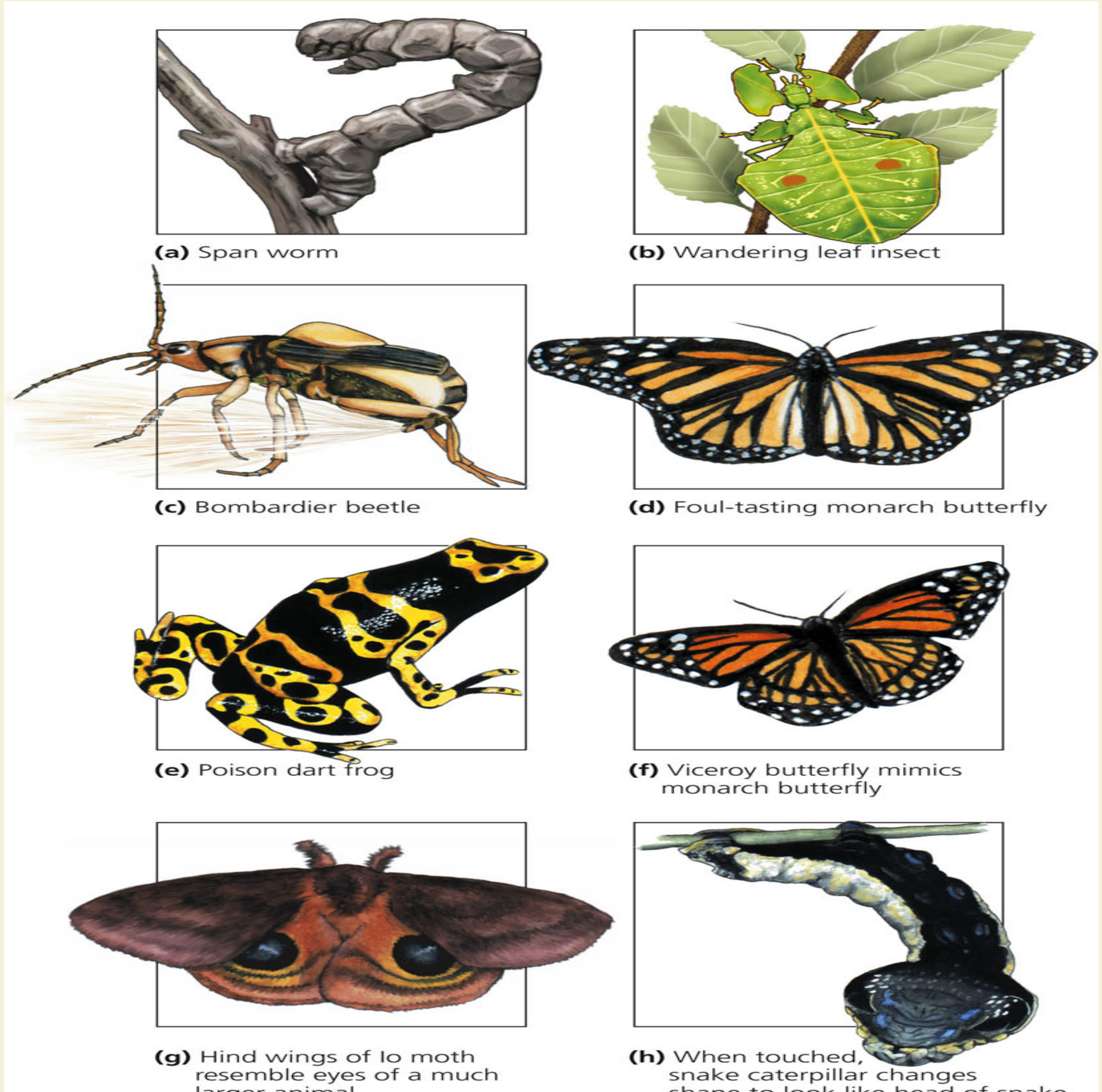
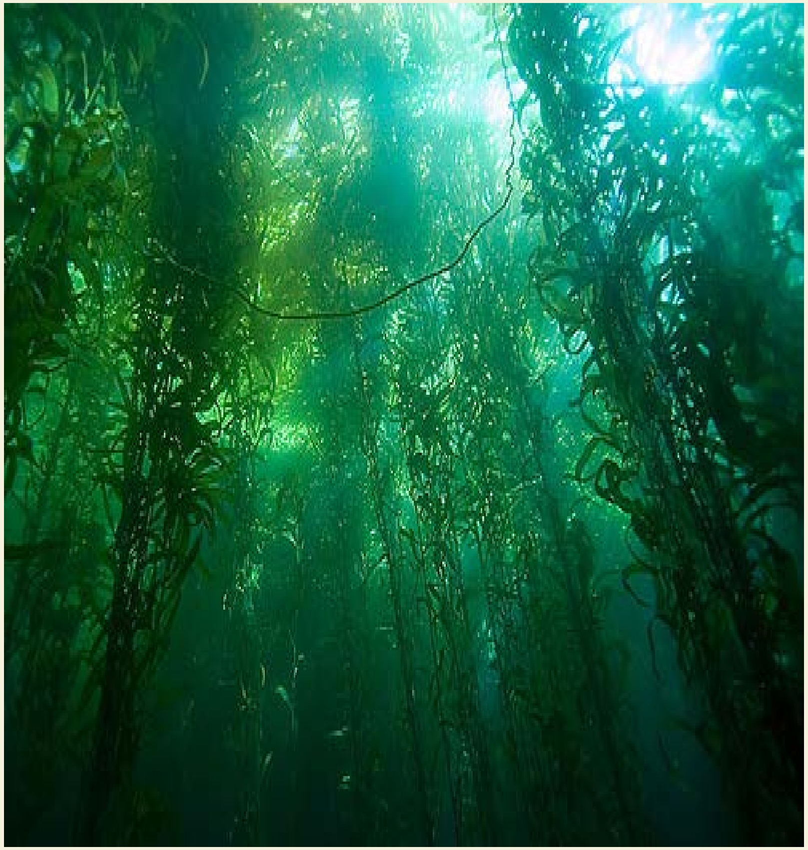


Fig. 5-5, p. 109

Science Focus: Threats to Kelp Forests

- Kelp forests: biologically diverse marine habitat

- Major threats to kelp forests
  1. Sea urchins
  2. Pollution from water run-off
  3. Global warming



Predator and Prey Interactions Can Drive Each Other’s Evolution

- Intense natural selection pressures between predator and prey populations

- **Coevolution**
  - Interact over a long period of time
  - Bats and moths: echolocation of bats and sensitive hearing of moths

Co-evolution: Evolution Arms Race

Predator and Prey Interactions Can Drive Each Other's Evolution

- **Process by which two or more species evolve in response to one another.**

- **Prey and predator can become locked in a duel of escalating adaptation.**
  - **Example: cheetah and antelope**
    - **Importance: Cheetahs are fast which cause antelope to become faster in order to survive.**

