Chapter 50 Introduction to Ecology **A. Hunter from C. S. Major**

I. Ecologists study how organisms interact with their environment at different hierarchical levels.

A. Organismal Ecology
   1. Focuses on how individual organisms interact with their environment.
   2. Organismal ecologists study morphological, physiological, and behavioral adaptations that allow individuals to be successful in a particular habitat.
      a. Behavioral studies reveal how an individual responds to stimuli in its environment.
      b. Physiological studies reveal how individuals thrive in changing environmental conditions.
   3. An example of organismal ecology: the sockeye salmon
      a. Spend 4-5 years eating and growing in the ocean
      b. Swim hundreds to thousands of miles to return to the stream where they hatched
      c. Once they breed in that streambed, the adults die.
      d. Scientists are interested in studying their breeding habits, traits that make them reproductively successful, and how they adapt to the changing environment as they migrate.

B. Population Ecology
   1. Population -a group of individuals of the same species that live in the same area at the same time.
   2. Population ecology seeks to understand how the numbers of individuals in a pop. change over time.
      a. These studies have helped predict the fate of endangered species.
      b. For example, population ecology studies have predicted that salmon populations are in danger based on their recent decline due to man-made changes to their environment.

C. Community Ecology
   1. A biological community consists of the species that interact with one another in a particular area.
   2. Community ecologists study the nature and consequence of the interactions between species in a community.
   3. Community ecologists are often make predictions about how human actions will affect ecological communities in the future.
   4. Example of a community ecology study: Salmon and their neighbors
      a. Salmon eat smaller fish and are eaten by bigger fish and mammals.
      b. In both habitats, salmon are affected by disease and parasites as well as human disturbances such as damming and overfishing.

D. Ecosystem Ecology
   1. An ecosystem consists of all organisms living in a certain area plus all nonliving, abiotic components such as air, water, and soil.
   2. Ecosystem ecologists study ecosystem nutrient cycles and energy flows.
   3. Because humans are changing the way that nutrients cycle, ecosystem ecology has had particular importance lately.
      a. Global warming has been particularly important to public policy.
      b. Ecosystem ecologists are also a key factor in predicting the impact of pollution on Earth and its inhabitants.
   4. Sockeye salmon and their ecosystem
      a. Salmon form a link between marine and freshwater ecosystems as they carry nutrients and energy from one ecosystem to the other.
      b. Human-induced changes in these ecosystems will profoundly affect salmon populations.

E. How do ecology and conservation efforts interact?
   1. Conservation biology is the practical application of the basic science of ecology, much like medical science is the practical application of basic animal physiology.
   2. Conservation biologists work to preserve populations, communities, and ecosystems that are threatened.

II. The Nature of the Environment

A. The environment is a mixture of biotic and abiotic components.
   1. Abiotic components include temperature, precipitation, wind, sunlight, and chemical content of soil and water.
   2. Biotic components consist of all living organisms in a community or ecosystem.
   3. Ecologists study the environment because humans are altering it at an alarming rate.
      a. Humans alter the abiotic environment through air and water pollution.
      b. Humans alter the biotic environment by reducing native species and introducing exotic species to areas that they do not naturally grow.

B. The abiotic environment in a given region is characterized by its climate.
   1. Climate vs. weather
      a. Climate is the prevailing long-term weather conditions in a given area.
      b. Weather is the short-term atmospheric conditions such as temperature, moisture, sunlight, and wind.
         (1) Temperature is an important factor to study, not just because an organism's enzymes function in only a small range of temperatures, but because temperature affects the availability of water.
         (2) Moisture is significant to terrestrial organisms because they lose water constantly and need to replace it.
         (3) Sunlight is required for photosynthesis, which provides the basal level of energy for all organisms.
         (4) Wind is an important factor to study because it exacerbates the effects of temperature and moisture.
   2. Specific climate questions illustrate how ecologists evaluate the impact of climate on biotic components.
      a. Why are the tropics warm and the poles cold?
         (1) Generally, areas that receive a lot of sunlight are warm and those that receive less are cold.
         (2) Earth is round, so the equator receives a lot of sunlight per unit area because the sunlight often hits the equator at a 90° angle.
         (3) Because Earth slopes away from the equator, sunlight strikes Earth's surface at lower and lower angles as you move away from the equator.
         (4) Sunlight arriving at lower angles results in much lower energy reception per unit area.
         (5) Therefore, average temperature drops as latitude increases.
      b. Why are the tropics wet?
         (1) Equatorial regions receive the most moisture, whereas regions 30° of latitude north and south of the equator are extremely dry (deserts).
         (2) Major pattern in global air circulation is responsible for this distribution.
            (*a*) This pattern of global air circulation is called a Hadley cell.
            (*b*) At about 30° latitude north or south of the equator, this air mass has cooled so much that its density increases and it begins to sink.
            (*c*) As it sinks, the cell warms and gains water-holding capacity.
            (*d*) The area then receives little rain and is bathed in warm air.
            (*e*) This pattern of air movement is responsible for the world's great deserts.
      c. What causes seasonality in weather?
         (1) Seasons are regular, annual fluctuations in temperature and precipitation.
         (2) These fluctuations occur because Earth is tilted on its axis.
            (*a*) Due to the tilt, the Northern Hemisphere is closest to the Sun in June and July, creating a warm summer.

