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Tropical forests face increased soil carbon loss due to climate change

Tropical forests account for more than 50% of the global terrestrial carbon sink, but climate change threatens to alter the carbon balance of these ecosystems. New research by Lawrence Livermore National Laboratory (LLNL) scientists and colleagues from Colorado State University and the Smithsonian Tropical Research Institute has found that warming and drying of tropical forest soils may increase soil carbon vulnerability, by increasing degradation of older carbon.

Tropical forests exchange more CO_2 with the atmosphere than any other terrestrial biome and store nearly one-third of global soil carbon stocks. Tropical terrestrial ecosystems also have the shortest mean residence time for carbon on Earth, as short as 6-15 years, meaning that any change in carbon inputs or outputs (including CO_2 emitted by soil) could have large and relatively rapid consequences for tropical ecosystem carbon balance and carbon-climate feedbacks. The research, conducted during climate manipulation experiments in tropical forests in Panama, shows that both whole-profile in situ heating of soil by 4 °C and exclusion of 50% of rainfall increased carbon-14 in the CO_2 released by the soil, increasing the average age of the carbon by the equivalent of ~2–3 years.

Importantly, the mechanisms underlying this shift differed between warming and drying. Warming accelerated decomposition of older carbon as increased CO_2 emissions depleted newer carbon. Drying suppressed decomposition of newer carbon inputs and decreased soil CO_2 emissions, thereby increasing the contributions of older carbon to CO_2 release. Most of the previous work in tropical forests only considered total CO_2 flux rates, which are important for determining the overall carbon balance of tropical forests, but are limited in their ability to uncover mechanisms behind observed change. Those mechanisms can be revealed by carbon-14 values, which indicate the average age of the carbon sources being metabolized and released as CO_2.

In the current study, the team determined how warming and drying impact the amount and age of carbon released as soil CO_2 in two distinct lowland tropical forest areas in Panama that are subject to experimental soil warming or experimental drying. They measured the carbon-14 and carbon-13 isotopes of soil-respired CO_2. (Source: Karis J. McFarlane et al, *Nature Communications* (2024).