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UC Davis Researcher Leads Climate-Change Discovery

A team of researchers led by a first-year UC Davis faculty member has resolved a longstanding paradox in the plant world, which should lead to far more accurate predictions of global climate change.

A paper describing the research will be published online Wednesday (June 18) by the journal Nature.

The paradox centers on puzzling aspects of the nitrogen cycle in temperate and tropical forests. Defying the usual laws of supply and demand, trees capable of extracting nitrogen directly from the atmosphere (a process called nitrogen fixation) often thrive where it is readily available in the soil, but not where it is in short supply.

Nitrogen is an essential nutrient for all life on Earth, and determines how much carbon dioxide plants (and entire ecosystems) can absorb from the atmosphere, said UC Davis assistant professor Benjamin Houlton, the paper's lead author. Because carbon dioxide is the principal greenhouse gas causing global warming, any process that changes the amount of nitrogen available for plant growth will affect global temperatures.

But any serious attempt to consider the impact of nitrogen on climate change has been limited by a lack of understanding of the global pattern of nitrogen fixation, Houlton said.

"You would expect that nitrogen-fixing species would have a competitive advantage in ecosystems where nitrogen is in low supply, but not where nitrogen is abundant, because fixation is energetically very costly to an organism. And that's the way ecologists have found it works in the open ocean and in lakes," he continued.

"But in mature temperate forests, where the soils have limited amounts of nitrogen, nitrogen-fixing tree species are scarce. And in the tropical lowland forests, which are nitrogen-rich, nitrogen-fixing trees often are abundant. We asked why."

The researchers found the explanation lies in the key roles played by two other factors: temperature and the abundance of another key element, phosphorus.

Temperature, they determined, affects the activity of a nitrogen-fixing enzyme called nitrogenase. In cooler, temperate climates, more of the enzyme is needed to fix a given amount of nitrogen. This higher cost would offset the benefit of nitrogen fixation in temperate forests, despite low-nitrogen soils.

In tropical forests, it's the link between nitrogen and phosphorus that explains the abundance of nitrogen-fixing species.

"Many tropical forest soils are severely depleted in phosphorus, even where nitrogen is relatively abundant," said Houlton. "The extra nitrogen added to the soil by nitrogen-fixers helps mobilize phosphorus, making it easier for roots to absorb. That stimulates the growth of these plant species and puts them at a competitive advantage, despite the energetic cost of nitrogen fixation."

Houlton’s co-authors are top international ecologist Peter Vitousek, the Clifford G. Morrison Professor in Population and Resource Studies at Stanford University; Christopher Field of the Carnegie Institution’s Department of Global Ecology; and Yingping Wang of Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO).

The paper is titled “‘A unifying framework for dinitrogen fixation in the terrestrial biosphere.” It will be published in regular editions of Nature on Thursday (June 19).

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