(*b*) Summer in the Southern Hemisphere is in November–December because that is when this region is tilted toward the Sun.
(*c*) The warmest months for the equator are March and September, because it is then that the equator faces the Sun most directly.

d. Mountains and oceans: regional effects on climate
(1) The presence of mountains or oceans creates local differences in climates that are initially dictated by the global weather patterns discussed earlier.
(2) Mountains cool the air and wring the water out of the air as it cools.
(*a*) As the moist air from the Pacific Ocean hits the Cascade Mountain range, a lot of rain falls from northern California to southeast Alaska.
(*b*) Once the air has passed over a mountain crest, it is relatively dry and the land on the other side is in a rain shadow that receives little to no precipitation.
(3) Oceans moderate temperatures.
(*a*) Because water has a high specific heat, it can absorb a lot of heat in the summer when the water temperature is cooler than the air.
(*b*) Conversely, in the winter, when the water is warmer than the air, it releases heat to warm the air.

III. Types of Terrestrial and Aquatic Ecosystems

A. Climate (temperature and precipitation) affects the productivity of terrestrial biomes.
1. Tropical wet forests
a. Also called rain forests, they are found in equatorial regions where temperatures and rainfall are high and variation is low.
b. These forests are not seasonal (aseasonal).
(1) Plants grow all year long.
(2) There is no complete, seasonal loss of leaves.
c. Year-round growing conditions results in vigorous growth, high productivity, and high amounts of aboveground biomass.
(1) Productivity is the total amount of photosynthesis per unit area per year.
(2) Aboveground biomass is the total mass of living plants, excluding roots.
d. These wet forests contain the highest amounts of biodiversity on Earth.
(1) Over 200 tree species may be found in one 10 × 100 meter plot.
(2) The wet forests may contain 30 million species of arthropods alone.
e. The wet forests contain extraordinary structural diversity.
(1) A multilayered tree canopy is intermingled with vines, epiphytes, shrubs, and herbs.
(2) Epiphytes are plants that grow entirely on other plants.
(3) This diversity presents a vast array of habitat types for animals.
2. Subtropical deserts
a. Found in bands about 30 degrees of latitude north and south of the equator
b. Mean monthly temperatures vary, but never fall below freezing.
c. The most striking feature is their low annual precipitation.
(1) This causes the productivity in deserts to be very low.
(2) Individual plants are widely spaced due to intense competition for water.
d. Desert species must cope with extreme temperatures and aridity.
(1) Morphological and physiological adaptations (example: cacti)
(2) Traits that allow them to escape drought include dormancy and short reproductive stages.
3. Temperate grasslands
a. Found throughout central North America and the heartland of Eurasia

b. Precipitation conditions are still quite dry, but annual precipitation is much greater than amounts recorded in the desert.
c. Temperatures are moderate (temperate), but highly seasonal.
    (1) Temperature variation dictates a well-defined growing season.
    (2) Plant growth occurs only in months of adequate moisture and warmth.
d. These areas are also called prairies or steppes.
e. They exist because conditions are too dry to support tree growth, but too cold and seasonal for drought-adapted desert species.
f. Grasslands can develop in forested regions if recurring fires burn out encroaching trees.
    (1) Fires can occur naturally from lightening strikes.
    (2) Fires can be set as a management tool.
g. The plants that dominate grasslands are tolerant of fire and will quickly resprout after burning.
h. Productivity is lower than in forests; however, grassland soil is highly fertile.
    (1) Subsurface is packed with roots that add organic material to the soil as they decay.
    (2) Soil retains nutrients because rainfall is low enough to keep key ions from dissolving and leaching out.
    (3) Grasslands make ideal regions for agriculture.

