Ecosystem

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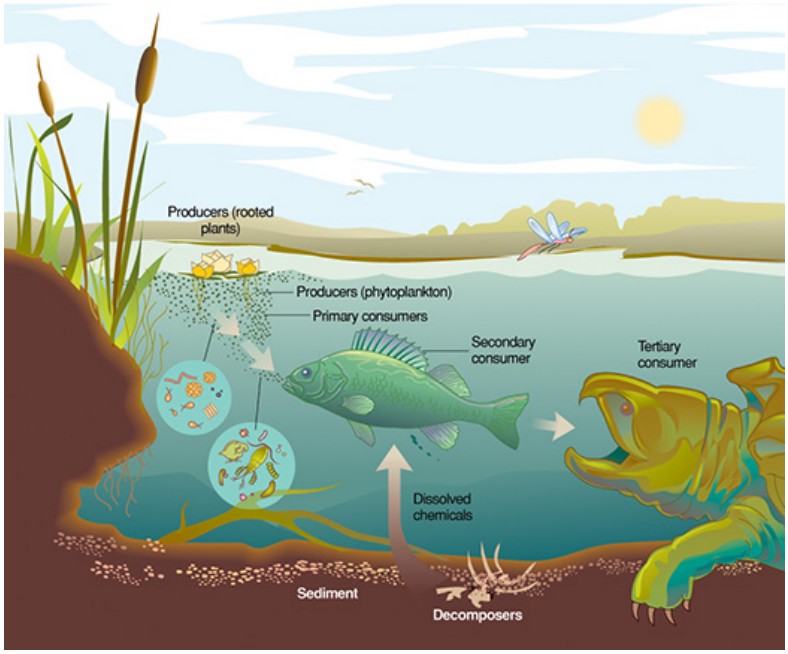

Ecosystems (or ecological system) are communities of organisms and their environment. Ecosystems can vary greatly in size, from those found in tidal pools, back yard compost piles, or in the rumen of a cow, to larger ecosystems like lakes or forests. Landscape-scale ecosystems comprise still-larger regions. Earth's life and its physical environment represents an ecosystem known as the biosphere.

Background and Scientific Foundations

Ecosystems can be studied in various contexts: the flow of energy through ecosystems; interactions between organisms living within a community; and interactions between organisms and their physical environment.

Ecosystems are often defined by precipitation levels and typical temperatures. Examples include tropical rain forest, desert, temperate forest, tundra, and savanna or grasslands. Aquatic ecosystems include lakes, rivers, estuaries, coral reefs, kelp forests, open ocean, and deep ocean.

Key Terms
Biome
A well-defined terrestrial environment (e.g., desert, tundra, or tropical forest) and the complex of living organisms found in that

region.
Bycatch
Non-target species killed in the process of fishing.
Community
All of the populations of species living in a certain environment.
Ecological niche
The sum of the environmental requirements necessary for an individual to survive and reproduce.
Precipitation
Moisture that falls from clouds as a result of condensation in the atmosphere.
Transpiration
Loss of water taken in by roots from leaves through evaporation.

Historical Background and Scientific Foundations

Ecosystems include a collection of organisms (biological community) and physical components of the environment. Biological communities include all populations of animals, plants, fungi, and bacteria. A population is all members of a certain species that live in a location. In terrestrial ecosystems, the physical environment includes the type and conditions of soil or rocky terrain, general climatic conditions, amount of precipitation, and amount of sunlight available. In aquatic ecosystems, the physical environment includes salinity, temperature, and acidity of the water, amount of sunlight available, amount of sedimentation in the water, amount of nutrients dissolved in the water, and type of substrate below the water.

With so much variation in what constitutes an ecosystem, ecologists typically define the barrier of a system under study. An ecosystem might be delineated as the shoreline vegetation around a lake, the entire waterbody, or the lake plus all the land that drains into it (a watershed).

Ecosystems take various forms of energy and simple inorganic materials and create relatively focused combinations of these, occurring as the total amount of biological material (the biomass) of plants, animals, and microorganisms. Solar electromagnetic energy, captured by the chlorophyll of green plants, is a common energy source. The most important of the simple inorganic materials are carbon dioxide, water, and ions or small molecules containing nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, and some other nutrients.

