Carbon Dioxide and the Human Community

Two centuries of modern industry and population growth have increased levels of atmospheric carbon dioxide (CO_2). While long-term consequences of this and other atmospheric variations aren't yet known, computer models have suggested that changes in global carbon cycling may lead to marked global climate change.

So one year ago, President Clinton announced the United States Climate Change Action Plan. This blueprint for responding to the potential threat of global climate change should help guide the U.S. economy toward environmentally sound economic growth into the 21st century.

The planners have drawn up a suite of almost 50 actions involving all sectors of the U.S. economy. Included are plans to mitigate the effect of increased atmospheric CO_2 by better managing forests and planting millions of trees that would absorb the CO_2 and serve as a carbon storage mechanism, or sink.

Over the past few years, scientists' understanding of carbon cycling has improved. They know that atmospheric CO_2 provides a vital link between biological, physical, and human processes: Life could not exist without it. Carbon is continually exchanged between the atmosphere and oceans, the terrestrial biosphere, and even sedimentary rocks.

In the absence of CO_2 created by human activity, the carbon cycle had periods of millennia in which large carbon exchanges were in near balance, implying nearly constant reservoir contents.

Then humans began to upset that dynamic balance. Fossil fuel burning for energy, together with forest harvest and other changes in land use, all released carbon—mainly as CO_2—into the atmosphere.

Carbon that is caused by human activity also cycles between the atmosphere, the oceans, and the terrestrial biosphere. Because carbon cycling in the terrestrial and ocean biospheres occurs slowly, the effect of injecting additional carbon into the atmosphere is a long-lasting disturbance.

Concern about how any global climate change will affect the Earth, its ecosystems, and our way of life has spurred internationally mandated research on each nation's sources and sinks of CO_2.

During the 1980's, total emissions of human-caused CO_2 averaged about 5.5 billion tons of carbon per year. The measured average annual rate of atmospheric increase during that same decade was about 3.2 billion tons. This would indicate that about 2.3 billion tons of carbon are taken up by biological processes each year.

Biological uptake can only proceed by means of photosynthesis. Therefore, the big question for plant scientists must be: How does photosynthesis respond to increasing CO_2? And how has natural resource conservation captured CO_2 and created sinks, as a beneficial side effect of protecting vital soil resources?

The Agricultural Research Service has been in the forefront in defining the role of terrestrial plants in the constantly changing carbon cycle and in quantifying the long-term contribution of plants to sequestering—capturing and holding—atmospheric carbon.

Potential terrestrial CO_2 sinks may result from several photosynthetic processes, including the regrowth of Northern Hemisphere forests, improved forest growth due to CO_2 "fertilization" and nitrogen deposition, and other positive responses to climate change.

To determine how much change in carbon cycling has occurred as a result of more than 50 years of natural resource conservation programs, scientists are gathering data on privately owned and managed lands.

The spin-off from soil-stabilizing conservation programs is an increase in soil organic carbon and aboveground biomass accumulation and, so, more carbon bound up through cropping, range, and forestry operations. This can be considered a significant accomplishment from efforts to reduce soil erosion and increase long-term food and fiber production.

USDA—in conjunction with the U.S. Department of Energy (DOE), the National Science Foundation, and the U.S. Environmental Protection Agency—is seeking to understand the scope and magnitude of the uptake and release of CO_2 associated with intensively managed crop, range, and forest ecosystems.

This issue of *Agricultural Research* reviews some of what ARS scientists have learned so far in a giant experiment designed to simulate future crop fields that will be exposed to twice as much CO_2 as today's croplands are.

One significant finding thus far is that plants will yield more, while using less water. ARS' cooperators in this research include DOE and Tuskegee University in Alabama.

As we begin to understand the complex interactions associated with photosynthetic changes and the likely responses of plant communities to changes in atmospheric temperature and moisture levels, we can begin to design ways to cope.

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