4. Temperate forests
    a. Found in temperate areas with high precipitation
    b. Have a period when mean monthly temperatures fall below freezing and plant growth stops
    c. Precipitation is high and relatively constant throughout the year.
        (1) This abundance of moisture allows trees to dominate the landscape.
        (2) Plants experience a seasonal period of dormancy.
    d. Deciduous trees dominate these forests in North America and Europe, but broad-leaved evergreens dominate those in New Zealand and Chile.
    e. These forests have productivity levels higher than those of deserts or grasslands, but lower than those of tropical forests.
    f. The level of biodiversity is moderate.
5. Boreal forests (also called taiga)
    a. Found across most of Canada, Alaska, Russia, and Northern Europe (subarctic)
    b. Characterized by very cold winters and cool, short summers
    c. Contain extraordinarily high annual variation in temperature
    d. Annual precipitation is often very close to that found in temperate grasslands.
    e. Due to the cold, evaporation is minimal; abundant moisture results.
    f. Cold-tolerant conifers, most of which are evergreen, dominate the landscape.
    g. In boreal forests, why do evergreens dominate even though they do not photosynthesize in winter?
        (1) They can begin photosynthesizing very early in the spring, before the snow melts.
        (2) Subarctic soils are acidic and contain little nitrogen; so, since leaves are rich in nitrogen, trees that have to produce a new set of leaves each year are at a disadvantage.
    h. Productivity is low, but aboveground biomass is high and biodiversity is exceptionally low.
6. Arctic tundra
    a. Extends north (or south) of the subarctic all the way to the poles
    b. Growing season is 6 to 8 weeks long at most.
    c. Outside of the growing season, temperatures are below freezing.
    d. Precipitation is also very low.
        (1) Annual amounts may be lower than in deserts.
        (2) Very low evaporation rates keep the soil saturated year-round.
    e. The arctic is completely treeless.

(1) Growing season is too short & cool to support production of non-photosynthetic tissue.
(2) Tall trees above snow may experience damage from blowing snow and ice crystals.
(3) Small, woody shrubs are common.

f. Biodiversity, productivity, and aboveground biomass are all low.
g. Soils are perennially frozen in a state called permafrost, but plants may cover the ground.
h. Animal diversity is low, but insect diversity may be very high.

B. Depth of water and rate of water movement characterize aquatic environments.
1. Water depth affects the amount and wavelengths of light that can reach organisms.
a. Water absorbs and scatters light.
b. Ocean water near the coast specifically removes light in the red and blue wavelengths that are required for photosynthesis.
c. As water depth increases, the amount of available wavelengths decreases.
d. Virtually no light penetrates depths of 40 m or more in pure seawater.
2. The rate of water flow influences aquatic environments.
a. Organisms that live in fast-moving water have to cope with the physical force of the water.
b. Marine organisms in intertidal zones are exposed to air in calm tide & violent waves during storms.
3. Freshwater environments
a. Lakes, ponds, and wetlands
(1) Ponds are small, lakes are big enough that water within them can be mixed by the wind.
(2) Wetlands are shallow habitats where the soil is saturated with water.
(*a*) Wetlands have emergent vegetation that grows above the surface of the water.
(*b*) Ponds and lakes do not have emergent vegetation.
(3) Ponds and lakes have different zones with different biotic components.
(*a*) The littoral zone consists of shallow waters near shore, where photosynthesis is possible and flowering plants and plankton can grow.
(*b*) The limnetic zone consists of open water in which photosynthesis is possible and floating plants, algae, and cyanobacteria thrive.
(*c*) The bottoms of lakes and ponds make up the benthic zone, where photosynthesis is not possible but burrowing animals and bacteria that eat detritus can live.
(*d*) The littoral and limnetic zones are considered photic because they receive light.
(*e*) The parts of the benthic zone that do not receive light are considered aphotic.
(*f*) The littoral and limnetic zones are warmer than the benthic zone because they receive more light.
(4) There are three major types of wetlands.
(*a*) Marshes are usually connected to lakes or streams and lack trees but usually have a slow, steady rate of water flow.
(*b*) Swamps are similar to marshes but have trees.
(*c*) Bogs are bodies of water that develop in depressions that have little to no water flow; thus they do not have enough circulating oxygen to support much life.
b. Streams
(1) Streams are bodies of water that move only in one direction.
(2) Creeks are small and rivers are large.
(3) The structure of a stream changes along its length.
(*a*) At its mountain origin, a stream is usually cold, narrow, and fast.
(*b*) As it reaches its ocean or lake destination, it becomes larger, warmer, and slower.
(4) The organisms in a stream vary along its length.
(*a*) Small, fast-moving streams rarely have photosynthetic organisms.
(*b*) Wider, slower streams have algae and plants.
(5) Estuaries are unique environments.

(*a*) When a stream meets an ocean, freshwater and saltwater mix.
(*b*) Because the water is shallow in estuaries and nutrients are constantly renewed by the incoming stream, estuaries are very productive environments.

