Conservation Biology and Global Change

(chapter 56)
HOW many species??

- Scientists have named and described 1.8 million species
- Biologists estimate 10-100 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
Conservation biology, which seeks to preserve biodiversity (the variety of life), integrates several fields:

- Ecology
- Physiology
- Molecular biology
- Genetics
- Evolutionary biology
Three Levels of Biodiversity

Genetic diversity: source of variations that enable populations to adapt to environmental changes

Species diversity: important in maintaining structure of communities and food webs

Ecosystem diversity: provides life-sustaining services such as nutrient cycling and waste decomposition
The local extinction of one species can have a negative impact on other species in an ecosystem.

For example, flying foxes (bats) are important pollinators and seed dispersers in the Pacific Islands.
Benefits of Species and Genetic Diversity

- Species related to agricultural crops can have important genetic qualities
  - Ex: plant breeders bred virus-resistant commercial rice by crossing it with a wild population
- In the U.S., 25% of prescriptions contain substances originally derived from plants
  - For example, the rosy periwinkle contains alkaloids that inhibit cancer growth
• The loss of species also means loss of unique genes and genetic diversity
• The enormous genetic diversity of organisms has potential for great human benefit
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
Threats to Biodiversity

- Most species loss can be traced to four major threats:
  - Habitat loss
  - Introduced species
  - Overharvesting
  - Global change
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.
- Ex: Lionfish
Invasive lionfish in the Atlantic

- Likely introduced by aquarists
- Very few predators
- They are voracious predators!!
Overharvesting

- DNA analysis can help conservation biologists identify the source of illegally obtained animal products
  - For example, DNA from illegally harvested ivory can be used to trace the original population of elephants to within a few hundred kilometers
Can Extinct Species Be Resurrected?

- Species recovery may be possible through cloning technology if frozen tissue is available.
- Current research is underway to determine if ancient extinct species frozen in Arctic ice can be successfully cloned.
- Resurrection of extinct species raises ethical questions.
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
Small-Population Approach

- The small-population approach studies processes that can make small populations become extinct.
- A small population is prone to inbreeding and genetic drift, which 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.
- Small populations and low genetic diversity do not always lead to extinction.
Small population

Inbreeding, genetic drift

Lower reproduction, higher mortality

Loss of genetic variability

Lower individual fitness and population adaptability

Smaller population
Case Study: *The Greater Prairie Chicken and the Extinction Vortex*

- Populations were fragmented by agriculture and found to have decreased fertility.

- To test the extinction vortex hypothesis, scientists imported birds from larger populations.

- The declining population rebounded, confirming that low genetic variation had been causing an extinction vortex.
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.
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
Case Study: *Decline of the Red-cockaded Woodpecker*

- Red-cockaded woodpeckers require living trees in mature pine forests
- These woodpeckers require forests with little undergrowth
- Logging, agriculture, and fire suppression have reduced suitable habitat
Red-cockaded woodpeckers take months to excavate new nesting cavities.

In a study where breeding cavities were constructed, new breeding groups formed only in these sites.

Based on this experiment, a combination of habitat maintenance and excavation of breeding cavities enabled this endangered species to rebound.
Weighing Conflicting Demands

- Conserving species often requires resolving conflicts between habitat needs of endangered species and human demands
- For example, in the U.S. Pacific Northwest, habitat preservation for many species is at odds with timber and mining industries
- Managing habitat for one species might have positive or negative effects on other species
Landscape and regional conservation help sustain biodiversity

- The structure of a landscape can strongly influence biodiversity
Fragmentation and Edges

- The boundaries, or edges, between ecosystems are defining features of landscapes.
- An edge has its own set of physical conditions, which differ from those on either side of it.
- Some species take advantage of edge communities to access resources from both adjacent areas.
**Corridors That Connect Habitat Fragments**

- A **movement corridor** is a narrow strip of habitat connecting otherwise isolated patches to promote dispersal and help sustain populations.

- In areas of heavy human use, artificial corridors are sometimes constructed.

- Corridors can also be harmful by facilitating the spread of disease between populations.
Preserving 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—and they may change over time with climate.
The field of **urban ecology** examines organisms and their environment in urban settings.

A critical area of research centers on urban streams, which experience rapid water fluctuations after rainfall.

Restoration of Guichon Creek, near Vancouver, British Columbia, has allowed for the successful reestablishment of cutthroat trout.
Earth is changing rapidly as a result of human actions

- Human-caused changes in the environment include
  - Nutrient enrichment
  - Accumulation of toxins
  - Climate change
  - Ozone depletion
Nutrient Enrichment

- Human activity often removes nutrients from one part of the biosphere and adds them to another
- Harvest of agricultural crops exports nutrients from the agricultural ecosystem
- Agriculture leads to the depletion of nutrients in the soil
- Fertilizers add nitrogen and other nutrients to the agricultural ecosystem
- **Critical load** is the amount of added nutrient that can be absorbed by plants without damaging ecosystem integrity.

- Nutrients that exceed the critical load leach into groundwater or run off into aquatic ecosystems.

- Agricultural runoff and sewage lead to phytoplankton blooms in the Atlantic Ocean.

- Decomposition of phytoplankton blooms causes “dead zones” due to low oxygen levels.
Toxins in the Environment

- Humans release many toxic chemicals, including synthetics previously unknown to nature.
- In some cases, harmful substances persist for long periods in an ecosystem.
- One reason toxins are harmful is that they become more concentrated in successive trophic levels.
- **Biological magnification** concentrates toxins at higher trophic levels, where biomass is lower.
- Pharmaceutical drugs enter freshwater ecosystems through human sewage and agricultural runoff.
- Estrogen used in birth control pills can cause feminization of males in some species of fish.
Greenhouse Gases and Climate Change

- One pressing problem caused by human activities is the rising level of CO$_2$ and other greenhouse gases in the atmosphere.

- Due to burning of fossil fuels and other human activities, the concentration of atmospheric CO$_2$ has been steadily increasing.
Climatologists can make inferences about past environments and climates

- Pollen and fossil plant records reveal past vegetation
- $\text{CO}_2$ levels are inferred from bubbles in glacial ice
- Chemical isotope analysis is used to infer past temp
- Many organisms may not be able to survive rapid climate change
- Some ecologists support **assisted migration**, the translocation of a species to a favorable habitat beyond its native range
Climate Change Solutions

- Global warming can be slowed by reducing energy needs and converting to renewable sources of energy
- Stabilizing CO$_2$ emissions will require an international effort
- International negotiations have yet to reach a consensus on a global strategy to reduce greenhouse gas emissions
- Reduced deforestation would also decrease greenhouse gas emissions
Sustainable Development

- Sustainable development can improve human lives while conserving biodiversity

- **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 (*interdisciplinary*)