CHAPTER 50 CONSERVATION BIOLOGY

Chapter Outline

50.1 Conservation Biology and Biodiversity

A. Conservation Biology
   1. Conservation biology is a new discipline studying aspects of biodiversity in order to conserve natural resources.
   2. Conservation biology involves both scientific concepts and their application to practical problems.
   3. It supports four principles.
      a. Biodiversity is desirable for both the biosphere and for humans.
      b. Extinctions due to human actions are undesirable.
      c. The complex interactions in ecosystems support biodiversity and are therefore desirable.
      d. Biodiversity from evolutionary change has value by itself regardless of any practical benefit.
   4. Estimates vary but at least 10–20% of all species now living will most likely become extinct in 20–50 years.

B. Biodiversity
   1. Species biodiversity is the number of species of bacteria, plants, animals, etc.
   2. Most estimates place the number of species living on earth as between 5 and 15 million species; most are yet to be found and described.
   3. To add more meaning for applications, diversity also includes genetic diversity, community diversity, and landscape diversity.
   4. Genetic diversity helps maintain reproductive vitality and assists adaptation.
      a. The 1846 potato blight in Ireland was due to too little genetic diversity.
      b. 1922 saw a similar Soviet wheat failure.
      c. Florida had an outbreak of citrus canker in 1984 made worse by limited genetic variation.
      d. Such limited genetic variation creates the risk of extinction in natural populations.
   5. Community diversity refers to the variation in species composition in a community.
      a. Different communities have different species; therefore different communities add to species diversity.
      b. Attempts to save just one species are shortsighted when the community itself is threatened.
      c. Disrupting a community can threaten many species.
   6. Landscape Diversity
      a. Landscape diversity incorporates a number of interacting ecosystems: plains, mountains, rivers, etc.
      b. Fragmented ecosystems may connect by **habitat corridors,** strips allowing organisms to move between patches.

C. Distribution of Diversity
   1. Biodiversity is not evenly distributed; saving some areas saves more species than saving others.
   2. Biodiversity is highest in the tropics and declines toward the poles on land, in fresh water, and in the ocean.
   3. Biodiversity hotspots contain unusually large concentrations of species; 20% of these species are in only 1/2% of the earth's land area.
   4. Madagascar, the Cape of South Africa, and the Great Barrier Reef of Australia are all biodiversity hotspots.
   5. Biodiversity frontiers such as the rain forest canopies and the deep sea benthos have more species than formerly suspected.