Coevolution: A Langohrfledermaus Bat Hunting a Moth

Fig. 5-6, p. 110

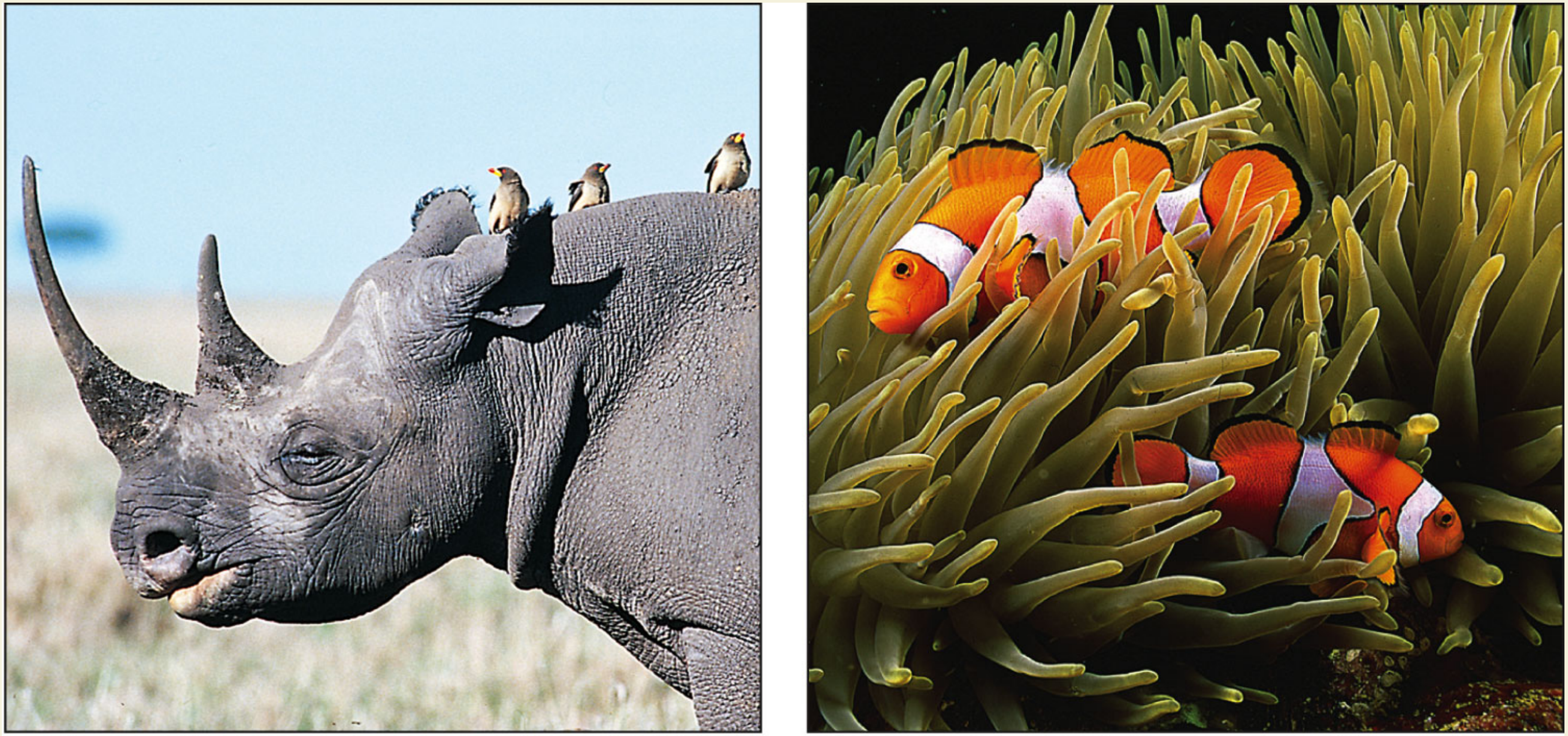
PARASITISM (+, -)

- Some species feed off other species by living on or in them
- Parasite is usually much smaller than the host
- Parasite rarely kills the host
- Parasite-host interaction may lead to coevolution

MUTUALISM (+, +)

- In some interactions, both species benefit
- Nutrition and protection relationship
- Gut inhabitant mutualism
- Not cooperation: it’s mutual exploitation

Mutualism: Oxpeckers Clean Rhinoceros; Anemones Protect and Feed Clownfish



(a) Oxpeckers and black rhinoceros

(b) Clownfish and sea anemone

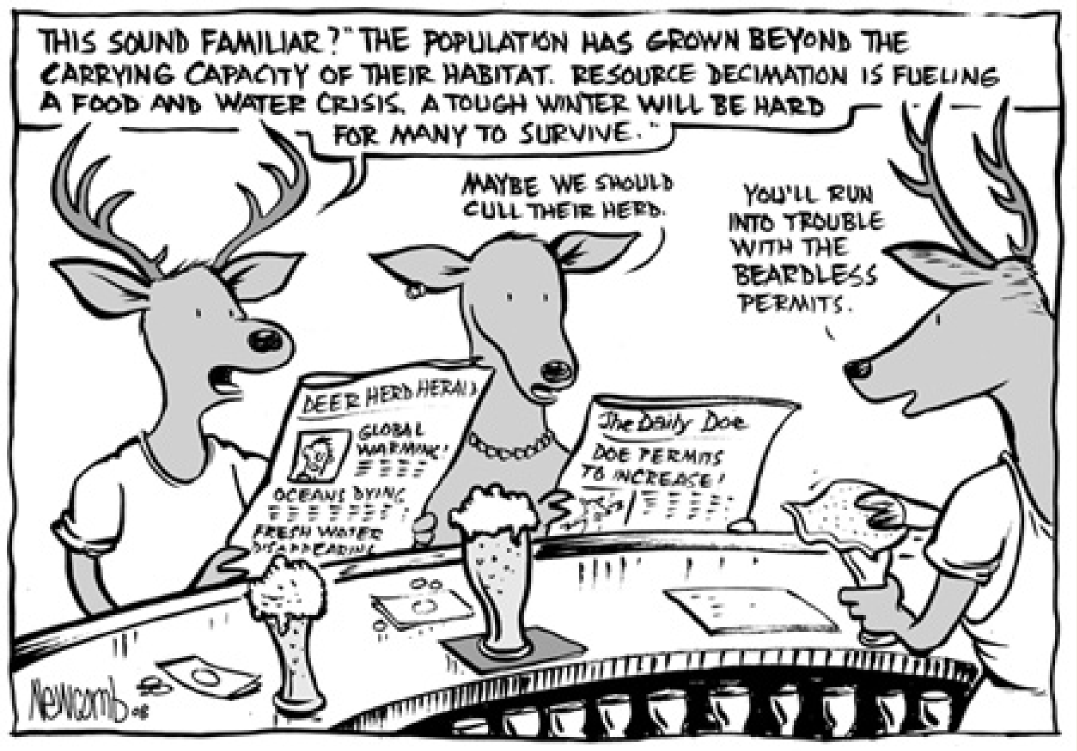
Fig. 5-9, p. 111

COMMENSALISM (+, 0)

- In some interactions, one species benefits and the other is not harmed
- Epiphytes
- Birds nesting in trees

5-2 What Limits the Growth of Populations?

- **Concept 5-2** *No population can continue to grow indefinitely because of limitations on resources and because of competition among species for those resources.*



What Are Populations?

- **Population**: group of interbreeding individuals of the same species

Population distribution

(a) Clumped (elephants) (b) Uniform (creosote bush) (c) Random (dandelions)

Most Populations Live Together in Clumps or Patches

Why clumping?

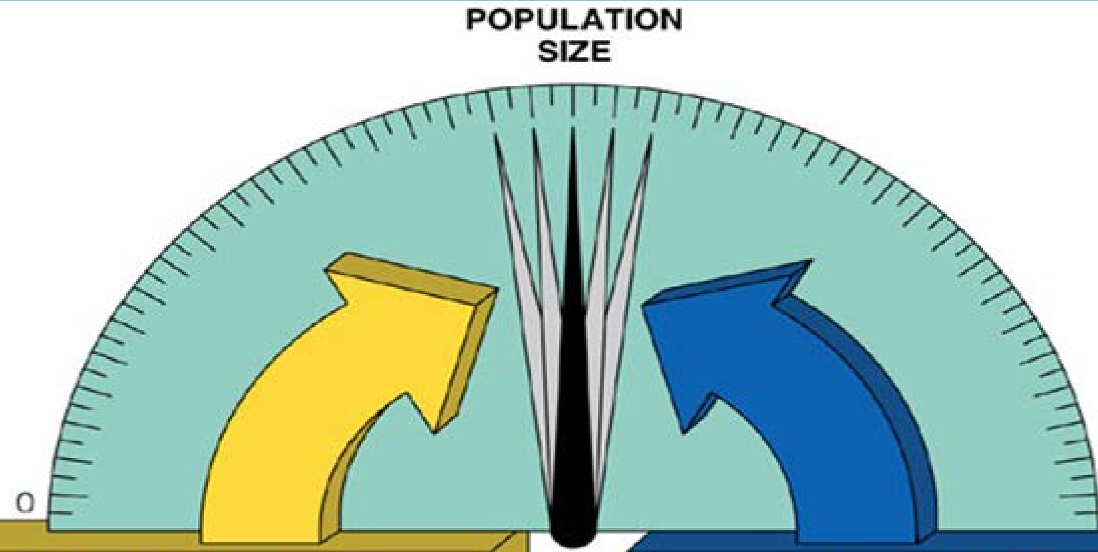
1. Species tend to cluster where resources are available
2. Groups have a better chance of finding clumped resources
3. Protects some animals from predators
4. Packs allow some to get prey

Population of Snow Geese

Populations Can Grow, Shrink, or Remain Stable

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

- Population change =
  (births + immigration) – (deaths + emigration)



Growth factors (biotic potential)

Abiotic

- Favorable light
- Favorable temperature
- Favorable chemical environment (optimal level of critical nutrients)

Biotic

- High reproductive rate
- Generalized niche
- Adequate food supply
- Suitable habitat
- Ability to compete for resources
- Ability to hide from or defend against predators
- Ability to resist diseases and parasites
- Ability to migrate and live in other habitats
- Ability to adapt to environmental change

Decrease factors (environmental resistance)

Abiotic

- Too much or too little light
- Temperature too high or too low
- Unfavorable chemical environment (too much or too little of critical nutrients)

