Ecology

By William E. Werner Jr.

Ecology is the scientific study of the interrelationships of plants, animals, and the environment. In recent years the word has sometimes been misused as a synonym for environment. The principles of ecology are useful in many aspects of the related fields of conservation, wildlife management, forestry, agriculture, and pollution control.

The word ecology (Greek: oikos, "house," and logos, "study of") is generally believed to have been coined by Ernst Haeckel, who used and defined it in 1869. The historical roots of ecology lie not only in natural history, but in physiology, oceanography, and evolution as well. It has occasionally been called scientific natural history (a phrase originated by Charles Elton) because of its origin and its heavy reliance on measurement and mathematics. Ecology is variously divided into terrestrial ecology, fresh-water ecology (limnology), and marine ecology, or into population ecology, community ecology, and ecosystem ecology.

Ecological Classification of Organisms

Ecologists commonly classify organisms according to their function in the environment. Autotrophs ("self-nourishers," also called producers), which are mainly green plants, manufacture their own food from carbon dioxide, water, minerals, and sunlight, whereas heterotrophs - a wide assortment of organisms - lack the metabolic machinery to synthesize their own food and must obtain it from other sources. Herbivores eat plants; carnivores, or predators, eat animals; and omnivores eat both plants and animals. Scavengers eat large dead organisms; decomposers, such as bacteria and fungi, feed on all dead organisms. Parasites eat living organisms, but do not devour them at one time. Parasites include ticks and fleas, which live on their hosts, and tapeworms, roundworms, and bacteria, which live within their hosts.

Communities

Organisms live together in assemblages called communities. Some communities are very small, such as those composed of invertebrates and decomposers living within a rotting log. Others may be as large as an entire forest. The most extensive communities, called biomes, occupy wide geographic areas. The major biomes are arctic tundras, northern coniferous forests, deciduous forests, grasslands, deserts, and tropical rain forests. Chaparrals (shrubby forests) and coniferous rain forests are sometimes also considered biomes. The distinctive appearance of each biome is generally determined by the predominance of characteristic plant species, but the animals that are characteristically associated with it also contribute to its distinctiveness.

Communities are composed of both plants and animals. Each species is distributed according to its own biological requirements, which may be affected by other species. For example, sugar maple seedlings require shade and may therefore mature easily in dense forests, whereas seedlings of eastern white pine require full sunlight for vigorous growth. Some species are sometimes associated with each other, but the exact degree of dependence is difficult to determine and has led to differences of opinion concerning the extent to which communities are discrete entities. By tabulating all plants found along a line passing through adjacent communities on mountainsides, it has been shown that the distribution pattern of each species is independent of most others, suggesting a continuum rather than discrete communities.

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Another aspect of communities is temporal (time) structure. Some animals are diurnal (active in daytime), some are nocturnal (active at night), and still others are crepuscular (active at twilight hours). This allows more organisms to occupy the same area without interfering with each other. There may also be seasonal activity patterns. In temperate areas, for example, frogs of different species use ponds to reproduce at various times throughout the spring. This prevents excessive competition for space and food at any one time.

The number of species within a community is called species diversity. Species diversity has two components, richness and evenness. If there are many species in a community, it is said to have a rich diversity. All species, however, are not always equally represented. If, as commonly happens, only a few species are abundant, the diversity is said to be uneven. If a community is made up of many species and each is relatively abundant, the community is considered relatively stable, because the reduction or removal of any one species would be far less important than the loss of an abundant species in a community where only a few are numerous.

If a community that has been disturbed by a disaster, such as fire, flood, windstorm, volcanic eruption, plow, or bulldozer, is left undisturbed for a long time, it will eventually restore itself; this process is called succession. A forest completely destroyed by fire may take hundreds or thousands of years to become completely renewed, depending on the climate, the nature of the soil, and other environmental factors. A forest destroyed by fire in Minnesota might be restored in a few hundred years, whereas one in Mexico destroyed by a lava flow might not be restored for several thousand years. Succession also occurs very slowly in the desert and in the tundra because of climatic and soil conditions.

The first species to invade a destroyed area are called pioneers. These opportunistic species usually have good means of dispersal and high reproductive capacities. Lichens, grasses, and other herbaceous species are the most common pioneers, but trees such as cottonwood, elm, aspen, and silver maple, which produce abundant windblown seeds, are sometimes found as well. Availability of sources of spores or seeds at the periphery of the disturbed area, as well as the suitability of the disturbed site for each species, determines the species composition of the first community formed. The invading species begin to change the environment by increasing the organic content of the soil with their dead parts and excreted wastes, creating shade, and changing moisture conditions. Some species harbor nitrogen-fixing bacteria that release nitrogenous compounds into the soil and thereby fertilize it.

In the course of succession, conditions are generally made more suitable for new types of organisms that use less energy for reproduction and more energy to maintain themselves. These species gradually win out in competition with the pioneers. Collectively, they produce a new community. The process of replacement of species may continue for a long time, resulting in several visibly different communities, although the changes occur gradually. Eventually a point is reached at which the environmental and species changes are minimal and species diversity is high. This relatively stable community is called a climax community.