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One of Earth's major carbon sinks collapsed in 2023

Forests and other land ecosystems emitted almost as much carbon dioxide as they absorbed in 2023 – it will be much harder to restrict global warming to agreed targets

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British Columbia in Canada, during the 2023 wildfire season
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Extreme heat, drought and wildfires caused forests and other land ecosystems to emit almost as much carbon dioxide as they removed from the atmosphere in 2023, nearly canceling out a major natural sink of the greenhouse gas.

Researchers say the temporary decline of this sink – which usually removes about a quarter of our annual CO_2 emissions from the atmosphere – bodes ill for how these ecosystems will respond to future climate change.

"It's pretty grim," says Scott Denning https://www.atmos.colostate.edu/people/faculty/denning/ at Colorado State University, who wasn't involved in the study. "If there's no more sink, then CO_2 will start to increase much faster."

Philippe Ciais https://www.wcrp-climate.org/gc-carbon-feedbacks-leadership/39-philippe-ciais at the Pierre-Simon Laplace Institute in France and his colleagues set out to explain why 2023 saw a jump in atmospheric CO_2 that was far greater than could be explained by an increase in human-caused emissions alone. The researchers analysed measurements of atmospheric CO_2 and used models of the global carbon cycle to understand what was behind this rapid rise.

They found that changes in the balance between the amount of CO_2 taken up and emitted by ecosystems on land was the main culprit. This "land carbon sink" exists because forests and other land ecosystems take up slightly more CO_2 as they grow /article/2434129-forests-may-grow-more-slowly-than-expected-as-co2-levels-rise/ than they release when plants die and decompose or burn each year. This growth is boosted by increased levels of CO_2 fertilising plants. From 2010 to 2022, this sink removed about 2 gigatonnes of carbon from the atmosphere each year, on average.

In 2023, however, the land sink removed only 0.23 to 0.65 gigatonnes of carbon – the lowest amount since 2003 and more than three times lower than the average over the past decade, according to the researcher's estimates. Conversely, they found that the ocean carbon sink /article/2366476-can-we-counter-climate-change-by-dumping-carbon-in-the-ocean/ increased in 2023 by around a gigatonne, ruling the oceans out as a source of the jump in atmospheric CO_2.

During the first half of the year, the researchers attributed the change in the land carbon sink to slower vegetation growth in ecosystems in the northern hemisphere, along with extreme wildfires in Canada /article/2376662-wildfires-across-canada-have-emitted-record-breaking-amounts-of-carbon/, other parts of the Arctic, and South-East Asia. Drought and fires weakening the Amazon carbon sink /article/2336521-the-amazon-rainforest-has-already-reached-a-crucial-tipping-point/ in the second half of the year made up the largest portion of the change, offsetting increased take-up in places like central Africa that saw wetter conditions.

Driving these changes were 2023's record high temperatures /article/2422583-red-alert-after-key-global-warming-records-were-smashed-in-2023/#:~:text=Overall%2C%202023%20was%20the%20warmest,EU's%20Copernicus%20climate%20monitoring%20service., which were mainly due to rising greenhouse gases and a shift to hotter El Niño conditions /article/2432325-el-nino-is-ending-after-a-year-of-driving-extreme-weather/ in the middle of the year. The team found that almost 30 per cent of the decline in the land carbon sink was due to net emissions in areas that saw the hottest 5 per cent of temperatures, as the heat stressed ecosystems and exacerbated drought and fire.

"The decline of the northern [land] sink was masked by recent good conditions in the Tropics absorbing CO_2, but in the coming years if this decline continues, we may see a rapid acceleration of CO_2 and global warming which was unforeseen in future climate models projections," Ciais wrote on X.

Whether 2023's weakened land carbon sink represents a passing response to an extremely hot year or a more lasting shift remains uncertain, says Denning. Past El Niño years have also seen dramatic declines in the land carbon sink and it will take more time to tease out the precise reasons for the shift. "But every time a hot episode wipes out part of the sink, or in this case all of the sink, it adds credence to the idea that the sink can't be sustained in the long term," he says.

Projections of how the carbon cycle will respond https://bg.copernicus.org/articles/20/1829/2023/ to future warming with rising CO_2 anticipate a weakening land carbon sink by the end of the century. But those models don't capture the extreme events that now appear to be driving the carbon cycle, says David Schimel https://science.jpl.nasa.gov/people/Schimel/ at NASA's Jet Propulsion Laboratory in California. That may mean we can emit even less CO_2 than previously thought /article/2400140-we-can-now-only-stay-under-1-5c-target-if-we-achieve-net-zero-by-2034/ and still keep the rise in global temperatures below 2°C, he says.