THE ENVIRONMENTAL LITERACY COUNCIL (HTTPS://ENVIROLITERACY.ORG/)

Soil Ecosystems

Soils are rich ecosystems, composed of both living and non-living matter with a multitude of interaction between them. Soils play an important role in all of our natural **ecological cycles**—carbon, nitrogen, oxygen, water and nutrient. They also provide benefits through their contribution in a number of additional processes, called **ecosystem services**. These services range from waste decomposition to acting as a water filtration system to degrading environmental contaminants.

The diversity and abundance of life that exists within the soil is greater than in any other ecosystem. A handful of soil can contain billions of different organisms that play a critical role in soil quality to support plant growth. Although we understand the vital services that these organisms provide by breaking down organic debris (plants, animals, and other organic materials) and recycling nutrients, scientists have only begun to study the rich and unique diversity that is a part of the soil ecosystem.

Ecological Cycling

Each ecological cycle is unique, although similar elements can appear in more than one cycle. While most move between the atmosphere (air), hydrosphere (water), lithosphere (land) and biosphere (living things), other **nutrient cycles** are limited to movement between rocks and soils and plants and animals. However, even the nutrients from these limited cycles, such as potassium, calcium, phosphorus and magnesium, are essential for life.

Water and nitrogen resources, both essential to all living things, stay constant within their cycles—meaning their only change is in the forms they take. The **water cycle** is very dynamic as water can change from vapor to liquid to snow to ice. Soils role in this process is through infiltration, storage, and transpiration. Nitrogen, which makes up more than three-quarters of the Earth's atmosphere, must be broken down into other forms in order to be used by living organisms. It is within the **nitrogen cycle** that soil bacteria converts nitrogen into usable elements (called nitrogen fixing) for plants, animals and humans before it is eventually returned to the atmosphere.

Oxygen is unique in that it not only has its own cycle, it is often integrated into elements within other ecological cycles, as water (H_2O), carbon dioxide (CO_2), iron oxide (Fe_2O_3), and many others. Within the biosphere, photosynthesis is the key driver of the **oxygen cycle** as plants take in carbon dioxide and expel oxygen for animal and human use. Additionally, in water, oxygen is constantly being dissolved and consumed by microorganisms leading to balance.

The carbon cycle is by far the cycle of greatest interest due to its importance in both climate change and global warming. Soil plays a critical role in this cycle since the majority of carbon in the atmosphere comes from biological reactions within the soil. The **biological/physical carbon cycle** occurs over days, weeks, months, and years and involves the absorption, conversion, and release of carbon by living organisms through photosynthesis, respiration, and decomposition. The **geological carbon cycle** takes place over hundreds of millions of years and involves the cycling of carbon through the various layers of the Earth. A large amount of organic carbon sinks to the ocean floor to be buried into the Earth's crust. It is thought that more carbon dioxide is stored in the world's soils than is circulated within the atmosphere. Throughout the Earth's history, the release of CO_2 from deep below the surface occurs as a geological event, such as a volcanic eruption.

Ecosystem Services

Aside from its participation in various biogeochemical cycles and nutrient exchange, soil provides a number of other critical ecosystem services. These services differ from other ecosystem benefits in that there is a human demand for the natural assets and/or benefits. Several important benefits are listed below.

Soil is a natural protector of seeds and plants. Within a soil ecosystem seeds can disperse and germinate. The soil provides a physical support system for plants, while both retaining and delivering nutrients to them. This, in turn, provides humans and other animals with a source of food as well as resources for potential medicinal or other goods. In addition, soil can both hold and release water, thereby providing for plant growth, flood control, and water filtration and purification services.

Soils also play a central role in the management, processing and detoxification of a variety of wastes, both natural and man-made. Soil organisms decompose many organic compounds, such as manure, remains of plants, fertilizers and pesticides, preventing them from entering water and becoming pollutants. Human activity adds a wide variety of substances to the environment, some of which are hazardous or toxic. As long as the concentration is not greater than the ecosystem's ability to handle it, microorganisms in the soil can degrade or detoxify many of these substances, rendering them harmless to humans, animals, and the environment.

Recommended Resources

Biogeochemical Cycles
(http://homepages.nyu.edu/~pet205/biogeochem1.html) This webpage from Patricia Toledo of New York University links to explanations and graphics of various cycles, including carbon, nitrogen and oxygen.

The Water Cycle
(http://ga.water.usgs.gov/edu/watercyclesummary.html) The U.S. Geological Survey provides an excellent illustration, along with a complete summary, of the water cycle.

The Missing Carbon Sink (http://whrc.org/carbon/missingc.htm)
This piece, from the Woods Hole Research Center, provides a bit of background on a scientific investigation into missing carbon emissions.

Ecosystem Services: A Primer
(http://www.actionbioscience.org/environment/esa.html) The Ecological Society of America authored this short primer on what ecosystem services are, what they are worth, and what can disrupt these essential services.