Biotic

- Low reproductive rate
- Specialized niche
- Inadequate food supply
- Unsuitable or destroyed habitat
- Too many competitors
- Insufficient ability to hide from or defend against predators
- Inability to resist diseases and parasites
- Inability to migrate and live in other habitats
- Inability to adapt to environmental change

Population's Age Structure

Age Structure Stages

- **Pre-reproductive age: not mature enough to reproduce**
- **Reproductive age: capable of reproduction**
- **Post-reproductive age: too old to reproduce**

Some Factors Can Limit Population Size

- **Limiting Factor Principle**
  - Too much or too little of any physical or chemical factor can limit or prevent growth of a population, even if all other factors are at or near the optimal range of tolerance
  - Examples:
    - →Precipitation
    - →Nutrients
    - →Sunlight, etc

LIMITING FACTOR

DEFINITION: anything that tends to make it more difficult for a species to live and grow, or reproduce in its environment

<u>ABIOTIC</u>

- temperature

- water

- climate/weather

- soils (mineral component)

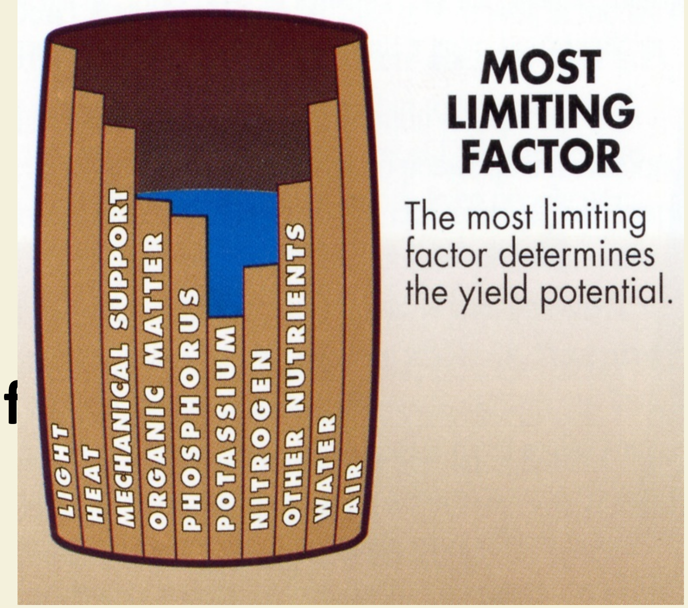
<u>BIOTIC</u>

- competition: interspecific and intraspecif

- predation/parasitism

- amensalism

- mutualism



Trout Tolerance of Temperature

Range of tolerance

- **Variations in physical and chemical environment**

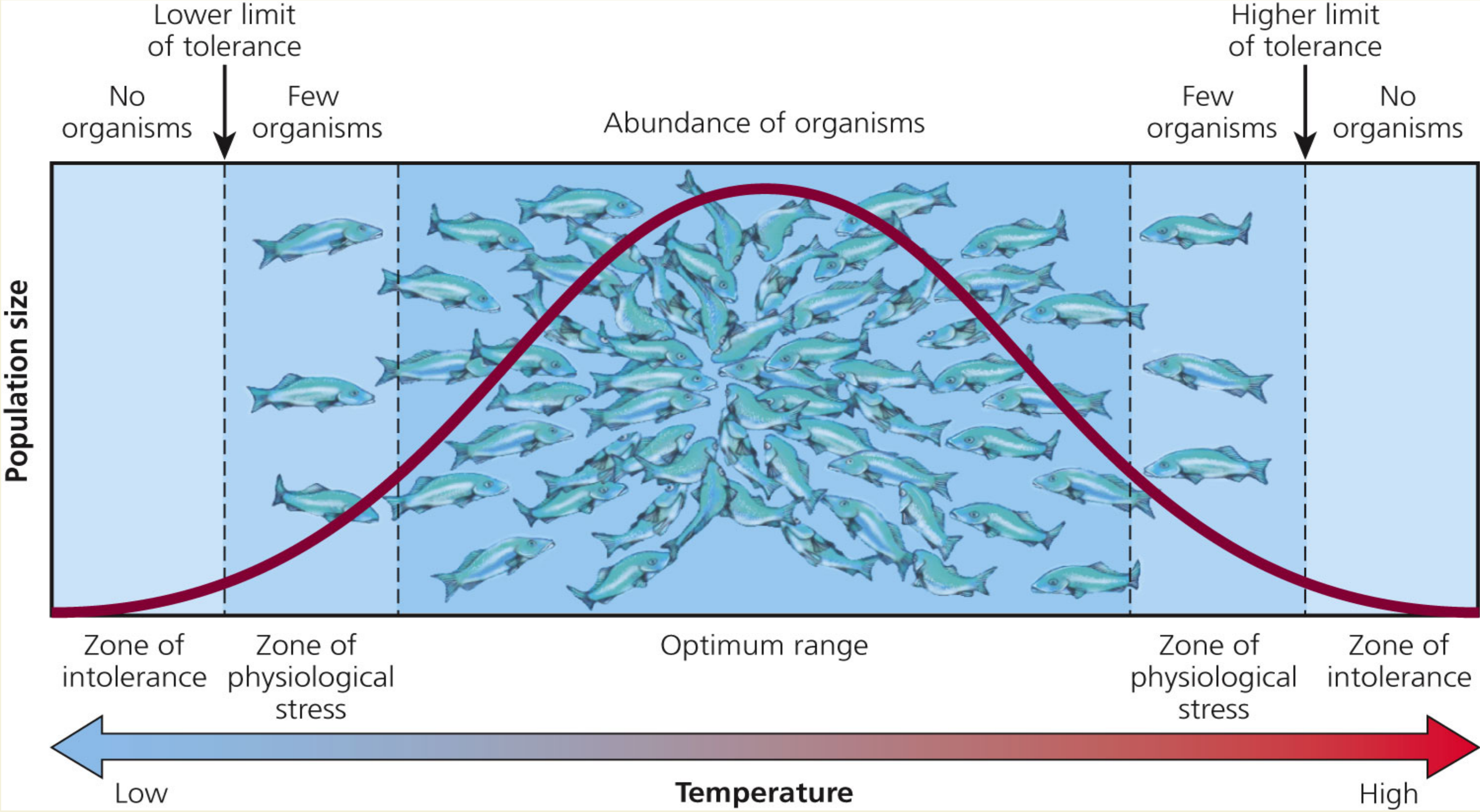


Fig. 5-13, p. 113

LIMITS TO POPULATION GROWTH
Resources & Competition

<u>Biotic potential</u>: capacity for growth

<u>Intrinsic rate of increase (r):</u> rate at which a population would grow if it had unlimited resources

<u>Environmental resistance</u>: all factors that act to limit the growth of a population

<u>Carrying Capacity (K):</u> maximum # of individuals of a given species that can be sustained indefinitely in a given space (area or volume)

