Previously unknown mechanism causes increased forest water use, new study says

July 31 2019

Credit: CC0 Public Domain

Researchers have discovered a previously unknown mechanism that causes increased forest water use, advances understanding of soil biogeochemical control of forest water cycles and highlights threats to plants from water stress under acid deposition, according to a new study.

In a study published in the journal *Science Advances*, the researchers

report the mechanism works this way: Sulfuric and nitric acid fall to the ground when fossil fuels are burned, causing acidification of the soil. When that happens, a significant amount of soil calcium washes out of the soil, and then plants suffer from calcium deficiency. Calcium deficiency causes the plants to intensify their use of water.

Lixin Wang, an associate professor in the School of Science at IUPUI, is the senior author of this research, and his Ph.D. student Matthew Lanning is the first author.

This research is funded by the National Science Foundation's Hydrological Sciences program. Other authors of the research team include Todd Scanlon and Howard Epstein at the University of Virginia, Matthew Vadeboncoeur at the University of New Hampshire, Mary Beth Adams at the United States Forest Service, and Daniel Druckenbrod at Rider University.

Calcium plays a unique role in plant cells by regulating the minute pores, called stomata, in the plants' leaves or stems, Wang said. If plants don't have enough calcium, they can't close those pores, and their water use increases. Also, when plants suffer from calcium deficiency, they will pump up more water through transpiration, the process of water movement through a plant and its evaporation from leaves, to meet their calcium demand, he said.

"We hypothesized that the leaching of the soil calcium supply, induced by acid deposition, would increase large-scale vegetation water use," Lanning said. "We present evidence from a long-term whole watershed acidification experiment demonstrating that the alteration of the soil calcium supply by acid deposition can significantly intensify water use."

The researchers found multiple lines of evidence showing that calcium leaching induced by acid deposition not only increased vegetation water

use but markedly decreased the soil water pool on the treated watershed.

"When plants are always using a lot of water, it means there will be less water left for people," Wang said. "It also means that these plants are very sensitive to drought. If a drought comes, and they can't close their stomata, they are subject to high levels of mortality due to water stress."

Traditionally, forest water use was considered a function of meteorological factors, species composition and soil water availability. The impacts of soil biogeochemistry on large-scale forest water use had not been investigated.

Nitrate and sulfate deposition are the primary drivers of soil acidification in the northeastern United States and eastern Europe, where atmospheric inputs exceed soil-generated acidity. In the United States and most of Europe, emissions of nitrate and sulfate have been curbed by legislation, but the impacts of acid deposition are still of global concern, especially in areas downwind of major cities or high-production agricultural areas.

More information: Intensified vegetation water use under acid deposition, *Science Advances* 31 Jul 2019: Vol. 5, no. 7, eaav5168, DOI: 10.1126/sciadv.aav5168 , advances.sciencemag.org/content/5/7/eaav5168

Provided by Indiana University