Climate 'spiral' threatens land carbon stores, finds study

February 22 2023

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The world's forests are losing their ability to absorb carbon due to increasingly 'unstable' conditions caused by humans, a landmark study has found.

Dramatic changes to forests, and other habitats that store carbon in plants and soils, are becoming more likely in some regions across Earth, with less carbon consistently absorbed by the 'land carbon sink' provided by trees, soil and plants, according to scientists writing in *Nature*.

The short-term impacts of rising temperatures, deforestation and farming on many vulnerable landscapes means carbon stores on land are less likely to recover in the longer term, the scientists say. This reduces the overall storage capacity of the land to absorb carbon and undermines global efforts to curb or reduce levels of greenhouse gases in the atmosphere.

Dr. Patrick McGuire, a climate scientist working jointly in the Department of Meteorology and the National Centre for Atmospheric Science branch, both at the University of Reading, UK, was a co-author of the new study, which was led by colleagues at CREAF, Barcelona, and Antwerp University.

Dr. McGuire said, "We found that large regions of the world are vulnerable to sudden and dramatic changes to their landscape, because the ability of their ecosystems to absorb carbon starts to destabilize."

"For example, forest fires in California are more likely because of extremely dry and hot conditions caused by a hotter atmosphere. More fires means forest turns to scrubland, sometimes permanently. This reduces the land's overall ability to suck carbon out of the atmosphere as it did before."

"This creates a vicious cycle as areas such as these become more vulnerable to the effects of climate change in the future."

Unstable carbon storage

Researchers found that from 1981-2018, ecosystems across the world moved through different phases, ranging from high productivity, when plants were able to take in more carbon, to low productivity, when plants were less able to absorb carbon.

The scale of these fluctuations creates a greater risk of destabilization, increasing the risk of abrupt landscape changes as ecosystems cannot acclimate to climate change, deforestation, and changes to biodiversity, among other factors.

The study, published in *Nature*, found the regions most at risk typically have less forest cover and more cropland, are warmer, and have experienced greater rises in temperature, which could be related to an increase in extreme weather events, such as heatwaves and cold snaps. The areas identified as most at risk include the Mediterranean Basin, Southeast Asia and the west coasts of North and Central America.

The researchers said these vulnerable areas have developed a 'memory'—described as a 'temporal autocorrelation'—meaning that years where carbon uptake is lower are more likely to be followed by years where carbon uptake diminishes further. Researchers say that as less carbon is absorbed in areas where forestland dominates, the likelihood of scrubland becoming the permanent landscape increases and forests could be lost forever.

Global variation

While several regions are at risk of abrupt changes in their landscapes, there are parts of the world where carbon absorption levels are consistent and ecosystem collapse is less likely as a result of carbon fluctuations. This includes the tropical forests of the Amazon, and parts of central and northern Europe, where carbon absorption capacity has increased. However, the researchers warn that regions such as the Amazon face

other climate threats, such as future shifts in regular patterns of rainfall.

The scientists say these global variations could make it harder to predict the global impact of schemes to absorb carbon, such as planting trees, in helping the world reach carbon net zero.

Dr. McGuire said, "Ecosystems on land currently absorb almost one-third of the carbon emissions created by humans. If they start to absorb less carbon, the earth's natural ability to curb climate change diminishes. This means we may need to cut man-made carbon emissions even faster than we had previously thought."

More information: Marcos Fernández-Martínez, Diagnosing destabilization risk in global land carbon sinks, *Nature* (2023). DOI: 10.1038/s41586-023-05725-1.
www.nature.com/articles/s41586-023-05725-1

Provided by University of Reading