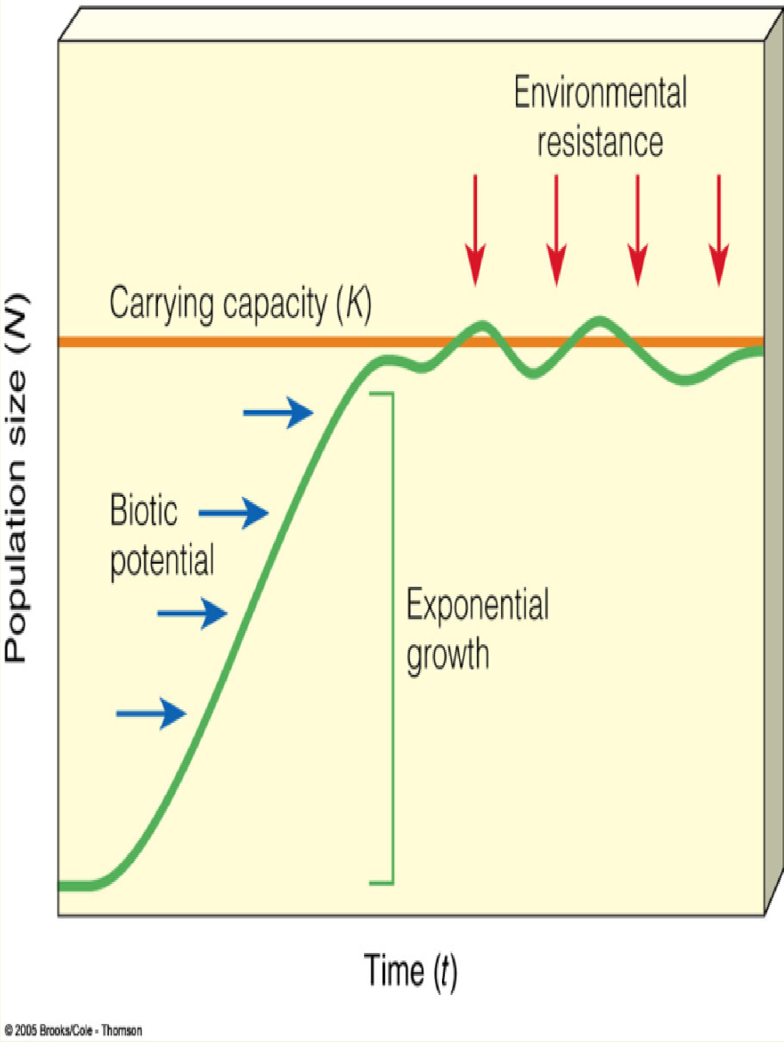
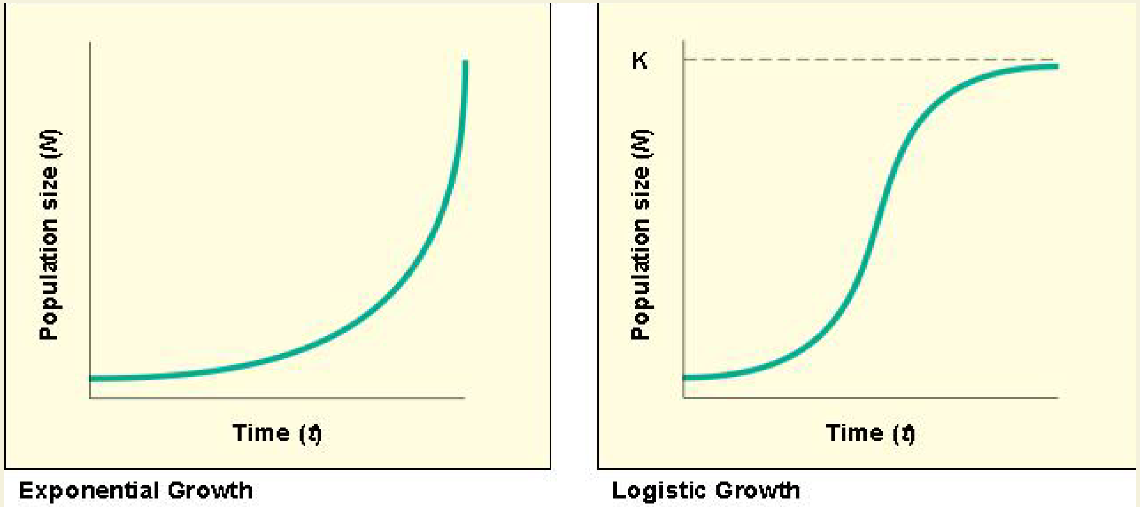


Fig. 5-15 p. 115

Exponential and Logistic Growth

No Population Can Grow Indefinitely



EXPONENTIAL GROWTH

- **Population w/few resource limitations; grows at a fixed rate**
- **Decreased population growth rate as population size reaches carrying capacity**

LOGISTIC GROWTH

- **Rapid exp. growth followed by steady dec. in pop. growth w/time until pop. size levels off**
- **Starts slowly, then accelerates to carrying capacity when meets environmental resistance**

Logistic Growth of Sheep in Tasmania

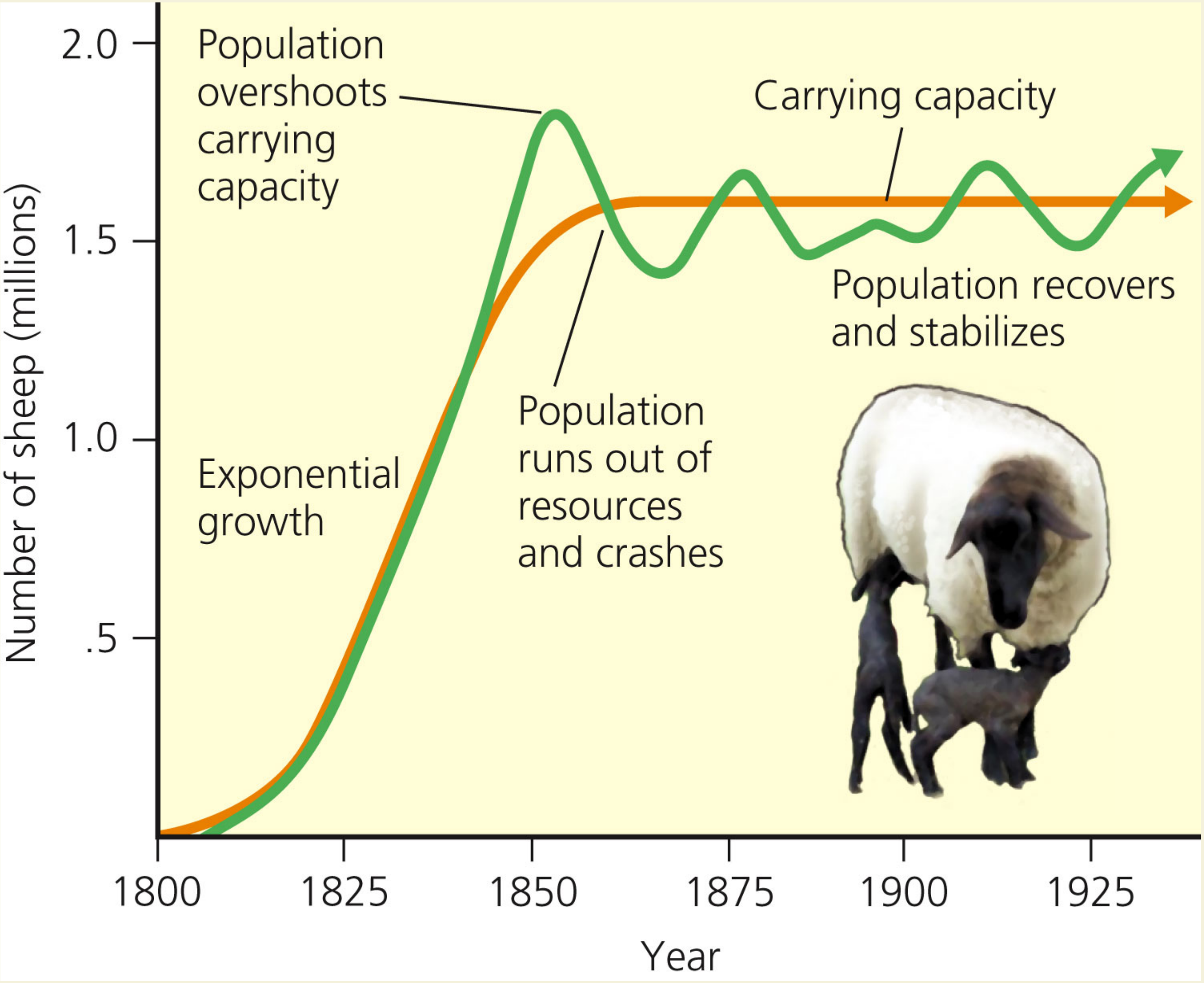
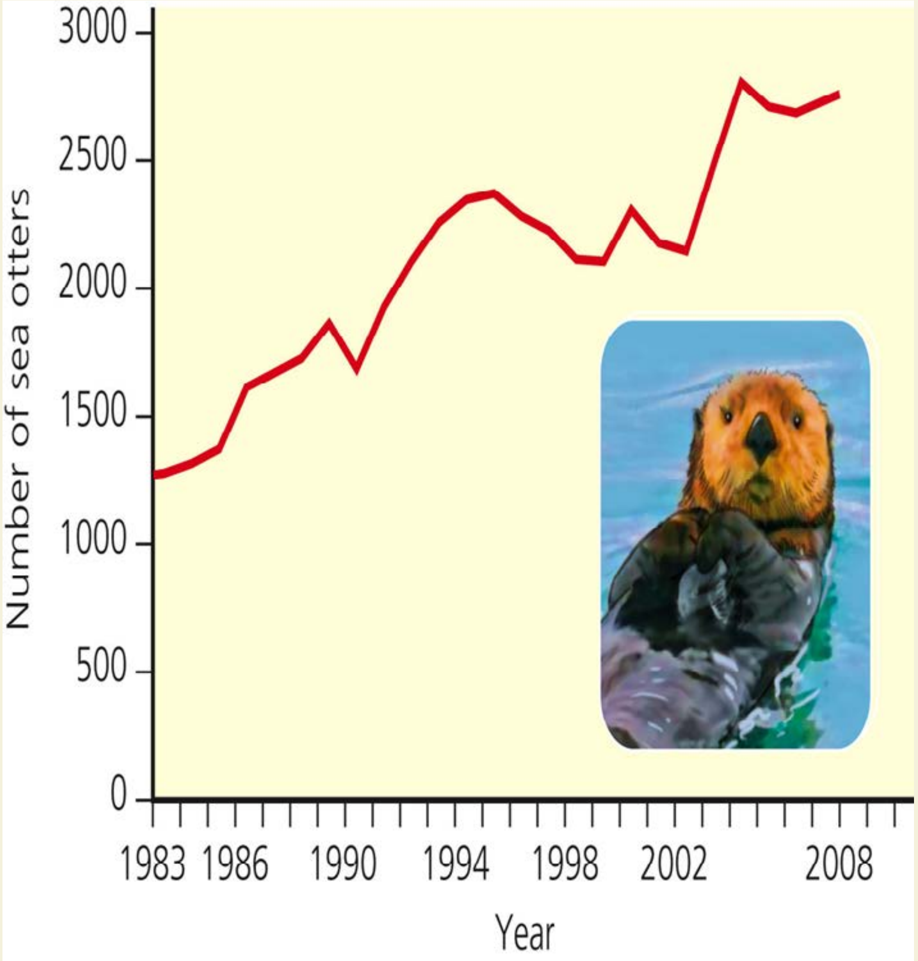


