Chapter 56

Conservation Biology and Restoration Ecology

PowerPoint® Lecture Presentations for

Biology

Eighth Edition

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Key concepts

1. Apply the knowledge of ecology to have sustainable biosphere.
2. We are most likely to protect what we appreciate, and we are most likely to appreciate what we understand.

Overview: Striking Gold

- 1.8 million species have been named and described
- Biologists estimate 10–200 million species exist on Earth
- Tropical forests contain some of the greatest concentrations of species and are being destroyed at an alarming rate
- Humans are rapidly pushing many species toward extinction

Fig. 56-1

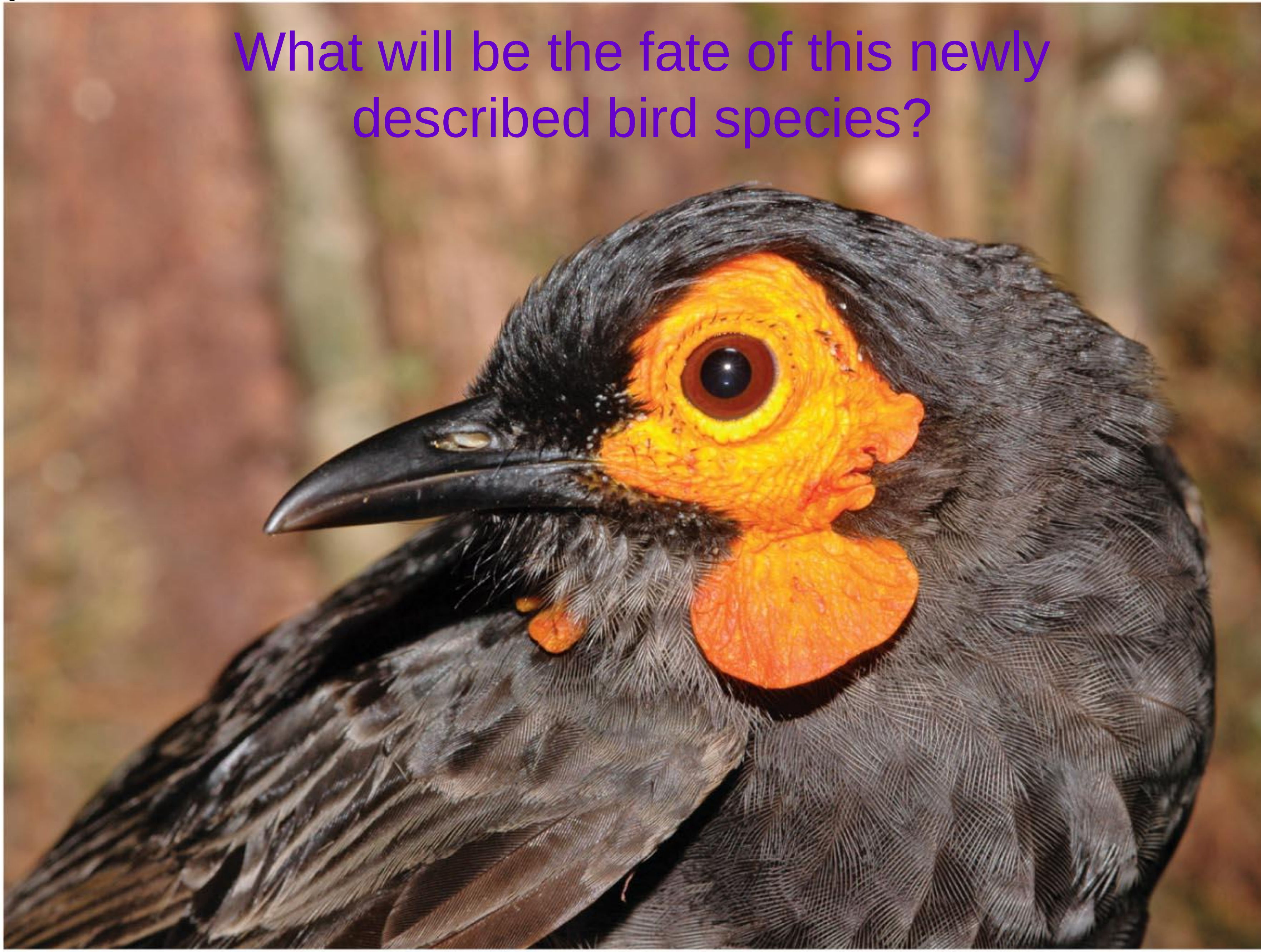


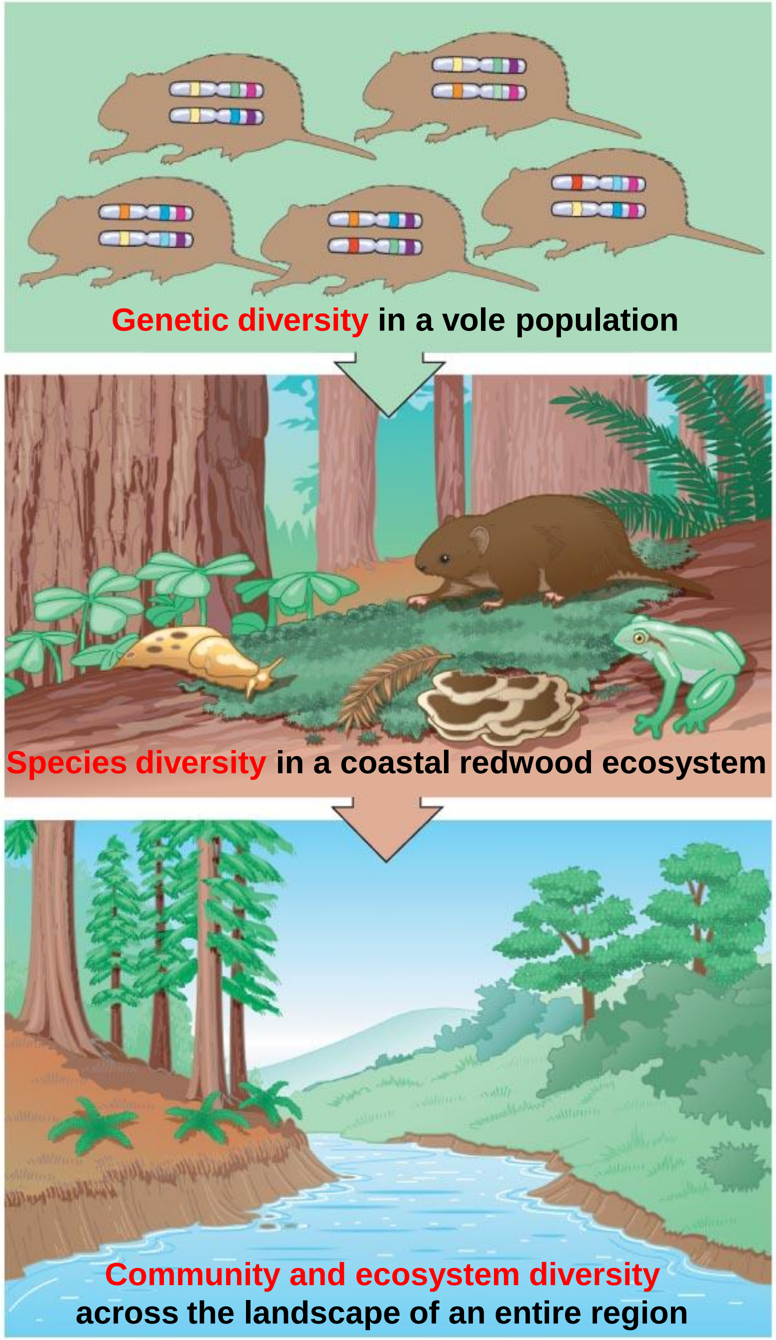
Fig. 56-2


Tropical deforestation in West Kalimantan, an Indonesian province

- **Conservation biology**, which seeks to preserve life, integrates several fields:
  - Ecology
  - Physiology
  - Molecular biology
  - Genetics
  - Evolutionary biology