All ecosystems rely on inputs of solar energy to drive the physiological processes by which biomass is synthesized from simple molecules. To carry out various functions, ecosystems also need access to nutrients. Unlike energy, which can only flow through an ecosystem, nutrients can be utilized repeatedly. Through biogeochemical cycles, nutrients are recycled from dead biomass back into living organisms.

Flow of energy through an ecosystem plays a key role in its stability and function. With few exceptions, the energy for life originates with light energy from the sun. Plants convert this energy to chemical energy stored in carbohydrates through photosynthesis. Herbivores consume the carbohydrates in plants, using energy from the chemical bonds for growth and reproduction. Carnivores consume herbivores, assimilating energy stored in the chemical bonds of the herbivores. Finally, the carnivores die; their organic remains are decomposed by bacteria and fungi. These decomposers use the stored chemical energy in organism's chemical bonds, converting the organic material into inorganic material plants require to perform photosynthesis. With each successive step in the food chain (food web in complex ecosystems) energy is lost as heat to the environment. Approximately 10 percent of energy harvested from the sun by plants gets passed on to herbivores. Approximately 10 percent of energy stored in the chemical bonds of herbivores passes to carnivores. As a result, most ecosystems have significantly more plants than predators.

Every organism in an ecosystem depends on many other organisms to grow and reproduce. The struggle to obtain food and to avoid becoming food are major goals of biological interactions in ecosystems. Predation is the consumption of one species by another species. Predators have developed adaptations allowing them to hunt prey more effectively. For example, tuna have special muscles that allow them to swim quickly after smaller fish. Prey develop adaptations to avoid predators, such as the chemicals skunks spray when threatened.

Another type of ecological interaction is competition for resources, such as shelter, territory, food, sunlight, and water. Members of the same species may also compete for mates.

The sum of resource requirements for an organism is called its ecological niche. When organisms have ecological niches that overlap, competition is more intense. Because individuals of the same species have identical resource requirements, competition within a species is often quite intense. Resources in such short supply as to prevent population growth are called limiting factors. Limiting factors often control the available ecological niches within an ecosystem. More ecological niches equals greater numbers of species, or biodiversity.

Although the flow of energy moves through ecosystems in one direction, many of the physical components of ecosystems are recycled. Chemicals critical to growth and reproduction in animals—water, carbon, nitrogen, and phosphorus—all flow through both the biotic, or living, and abiotic, or nonliving, components of ecosystems. Patterns of flow are called biogeochemical cycles. Each cycle varies depending on the chemical properties of the matter. For example, the generalized biogeochemical cycle for carbon begins with carbon dioxide from the atmosphere becoming assimilated into carbohydrates during plant photosynthesis, which is passed to animals as plants are consumed. Animals release carbon dioxide to the atmosphere through respiration. Plants not consumed die and become buried. In some cases, over long time periods, buried plants become fossil fuels, which when burned return carbon dioxide to the atmosphere. The hydrologic cycle involves water evaporation from lakes and oceans. Precipitation returns water to Earth where plants and animals use it to grow. A process known as transpiration returns water to the atmosphere

from plants. The movement of air transports water from region to region, controlling the climate.

Ecosystems vary in size and structure depending on their physical properties. Ecosystems nest within ecosystems. For example, the ocean is an ecosystem. So is a rocky shoreline and a tide pool within a rocky shoreline, which consists of animals, plants, and decomposers. Within a tide pool, the back of a decorator crab might be an ecosystem, complete with moss, barnacles, limpets, shrimp, and even parasites.

There are several broad types of ecosystems worldwide, also called biomes. Major land biomes include tropical rain forest, desert, temperate forest, tundra, and savanna or grasslands.

The wettest and warmest of ecosystems is the tropical rain forest, which is the most diverse, containing the most species and species interactions. Rain forests have abundant ecological resources and possess many different environmental niches, due to precipitation and consistently warm temperatures. Numerous species of insects, birds, reptiles, amphibians, sloths, and monkeys live within the tree canopies of rain forests.

