Dryland ecosystems emerge as driver in global carbon cycle

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Illustrated here is an example of a greening semi-arid ecosystem in the Northern Territory of Australia that played a key role in the record 2011 global land carbon sink following prolonged La Nina rainfall and long-term changes in vegetation. Credit: Eva van Gorsel (CSIRO)

Dryland ecosystems, which include deserts to dry-shrublands, play a more important role in the global carbon cycle than previously thought. In fact, they have emerged as one of its drivers, says Montana State

University faculty member Ben Poulter.

Surprised by the discovery, Poulter and his collaborators explained their findings in *Nature*. At the same time, they urged global ecologists to include the emerging role of dryland ecosystems in their research.

"Our study found that natural events in Australia were largely responsible for this anomaly," Poulter said. "La Nina-driven rainfall during 2010 and 2011, as well as the 30-year greening up of its deserts and other drylands contributed to significant changes across the globe."

Poulter, who has a dual appointment in MSU's Department of Ecology and the Institute on Ecosystems, came to MSU in January. Before that, he worked in France at the Laboratoire des Sciences du Climat et de l'Envionnement (LSCE) where he contributed to compiling information for the Global Carbon Project's annual global carbon budget assessment.

He realized during that process that the world's land carbon sink in 2011 seemed to be absorbing an unusually large amount of carbon, Poulter said. Carbon dioxide moves constantly between land, oceans, vegetation and the atmosphere. When one of those absorbs more carbon dioxide than it releases, it's referred to as a carbon sink.

Poulter and his collaborators investigated the phenomena with a variety of data sets and modeling approaches. They eventually discovered surprising interactions between climate extremes and desert greening that increased in importance over the past 30 years. Further study showed that the dryland systems in the Southern Hemisphere, specifically Australia, had particularly high productivity in response to increased La Nina-phase rainfall.

"What surprised us was that no analogous biosphere response to similar climatic extremes existed in the past 30 years, prompting us to explore whether documented dryland-greening trends were responsible for changes in the carbon cycle dynamics," said Philippe Ciais, co-author and senior scientist at LSCE.

The authors discovered that an increase in the precipitation sensitivity of a range of ecosystems processes occurred between the periods of 1982-1996 and 1997-2011. One of those processes was the greening of desert vegetation. Together those processes led to a four-fold increase in net carbon uptake to precipitation over the past 30 years.

"Novel responses of the biosphere have been predicted to occur following human activities that have caused unprecedented changes in atmospheric carbon dioxide concentrations, climate and land cover," Poulter continued. "Our study provides new evidence that interactions among these human activities are now also impacting dryland biomes. These findings have global implications that should be considered in monitoring networks and earth system models."

The large 2011 land carbon uptake is not expected to lead to long-term increases in ecosystem carbon accumulation, according to the researchers.

"Dryland systems have high rates of carbon turnover compared to other biomes," Ciais said. "We can expect the carbon to be quickly respired or consumed in wildfires, already partly reflected by the high atmospheric carbon dioxide growth rate in 2012."

In Poulter's new role at MSU, he said he will work with colleagues investigating the role of fire and invasive species in dryland systems to further understand the mechanisms for dryland greening and carbon cycle consequences.

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