50.2 Value of Biodiversity

A. To reverse the trend toward species extinction, all people must realize the value of biodiversity as a resource.
B. Medicinal Value
    1. Most U.S. prescription drugs were originally derived from living organisms.
    2. The rosy periwinkle from Madagascar provides chemicals that treat the two cancers: leukemia and Hodgkin disease.
    3. Based on the past rate of drug discovery, there are perhaps 328 more drugs likely to be found in tropical rain forests with $147 billion value.
    4. Fungi and soil bacteria have provided penicillin, tetracycline, and streptomycin.
    5. The nine-banded armadillo is the only other animal to contract human leprosy; this allowed research to find a cure.
    6. The blood of horseshoe crabs contains limulus amoebocyte lysate that keeps pacemakers free of bacteria.
C. Agricultural Value
    1. Wheat, corn and rice crops are uniform; when devastated by pests, the wild strains they came from are a source of genes for disease resistance.
    2. When high-yield rice was devastated by a virus in Africa, it was necessary to locate a wild rice plant that was resistant and breed the gene into the high yield rice.
    3. Biological pest controls are economically important replacements when pests are pesticide resistant.
    4. Most flowering plants are pollinated by animals (e.g., bees, wasps, butterflies, birds, bats, etc.).
    5. The honeybee is a multi-faceted example.
        a. Domesticated bees pollinate over $10 billion worth of food crops annually.
        b. Tracheal mites have wiped out more than 20% of commercial honeybees in the U.S.
        c. Any hope for a resistant bee depends on wild bees; wild pollinators provide a $4.1 to $6.7 billion service each year.
D. Consumptive Use Value
    1. The cultivation of crops and domestication of animals (farming) has been a successful enterprise.
    2. However, fishing of wild species has not yet been replaced by aquaculture.
    3. Harvesting wild fruits, vegetables, skins, fibers, beeswax, seaweed, and hunting meat are important to many peoples.
    4. Calculations show that the timber harvested from the natural environment in the Peruvian Amazon is of less value than harvest of tree fruits and rubber production.
E. Indirect Value
    1. Biogeochemical Cycles
        a. Biodiversity contributes to the water, carbon, nitrogen, and phosphorus cycles of our ecosystem.
        b. We depend upon normal cycles to provide fresh water, remove carbon dioxide, etc.
        c. Technology cannot artificially create these cycles in place of the ecosystem.
    2. Waste Disposal
        a. Decomposers break down organic matter and other wastes into nutrients used by producers.
        b. Decomposition in nature is more economical and complete than sewage treatment.
        c. Biological communities purify water and break down pollutants; Canada estimates this wetland value at $50,000 per hectare.
    3. Provision of Fresh Water
        a. Most terrestrial organisms, including humans, need freshwater ecosystems.
        b. Desalination plants cost four to eight times the average cost of water taken from the water cycle.
        c. Forests are “sponges” that hold and release water over time; value of marshland outside of Boston, Massachusetts, is estimated at $72,000 per hectare based on its ability to reduce floods.
    4. Prevention of Soil Erosion
        a. Intact ecosystems naturally retain soil and prevent erosion.
        b. Deforestation results in silt that fills reservoirs and denudes hillsides; a dam in Pakistan is filling much faster due to silt.
        c. Silt from deforestation also smothers mangrove and coastal ecosystems and ruins fisheries.

5. Regulation of Climate
    a. Trees provide both shade and natural "air conditioning."
    b. Globally, tropical rain forests act as a sink for carbon dioxide; when trees are burned the CO_2 is released back to the atmosphere.
    c. CO_2 is a greenhouse gas and contributes to global warming; not all life may be able to adjust to the climate change.
6. Ecotourism
    a. In U.S., 100 million people spend a total of $4 billion a year on fees, travel, lodging, and food in order to enjoy natural environments.
    b. Activities include sport fishing, boating, hiking, birdwatching, whale watching, etc.

F. Biodiversity and Natural Ecosystems
1. Massive changes in biodiversity impact ecosystems and the ability to provide the above values.
2. Research indicates that high diversity improves the efficiency of ecosystems.
    a. Minnesota grassland plots with more species had lower inorganic soil nitrogen.
    b. California plots with more diversity had greater overall resource usage.
    c. Net primary productivity increased as diversity increased at all trophic levels.
    d. Computer modeling predicts 30% more photosynthesis with nine different tree species rather than one single species.
3. Additional research may determine the effects of environmental change, invasion, pathogens, and fragmentation.

50.3 Causes of Extinction

A. Identifying Causes
1. 1,880 threatened and endangered species were examined for the cause of their status.
    a. Habitat loss was involved in 85% of cases.
    b. An alien (exotic or introduced) species was involved in nearly 50%.
    c. Pollution was a factor in 24%.
    d. Overexploitation occurred in 17%.
    e. Disease was involved in 3%.
2. As an example, the decline in macaws is the result of timber and mining activities, and hunting for food and pet trade.

B. Habitat Loss
1. Rain forest destruction follows a pattern.
    a. A highway is constructed into the forest interior.
    b. Small towns, industry and roads then branch off into the forest.
    c. Settlers, often subsidized, burn the trees and raise crops on the three-year supply of nutrients.
    d. After the land degrades, the farmers must move to another portion of forest.
2. Coastal degradation is due to high human populations that live along the shore.
3. Already 60% of coral reefs are destroyed or near destruction; all coral reefs could disappear in 40 years.
4. 45% of Indonesia's mangrove forests have already been destroyed.
5. Wetlands, estuaries and seagrass beds are being rapidly destroyed.