- **Restoration ecology** applies ecological principles to return degraded ecosystems to conditions as similar as possible to their natural state

Fig. 56-3



Biodiversity has three main components

Species Diversity

- Species diversity is the variety of species in an ecosystem or throughout the biosphere

- According to the U.S. Endangered Species Act:
  - An **endangered species** is “in danger of becoming extinct throughout all or a significant portion of its range”
  - A **threatened species** is likely to become endangered in the foreseeable future

- Conservation biologists are concerned about species loss because of alarming statistics regarding extinction and biodiversity
- Globally, 12% of birds, 20% of mammals, and 32% of amphibians are threatened with extinction

Fig. 56-4

(a) Philippine eagle

(b) Yangtze River dolphin

A hundred heartbeats from extinction

(c) Javan rhinoceros

Fig. 56-5

The endangered Marianas “flying fox” bat, an important pollinator

Biodiversity and Human Welfare

- Human *biophilia* allows us to recognize the value of biodiversity for its own sake
- Species diversity brings humans practical benefits

Fig. 56-6

Benefits of Species and Genetic Diversity

The rosy periwinkle contains alkaloids that inhibit cancer growth

Ecosystem Services

- **Ecosystem services** encompass all the processes through which natural ecosystems and their species help sustain human life
- Some examples of ecosystem services:
  - Purification of air and water
  - Detoxification and decomposition of wastes
  - Cycling of nutrients
  - Moderation of weather extremes

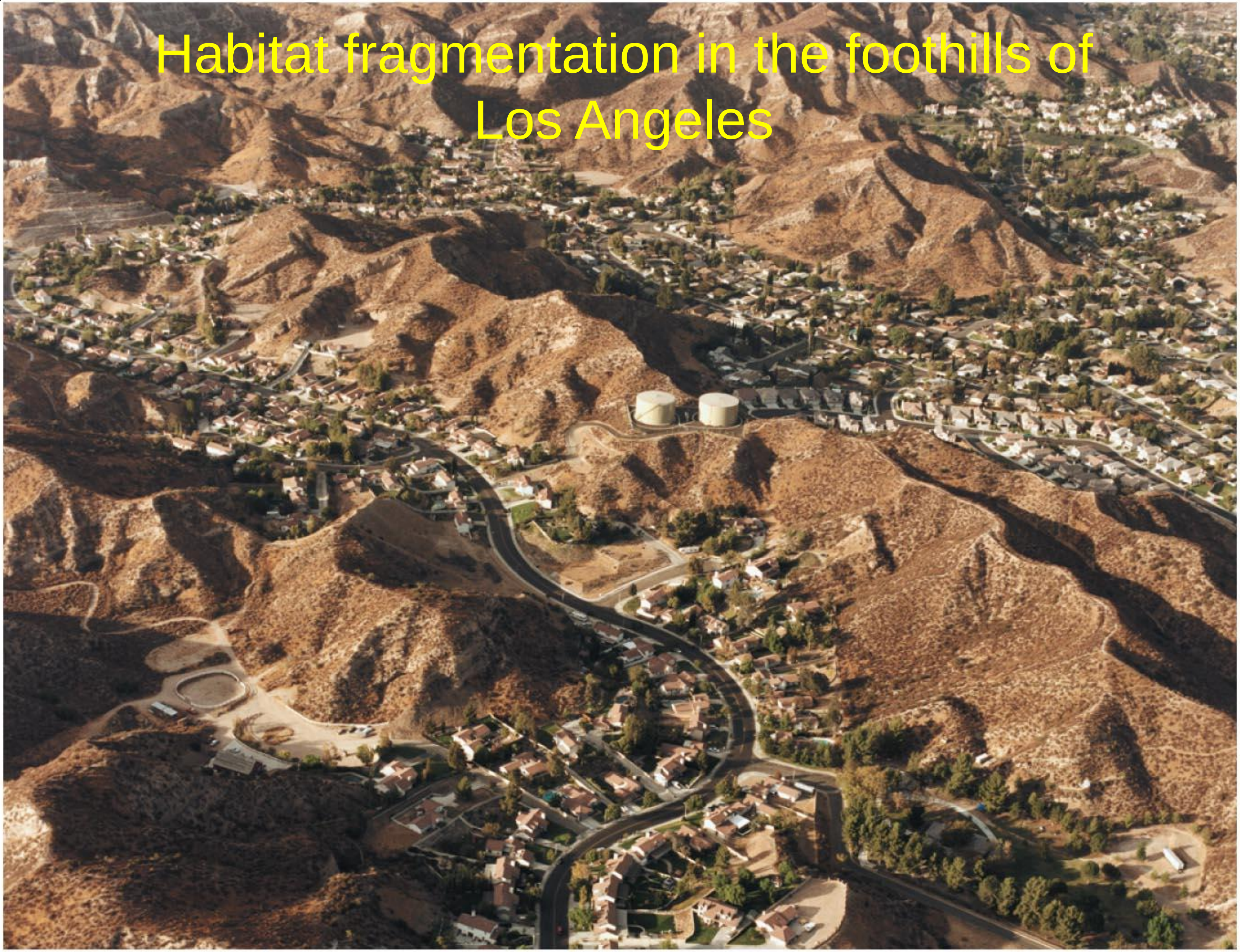
Three Threats to Biodiversity

- Most species loss can be traced to three major threats:
  - Habitat destruction
  - Introduced species
  - Overexploitation

Habitat Loss

- In almost all cases, habitat fragmentation and destruction lead to loss of biodiversity
- For example
  - In Wisconsin, prairie occupies <0.1% of its original area
  - About 93% of coral reefs have been damaged by human activities