Fig. 5-15, p. 115

Science Focus: Why Do California's Sea Otters Face an Uncertain Future?

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

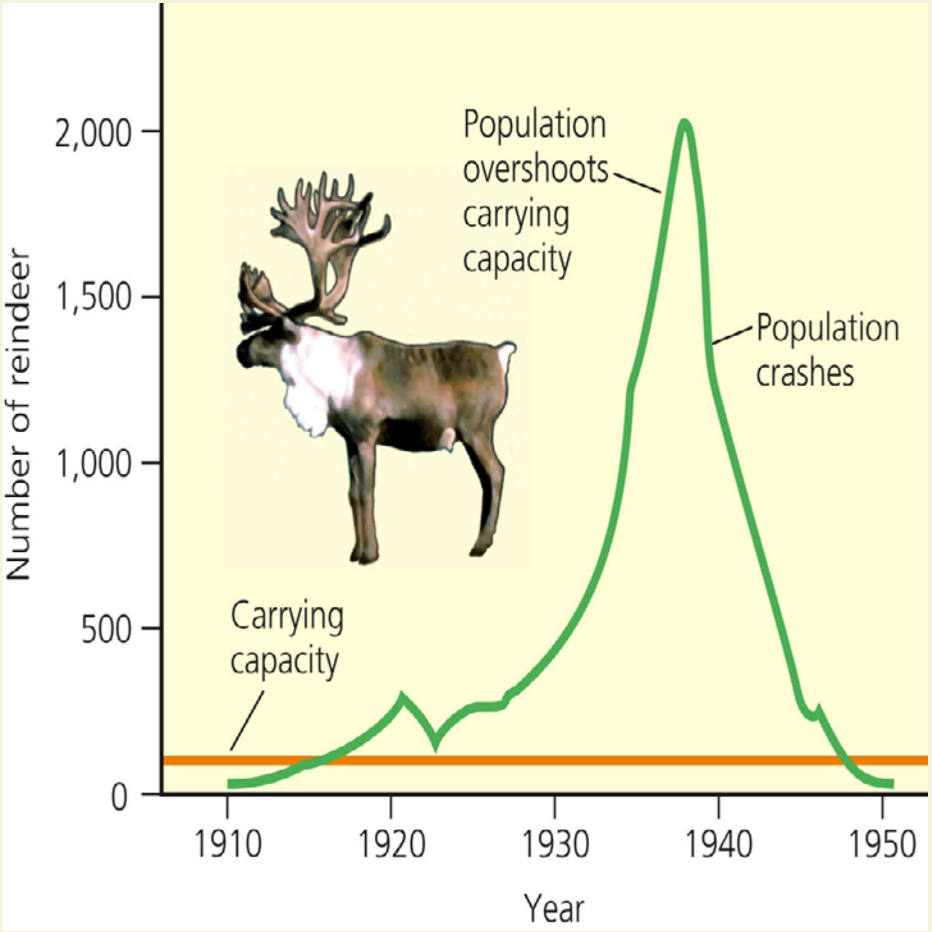


Case Study: Exploding White-Tailed Deer Population in the U.S.

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

Mature Male White-Tailed Deer

Population Crash: Exceeding a Habitat's Carrying Capacity



- population exceeds the area's carrying capacity
- reproductive time lag may lead to overshoot
- damage may reduce area's carrying capacity

Species Reproductive Patterns

Cockroach

Dandelion

Elephant

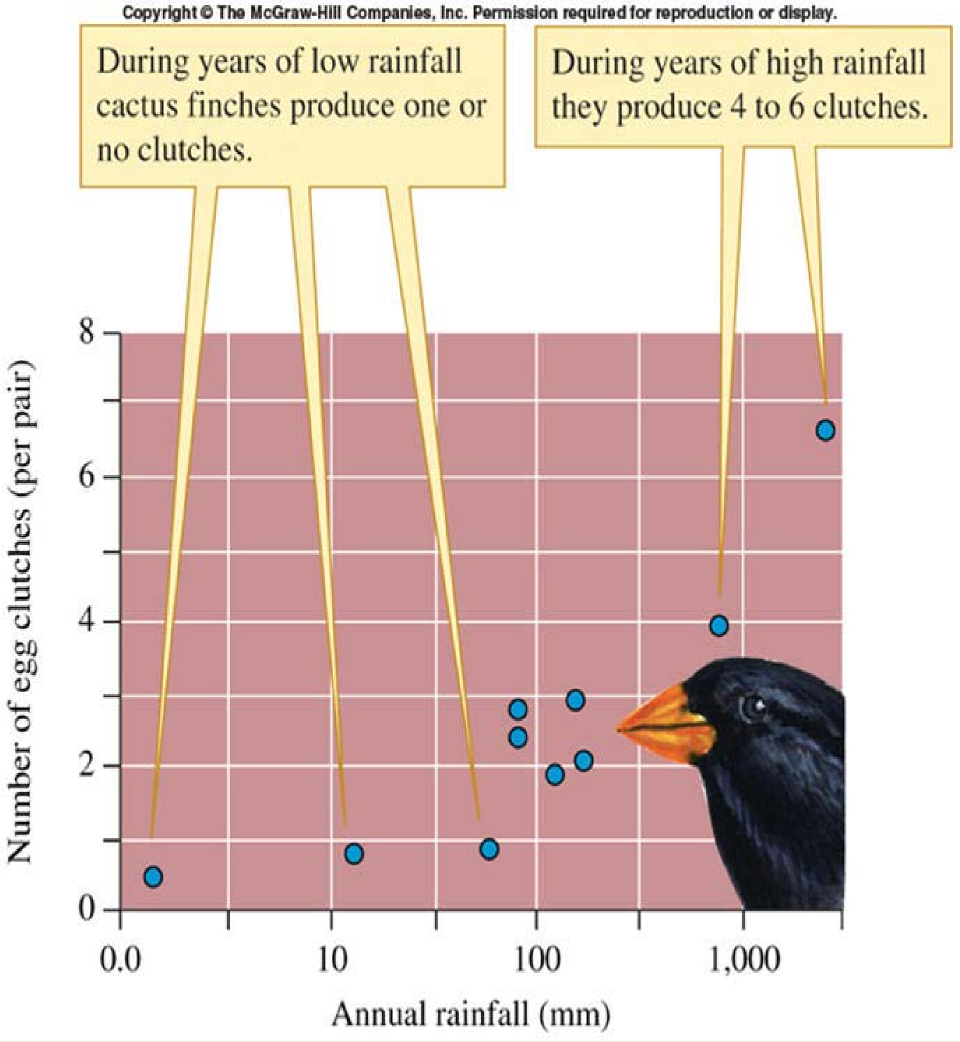
Saguaro

r-Selected Species	K-Selected Species
Many small offspring	Fewer, larger offspring
Little or no parental care and protection of offspring	High parental care and protection of offspring
Early reproductive age	Later reproductive age
Most offspring die before reaching reproductive age	Most offspring survive to reproductive age
Small adults	Larger adults
Adapted to unstable climate and environmental conditions	Adapted to stable climate and environmental conditions
High population growth rate (*r*)	Lower population growth rate (*r*)
Population size fluctuates wildly above and below carrying capacity (*K*)	Population size fairly stable and usually close to carrying capacity (*K*)
Generalist niche	Specialist niche
Low ability to compete	High ability to compete
Early successional species	Late successional species

