Chapter 8

BIOGEOGRAPHY

CASE STUDY: Reintroducing a Rare Species

- Human interference with the distributions of organisms has had varied results in terms of biological diversity. Habitat degradation and hunting has resulted in a reduction of the range of the whooping crane. It is now being reintroduced into areas where it once thrived. This positive action can be contrasted to the accidental introduction of foreign species, such as a seaweed named *Caulerpa taxifolia* from its native habitat in the Pacific Ocean to the Mediterranean Sea, where it is choking out native seaweeds that serve as food for Mediterranean animals.

8.1 WHY WERE INTRODUCTIONS OF NEW SPECIES INTO EUROPE SO POPULAR?

● Species introductions are a serious ecological problem. In 1747 Linneaus made a collecting trip to N. America to obtain new species for European gardens. Western Europe's flora was less diverse than N. America's.

8.2 WALLACES REALMS: BIOTIC PROVINCES

● In 1876 Alfred Russell Wallace proposed that the world could be divided into six biogeographic regions, referred to as **Wallace's realms**, on the basis of fundamental features of the animals common to those areas. These realms were Nearctic (N. America), Neotropical (Central and S. America), Palaearctic (Europe, N. Asia, N Africa), Ethiopian (central and S. Africa), Oriental (Indican subcontinent and Malaysia), and Australian.

● All species are grouped into taxa, where a taxon is a group of related individuals, species or higher groups. Group hierarchy begins at the most inclusive level, the **kingdom**, next comes the **phylum, then the class, order, family, genera**, and **species**. Different families of animals dominate in each of the realms. This is the basis for Walace's realms. These realms are still valid, now referred to as **biotic provinces**, but the concept has been extended to plants and invertebrates. A biotic province is a region inhabited by a characteristic set of taxa (species, families, orders) bounded by barriers that inhibit the exchange of taxa. These barriers result in the coevolution of taxa within each province in isolation from taxa from other provinces. The barriers have arisen due to continental drift.

8.3 BIOMES

● The **biome** is another major biogeographic pattern. Biomes are major ecosystems that are usually defined by their dominant vegetation and climate. The same biome can be found in different biogeographic provinces when the climates are similar, because similar environments select for similar traits. One can think of the environment as presenting an engineering challenge, and natural selection finds a solution. For example, biomes

dominated by trees are always found in climates with abundant rainfall, never in dry climates. Similar environmental constraints force similar solutions, a process known as **convergent evolution**. This opposite of this, **divergent evolution,** also occurs when species become separated by barriers and is a major cause of speciation.

8.4 GEOGRAPHIC PATTERNS

● The same processes that led to continental scale patterns also produce patterns on the subcontinental scale. Each continent has its own pattern of climate and geomorphology that have shaped the distribution and evolution of its own species (See. Fig. 8.8).

A CLOSER LOOK 8.1: A Biogeographical Cross Section of North America

● Fig. 8.8 shows the relationships among climate, topography, and biota along a transect across the U.S.. The terrestrial biomes reflect the distribution of rainfall and temperature. Winds move on average from west to east. The Rocky Mtns produce a rain shadow on their east side, which has influenced the development of prairies. The forces that produce these biogeographic patterns across the U.S. are common to all the continents and produce similar results.

8.5 ISLAND BIOGEOGRAPHY

● The species diversity of islands is proportional to the size of the island and is inversely proportional to the distance of the island from the nearest continent. This is the basis for the theory of island biogeography.

● The Gal<pagos Islands provide wonderful examples of the processes that shape island biogeography and provided Charles Darwin with powerful insights into evolution and natural selection. For example, the finches on the island are closely related and are descended from a common ancestor, yet each island has a unique species that possess adaptations that give it a competitive advantage on its island. This process is known as **adaptive radiation**.

● The following generalizations about species diversity on islands can be made: (1) the two sources of new species are migration from the mainland and evolution of new species; (2) islands have fewer species than continents; (3) diversity is proportional to island size; and (4) diversity is inversely proportional to distance from the nearest mainland. These concepts apply also to ecological islands.

8.6 BIOGEOGRAPHY AND PEOPLE

● Biogeography affects biological diversity, and changes in diversity in turn affect people and their living resources.

● The European continent has low species diversity because of the combination of climate change and topography. In Europe the major mountain ranges run east-west, which blocked the migration of species during previous glacial periods, whereas N. American mountain ranges run north-south and did not block the retreat of species.

● Soon after Europeans colonized N. America they began to import many exotic species. For example, the number of tree species native to Britain is only 30, and today there are 100s.

● People have altered biodiversity by hunting, habitat alteration, and by introducing exotics. Introductions of exotics can have positive and negative effects. Introductions of new species on islands, e.g. Hawaii, have been catastrophic for native species. Introductions of new species are prohibited in most cases.
● The effects of species introductions are usually unpredictable, but several generalities can be made: Moving a species within its own biotic province is not likely to be harmful. Moving a species in to the same biome from a different biotic province is likely to be harmful, and local moves are likely to be less harmful than global moves.