Fig. 56-7



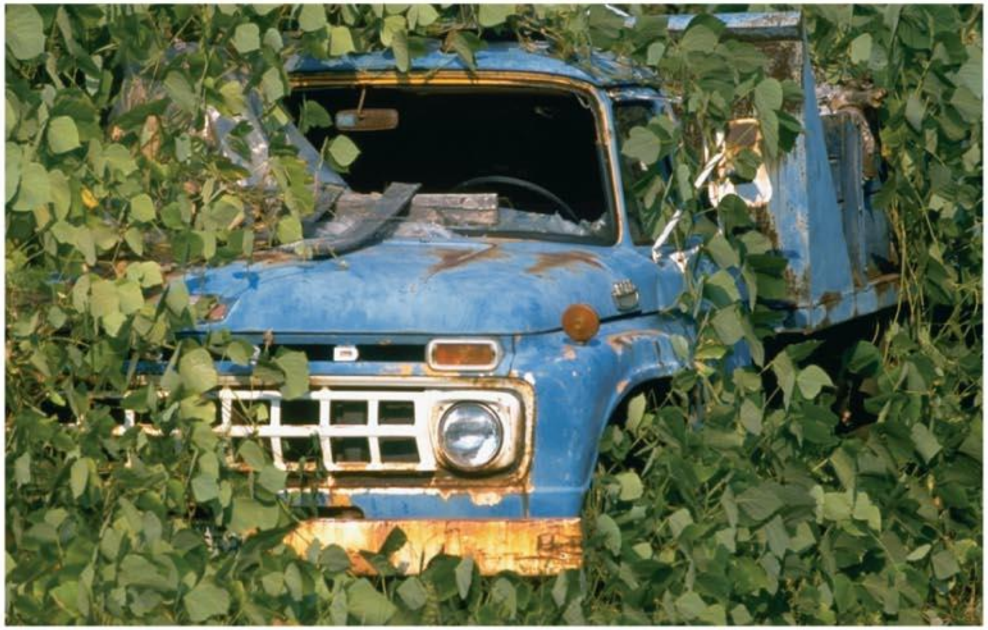
Introduced Species

- **Introduced species** are those that humans move from native locations to new geographic regions
- Without their native predators, parasites, and pathogens, introduced species may spread rapidly
- Introduced species that gain a foothold in a new habitat usually disrupt their adopted community

Fig. 56-8

Two introduced species

(a) Brown tree snake



(b) Kudzu

Overexploitation

- *Overexploitation* is human harvesting of wild plants or animals at rates exceeding the ability of populations of those species to rebound
- Overexploitation by the fishing industry has greatly reduced populations of some game fish, such as bluefin tuna

Fig. 56-9

Concept 56.2: Population conservation focuses on population size, genetic diversity, and critical habitat

- Biologists focusing on conservation at the population and species levels follow two main approaches:
  - The small-population approach
  - The declining-population approach

The Extinction Vortex

- A small population is prone to positive-feedback loops that draw it down an **extinction vortex**
- The key factor driving the extinction vortex is loss of the genetic variation necessary to enable evolutionary responses to environmental change

Fig. 56-10

Processes culminating in an extinction vortex

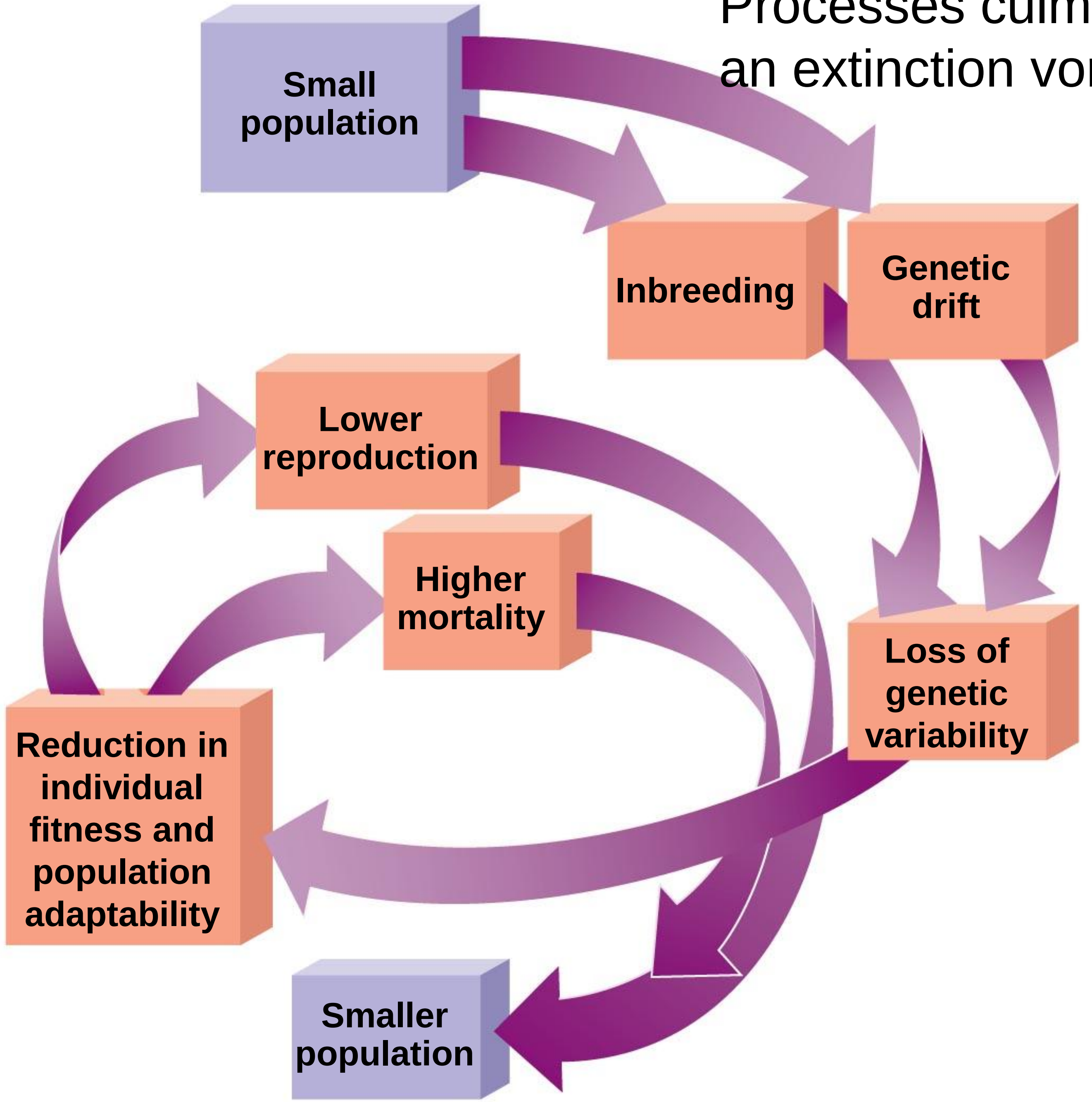
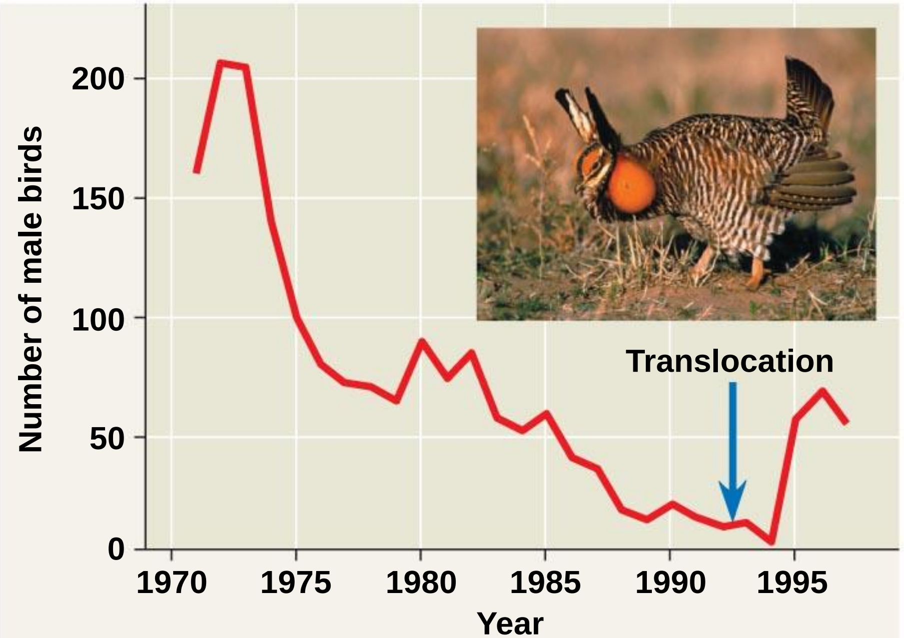
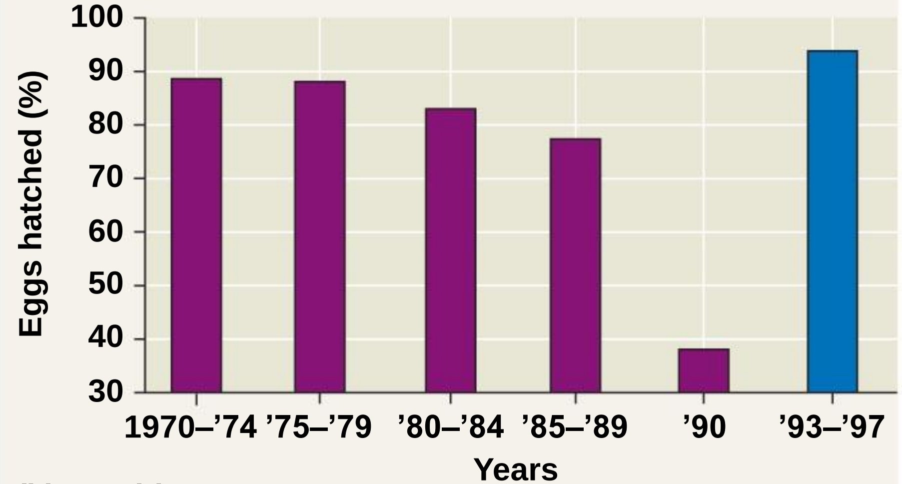


