Bedrock nitrogen may help forests buffer climate change, study finds

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The forests of South Fork Mountain in northern California draw nitrogen from bedrock, making them some of the state's most productive forests. Understanding and quantifying this newly identified source of nitrogen may significantly impact scientists understanding of forest productivity, carbon storage and nitrogen cycling on land. Credit: Photo by Scott Morford/UC Davis

For the first time, researchers at the University of California, Davis, have demonstrated that forest trees have the ability to tap into nitrogen found in rocks, boosting the trees' growth and their ability to pull more carbon dioxide from the atmosphere.

Given that carbon dioxide is the most important climate-change gas, the nitrogen in rocks could significantly affect how rapidly the earth will warm in the future, the researchers say. They report their findings in the

Sept. 1 issue of the scientific journal *Nature*.

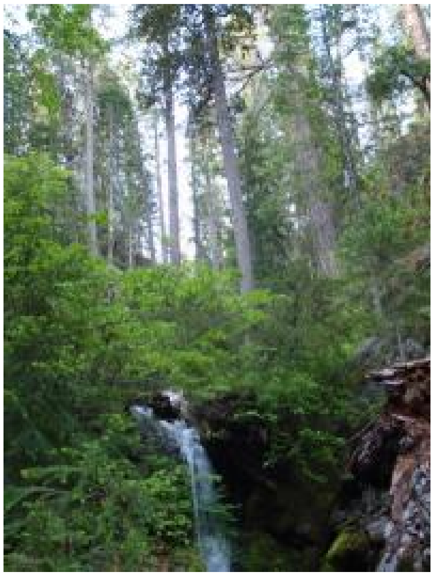
If trees can access more nitrogen than previously thought, that could lead to more storage of carbon on land and less carbon remaining in the atmosphere.

"We were really shocked; everything we've ever thought about the nitrogen cycle and all of the textbook theories have been turned on their heads by these data," said Professor Benjamin Houlton, a biogeochemist and one of the study's co-authors.

"Findings from this study suggest that our climate-change models should not only consider the importance of nitrogen from the atmosphere, but now we also have to start thinking about how rocks may affect climate change," he said.

The importance of nitrogen:

Nitrogen, found in such vital molecules as DNA and protein, is necessary for all life and is used worldwide as a fertilizer for food crops. It is the nutrient that most often limits plant growth in natural ecosystems .



The forests of South Fork Mountain in northern California draw nitrogen from bedrock, making them some of the state's most productive forests. Understanding and quantifying this newly identified source of nitrogen may significantly impact scientists understanding of forest productivity, carbon storage and nitrogen cycling on land. Credit: Photo by Scott Morford/UC Davis

It was previously believed that nitrogen could only enter ecosystems from the atmosphere -- either dissolved in rainwater or biologically "fixed" or assimilated by specialized groups of plants and other organisms. Because the amount of nitrogen in these atmospheric pathways is rather limited, it was thought that most ecosystems could not get enough of this vital nutrient to facilitate plant growth at maximum rates.

Following this line of thought, it was estimated that the nitrogen contribution from rocks in Northern California was on the same order as atmospheric nitrogen sources, made available through fixation and deposited via rainwater.

"To put it in perspective, there is enough nitrogen contained in one inch of the rocks at our study site to completely support the growth of a typical coniferous forest for about 25 years," said Professor Randy Dahlgren, a biogeochemist and a study co-author.

"This nitrogen is released slowly over time and helps to maintain the long-term fertility of many California forests," Dahlgren said. "It is also interesting to consider that the nitrogen in the rocks from our study site originates from the time of the dinosaurs, when plant and animal remains were incorporated into the sediments that eventually formed the rocks."

The UC Davis findings:

The UC Davis study, led by Scott Morford, a graduate student in the Department of Land, Air and Water Resources, focused on measuring the nitrogen in rocks, soils and plants, and found that rocks enriched in nitrogen have a profound effect on the fertility of forests.

Data from the study indicate that the amount of carbon stored in forest soils derived from the nitrogen-rich bedrock was nearly twice that of sites associated with nitrogen-poor rocks in Northern California. Furthermore, the researchers used the inventory of forest growth data from the National Forest Service to determine that this was not just a localized effect. In fact, the productivity of forests growing on nitrogen-rich rock was approximately 50 percent higher than the productivity of forests growing on nitrogen-poor rocks throughout Northern California and into Oregon.

"We were all stunned when the data showed that the nitrogen in the trees was extremely high in forests that were living on the rocks with high nitrogen," said Morford.

To confirm the link between the nitrogen in the trees and that in the surrounding rock, the researchers traced the nitrogen from the rocks using the different isotopes of nitrogen. They found that the nitrogen isotopes in the rock matched those of the soils and trees, confirming that the nitrogen was coming from the rocks.

"It was like a fingerprint; we found the culprit, and it was the nitrogen in the rocks," Morford said.

Implications for climate change:

The researchers stress that, since nitrogen tends to be elevated in rocks of sedimentary origin, which cover roughly 75 percent of the Earth's land surface, the discovery that bedrock nitrogen has the potential to stimulate forest productivity and carbon storage has tremendous global significance.

"The stunning finding that forests can also feed on nitrogen in rocks has the potential to change all projections related to climate change," said Houlton. "This discovery may also help explain several other studies that have found that the nitrogen 'budgets' of forests are out of balance, the nitrogen accumulation in their soil and plants being substantially greater than the apparent nitrogen inputs."

Houlton noted that nitrogen is becoming increasingly important in climate-change studies and researchers have begun to incorporate nitrogen in their climate-change models. Some models indicate that the nutrient could cause an additional increase in global temperatures of up to one degree Celsius (1.8 degrees Fahrenheit) by 2010, as it limits the amount of carbon dioxide that plants around the world can extract from the atmosphere. If more nitrogen is available than predicted from the traditional nitrogen-cycling pathways, as the UC Davis study suggests, it could lead to more carbon storage on land and less carbon remaining in the atmosphere.

The researchers call for further studies in other parts of the world to determine if nitrogen in rocks affects forests outside of the Pacific Northwest.

Provided by University of California - Davis

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