# Soil nutrients may limit ability of plants to slow climate change

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Credit: SC Department of Agriculture

Many scientists assume that the growing level of carbon dioxide in the atmosphere will accelerate plant growth. However, a new study co-written by University of Montana researchers suggests much of this growth will be curtailed by limited soil nutrients.

The end result: By the end of the century, there may be more than an

additional 10 percent of CO2 in the atmosphere, which would accelerate climate change.

"If society stays on its current trajectory of CO2 emissions and the growth rates of plants don't increase as much as many models project, the result by the end of the century could be more extreme than we predicted," said Cory Cleveland, a UM associate professor of biogeochemistry.

The study was published in the journal *Nature Geoscience*. Cleveland and former UM doctoral student Bill Smith did the research, along with partners at the University of Colorado and the Pacific Northwest National Laboratory.

"Humanity so far has greatly benefited from plants removing carbon dioxide from the atmosphere," said Will Wieder, a National Center for Atmospheric Research scientist affiliated with CU. "But if a lack of nutrients limits their ability to keep soaking up CO2, then climate change becomes an even bigger problem than we thought - unless society can cut back on emissions."

Cleveland and co-authors looked at 11 leading climate models to examine changes in nitrogen and phosphorous. They found that nitrogen limitation actually will reduce plant uptake of CO2 by 19 percent, while a combined nitrogen and phosphorous limitation will reduce plant uptake by 25 percent.

Most of the world's leading climate models assume that plants will respond to increased atmospheric levels of CO2 by growing more and more, which is known as the CO2 fertilization effect. The more the plants grow, the more CO2 they absorb from the atmosphere, thereby slowing climate change.

"But CO2 is far from the only determinant of plant growth," Cleveland said. "Soil nutrients - especially nitrogen and phosphorus - also are critical. Because the supply of such nutrients is limited, scientists have warned that plant growth will be less than indicated in climate models."

He said most climate models so far have not included nutrients because such biogeochemical processes are difficult to simulate and vary greatly from one type of terrestrial ecosystem to another. The Community Earth System Model from the National Center for Atmospheric Research, jointly funded by the National Science Foundation and the U.S. Department of Energy, is one of the first to begin considering the role of soil nutrients in the models that are used for climate change projections.

In the new study, the researchers studied the world's leading climate models that were used in an international study known as the Coupled Model Intercomparison Project, Phase 5. They focused on how the models represented plant growth in specific geographic regions, comparing that to changes in nitrogen and phosphorus availability caused by deposition of airborne particles and other factors.

"We found that instead of acting as a carbon sink and drawing down CO2, the terrestrial biosphere could become a net source of the greenhouse gas to the atmosphere by the end of the century, with soil microbes releasing more carbon than growing plants could absorb," Cleveland said.

Uncertainties remain, however. One of the questions is how soil microbes - which free up nitrogen in the soil, but also release carbon dioxide into the atmosphere - will respond to warming temperatures. Similarly, scientists don't know if plants will become more efficient at drawing up additional nutrients from the soil. If not, plants won't be able to keep up with society's CO2 emissions.

"To store that much carbon on land, plants will need more nitrogen and phosphorus," Wieder said. "If they can't get it, we're going to go from terrestrial ecosystems sponging up CO2 to actually having them contribute to the problem."

**More information:** Future productivity and carbon storage limited by terrestrial nutrient availability, DOI: 10.1038/ngeo2413

Provided by University of Montana