Fig. 56-11

RESULTS



(a) Population dynamics



(b) Hatching rate

To test the extinction vortex hypothesis, scientists imported genetic variation by transplanting birds from larger populations

Minimum Viable Population Size

- **Minimum viable population (MVP)** is the minimum population size at which a species can survive
- The MVP depends on factors that affect a population's chances for survival over a particular time
- A meaningful estimate of MVP requires determining the **effective population size**, which is based on the population's breeding potential

- Effective population size N_e is estimated by:

$$N_e = \frac{4N_fN_m}{N_f + N_m}$$

  - where N_f and N_m are the number of females and the number of males, respectively, that breed successfully

Case Study: *Analysis of Grizzly Bear Populations*

- One of the first population viability analyses was conducted as part of a long-term study of grizzly bears in Yellowstone National Park
- This grizzly population is about 400, but the N_e is about 100
- The Yellowstone grizzly population has low genetic variability compared with other grizzly populations

Fig. 56-12

Long-term monitoring of a grizzly bear population

Declining-Population Approach

- The declining-population approach
  - Focuses on threatened and endangered populations that show a downward trend, regardless of population size
  - Emphasizes the environmental factors that caused a population to decline

Fig. 56-13

- Red-cockaded woodpeckers require living trees in mature pine forests
- In a study where breeding cavities were constructed, new breeding groups formed only in these sites

(a) Forests with low undergrowth **(b) Forests with high, dense undergrowth**

Weighing Conflicting Demands

- Conserving species often requires resolving conflicts between habitat needs of endangered species and human demands
- Managing habitat for one species might have positive or negative effects on other species

Fragmentation and Edges

- The boundaries, or edges, between ecosystems are defining features of landscapes
- Some species take advantage of edge communities to access resources from both adjacent areas

Fig. 56-14

(a) Natural edges

(b) Edges created by human activity

- The Biological Dynamics of Forest Fragments Project in the Amazon examines the effects of fragmentation on biodiversity
- Landscapes dominated by fragmented habitats support fewer species due to a loss of species adapted to habitat interiors