Population Density Effects
Density-Independent Controls

Density-independent controls

- **floods, hurricanes, unseasonable weather, fire, habitat destruction, pesticide spraying, pollution**
- **EX: Severe freeze in spring can kill plant pop. regardless of density**

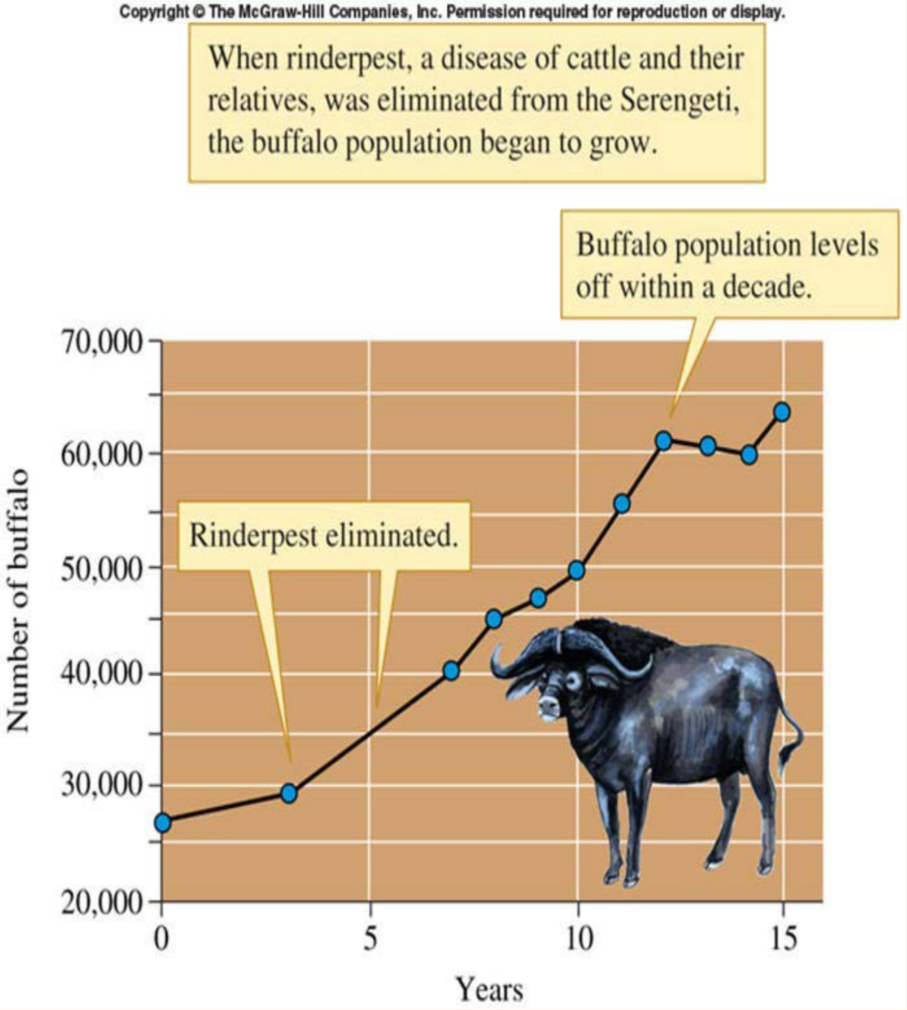


Population Density Effects
Density-dependent Controls

Density-dependent controls

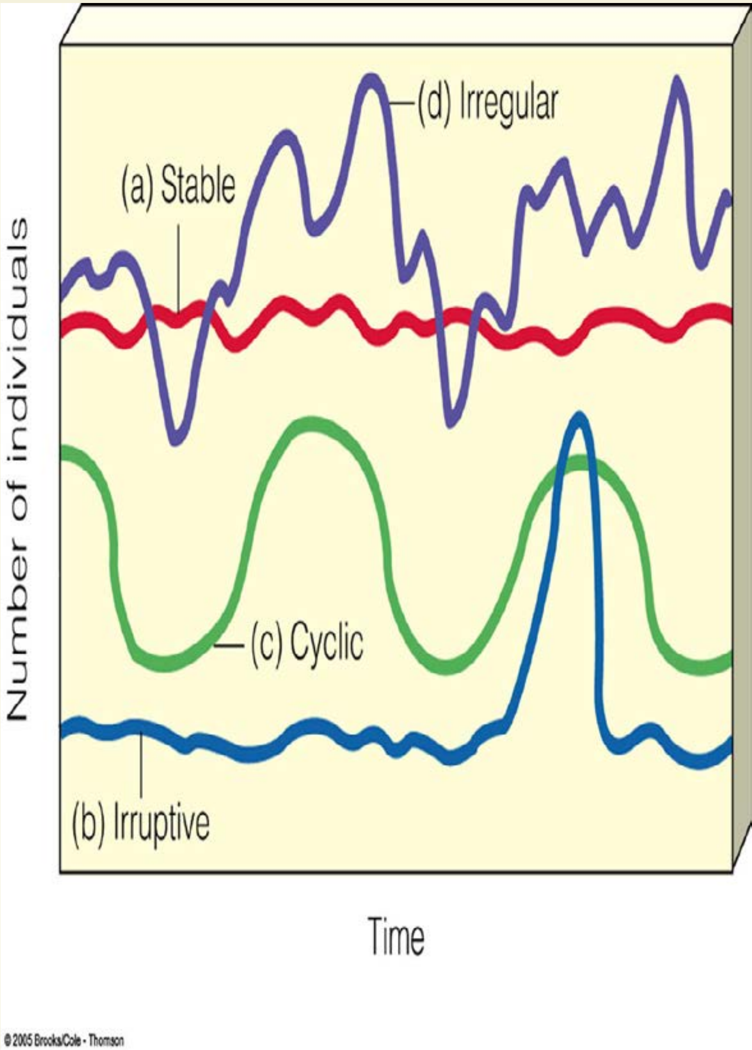
- **competition for resources, predation, parasitism, infectious diseases**

- **EX: Bubonic plague swept through European cities in 14th century**



Several Different Types of Population Change Occur in Nature

- <u>Stable</u>
  - → pop. size fluctuates above or below its carrying capacity
- <u>Irruptive</u>
  - → pop. growth occasionally explodes to a high peak then crashes to stable low level
  - → pop. surge, followed by crash
- <u>Cyclic fluctuations, boom-and-bust cycles</u>
  - → Fluctuations occur in cycles over a regular time period
  - → Top-down vs. Bottom-up pop. regulation
- <u>Irregular</u>
  - → No recurring pattern in changes of pop. size



