Arctic Tundra Has Long Helped Cool Earth. Now, It's Fueling Warming.

Wildfires and thawing permafrost are causing the region to release more carbon dioxide than its plants remove, probably for the first time in thousands of years.

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By Raymond Zhong

Dec. 10, 2024

For thousands of years, the shrubs, sedges, mosses and lichens of the Arctic have performed a vital task for the planet: gulping down carbon dioxide from the air and storing the carbon in their tissues. When the plants die, this carbon is entombed in the frigid soil, where it no longer helps warm Earth's surface.

But as fossil fuel emissions heat the planet, balmier air temperatures are thawing Arctic tundra, activating carbon-hungry microbes, and more vegetation is being burned up by wildfires.

The result, for the past two decades or so, is that the tundra has been adding more carbon dioxide to the atmosphere than it has removed, a reversal from the usual state of affairs since the peak of the last ice age.

It's one of many signs of rapid change in the National Oceanic and Atmospheric Administration's Arctic Report Card, the agency's yearly checkup on the polar region. The 2024 report card was issued on Tuesday in Washington at the annual meeting of the American Geophysical Union, an association of earth and space scientists.

For the 11th year in a row, the Arctic this year was more abnormally warm than the world as a whole, the report card said. The period from October 2023 to September was the second-warmest for the region since 1900. In the Northwest Passage, the sea route that links the Atlantic and the Pacific through the islands of northern Canada, the area covered by sea ice this summer was the lowest since records began. Parts of Arctic Canada had their shortest snow season on record.

"The Arctic today, year after year, looks vastly different than the Arctic did 20 years ago," said Twila Moon, an editor of the report card and the deputy lead scientist at the National Snow and Ice Data Center in Boulder, Colo.

In the Arctic tundra, there have long been signs of a shift in how much carbon is moving between the land and the air. But by incorporating more data and better methods of analysis, scientists can now describe the trend with confidence: Between 2001 and 2020, wildfires and thawing permafrost caused the tundra to release more carbon dioxide than its plants removed from the air, probably for the first time in many millenniums.

How much this gap widens depends in large part on how much nations rein in greenhouse warming, said Brendan Rogers, an Arctic scientist at the Woodwell Climate Research Center in Falmouth, Mass., who contributed to the report card.

"The more we can do to lower the overall temperature changes globally, the better we're going to be able to deal with permafrost emissions," Dr. Rogers said.

Gathering data in the vast Arctic environment is always a challenge, but Russia's war in Ukraine has compounded the difficulties, including for scientists assessing the carbon cycle. "There are large parts of Siberia that we just don't have any data from," Dr. Rogers said.

Not all of the news in this year's report card was bad.

In the seas around Alaska, ice seal populations challenged by rising temperatures were deemed healthy. And a cool winter helped Greenland's vast ice sheet shed the smallest volume of ice since 2013, around 55 billion tons, though the long-term trend is still that melting ice from the island is adding enormously to rising sea levels worldwide.

A correction was made on Dec. 10, 2024: An earlier version of this article stated incorrectly the location of Woodwell Climate Research Center. It is in Falmouth, Mass., not Falwell.

When we learn of a mistake, we acknowledge it with a correction. If you spot an error, please let us know at nytnews@nytimes.com. Learn more

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