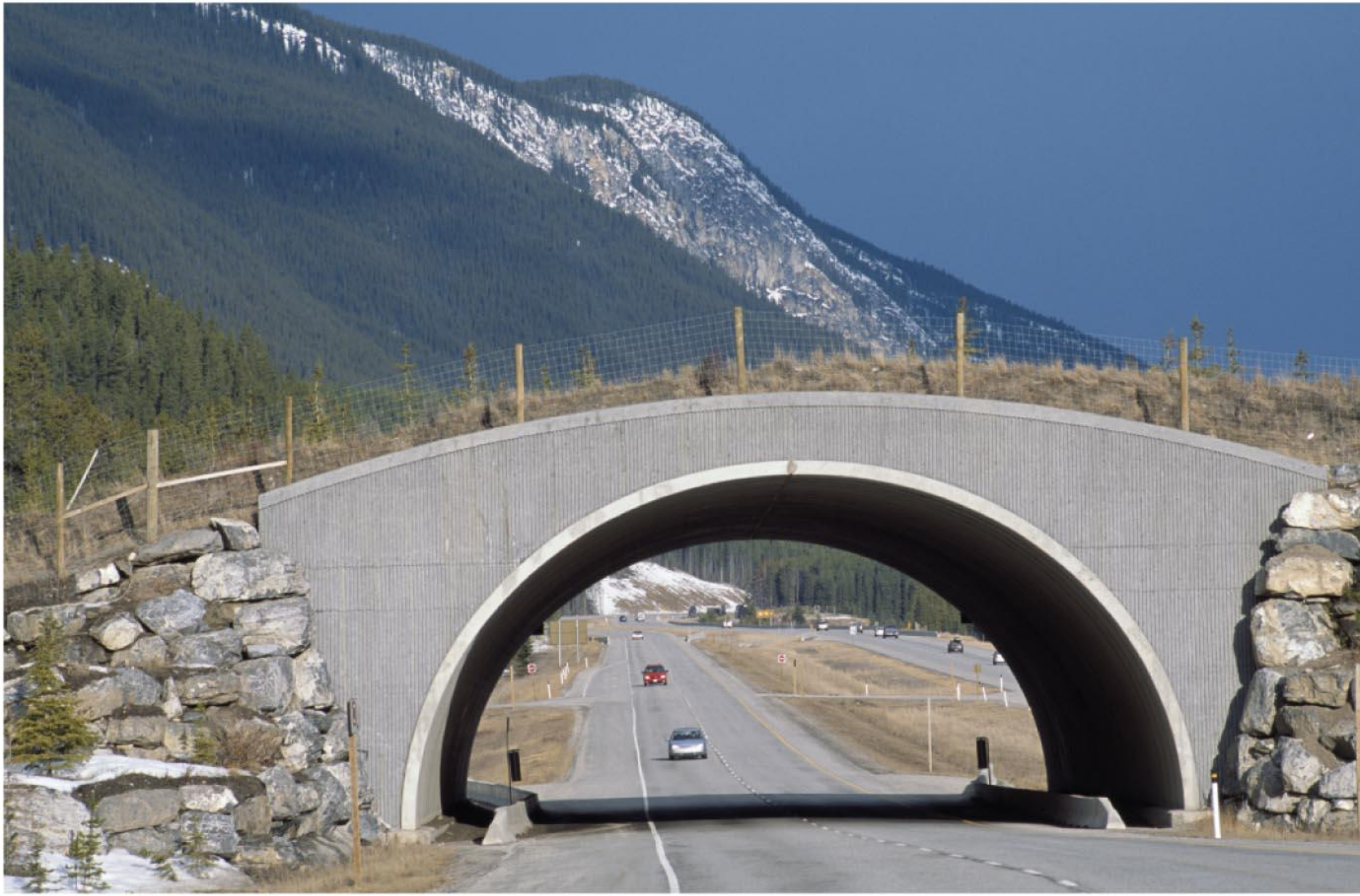
Fig. 56-15

Corridors That Connect Habitat Fragments

- A **movement corridor** is a narrow strip of quality habitat connecting otherwise isolated patches
- Movement corridors promote dispersal and help sustain populations
- In areas of heavy human use, artificial corridors are sometimes constructed

Fig. 56-16

An artificial corridor

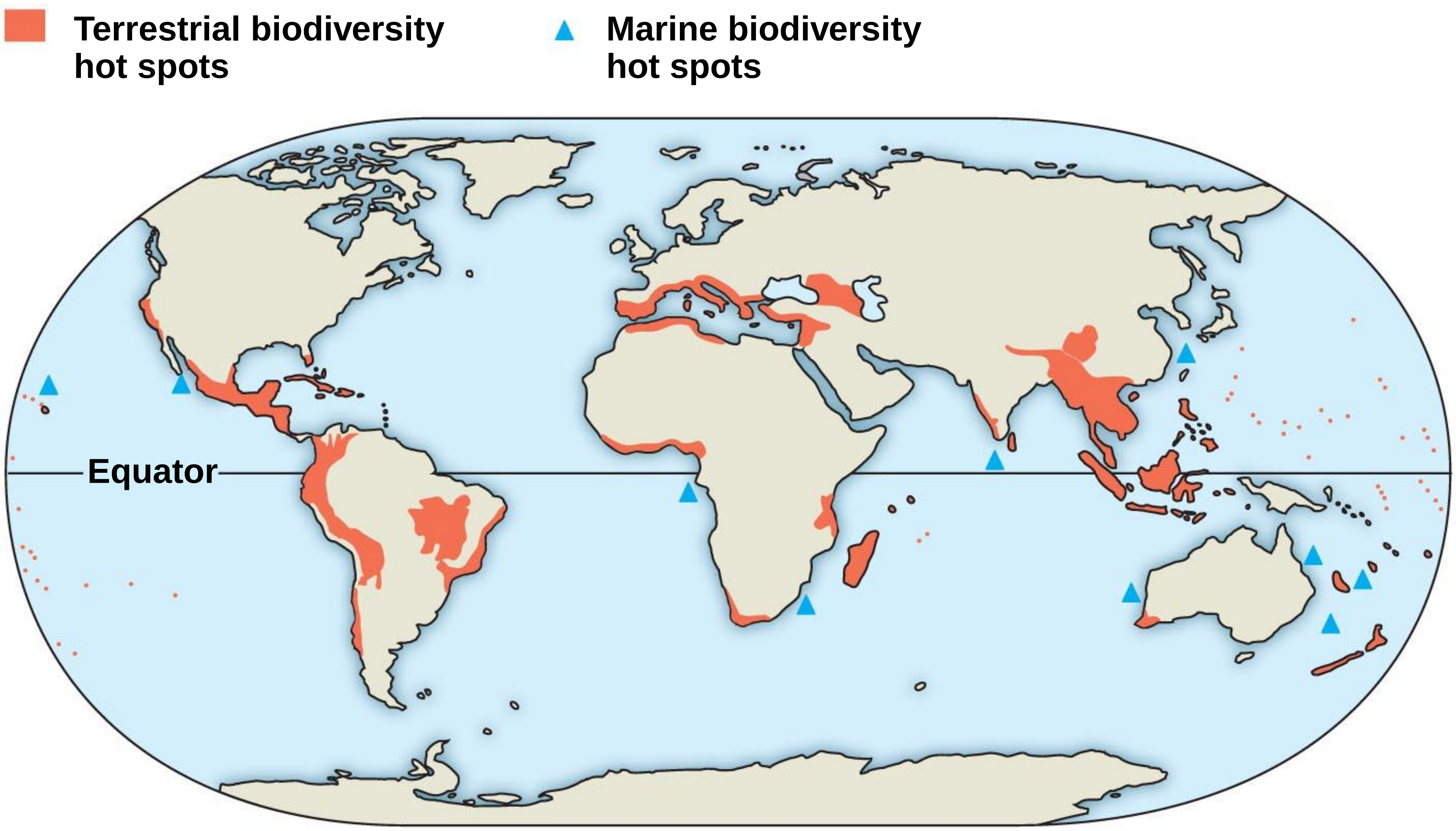


Finding Biodiversity Hot Spots

- A **biodiversity hot spot** is a relatively small area with a great concentration of endemic species and many endangered and threatened species
- Biodiversity hot spots are good choices for nature reserves, but identifying them is not always easy

