Ecosystems Primer

Key Concept

An ecosystem is defined as a complex set of interconnections between living and non-living components.

Ecosystems encompass organisms, including us, and their relationships to one another and their physical environment. We find an immense diversity of types and scale of ecosystems, from open ocean to deserts to mountaintops to our schoolyards to ponds.

There is immense diversity of ecosystems on Earth, from deep sea vents to frozen deserts of Antarctica, from mountain tops to our own schoolyards. But what is an ecosystem?

The complexity of ecosystems, with a myriad of components and interrelationships, makes them daunting to conceptualize. This lends them to systems thinking, which seeks to identify and understand the parts in the context of their connections to other parts and the whole. By considering connections and interrelationships that identify and define ecosystems, we appreciate and clarify both their complexity and their integrity.

The term interrelationship refers to how components of an ecosystem interact in an interdependent way. The primary connectors within and between ecosystems are the flow of energy and the cycling of matter, especially nutrients. Ecologists and other scientists who study ecosystems work to identify components and key interrelationships, thereby helping us to better understand and make sense of ecosystems. Biologists approach their studies through a hierarchical model of the world: levels of organization. Starting at the level of an individual organism, such as a deer, we can then consider how a group of deer behaves and interacts in a given area. Such a group of interacting individuals of one species is called a population. Deer populations interact with populations of other organisms, from bacteria to willows to wolves. These interactions of species in an area form the next level, a community. The interrelationships between the living community and the physical and chemical environment define the ecosystem level.

There are two main components of ecosystems: the biotic and the abiotic. Life, from bacteria to protozoa to people to cedars to whales, as well as dead organisms in decomposition, is the biotic component. Organisms grow and live in particular habitats that provide food, shelter, water and space. The abiotic are non-living-physical and chemical factors that can be grouped as atmosphere, water and the solid earth. For example, sun, wind, temperature, water salinity, pH, and minerals play major roles in ecosystems. Geological and hydrological processes and products come to bear upon ecosystems in soil creation, landforms, ocean currents and the water cycle.

We are all familiar with the many types of interrelationships between the biotic: plants, animals and microbes. All play particular roles within their communities. Within an ecosystem, interrelationships exist between the abiotic components themselves, for example wind erosion of rocks, heating of water bodies by the sun, and nutrient leaching from soils. This aff ects life, and life aff ects the abiotic as well: for example, cool, moist conditions arise from a thick canopy of trees and soils become aerated by tunneling worms. Biotic decomposition results in nutrients joining the abiotic component. And without life, we would likely have an oxygen-free atmosphere like Mars or Venus.

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All ecosystem components are connected by the flow of energy and cycling of nutrients.

When an animal - including humans – eats, it breaks the chemical bonds of its food and releases useful energy within its cells. This energy is then used for a variety of functions, including growth, movement, cell membrane function, and reproduction. A portion of an organism's stored energy passes to another when all or part of it is consumed: energy fl ow. At the same time, useful materials, or nutrients transfer from one organism to another in a food chain. Intertwining food chains in a community result in often complex food webs.

The life sustaining fl ow of energy and the cycling of matter begin with green organisms that can capture the sun's energy and convert it to food in the process of photo-synthesis. These producers, plants, algae, and some bacteria, incorporate raw materials such as carbon dioxide, water and nutrients, into the more complex chemistry of life. Nutrient cycling returns materials to water or soil where they can once again be utilized by photosynthetic organism. Nutrient cycling is tightly connected to energy fl ow. Photosynthesis depends upon chlorophyll, or a similar pigment, to capture light and along with water and carbon dioxide, convert it into the chemical bond energy of carbohydrate. The products of photosynthesis are oxygen, water and carbohydrates. Thank a green plant today, because we wouldn't be alive without them! Consumers obtain their energy by eating plants or other animals. When the chemical bonds in the carbohydrates are broken apart within a consumer's cells in the process of cellular respiration, energy is released and used for that organism's life processes. Respiration complements photosynthesis; the products are carbon dioxide, water and energy.

Primary consumers, also called herbivores, eat producers. Secondary consumers, often carnivores eat herbivores, and so on. Each level, including producers, is referred to as a trophic, or food, level. All organisms eventually die and are consumed by decomposers. People often underestimate the importance of decomposers (or detritivores), as they reduce the amount of organic waste and recycle the bulk of nutrients from the biotic to the abiotic and back again. An example is the cycling of nitrogen. Our atmosphere is composed of almost eighty percent nitrogen, yet most living organisms cannot use this nitrogen to make essential organic molecules such as proteins and DNA. Various soil microorganisms not only incorporate atmospheric nitrogen, but also process dead organisms and organic wastes into nitrogen forms that plants can use. Once the plants have the nitrogen, the rest of the food chain gains access to it.

Food chains describe the flow of energy from a producer to a consumer to a consumer, etc, until we run out of trophic levels. An example of a terrestrial food chain would be grass seed eaten by mice eaten by snake eaten by hawk. Each trophic level connects to decomposers or detritivores such as slugs or worms, bacteria and fungi. Since energy is lost at every act of consumption, biomass, the amount of living material, decreases as we ascend a food chain. This translates into few large predatory animals or many parasites at the top of food chains, but always less biomass. Since mice eat other food besides grass seed and are consumed by more predatory species than snakes and an array of parasites, a number of food chains link to form a food web.

Key Concept

Ecosystems are constantly changing.

Ecosystems, in their complexity, often give us the impression of stability. However, even the most majestic temperate rain forest is no static museum. The dynamics of ecosystems are in constant flux, and what appears to be balance can change over eons or can be tipped in what amounts to a geologic instant. Disturbance, such as a forest fire, changes the landscape suddenly, but the land is quickly re-colonized by plants and animals. Over a number of years, the initial plant invaders change the biotic and abiotic factors of their ecosystem so that their own offspring cannot grow, creating favourable conditions for other species of plants. The new plant community may foster new animal and microbe species, yet eventually provide better growing conditions for species other than themselves. In this way, communities and ecosystems change in a pattern called ecological succession. Generally, succession leads to a climax community: one that sustains itself, such as the temperate rain forest that burned. Older communities tend to be more complex than younger ones, with more biodiversity in more intricate ecosystems. Temperate rain forests may take thousands of years to reach climax.

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Change comes naturally to ecosystems. We humans are an integral part of ecosystems. We are benefactors of their goods and services - they sustain us. In thousands to millions of years, ecosystems have evolved to apparent balance, partly due to adaptation to climate and landscape, the complexity of interrelationships, and high biodiversity. Yet we often do not sustain ecosystems. We change them rapidly, disturb them, and even destroy them. Our negative influences stem largely from the demands of the most abundant population of large animal on the planet to grow food and extract resources. The greatest threat to our familiar planetary ecosystem is climate change, and overwhelming evidence indicates that we are the perpetrators of this change. Increasingly, people have become highly concerned about how we disrupt the connections, diversity, and sustainability of ecosystems, often with unpredictable consequences.

Ecosystem studies coupled with knowledge of human history equip us with knowledge that can allow us to make decisions for actions that sustain the ecosystems that sustain us so that our children and grandchildren can live in harmony with the Earth.

References

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