Chapter 56

Conservation Biology and Global Change

Conservation biology, which seeks to preserve life, integrates several fields

– Ecology

– Physiology

– Molecular biology

– Genetics

– Evolutionary biology

Human activities threaten Earth's biodiversity

Rates of species extinction are difficult to determine under natural conditions

The high rate of species extinction is largely a result of ecosystem degradation by humans

Humans are threatening Earth's biodiversity

Three Levels of Biodiversity

Biodiversity has three main components

Genetic diversity

Species diversity

Ecosystem diversity

Genetic Diversity

Genetic diversity comprises genetic variation within

a population and between populations

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

Extinction may be local or global

Ecosystem Diversity

Human activity is reducing ecosystem diversity, the variety of ecosystems in the biosphere

More than 50% of wetlands in the contiguous United States have been drained and converted to other ecosystems

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

Biodiversity and Human Welfare

Human biophilia allows us to recognize the value of

biodiversity for its own sake

Species diversity brings humans practical benefits

Benefits of Species and Genetic Diversity

Species related to agricultural crops can have important genetic qualities

> For example, plant breeders bred virus-resistant commercial rice by crossing it with a wild population

In the United States, 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 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 destruction

- – Introduced species

- – Overharvesting

- – Global change

Habitat Loss

Human alteration of habitat is the greatest threat to biodiversity throughout the biosphere

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

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

Overharvesting

Overharvesting is human harvesting of wild plants or animals at rates exceeding the ability of populations of those species to rebound

Large organisms with low reproductive rates are especially vulnerable to overharvesting

For example, elephant populations declined because of harvesting for ivory

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

Global Change

Global change includes alterations in climate,

atmospheric chemistry, and broad ecological

systems

Acid precipitation contains sulfuric acid and nitric

acid from the burning of wood and fossil fuels

Air pollution from one region can result in acid precipitation downwind

For example, industrial pollution in the midwestern United States caused acid rain in eastern Canada in the 1960s

Acid precipitation kills fish and other lake-dwelling organisms

Environmental regulatins have helped to decrease acid precipitation

For example, sulfur dioxide emissions in the United States decreased 31% between 1993 and 2002

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

The Extinction Vortex: Evolutionary Implications of Small Population Size

A small population is prone to inbreeding and genetic drift 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

Small populations and low genetic diversity do not always lead to extinction

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

Effective Population Size

A meaningful estimate of MVP requires

determining the **effective population size**, which

is based on the population's breeding potential

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

Steps for Analysis and Intervention

The declining-population approach involves several steps

1. Confirm that the population is in decline
2. Study the species' natural history
3. Develop hypotheses for all possible causes of decline
4. Test the hypotheses in order of likeliness
5. Apply the results of the diagnosis to manage for recovery

Landscape and regional conservation help sustain biodiversity

Conservation biology has attempted to sustain the biodiversity of entire communities, ecosystems, and landscapes

Ecosystem management is part of landscape ecology, which seeks to make biodiversity conservation part of land-use planning

Landscape Structure and Biodiversity

The structure of a landscape can strongly

influence biodiversity

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

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

Establishing Protected Areas

Conservation biologists apply understanding of ecological dynamics in establishing protected areas to slow the loss of biodiversity

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

Designation of hot spots is often biased toward

saving vertebrates and plants

Hot spots can change with climate change

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 large 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

Earth is changing rapidly as a result of human actions

The locations of preserves today may be unsuitable for their species in the future

Human-caused changes in the environment include

      Nutrient enrichment

      Accumulations of toxins

      Climate change

      Ozone depletion

Nutrient Enrichment

In addition to transporting nutrients from one location to another, humans have added new materials, some of them toxins, to ecosystems

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

PCBs and many pesticides such as DDT are subject to biological magnification in ecosystems

Herring gulls of the Great Lakes lay eggs with PCB levels 5,000 times greater than in phytoplankton

In the 1960s Rachel Carson brought attention to the biomagnification of DDT in birds in her book *Silent Spring*

DDT was banned in the United States in 1971

Countries with malaria face a trade-off between killing mosquitoes (malarial vectors) and protecting other species

Greenhouse Gases and Global Warming

One pressing problem caused by human activities

is the rising level of atmospheric CO_2

Rising Atmospheric CO$_2$ Levels

Due to burning of fossil fuels and other human activities, the concentration of atmospheric CO$_2$ has been steadily increasing

Most plants grow faster with CO$_2$ concentrations increase

C$_3$ plants (for example, wheat and soybeans) are more limited by CO$_2$ than C$_4$ plants (for example, corn)

The Greenhouse Effect and Climate

CO_2, water vapor, and other greenhouse gases reflect infrared radiation back toward Earth; this is the **greenhouse effect**

This effect is important for keeping Earth's surface at a habitable temperature

Increasing concentration of atmospheric CO_2 is linked to increasing global temperature

Climatologists can make inferences about past environments and their climates

- – Pollen and fossil plant records reveal past vegetation

- – CO_2 levels are inferred from bubbles trapped in glacial ice

- – Chemical isotope analysis is used to infer past temperature

Northern coniferous forests and tundra show the strongest effects of global warming

– For example, in 2007 the extent of Arctic sea ice was the smallest on record

A warming trend would also affect the geographic distribution of precipitation

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

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

Recent 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

Depletion of Atmospheric Ozone

Life on Earth is protected from damaging effects of UV radiation by a protective layer of ozone molecules in the atmosphere

Satellite studies suggest that the ozone layer has been gradually thinning since the mid-1970s

Destruction of atmospheric ozone results mainly from chlorofluorocarbons (CFCs) produced by human activity

CFCs contain chlorine which reacts with ozone to make O_2

This decreases ozone in the atmosphere

The ozone layer is thinnest over Antarctica and southern Australia, New Zealand, and South America

Ozone levels have decreased 2–10% at mid-latitudes during the past 20 years

Ozone depletion causes DNA damage in plants and poorer phytoplankton growth

An international agreement signed in 1987 has resulted in a decrease in ozone depletion

Sustainable development can improve the human condition while conserving biodiversity

The concept of sustainability helps ecologists

establish long-term conservation priorities

Sustainable Biosphere Initiative

Sustainable development is development that meets the needs of people today without limiting the ability of future generations to meet their needs

The goal of the Sustainable Biosphere Initiative is to define and acquire basic ecological information for responsible development, management, and conservation of Earth's resources

Sustainable development requires connections between life sciences, social sciences, economics, and humanities