Defining which types of forests can store the most carbon and under what conditions

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Species diversity allows great carbon storage only in equatorial and tropical rain forests, such as northern Chilean Patagonia Forest illustrated here. Credit: UNIGE/ Madrigal-Gonzalez

An international team led by the University of Geneva (UNIGE) has studied which types of forest, in terms of biodiversity, are the most effective in storing carbon. Inventory data from natural forests on five continents show that species diversity is optimal for equatorial and tropical rainforests, and that, conversely, in forests located in cold or dry regions, it is the abundance of trees and not their diversity that favors the recapture of CO_2. The results of the study, published in *Nature*

Communications, are valuable in defining natural strategies to combat climate change.

Global warming is stressing forests through higher mean annual temperatures, longer-lasting droughts and more frequent and extreme weather events. At the same time, forests—and the wood they produce—can trap and store carbon dioxide (CO_2), they therefore play a crucial role in mitigating climate change. Trees and forests remove carbon dioxide from the atmosphere and convert it to carbon during photosynthesis, which they then store in the form of wood and vegetation, a process referred to as carbon sequestration. However, not all forests have the same capacity to capture and store carbon.

Opposite Assumptions

In recent decades, researchers have suggested that species diversity allows for denser stacking and niche compartmentalisation that promotes the abundance of trees within a forest and that this abundance increases the forest's carbon storage capacity. But another hypothesis suggests that it is not diversity that allows tree abundance but the availability of energy substrate. Areas with higher energy content allows more trees to thrive per unit area and thus increase carbon recapture. While these two hypotheses question the scientific community on the relationship between diversity and abundance, knowing the answer could pragmatically guide the fight against CO_2 emissions.

An international team around Jaime Madrigal-Gonzalez, scientific collaborator at the Institute for Environmental Sciences of the Sciences Faculty of UNIGE, investigated which of these hypotheses is more likely and under which climatic conditions one is more likely than the other. The question was addressed using inventory data from natural forests from five continents.

Forests of the Five Continents

"Having more species may not always be what is needed to achieve greater carbon storage in forests," states Dr. Madrigal-Gonzalez. Instead, this relation only seems to prevail in the most productive forest regions of the planet that are basically restricted to equatorial and tropical rain forests, and some temperate forests—in regions where deforestation and human-induced forest fires have ravaged pristine environments lately. On the contrary, in the forests located in the coldest or driest regions on Earth, it is seemingly the abundance, promoted by productivity, that determines the diversity. Here, any increase in the number of species will not necessarily result in more trees and will not therefore have a big contribution to carbon storage.

The findings of these studies are of substantial practical relevance as they will aid decision makers identifying nature-based climate change mitigation strategies and to successfully use forests and their sequestration of carbon to reach the climate goals defined in the Paris Agreement. "Increasing climatic stress in the most productive forests of the planet could diminish or even collapse the role of diversity against climate change" says Prof. Markus Stoffel, Professor at the Institute for Environmental Sciences of the UNIGE.

More information: Jaime Madrigal-González et al. Climate reverses directionality in the richness–abundance relationship across the World's main forest biomes, *Nature Communications* (2020). DOI: 10.1038/s41467-020-19460-y

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