Box 2.3 Are We Altering Earth's Basic Chemical Cycles?

Tracking the changes in Earth's chemical cycles—carbon, nitrogen, and water cycles—is essential to understanding the condition of ecosystems. These cycles serve as the basic metabolism of the biosphere, affecting how every ecosystem functions and linking them all on a global level. Human-induced changes in these global processes can alter climate patterns and affect the availability of basic nutrients and water that sustain plant and animal life.

The Carbon Cycle

Carbon dioxide (CO_2) concentrations in the atmosphere rose 30 percent from 1850 to 1998, from 285 parts per million to 366 parts per million (IPCC 2000:4) (see Box 1.6 Carbon Storage, p. 15). This rise in atmospheric CO_2 levels is largely the result of increased CO_2 emissions from burning fossil fuels. However, changes in use and management of ecosystems have also played a major role by releasing carbon that had been stored in vegetation and soil. About 33 percent of the carbon that has accumulated in the atmosphere over the past 150 years has come from deforestation and changes in land use (IPCC 2000:4).

Climate models tell us that rising carbon concentrations in the atmosphere will alter Earth's climate, affecting precipitation, land and sea temperatures, sea level, and storm patterns. The extent and structure of ecosystems will change as they transform in response to these basic physical parameters. Changing climate will also affect the rate of greenhouse gas emissions from some ecosystems. For example, models suggest that a warmer climate in the Arctic will elevate the rate of decomposition of the vast peat reserves in tundra and taiga ecosystems, increasing the release of CO_2 into the atmosphere.

Elevated atmospheric CO_2 can, in turn, have more direct impacts on ecosystems. Because plants depend on CO_2 for growth, elevated CO_2 concentrations will have a "fertilizer effect," increasing the growth rate of some plants and changing some of the chemical and physical characteristics of their cells. Some species will benefit more than others, and this in turn will alter the composition of biological communities.

Climate change could also have a profound impact on growing patterns and yields in agriculture. PAGE researchers estimated that a warmer climate could raise cereal production by 5 percent in mid- to high-latitude regions (mostly developed countries) but might decrease cereal yields in low-latitude regions by 10 percent (particularly in African developing countries).

The Nitrogen Cycle

Although we are more familiar with the influence humans have had on the carbon cycle, human influence on the global nitrogen cycle is more profound and already more biologically significant. In most natural systems, lack of nitrogen is an important limiting factor for plant growth, which is what accounts for significant increases in crop yields in response to nitrogen fertilizers. However, as explained in Chapter 1, the production and use of fertilizers, burning of fossil fuels, and land clearing and deforestation also increase—far beyond natural levels—the amount of nitrogen available to biological systems (Vitousek et al. 1997:5). This added nitrogen has caused serious problems, particularly in freshwater and coastal ecosystems where excess nitrogen stimulates growth of algae, sometimes depleting available oxygen to the point where other aquatic organisms suffocate, a process known as eutrophication.

The Freshwater Cycle

The scale of human impact on freshwater cycles is also massive. Humans currently appropriate more than half of accessible freshwater runoff, and by 2025, demand is projected to increase to more than 70 percent of runoff (Postel et al. 1996:7, 787). A substantial amount—70 percent—of the water currently withdrawn from all freshwater sources is used for agriculture (WMO 1997:9). By shifting water from freshwater systems to agroecosystems, crop production increases, but at significant cost to downstream ecosystems and downstream users. Some of the water diverted from rivers or directly consumed does return to rivers but, typically, carrying with it pollution in the form of agricultural nutrients or chemicals, or human or industrial waste. But as much as 60 percent of water withdrawn from rivers is lost to downstream uses (Postel 1993:56; Seckler 1998:4).

Global Cycles, Global Impacts

The importance of these global cycles to the functioning of ecosystems cannot be overstated. There is no question that sound management of Earth's ecosystems will require changes in the use of resources at a local level; but it is not enough to only examine and assess the condition of ecosystems at the local level. Some of the most important features of Earth's ecosystems—with the most profound influence on the future role of ecosystems in meeting human needs—can only be fully understood on regional and even global levels. Thus, it is vital that we examine and assess the condition of ecosystems at those levels.