C. Alien Species
1. Alien or exotic species are introduced accidently or deliberately into new ecosystems.
2. Natural ecosystems have evolved with their native organisms in balance.
3. Migration out of ecosystems is blocked by barriers; however, humans circumvent these barriers by various means.
    a. **Colonization** of European pioneers brought the dandelion as a salad green.
    b. **Horticulture** and **agriculture** have resulted in cultivated plants like kudzu escaping into countryside.
    c. **Accidental transport** due to global trade carried the European zebra mussels in ballast water to the U.S. where it now squeezes out native mussels.
4. Alien species disrupt food chains; an opossum shrimp introduced into Montana lakes led to less food for eagles and grizzly bears.

5. Islands are especially susceptible to disruption by introduction of exotics.
    a. When myrtle trees from the Canary Islands were introduced to Hawaii, symbiotic bacteria gave them a competitive edge over native trees.
    b. The brown tree snake introduced to Guam has reduced ten bird species to the point of extinction.
    c. On the Galapagos Islands, black rats have reduced the giant tortoise; goats and feral pigs have harmed cactus and converted forest to grassland.
    d. Mongooses introduced into Hawaii to control rats have preyed on native birds.

D. Pollution
1. Pollution is any environmental change that adversely affects the health of living things.
2. Pollution is directly the third main cause of extinctions and can lead to disease, another factor.
3. Acid Deposition
    a. Automobile exhaust and sulfur dioxide from power plants form acids when combined with the water vapor in air.
    b. These acids return to earth as acid rain/snow or dry deposition.
    c. Although sulfur and nitrogen oxides are emitted in one locale, deposition occurs elsewhere across boundaries.
    d. Acid deposition causes trees to weaken, kills small invertebrates and decomposers, and kills the life in northern lakes.
4. Eutrophication
    a. Lakes are stressed by excess nutrients from sewage treatment and agricultural runoff.
    b. Algae grow in abundance and then die off; the bacterial decomposers then use up all of the oxygen and kill the fish.
5. Ozone Depletion
    a. The ozone shield is a layer of ozone (O_3) in the stratosphere, some 50 km above the earth's surface.
    b. It absorbs most of the harmful ultraviolet (UV) radiation, preventing it from reaching earth's surface.
    c. The cause of ozone depletion traces to chlorine (Cl^-) atoms that come from the breakdown of CFCs.
    d. Freon is a common CFC that was used in refrigerators and air conditioners.
    e. Ozone shield depletion will lead to depression of the human immune system, impaired crop and tree growth, and death of plankton.
6. Organic Chemicals
    a. A wide variety of organic chemicals are produced and enter the environment.
    b. Nonylphenols are used in plastics, spermicides, cosmetics, etc.; such chemicals mimic the effects of hormones.
    c. Salmon switch development between fresh and salt water but this chemical prevents adaptation in 20–30% of young fish.

E. Global Warming
1. "Global warming" refers to an expected increase in average temperature in the 21st Century.
2. Greenhouse gases (named for their ability to trap heat like greenhouse glass) contribute to warming:
    a. carbon dioxide (CO_2) is produced by burning fossil fuels; and
    b. methane (CH_4) is produced by animal guts, oil and gas wells, and flooded rice paddies.
3. Data collected worldwide show a rise in greenhouse gases.
4. Computer models predict rising average temperature.
    a. The global climate appears to have risen since the industrial revolution.
    b. Some computer models predict a rise of from 1.5^o C to 4.5^o C by 2060.
5. As oceans warm, temperatures in polar regions would likely rise to a greater degree than other areas.
6. Glaciers would melt and sea levels would rise; a one meter rise would inundate 20–50% of coastal wetlands.
7. Regions of suitable climate for species would shift rapidly, probably faster than plants could migrate.
8. Coral reefs would suffer from high temperature driving off algae and the higher water "drowning" them.

F. Overexploitation
1. Overexploitation occurs when removal from the wild population drastically reduces their numbers.
2. Rarity causes a feedback cycle: the fewer specimens left, the more valuable they are.