Fig. 56-17

Earth's terrestrial and marine biodiversity hot spots

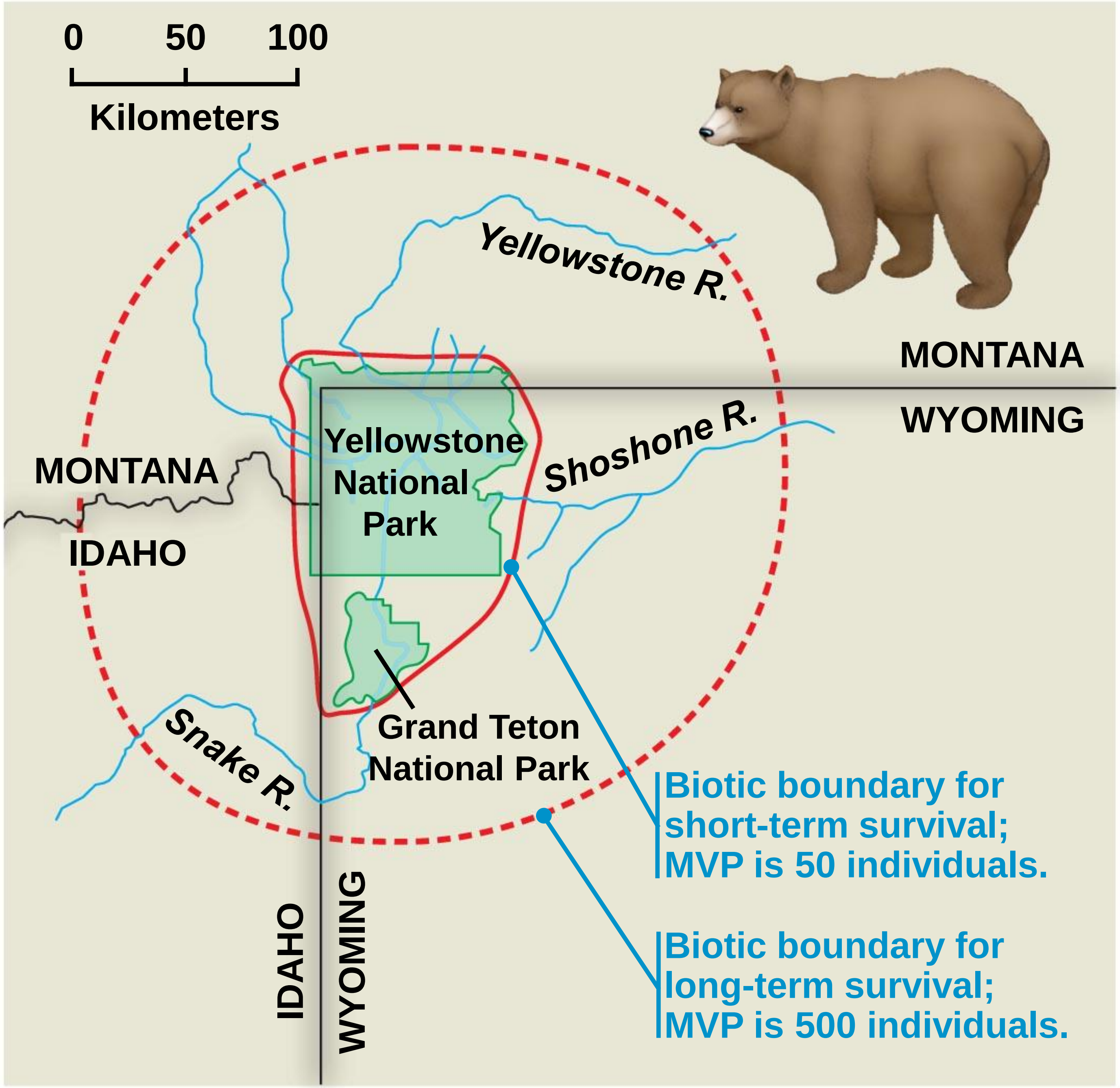


Philosophy of Nature Reserves

- Nature reserves are biodiversity islands in a sea of habitat degraded by human activity
- Nature reserves must consider disturbances as a functional component of all ecosystems

- An important question is whether to create fewer large reserves or more numerous small reserves
- One argument for extensive reserves is that large, far-ranging animals with low-density populations require extensive habitats
- Smaller reserves may be more realistic, and may slow the spread of disease throughout a population

Fig. 56-18



0
50
100
Kilometers
Yellowstone R.
MONTANA
WYOMING
Shoshone R.
Yellowstone
National
Park
MONTANA
IDAHO
Grand Teton
National Park
Snake R.
Biotic boundary for
short-term survival;
MVP is 50 individuals.
Biotic boundary for
long-term survival;
MVP is 500 individuals.
IDAHO
WYOMING

Zoned Reserves

- A **zoned reserve** includes relatively undisturbed areas and the modified areas that surround them and that serve as buffer zones
- Zoned reserves are often established as "conservation areas"

Fig. 56-19

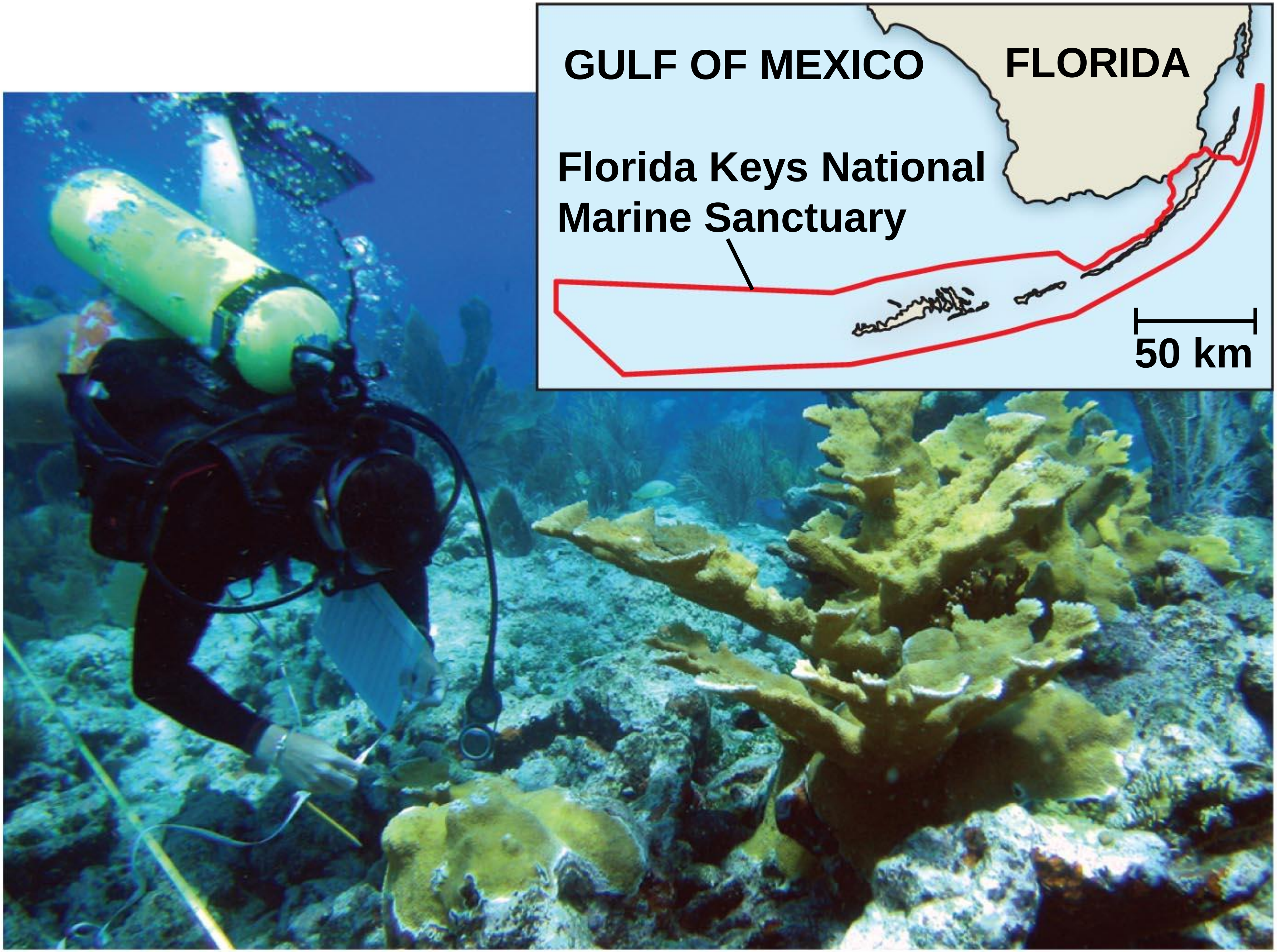
(a) Zoned reserves in Costa Rica

(b) Schoolchildren in one of Costa Rica's reserves

Costa Rica has become a world leader in establishing zoned reserves

- Some zoned reserves in the Fiji islands are closed to fishing, which actually improves fishing success in nearby areas
- The United States has adopted a similar zoned reserve system with the Florida Keys National Marine Sanctuary