3. Marine environments
   a. Like lakes and ponds, oceans have different zones based on depth.
      (1) The area near the surface that receives ample sunlight is called a photic zone.
      (2) The ocean floor makes up the benthic zone.
      (3) The aphotic zone consists of the middle depths that are too dark to support photosynthesis.
   b. Additional ocean zones are distinguished by depth and distance from the shore.
      (1) The intertidal or littoral zone is a shallow region along the shore.
         (*a*) Organisms on the rocky or sandy shore are exposed to air during low tide and are covered with water in high tide.
         (*b*) Productivity is high because light and oxygen are readily available.
      (2) The neritic zone extends from the intertidal zone toward the ocean to depths of about 200 m.
         (*a*) The edge of the neritic zone is the continental shelf.
         (*b*) This zone is still relatively productive because nutrients well up from the ocean depths.
         (*c*) Many fish live in the neritic zone, and most coral reefs are found in these areas.
      (3) The oceanic zone consists of the open ocean and is one of the most unproductive environments on Earth.
         (*a*) Even in the photic zone where light penetrates, nutrients are not abundant enough to support much life.
         (*b*) The aphotic zone is even less productive due to the lack of light to fuel photosynthesis.
         (*c*) Some of the world's most bizarre organisms live in the oceanic zone.
      (4) The bottom of the ocean is the benthic zone.
         (*a*) Most benthic regions lack light and are unproductive.
         (*b*) Sediments of dead organisms form in benthic zones.

IV. Biogeography is the study of how organisms are distributed in space.

A. No one species can survive the whole range of environmental conditions present on Earth.
   1. Most organisms have a specific set of conditions that must be available for them to live.
   2. At present, humans have the broadest range of any organism on Earth, but no one organism can live everywhere.
   3. Ecologists study historical, biotic, and abiotic factors to understand the environmental range of an organism.

B. The Role of History
   1. How a species came to occur in a certain area can be explained by its history of dispersal.
      a. Dispersal refers to the movement of an individual from its place of origin to the location where it lives and breeds as an adult.
      b. If a species is missing from an area it could potentially inhabit, it is likely that a physical barrier such as an ocean or mountain has blocked dispersal.
   2. Human activity is affecting dispersal of species in a number of ways.
      a. Flu outbreaks disperse all over the planet quickly via the respiratory passages of airplane passengers.
      b. Humans transport seeds, birds, insects, etc. across physical barriers to new locations.
         (1) A species introduced to an area where it would not normally live is called an exotic species.
         (2) If that species begins to outcompete other species, it is called an invasive species.

(*a*) Cheatgrass was introduced to the U.S. in 1889 in a shipment of crop seeds from Europe.
(*b*) Cheatgrass has taken over a large percentage of grasslands and shrublands of the western U.S.
(*c*) Other invasive species include kudzu, purple loosestrife, African honeybees, and zebra mussels.

C. The distribution of species is often limited by biotic factors.
   1. Interactions with other species can limit dispersal.
   2. Example: Warblers
      a. Townsend's warblers and hermit warbler ranges do not overlap because the Townsend's warblers have outcompeted the hermit warblers.
      b. The range of domestic cattle in Africa has been limited by the tsetse fly, which transmits a deadly parasite.
      c. Some species are limited by a specific food source.

D. Often, exotic species fail to thrive in the new environment due to abiotic factors.
   1. An area may simply be too cold or too warm for the exotic species.
      a. Kudzu thrives in the Southeast U.S., but cannot grow in colder environments of the northern and western U.S.
      b. Cheatgrass cannot grow in wet grasslands, because it cannot compete with the tall species that thrive there.

E. Sometimes the right combination of abiotic and biotic factors allows an exotic species to invade its new habitat.
   1. Cheatgrass has invaded dry, temperate grasslands and sage-steppe areas because it is not affected by fire.
      a. Cheatgrass is an annual plant that grows in clumps and dies every winter.
      b. The dead clumps of cheatgrass serve as fuel for the fires, but since the cheatgrass has already gone to seed, it is not damaged by the fire.
      c. Perennial species in the area are killed by the fire, favoring the spread of cheatgrass.
   2. The introduction of cows to these regions set the stage for the invasion of cheatgrass.
      a. Grasslands and sage-steppe areas were originally dominated by bunchgrass that grows in clumps.
      b. Bunchgrass depends on the soil-dwelling organisms of black-soil crust for its supply of nitrogen.
      c. European settlers introduced cows that ate the bunchgrass to the point of elimination, and trampled the black soil such that the nitrogen-fixing organisms could no longer grow.
      d. The bunchgrass could not recover because cheatgrass arrived and shaded the remaining black-soil crust, killing the remaining nitrogen-fixing microorganisms.
      e. Cheatgrass successfully competes with bunchgrass for nutrients, water, and space.