A carbon sink that can't be filled

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A new study by a team researchers including U of T Scarborough Professor Myrna Simpson reveals that as global temperatures rise the organic matter in forests appear to be breaking down more quickly, accelerating the release of carbon into the atmosphere. Credit: U of T Scarborough

Forests can store as much as 45 percent of the world's terrestrial carbon, making them a critical part of the process of regulating climate change.

As global temperatures rise, though, the organic matter in forests appears to break down more quickly, accelerating the release of carbon into the atmosphere.

This surprising conclusion comes out of a long-term study that was intended to find means to mitigate global warming, not exacerbate it.

"Our question was, 'How much carbon can the soil hold?'" says UTSC professor of environmental chemistry, Myrna Simpson. "But in our experiments, we found that soil was not the limiting factor. We couldn't even get to the carbon saturation point."

Since 1990, a team of international scientists have been running experiments in Harvard Forest in Massachusetts, testing the effect of adding (or removing) varying amounts and types of "litter" - leaves, twigs, seeds, roots and other organic material - above and below ground. Simpson joined this work in 2010. She contributed specialized expertise in nuclear magnetic resonance (NMR) spectroscopy to the mix. NMR allows researchers to scan every type of organic material in soil, molecule by molecule.

"The scientific community widely accepts that soil organic matter chemistry is tied to inputs," she says. "But we were surprised to see that all of our litter manipulation resulted in accelerated breakdown of organic matter."

Climate change could lead to "more productive" forests - bigger trees and more vegetation. This productivity would naturally increase the amount of litter, and therefore the amount of carbon sinking into the soil in the form of organic matter.

But in a paper published recently in the journal *Biogeochemistry*, Simpson and her co-authors describe how they simulated this change by

doubling the amount of litter in sections of the forest in the hope that the soil could absorb more carbon. Instead, the increased litter stimulated bacterial and fungal activity. Organic matter broke down more quickly, eliminating any carbon storage benefit and releasing more CO2 into the atmosphere.

"Altering the litter did more harm than good," Simpson says. "Ours was a human manipulation, but it could as easily be altered through climate change."

Simpson's experiments continue both at the Harvard Forest and at other experimental forests around the world in collaboration with a large network of ecologists and soil scientists. In each case, local plant species, climate and other factors might lead to different results. Also, litter is just one consideration in how long carbon stays sunk in a forest - Simpson is testing the effects of nitrogen and other variables that could affect forests' abilities to store carbon.

Soil breakdown is further complicated because plants create many products - from cellulose to lignin - each of which is affected differently by changes in soil content and environmental conditions. What accelerates one form of decomposition might slow down another.

"I want to emphasize that this was just one forest. We don't know if this is a global phenomenon," she says. "We're looking now to see how vegetation, temperature, moisture in different regions affects the process. These results just suggest that for forests like the Harvard Forest, adding extra litter is not a way to mitigate climate change and enhance carbon storage."

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