Fig. 56-20


GULF OF MEXICO
FLORIDA
Florida Keys National
Marine Sanctuary
50 km

Concept 56.4: Restoration ecology attempts to restore degraded ecosystems to a more natural state

- Given enough time, biological communities can recover from many types of disturbances
- Restoration ecology seeks to initiate or speed up the recovery of degraded ecosystems
- A basic assumption of restoration ecology is that most environmental damage is reversible
- Two key strategies are bioremediation and augmentation of ecosystem processes

A gravel and clay mine site in New Jersey before and after restoration

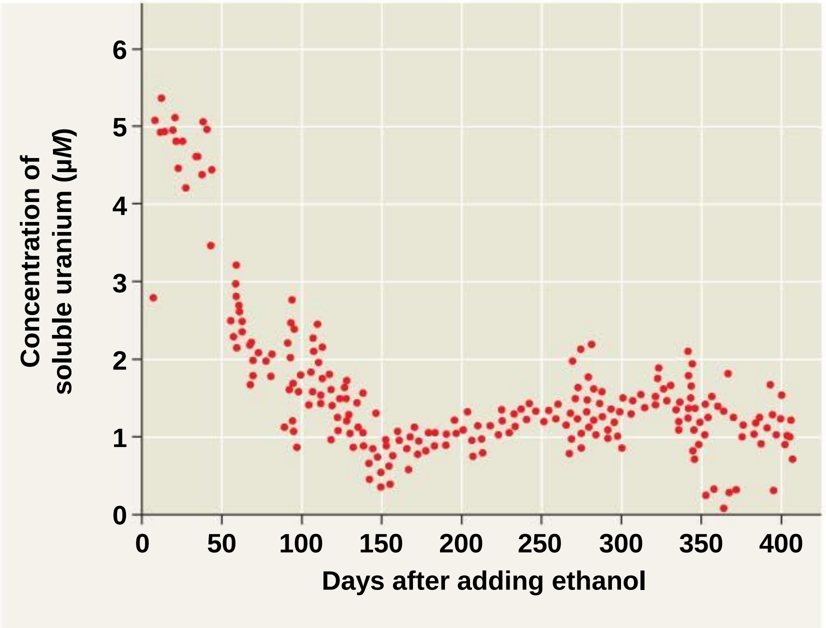
(a) In 1991, before restoration

(b) In 2000, near the completion of restoration

Fig. 56-22

Bioremediation is the use of living organisms to detoxify ecosystems

(a) Unlined pits filled with wastes containing uranium



(b) Uranium in groundwater

Bioremediation of groundwater contaminated with uranium at Oak Ridge National Laboratory, Tennessee

Biological Augmentation

- **Biological augmentation** uses organisms to add essential materials to a degraded ecosystem
- For example, nitrogen-fixing plants can increase the available nitrogen in soil