The driest ecosystems on Earth are desert ecosystems, where the climate is hot or temperate. Because there is very little water, plants have evolved adaptations to decrease evaporation water loss. Instead of leaves, which have a large surface area over which water can evaporate, desert plants have tiny leaves or spines. Other plants only grow leaves during rainy periods or have waxy coatings to prevent evaporation. Desert animals tend to be small. Many are nocturnal, hunting at night and hiding in shadows where it is cooler during the day.

The coldest ecosystems are taiga or tundra, where winters are long and cold, snow only melts for a short time each year, and there is not much precipitation. Because the soil is frozen, trees have difficulty taking root and most of the plants are small and bushy. Animals include lemmings, arctic foxes, snowshoe hares, and musk oxen.

Temperate forests exist where winter is cold and summer is warm, generally at mid-latitudes. Precipitation tends to be significant, and trees typically lose their leaves each winter. The nutrients from these leaves are recycled into the soil by decomposers like bacteria and fungi. Large mammals such as puma, bear, wolves, and bison are native to temperate forests.

Grasslands are found in places where temperatures are moderate, but where the precipitation is somewhat less than in temperate forests. Common throughout central Asia, Australia, Africa, central North America, and South America, their major vegetation is grass, which provides food for large herds of herbivores like bison and elk.

Common aquatic ecosystems include lakes, rivers, estuaries, coral reefs, kelp forests, the open ocean, and the deep ocean. Plants include phytoplankton, which are photosynthetic microorganisms that live in the surface layers of the water where sunlight is available. Other plants include kelp and sea grasses. When organisms die in aquatic systems, they sink to the ocean or lake floor where they are decomposed by bacteria, returning inorganic nutrients to the water for phytoplankton to use in photosynthesis.

Issues and Developments

Maintaining the health of ecosystems is important for numerous reasons. Natural ecosystems break down pollutants, recycle wastes, provide flood and erosion control, and create freshwater in aquifers. They provide habitat for organisms, including pests, diverting these organisms from urban centers. The diversity of plants in the many ecosystems is the source for many medicines. All oxygen on Earth results from photosynthesis from plants in forests and phytoplankton in the oceans.

Ecosystems throughout the world are threatened by human activity. Development, agriculture, mining, and grazing by ranchers have the most significant impact on land because they destroy native habitats. Pollution and climate change threaten the health of organisms in ecosystems, just as it threatens the health of humans. Because organisms within ecosystems depend on one another, impacts to one type of organism have repercussions throughout the entire ecosystem. Although every ecosystem is affected by these human activities, each type of biome has its own challenges due to its specific structure.

Desert soils are usually thin and easily damaged. In addition, desert soils are slow to recover from damage. Many grasslands are being converted to deserts through a process known as desertification, which occurs when grasslands in semiarid regions are overgrazed, exposing the soil to wind, which removes the fertile top layers. Plants are unable to take root and the land becomes unable to support biological communities.

Forests, tropical and temperate, are threatened by deforestation, which occurs when trees are removed either for the wood itself or to clear the land for grazing or farming. This removes trees that form the basis of the ecosystems. Tree removal exposes soils, leading to erosion and stops the influx of organic materials into soils making them less fertile. In wet areas, erosion leads to sedimentation of waterways, harming aquatic ecosystems. In dry areas, erosion can lead to desertification. Deforestation has caused species extinction, and affected migration flightpaths of birds and butterflies.

More than half of the world's population lives along coastlines. Aquatic ecosystems are threatened by urbanization, engineering projects, pollution, mining, and overfishing. Wetlands are disappearing at alarming rates. In the open ocean, pollution is a major issue threatening ecosystems. Ingestion of plastic waste, overfishing, and bycatch of large marine mammals disrupt aquatic food webs.

The National Biological Service undertook a broad study of endangered ecosystems as a means of assessing human impact on the environment. The study found that 85 percent of the forests had been destroyed by the 1980s. More than 90 percent of the old growth forests were destroyed. About 98 percent of all streams were degraded, losing their designation as wild or scenic waterways.

In response to studies on threatened ecosystems, conservation agencies and governments have begun buying land and setting aside areas with particularly sensitive or endangered ecosystems as well as providing incentives to land owners to restore ecosystems to natural conditions.

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