

# Without plants, Earth would cook under billions of tons of additional carbon

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Researchers based at Princeton University found that Earth's terrestrial ecosystems have absorbed 186 billion to 192 billion tons of carbon since the mid-20th century, which has significantly contained the global temperature and levels of carbon in the atmosphere. The study is the first to specify the extent to which plants have prevented climate change since pre-industrial times.

(Phys.org) —Enhanced growth of Earth's leafy greens during the 20th century has significantly slowed the planet's transition to being red-hot, according to the first study to specify the extent to which plants have prevented climate change since pre-industrial times. Researchers based at Princeton University found that land ecosystems have kept the planet cooler by absorbing billions of tons of carbon, especially during the past 60 years.

The planet's land-based [carbon](#) "sink"—or carbon-storage capacity—has kept 186 billion to 192 billion tons of carbon out of the atmosphere since the mid-20th century, the [researchers](#) report in the *Proceedings of the National Academy of Sciences*. From the 1860s to the 1950s, land use by humans was a substantial source of the carbon entering the atmosphere because of deforestation and logging. After the 1950s, however, humans began to use land differently, such as by restoring forests and adopting agriculture that, while larger scale, is higher yield. At the same time, industries and automobiles continued to steadily emit [carbon dioxide](#) that contributed to a botanical boom. Although a greenhouse gas and pollutant, carbon dioxide also is a plant nutrient.

Had Earth's terrestrial ecosystems remained a carbon source they would have instead generated 65 billion to 82 billion tons of carbon in addition to the carbon that it would not have absorbed, the researchers found. That means a total of 251 billion to 274 billion additional tons of carbon would currently be in the atmosphere. That much carbon would have pushed the atmosphere's current [carbon dioxide concentration](#) to 485 parts-per-million (ppm), the researchers report—well past the scientifically accepted threshold of 450 (ppm) at which the Earth's [climate](#) could drastically and irreversibly change. The current concentration is 400 ppm.

Those "[carbon savings](#)" amount to a current average global temperature that is cooler by one-third of a degree Celsius (or a half-degree Fahrenheit), which would have been a sizeable jump, the researchers report. The planet has warmed by only 0.74 degrees Celsius (1.3 degrees Fahrenheit) since the early 1900s, and the point at which scientists calculate the global temperature would be dangerously high is a mere 2 degrees Celsius (3.6 degrees Fahrenheit) more than pre-industrial levels.

The study is the most comprehensive look at the historical role of terrestrial ecosystems in controlling atmospheric carbon, explained first

author Elena Shevliakova, a senior climate modeler in Princeton's Department of Ecology and Evolutionary Biology. Previous research has focused on how plants might offset carbon in the future, but overlooked the importance of increased vegetation uptake in the past, she said.

"People always say we know carbon sinks are important for the climate," Shevliakova said. "We actually for the first time have a number and we can say what that sink means for us now in terms of carbon savings."

"Changes in [carbon dioxide emissions](#) from land-use activities need to be carefully considered. Until recently, most studies would just take fossil-fuel emissions and land-use emissions from simple models, plug them in and not consider how managed lands such as recovering forests take up carbon," she said. "It's not just climate—it's people. On land, people are major drivers of changes in land carbon. They're not just taking carbon out of the land, they're actually changing the land's capacity to take up carbon."

Scott Saleska, an associate professor of ecology and [evolutionary biology](#) at the University of Arizona who studies interactions between vegetation and climate, said that the researchers provide a potentially compelling argument for continued forest restoration and preservation by specifying the "climate impact" of vegetation. Saleska is familiar with the research but had no role in it.

"I think this does have implications for policies that try to value the carbon saved when you restore or preserve a forest," Saleska said. "This modeling approach could be used to state the complete 'climate impact' of preserving large forested areas, whereas most current approaches just account for the 'carbon impact.' Work like this could help forest-preservation programs more accurately consider the climate impacts of policy measures related to forest preservation."

Although the researchers saw a strong historical influence of carbon fertilization in carbon absorption, that exchange does have its limits, Saleska said. If carbon dioxide levels in the atmosphere continue rising, more vegetation would be needed to maintain the size of the carbon sink Shevliakova and her colleagues reported.

"There is surely some limit to how long increasing carbon dioxide can continue to promote plant growth that absorbs carbon dioxide," Saleska said. "Carbon dioxide is food for plants, and putting more food out there stimulates them to 'eat' more. However, just like humans, eventually they get full and putting more food out doesn't stimulate more eating."

The researchers used the comprehensive Earth System Model (ESM2G), a climate-carbon cycle model developed by the National Oceanic and Atmospheric Administration's Geophysical Fluid and Dynamics Laboratory (GFDL), to simulate how carbon and climate interacted with vegetation, soil and marine ecosystems between 1861 and 2005. The GFDL model predicted changes in climate and in atmospheric concentrations of carbon dioxide based on fossil fuel emissions of carbon. Uniquely, the model also predicted emissions from land-use changes—such as deforestation, wood harvesting and forest regrowth—that occurred from 1700 to 2005.

"Unless you really understand what the land-use processes are it's very hard to say what the system will do as a whole," said Shevliakova, who worked with corresponding author Stephen Pacala, Princeton's Frederick D. Petrie Professor in Ecology and Evolutionary Biology; Sergey Malyshev, a professional specialist in ecology and evolutionary biology at Princeton; GFDL physical scientists Ronald Stouffer and John Krasting; and George Hurtt, a professor of geographical sciences at the University of Maryland.

"After the 1940s and 1950s, if you look at the land-use change

trajectory, it's been slowed down in the expansion of agriculture and pastures," Shevliakova said. "When you go from extensive agriculture to intensive agriculture you industrialize the production of food, so people now use fertilizers instead of chopping down more forests. A decrease in global deforestation combined with enhanced vegetation growth caused by the rapid increase in carbon dioxide changed the land from a [carbon source](#) into a carbon sink."

For scientists, the model is a significant contribution to understanding the terrestrial carbon sink, Saleska said. Scientists only uncovered the land-based [carbon sink](#) about two decades ago, while models that can combine the effects of [climate change](#) and vegetation growth have only been around for a little more than 10 years, Saleska said. There is work to be done to refine climate models and the Princeton-led research opens up new possibilities while also lending confidence to future climate projections, Saleska said.

"A unique value of this study is that it simulates the past, for which, unlike the future, we have observations," Saleska said. "Past observations about climate and carbon dioxide provide a test about how good the model simulation was. If it's right about the past, we should have more confidence in its ability to predict the future."

**More information:** The paper, "Historical warming reduced due to enhanced land carbon uptake," was published Oct. 15 in the *Proceedings of the National Academy of Sciences*. [www.pnas.org/content/early/2013/10/15/1314047110.abstract](http://www.pnas.org/content/early/2013/10/15/1314047110.abstract)

Provided by Princeton University

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