Fig. 56-23a

Restoration ecology worldwide

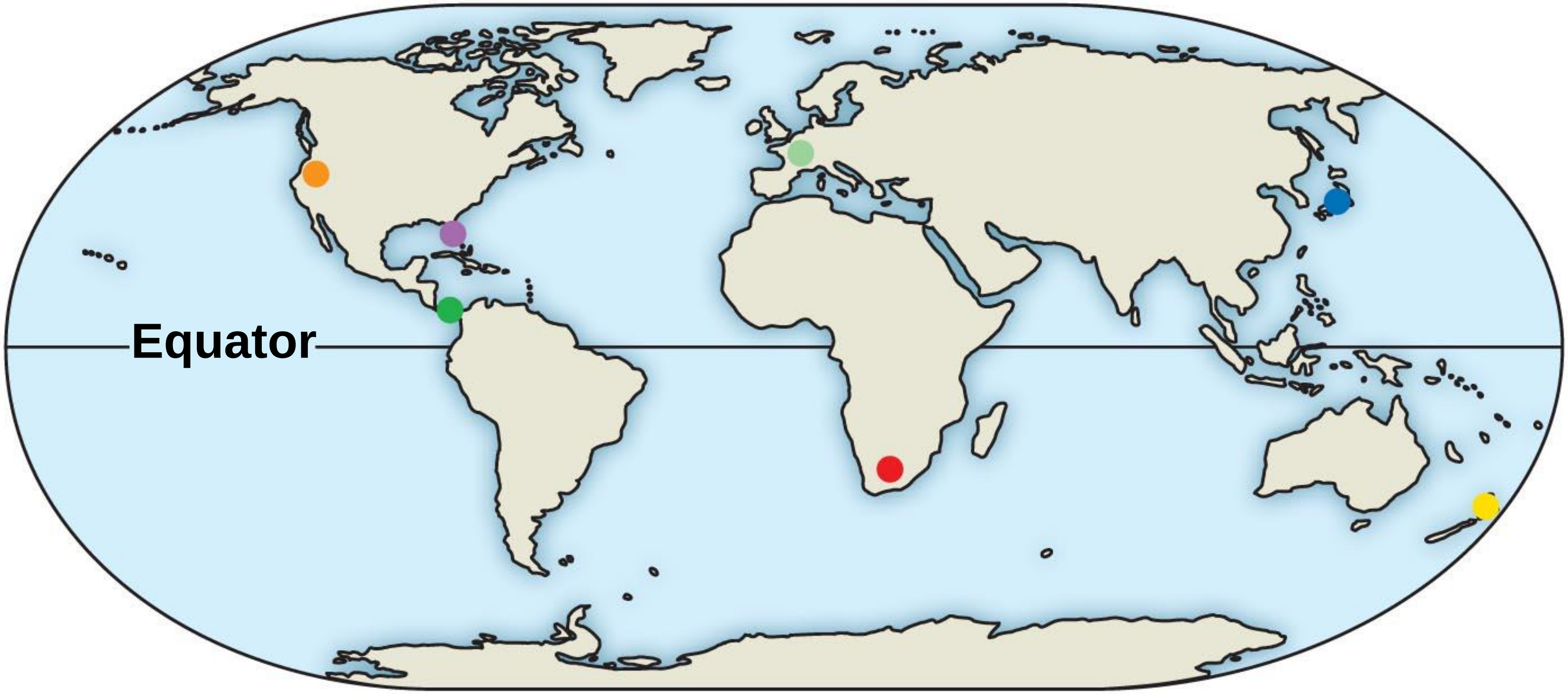


Fig. 56-23b

Truckee River, Nevada

Fig. 56-23c

Kissimmee River, Florida

Fig. 56-23d

Tropical dry forest, Costa Rica

Fig. 56-23e

Rhine River, Europe

Fig. 56-23f

Succulent Karoo, South Africa

Fig. 56-23g

● **Coastal Japan**

Fig. 56-23h

● **Maungatautari, New Zealand**

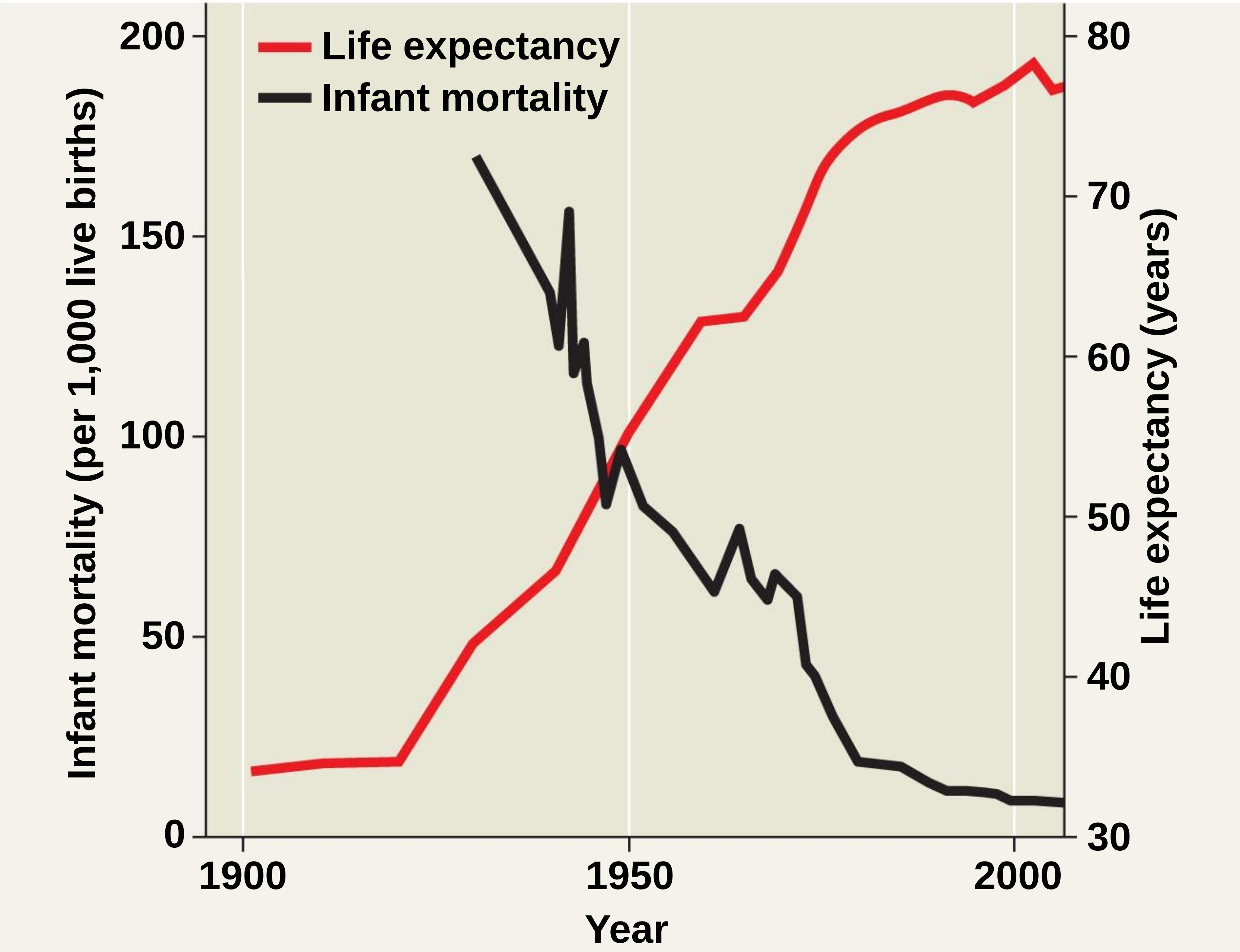
Concept 56.5: Sustainable development seeks to improve the human condition while conserving biodiversity

- The concept of sustainability helps ecologists establish long-term conservation priorities
- **Sustainable development** is development that meets the needs of people today without limiting the ability of future generations to meet their needs
- Sustainable development requires connections between life sciences, social sciences, economics, and humanities

Case Study: Sustainable Development in Costa Rica

- Costa Rica’s conservation of tropical biodiversity involves partnerships between the government, other organizations, and private citizens
- Human living conditions (infant mortality, life expectancy, literacy rate) in Costa Rica have improved along with ecological conservation

Fig. 56-24

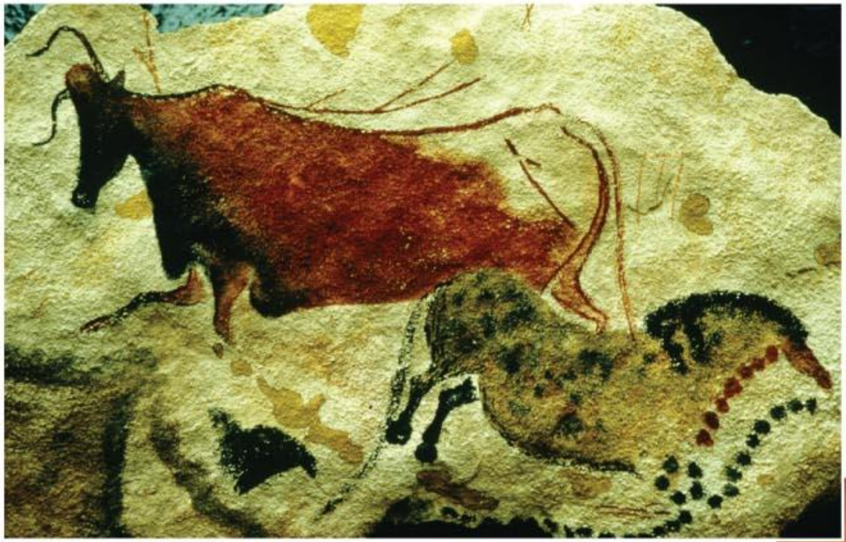


Life expectancy
Infant mortality
200
150
100
50
0
80
70
60
50
40
30
1900
1950
2000
Year
Infant mortality (per 1,000 live births)
Life expectancy (years)

Fig. 56-25

- Our behavior reflects remnants of our ancestral attachment to nature and the diversity of life—the concept of *biophilia*
- Our sense of connection to nature may motivate realignment of our environmental priorities

(a) Detail of animals in a 36,000-year-old cave painting, Lascaux, France



(b) A 30,000-year-old ivory carving of a water bird, found in Germany

(c) Biologist Carlos Rivera Gonzales examining a tiny tree frog in Peru

You should now be able to:

1. Distinguish between conservation biology and restoration biology
2. List the three major threats to biodiversity and give an example of each
3. Define and compare the small-population approach and the declining-population approach
4. Distinguish between the total population size and the effective population size

5. Describe the conflicting demands that may accompany species conservation
6. Define biodiversity hot spots and explain why they are important
7. Define zoned reserves and explain why they are important
8. Explain the importance of bioremediation and biological augmentation of ecosystem processes in restoration efforts

9. Describe the concept of sustainable development

10. Explain the goals of the Sustainable Biosphere Initiative