Population Cycles for the Snowshoe Hare and Canada Lynx

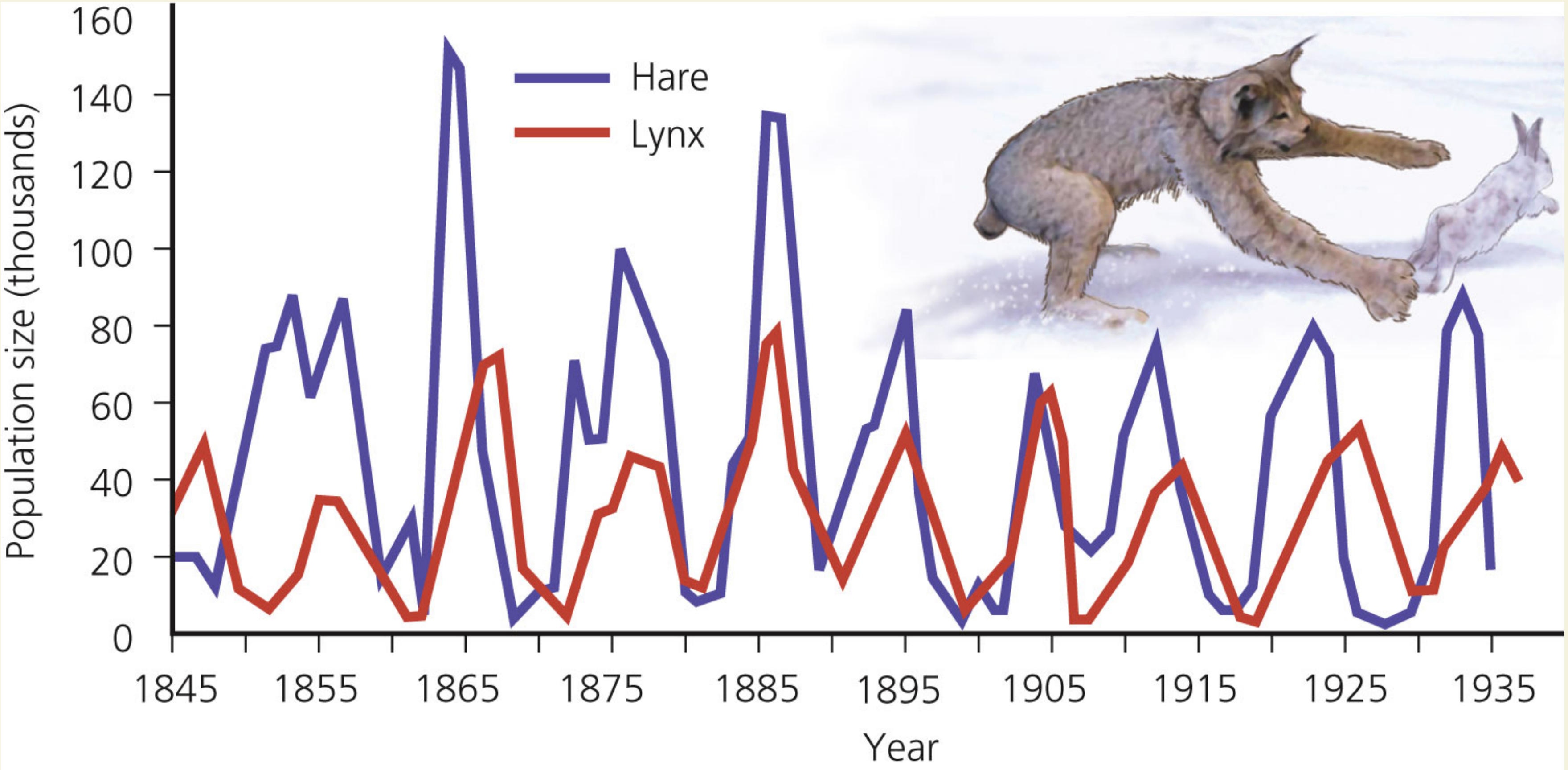


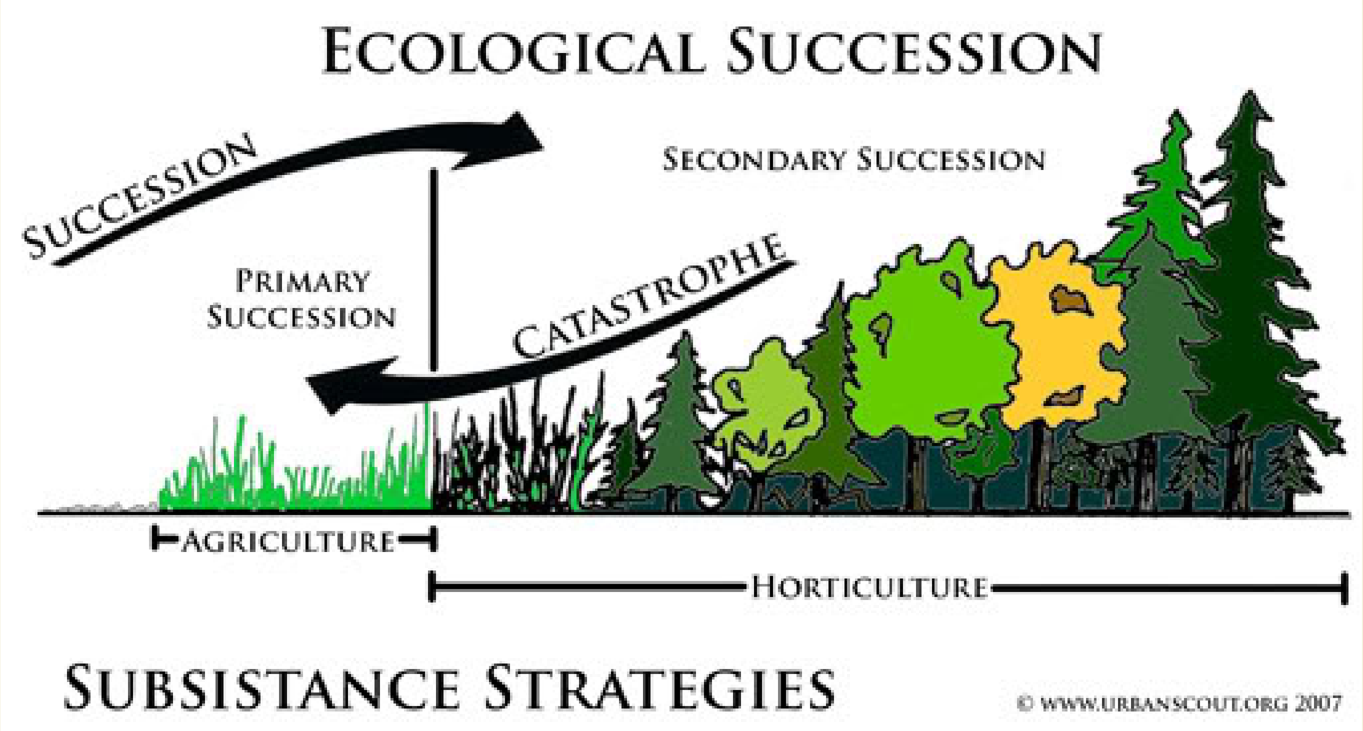
Fig. 5-18, p. 118

Humans Are Not Exempt from Nature's Population Controls

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

5-3 How Do Communities and Ecosystems Respond to Changing Environmental Conditions?

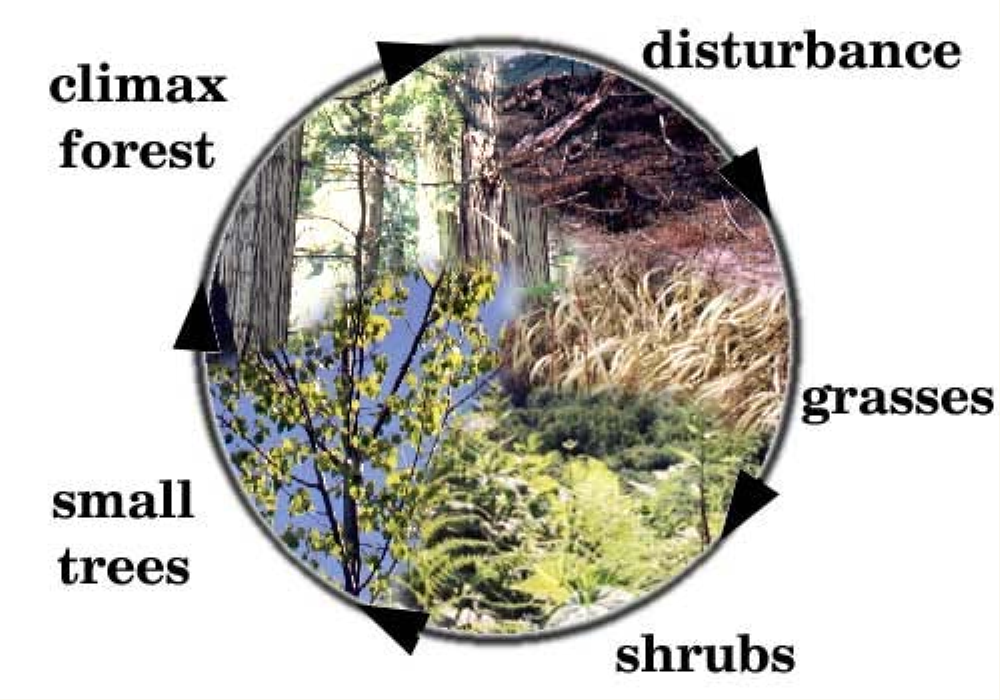
Concept 5-3 *The structure and species composition of communities and ecosystems change in response to changing environmental conditions through a process called ecological succession.*



