Global warming's ecosystem double whammy

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Plants and soils act like sponges for atmospheric carbon dioxide, but new research finds that one abnormally warm year can suppress the amount of carbon dioxide taken up by some grassland ecosystems for up to two years. The findings, which followed an unprecedented four-year study of sealed, 12-ton containerized grassland plots at DRI is the cover story in this week's issue (September 18) of the journal *Nature*.

"This is the first study to quantitatively track the response in carbon dioxide uptake and loss in entire ecosystems during anomalously warm years," said lead author Jay Arnone, research professor in the Division of Earth and Ecosystem sciences at DRI. "The 'lagged' responses that carry over for more than one year are a dramatic reminder of the fragility of ecosystems that are key players in global carbon sequestration."

The plants and soils in ecosystems help modulate the amount of carbon dioxide (CO2) in the atmosphere. Plants need CO2 to survive, and they absorb most CO2 during spring and summer growing seasons, storing the carbon in their leaves, stems and roots. This stored carbon returns to the soil when plants die, and it is released back into the atmosphere when soil bacteria feed on the dead plants and release CO2.

The four-year DRI study involved native Oklahoma tall grass prairie ecosystems that were sealed inside four, living-room-sized environment chambers. The dozen 12-ton, six-foot-deep plots were extracted intact from the University of Oklahoma's prairie research facility near Norman, Okla., in order to minimize the disturbance of plants and soil bacteria. Inside the DRI's sunlit-controlled EcoCELL chambers, scientists replicated the daily and seasonal changes in temperature, and rainfall that occur in the wild.

In the second year of the study, half of the plots were subjected to temperatures typical of a normal year, and the other half were subjected to abnormally warm temperatures -- on the order of those predicted to occur later this century by the Intergovernmental Panel on Climate Change. In the third year of the study, temperatures around the warmed plots were turned down again to match temperatures in the control plots. The CO_2 flux -- the amount of carbon dioxide moving between the atmosphere and biosphere -- was tracked in each chamber for all four years of the study.

DRI's EcoCELL facility gave the scientists an unprecedented degree of control over the enclosed ecosystems. Not only could they create the same air temperature conditions from year-to-year, they could also independently control the soil temperature in each chamber -- a key feature that enhanced the ecological relevance of the results. Each containerized ecosystem also sat on "load cells," the type of scales used to weigh trucks on highways. Scientists used the scales to track the amount of water that was taken up and lost by the plants and soil in both normal and abnormal years. Thus, each containerized ecosystem served as a weighing lysimeter, an instrument that's used to measure the water and nutrients that percolate through soils.

The scientists found that ecosystems exposed to an anomalously warm year had a net reduction in CO_2 uptake for at least two years. These ecosystems trapped and held about one-third the amount of carbon in those years than did the plots exposed to normal temperatures.

"Large reductions in net CO_2 uptake in the warm year were caused mainly by decreased plant productivity resulting from drought, while the lack of complete recovery the following year was caused by a lagged stimulation of CO_2 release by soil microorganisms in response to soil moisture conditions," explained co-author Paul Verburg, also from DRI.

Numerous studies have found that the Earth's atmospheric CO_2 levels have risen by about one-third since the dawn of the Industrial Age. CO_2 helps trap heat in the atmosphere, and political and economic leaders the world over are debating policy and economic reforms to reduce the billions of tons of CO_2 that burned fossil fuels are adding to the atmosphere each year.

"Our findings confirm that ecosystems respond to climate change in a much more complex way than one might expect based solely on traditional experiments and observations," said study co-author James Coleman, vice provost for research and professor of ecology and evolutionary biology at Rice University. "Our results provide new information for those who are formulating science-based carbon policies."

Source: Rice University