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
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.
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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

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(a) Oxpeckers and black rhinoceroses
(b) Clownfish and sea anemone
In Some Interactions, One Species Benefits and the Other Is Not Harmed

- Commensalism
- Epiphytes
- Birds nesting in trees
Commensalism: Bromeliad Roots on Tree Trunk Without Harming Tree
Animation: Life history patterns
Animation: Capture-recapture method
Video: Kelp forest (Channel Islands)
Video: Otter feeding
Video: Salmon swimming upstream
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
Sharing the Wealth: Resource Partitioning
Specialist Species of Honeycreepers

- Greater Koa-finch
- Kona Grosbeak
- Akiapolaau
- Maui Parrotbill
- Unknown finch ancestor
- Kuai Akialoa
- Amakihi
- Crested Honeycreeper
- Apapane
Fruit and seed eaters

Greater Koa-finch
Kona Grosbeak
Akiapolaau
Maui Parrotbill

Insect and nectar eaters

Kuai Akialaoa
Amakihi
Crested Honeycreeper
Apapane

Unknown finch ancestor

Fig. 5-9, p. 108
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 = 
  \[(\text{births} + \text{immigration}) - (\text{deaths} + \text{emigration})\]
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
No Population Can Continue to Increase in Size Indefinitely
Fig. 5-11, p. 111

Biotic potential
Population size
Carrying capacity ($K$)
Exponential growth
Population stabilizes
Environmental resistance

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

- Population overshoots carrying capacity
- Carrying capacity
- Population runs out of resources and crashes
- Population recovers and stabilizes

Number of sheep (millions) vs Year (1800-1925)
Exponential growth

Population overshoots carrying capacity

Carrying capacity

Population runs out of resources and crashes

Population recovers and stabilizes

Number of sheep (millions)

Year

1800
1825
1850
1875
1900
1925

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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
Population overshoots carrying capacity
Population crashes
Carrying capacity

Number of reindeer

0 500 1,000 1,500 2,000

Year

1910 1920 1930 1940 1950

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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
Carrying capacity

Number of individuals

$K$ species; experience $K$ selection

$r$ species; experience $r$ selection

Time
Genetic Diversity Can Affect the Size of Small Populations

- Founder effect
- Demographic bottleneck
- Genetic drift
- Inbreeding
- Minimum viable 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
Animation: Logistic growth
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

- Exposed rocks
- Lichens and mosses
- Small herbs and shrubs
- Heath mat
- Jack pine, black spruce, and aspen
- Balsam fir, paper birch, and white spruce forest community

Time
Exposed rocks

Lichens and mosses

Small herbs and shrubs

Heath mat

Jack pine, black spruce, and aspen

Balsam fir, paper birch, and white spruce forest community

Time

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

- Annual weeds
- Perennial weeds and grasses
- Shrubs and small pine seedlings
- Young pine forest with developing understory of oak and hickory trees
- Mature oak and hickory forest
Annual weeds
Perennial weeds and grasses
Shrubs and small pine seedlings
Young pine forest with developing understory of oak and hickory trees
Mature oak and hickory forest

Time
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**