8.7 EARTH'S BIOMES

● Earth has 17 major biomes: tundra, taiga (boreal forest), and so on. The two most important determinants of the biome type are moisture and temperature. For a given combination of temperature and moisture, you find the same type of biome anywhere on the planet. Within a given biome type, the species will differ from place to place, but they will look the same. Natural selection finds the optimum solution to environmental problems, such as limited water availability. Also note that this is a high correspondence between the biomass of a biome (see Fig. 8.14) and the global distribution of rainfall and temperature.
● Biodiversity varies among biomes. Tropical biomes typically have greater diversity than temperate biomes. The reasons for this pattern are still debated. One theory holds that diversity is related to climatic stability. Temperate zones have been repeatedly jolted by glacial cycles that have, perhaps, resulted in a loss of species. Also, the ecological specialization of a species, its niche, is thought to be related to environmental variability and predictability. Stable and predictable environments favor specialization, and perhaps greater species diversity is possible when niche dimensions are narrow.

8.8 THE GEOGRAPHY OF LIFE ON EARTH

● Tundra: treeless plains that occur in harsh climates of low rainfall and low average temperature (Fig. 8.16). The dominant vegetation types are grasses and sedges, mosses and lichens. Tundra includes arctic and alpine tundra.
● Taiga or boreal forest: The taiga includes high latitude and high altitude forests in cold climates. They are dominated by conifers, especially spruces, firs, larches and some pines. Aspen and birch are also common. Boreal forests include a few large ammals, small carnivores, rodents, many insects, and migratory birds.
● Temperate deciduous forests occur in somewhat warmer climates than the taiga with sufficient rainfall. They are dominated by maples, beeches, oaks, hickories and chestnuts. There are few remaining uncut deciduous forests left.
● Temperate rain forests occur where temperatures are moderate and precipitation exceeds 250 cm/yr. These are rare. Redwood forests of Californian and Oregon are examples.
● Temperate woodlands occur where climate is slightly drier than in temperate deciduous forest. They are dominated by small trees such as piZion pines and evergreen oaks. Fire is a common natural disturbance.
● Temperate shrublands (chaparral) are found in drier climates. Chaparral occurs in a Mediterranean climate (low rainfall that is concentrated in a cool season) like that found along the coast of California and Chile. Chaparral vegetation is aromatic (e.g. sage).

These aromatic compounds may be defensive, and they render the vegetation susceptible to fire. Chaparral is a fire-adapted ecosystem.
● Temperature grassland occurs where it is too dry for forests and too moist for desert. The soils have a deep organic layer and are ideally suited for crop plants (which are grasses). Grasslands harbor the highest abundance and diversity of large mammals. Fire is also a natural element.
● Tropical rain forests occur where average temperature is high and relatively constant and where rainfall is high. They have the highest diversity. Tropical soils are low in nutrients.
● Tropical seasonal forests and savannas occur at low latitudes where average temperature is high, relatively constant, and rainfall is abundant but seasonal. Such forests are found in India and SE Asia, Africa and S and Central America.
● Deserts occur in the driest regions, typically where rainfall is less than 50 cm/yr. There are cool and warm deserts. The vegetation is highly specialized for water use efficiency.
● Wetlands include swamps, fens, bogs, and saltwater marshes. The vegetation is dominated by trees or grasses depending on the type of wetland. For example, saltmarshes are dominated by grasses (saltmarshes are physiological deserts). Wetlands are important for a number of reasons. The transition between biomes is not sharp usually. Transition areas are referred to as **ecotones**. A wetland is viewed by many ecologists as an ecotone between aquatic and terrestrial biomes.
● Some other habitat types that may or may not be considered biomes include: freshwater lakes, ponds, rivers and streams; intertidal environments (includes salt marshes); benthic environments; upwelling regions and hydrothermal vents.

CRITICAL THINKING

Controlling Exotic Species

- The sea lamprey, a parasitic Atlantic Ocean fish, got into the lakes starting in 1921 through another canal. It has become a parasite of the lake trout, whose catch has declined from 15 million pounds a year to 300,000 pounds.
● The zebra mussel (*Dreissena polymorpha*) is native to the Caspian Sea. It reached North America in the mid-1980's, probably in ballast water. It rapidly became established in the Great Lakes and it eventually will colonize most of the water in North America except where it is too warm or saline. The zebra mussels form extensive The zebra mussel was discovered in the Hudson River in 1991. Since then they have expanded throughout much of the river in densities over 1000 individuals per square meter. This population is capable of filtering all of the water in the tidal-freshwater part of the river every 2 to 3 days. Prior the invasion of the zebra mussel all other filter feeders combined filtered the water about once every 50 days. small organisms and organic particles. The feeding of the zebra mussel has had a great impact on the Hudson River ecosystem and its food web. For example, phytoplankton that are one base of the aquatic food web have declined about 90% in biomass. Since the decline of the plankton population, beds of submerged aquatic vegetation (SAV) have expanded.
What would you hypothesize was the reason for the increase in SAV?
What are the potential positive and negative impacts of the mussel invasion?
What could be done to prevent similar invasions of aquatic organisms in the future?

Web Resources

http://www.actionbioscience.org/biodiversity/simberloff.html This is a comprehensive AIBS site maintained by Daniel Simberloff that is devoted to the ecological effects of invasive species.
http://nas.er.usgs.gov/ Here the USGS provides a database on nonindigenous aquatic plants and other organisms.

http://www.pewtrusts.org/pdf/env_oceans_species.pdf The Pew Commission report on introduced species in U.S. Coastal Waters.

http://www.vims.edu/chessie/zmtxt.html A VIMS website devoted to the introduced zebra mussel.