3. There are many cases of overexploited organisms.
    a. "Rustlers" dig up rare cacti to sell to gardeners.
    b. Parakeets and macaws are sold to pet stores.
    c. Tropical fish are harvested using dynamite and cyanide that kill many more.
    d. Siberian tigers are hunted for hides.
    e. Rhinoceros horn is ground up as medicine.
    f. Elephant tusk ivory is used for jewelry.
4. Fish stocks are being depleted by overfishing.
    a. The U.N. F.A.O. considers 11 of 15 major oceanic fishing areas "overexploited."
    b. Purse-seine fishing surrounds tuna.
    c. Huge trawling nets capture bottom-dwelling fish; this has been called the marine equivalent of clear-cutting trees.
5. Overfishing perch and herring caused a decline in seals and sea lions; orca killer whales had to switch to eating sea otters; sea otters ate the sea urchins that fed on kelp and without sea otters, the urchins decimated the kelp beds.

50.4 Conservation Techniques

A. Habitat Preservation
    1. Biodiversity **hotspots** merit preservation first.
    2. In Madagascar tropical rain forests, 93% of primates, 99% of frog species, and over 80% of plant species are endemic (unique and native).
    3. When **keystone species** are lost, their extinction leads to loss of other species.
    4. Bats pollinate and disperse seeds of tropical trees; loss of the bats leads to loss of the trees.
    5. Grizzly bears disperse berry seeds in their dung, keep prey populations healthy, and turn over soil.

B. Metapopulations
    1. **Metapopulations** are subdivided into several small, isolated populations due to habitat fragmentation.
    2. A **source population** lives in a favorable habitat and has a higher birth than death rate.
    3. **Sink populations** have death rates that equal or exceed birth rates.
    4. When trying to save a species, it is best to prevent it from moving into a sink habitat.

C. Landscape Dynamics
    1. Organisms like grizzly bears utilize many ecosystems; saving just one system would not save the species.
    2. Saving diverse ecosystems connected by corridors involves national forests, refuges and private land.
    3. Landscape protection for one species helps protect others; the grizzly range overlaps 40% of Montana's vascular plants of special concern.

D. The Edge Effect
    1. The edge of a habitat is different from the interior; the smaller the patch, the more edge produced.
    2. Forest edges are brighter, warmer, drier, windier and have more vines.
    3. Forest nesting songbirds have less success at the edge; cowbirds are nest parasites at the edge.

E. Computer Analyses
    1. **Gap analysis** uses computers to locate where the biodiversity is high outside of preserves.
    2. When species maps are superimposed on land-use maps, areas in need of preservation are exposed.
    3. **Population viability analysis** helps determine how much habitat a species needs to survive.
    4. Adequate size protects a population from chance swings in birth and death rates.
    5. A red-cockaded woodpecker population of 1,323 is needed to provide a breeding population of 500.
    6. Analysis of grizzly populations predicted a population of 70–90 bears were needed; more were necessary because only a few males bred.
    7. The Florida panther population is inbred; eight Texas cougars were introduced to bolster genetic diversity.

F. Habitat Restoration
    1. **Restoration ecology** seeks scientific ways to return ecosystems to their former state.
    2. Restoration involves three principles.
        a. Restoration should begin immediately before the remaining fragments are lost.
        b. Techniques that mimic natural processes should be used (i.e., controlled burning, biological pest control, etc.).
        c. The goal is sustainable development where the resulting ecosystem should be able to maintain itself.

3. The Everglades
    a. The Everglades is a natural wet sawgrass prairie with cypress or hardwood islands.
    b. Early settlers drained the land to the south and established a dike around the feeder lake; water was also channeled to prevent flooding.
    c. The water supplied by natural cycles of wet and dry seasons has been replaced by discharges from conservation lakes timed for public convenience.
    d. The resulting abnormal water supply has devastated the Everglades ecology; bird populations are dramatically reduced, etc.
    e. Restoration involves providing a natural seasonal flow of water to the Everglades.
    f. Sustainable development involves switching agriculture to sugarcane and rice and establishing an extended buffer zone with interconnected marshes.