Natural levels of nitrogen in tropical forests may increase vulnerability to pollution

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(PhysOrg.com) -- Waterways in remote, pristine tropical forests located in the Caribbean and Central America contain levels of nitrogen comparable to amounts found in streams and rivers flowing through polluted forests in the United States and Europe. This discovery by a Princeton University-led research team raises questions about how tropical forests might respond if they were to become exposed to additional nitrogen through water and air pollution.

Nitrogen, found naturally in soil, is a nutrient essential for plant growth. However, nitrogen also becomes a dangerous pollutant when increased levels from man-made fertilizers used for farming enter waterways, and when nitrogen emitted during the burning of fossil fuels enters the atmosphere and is then absorbed by the forests.

The study was initiated and led by Lars Hedin, a professor of ecology and evolutionary biology at Princeton and an associated faculty member at the Princeton Environmental Institute. Hedin published the findings with four co-authors in the paper "Sustained Losses of Bioavailable Nitrogen from Montane Tropical Forests" in the Jan. 15 online version of *Nature Geoscience*.

"The levels of nitrogen we found raise concerns about the fate of the forests and water quality of tropical regions where we know that nitrogen pollution will increase dramatically over the next decade," Hedin said.

"Tropical forests are significant reservoirs for carbon, and the future of

tropical forests relies on forest interactions with nutrient cycles," he said. "Our research shows these forests have high concentrations of nitrogen that have remained stable for nearly two decades. This is unexpected and remarkable, and it will have significant implications for future research into tropical forest nutrient cycles, tropical forest management and the role tropical forests collectively play as a significant carbon dioxide sink."

Hedin said the findings suggest the potential need for the development of new climate models, specifically created for tropical forests, to help researchers make more accurate predictions about the impact of pollution. Current models include data from temperate forests in the northeastern United States and Europe, but these data cannot be applied to tropical forests because pristine temperate forests naturally maintained low levels of nitrogen before becoming polluted.

Hedin's co-authors include Jack Brookshire, a former postdoctoral student in Hedin's lab and now an assistant professor at Montana State University; Daniel Sigman, a professor of geosciences at Princeton; and Denis Newbold and John Jackson from the Stroud Water Research Center in Avondale, Pa.

"Once we started looking for places to test our ideas, we immediately thought of the Stroud Water Research Center," Hedin said. "Stroud has a very unique 20-year record of data from undisturbed, natural tropical forest. Their collection is the longest record available over time for concentrations and isotopes. Such data sets are very rare."

The Stroud Water Research Center's data consists of observations of hydrology and nutrient fluxes in six watersheds located in Maritza, Costa Rica.

In 2006, during his first year as a postdoc in Hedin's lab, Brookshire

began the project by analyzing the Stroud data from Costa Rica and collecting data from 55 additional watersheds located throughout Central America and the Caribbean.

At first, Brookshire and Hedin thought the high levels of nitrogen found were a reflection of data from a specific year or were episodic. Instead the researchers discovered that from 1990 to 2008, these forests consistently showed high levels of nitrogen.

"The stable isotopes of nitrogen act as a fingerprint and show where the high nitrogen levels are coming from — revealing whether these levels are natural or are caused by air pollution, climate change or fertilizer," Hedin said. "We saw no evidence of change, leading us to conclude it is a natural state."

Nitrogen in soil is the most important element for plant development. There is a large reservoir of nitrogen in the air, but it is in a chemical form that is unavailable to plants and must be "fixed" into a usable form as nitrates or nitrites by soil and microorganisms.

Hedin said that extensive tropical forests play a significant role in the global nitrogen cycle and fix large amounts of nitrogen by means of their huge microbial populations.

However, he said, typically tropical rainforests are limited in their growth by low nitrogen levels because they lose vast quantities of nitrogen into the soil and, perhaps to a greater extent, into water as dissolved nitrogen. At the same time, humans have the capacity to greatly alter this cycle through the use of fertilizers containing nitrogen and by the release of nitrogen into the atmosphere by fossil fuel combustion and land conversion.

"Our research has led us to a deeper understanding of the remarkable,

unprecedented pattern of nitrogen stability in these forests, during a time when the world has been rapidly changing. In the future, we hope to conduct further investigations into how this growth element behaves," Hedin said.

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