Assessing nature's carbon sinks

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Manu National Park, a large (15,328-square-kilometer) protected area in southeastern Peru, includes several ecological zones and spans an elevation range of 150-4,200 meters above sea level. Manu's vast tracks of Amazonian rainforest are part of the global tropical forest carbon sink that is slowing the rate of increase in atmospheric carbon dioxide, a primary driver of climate change. Credit: Greg Asner/Carnegie Institution for Science

Protected areas such as rainforests occupy more than one-tenth of the Earth's landscape, and provide invaluable ecosystem services, from erosion control to pollination to biodiversity preservation. They also draw heat-trapping carbon dioxide (CO_2) from the atmosphere and store it in plants and soil through photosynthesis, yielding a net cooling effect on the planet.

Determining the role protected areas play as carbon sinks—now and in decades to come—is a topic of intense interest to the climate-policy community as it seeks science-based strategies to mitigate climate change. Toward that end, a study in the journal *Ambio* estimates for the first time the amount of CO_2 sequestered by protected areas, both at present and throughout the 21st century as projected under various climate and land-use scenarios.

Based on their models and assuming a business-as-usual climate scenario, the researchers projected that the annual carbon sequestration rate in protected areas will decline by about 40 percent between now and 2100. Moreover, if about one-third of protected land is converted to other uses by that time, due to population and economic pressures, carbon sequestration in the remaining protected areas will become negligible.

"Our study highlights the importance of protected areas in slowing the rate of climate change by pulling carbon dioxide out of the atmosphere and sequestering it in plants and soils, especially in forested areas," said Jerry Melillo, the study's lead author. Melillo is a distinguished scientist at the Marine Biological Laboratory (MBL) in Woods Hole, Massachusetts, and former director of the MBL's Ecosystems Center. "Maintaining existing protected areas, enlarging them and adding new ones over this century are important ways we can manage the global landscape to help mitigate climate change."

Based on a global database of protected areas, a reconstruction of global land-use history, and a global biogeochemistry model, the researchers estimated that protected areas currently sequester 0.5 petagrams (500 billion kilograms) of carbon each year, or about 20 percent of the carbon sequestered by all land ecosystems annually. Using an integrated modeling framework developed by the MIT Joint Program on the Science and Policy of Global Change, they projected that under a rapid climate-change scenario that extends existing climate policies; keeps protected areas off-limits to development; and assumes continued economic growth and a 1 percent annual increase in agricultural productivity, the annual carbon sequestration rate in protected areas would fall to about 0.3 petagrams of carbon by 2100.

When they ran the same scenario but allowed for possible development of protected areas, they projected that more than one-third of today's protected areas would be converted to other uses. This would reduce carbon sequestration in the remaining protected areas to near zero by the end of the century. (The protected areas that are not converted would be the more marginal systems that have low productivity, and thus low capacity to sequester carbon.)

Based on this analysis, the researchers concluded that unless current protected areas are preserved and expanded, their capacity to sequester carbon will decline. The need for expansion is driven by climate change: As the average global temperature rises, so, too, will plant and soil respiration in protected and unprotected areas alike, thereby reducing their ability to store carbon and cool the planet.

"This work shows the need for sufficient resources dedicated to actually prevent encroachment of human activity into protected areas," said John Reilly, one of the study's coauthors and the co-director of the MIT Joint Program on the Science and Policy of Global Change.

More information: Jerry M. Melillo et al. Protected areas' role in climate-change mitigation, *Ambio* (2015). DOI: 10.1007/s13280-015-0693-1

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