Communities and Ecosystems Change over Time: Ecological Succession

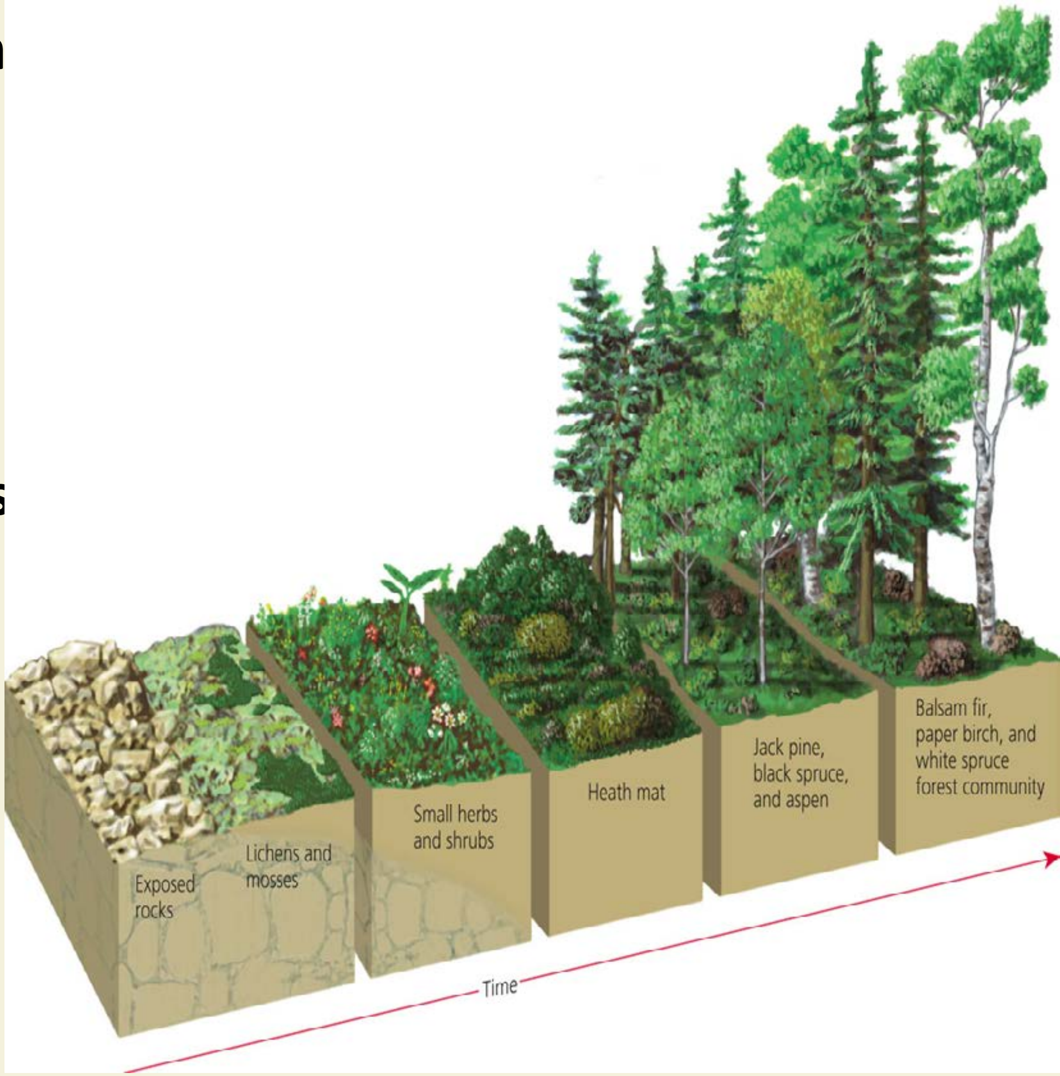
Natural ecological restoration

- Primary succession
- Secondary succession

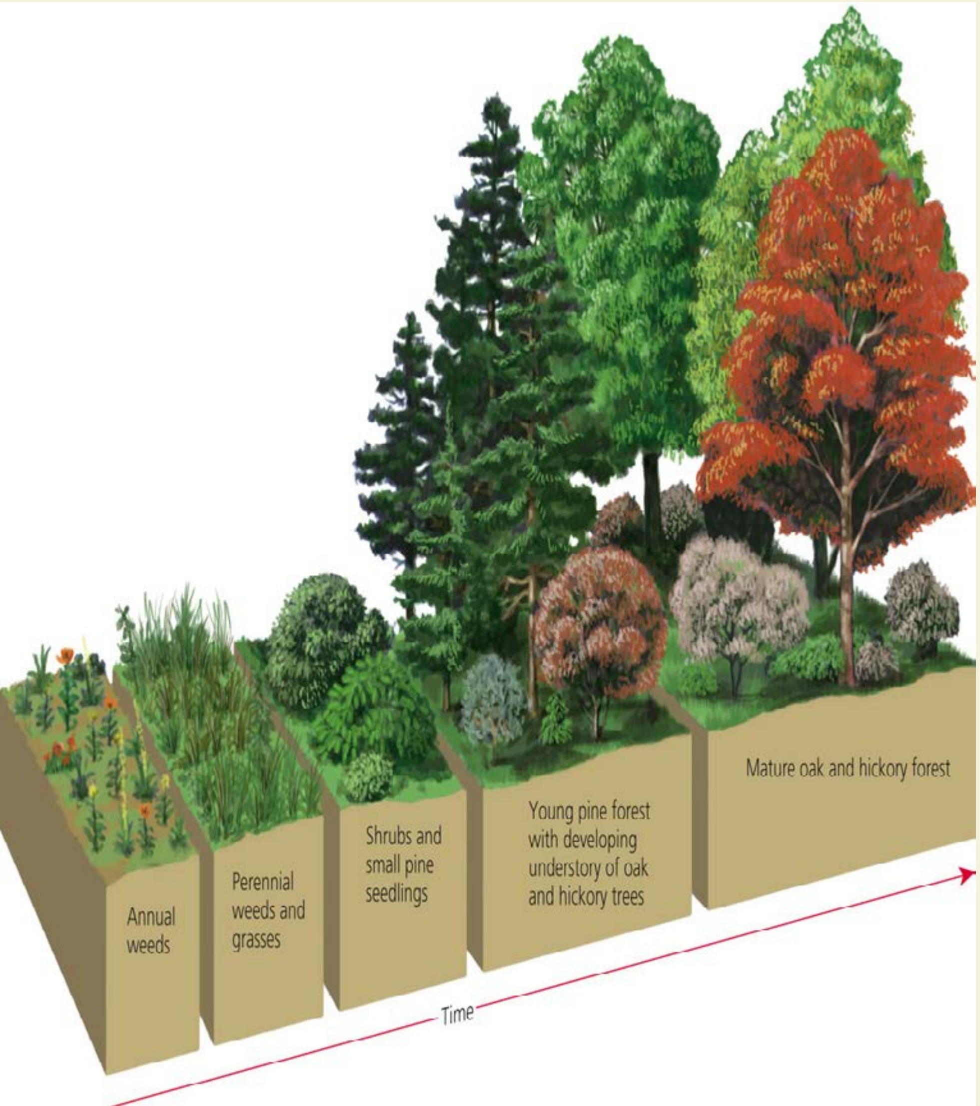


Some Ecosystems Start from Scratch: Primary Succession

- **No soil in a terrestrial system**
- **No bottom sediment in an aquatic system**
- **Takes hundreds to thousands of years**
- **Need to build up soils/sediments to provide necessary nutrients**



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



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

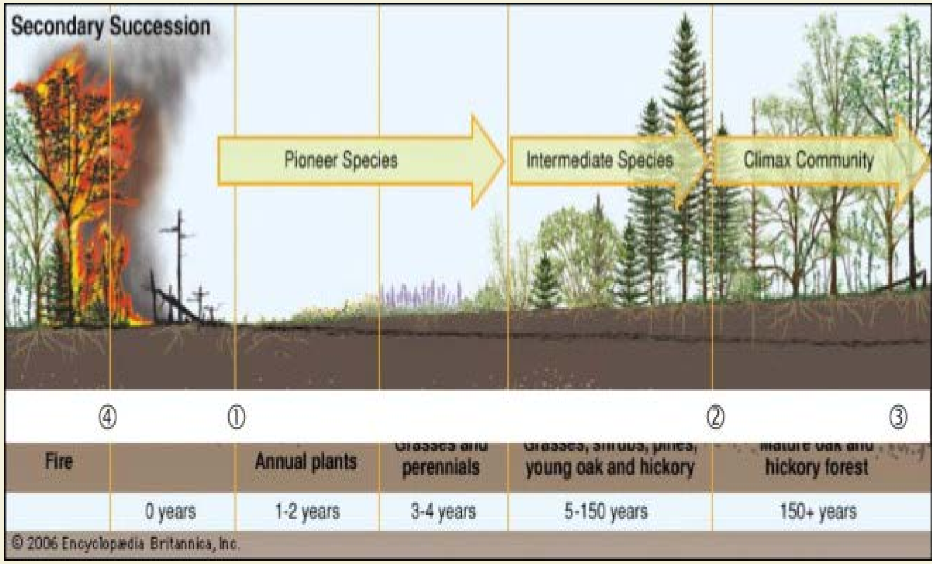
Secondary Ecological Succession in Yellowstone Following the 1998 Fire

Fig. 5-21, p. 120

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

- **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**



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
- Some systems have one property, but not the other: tropical rainforests

Three Big Ideas

1. **Certain interactions among species affect their use of resources and their population sizes.**

2. **There are always limits to population growth in nature.**

3. **Changes in environmental conditions cause communities and ecosystems to gradually alter their species composition and population sizes (ecological succession).**