Lightning identified as the leading cause of wildfires in boreal forests, threatening carbon storage

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Lightning is the dominant cause of wildfire ignition in boreal forests—areas of global importance for carbon storage—and will

increase in frequency with climate change, according to new research.

Dr. Matthew Jones of the University of East Anglia's (UEA) Tyndall Center for Climate Change Research, is senior author of the paper, "Extratropical forests increasingly at risk of lightning fires," which is published in *Nature Geoscience*. The study was led by Vrije Universiteit (VU) Amsterdam in collaboration with researchers from the University of Leeds, Jiangsu Academy of Agricultural Sciences (China), and BeZero Carbon Ltd. (London).

The study used machine learning to predict the dominant source of wildfire ignitions—human or 'natural' lightning ignitions—in all world regions. Reference data from seven world regions were used to optimize the predictions from the algorithm. The researchers say it's the first study to attribute fire ignition sources globally.

The study shows 77% of the burned areas in intact extratropical forests are related to lightning ignitions, in stark contrast to fires in the tropics, which are mostly ignited by people. Intact extratropical forests are those in an almost pristine state, with small human populations and low levels of land use, and they are primarily found in the remote boreal forests of the northern hemisphere.

Climate models were also used to investigate how lightning frequency will change as the planet warms. Lightning frequency was found to increase by 11 to 31% per degree of global warming over intact extratropical forests, meaning that climate change brings a risk of more wildfire ignitions.

Lightning fires are on average larger, more intense and more strictly constrained to remote areas and periods of extreme fuel dryness than anthropogenic fires.

The team's earlier work has shown that episodes of fire-prone weather are also becoming more frequent and intense as the climate warms, meaning that forests are also becoming more flammable, more regularly. Synchronous increases in the flammability of forests and the frequency of lightning strikes are a worrying sign that intact extratropical forests will face an increasing threat of wildfire in future.

Extratropical forests are globally significant because they store vast quantities of carbon in vegetation and permafrost soils. Approximately 91% of these forests in the northern hemisphere are underlain by permafrost. When fires occur in these regions, they emit large amounts of carbon dioxide (CO_2) and other greenhouse gases compared to other regions.

Despite occupying only around 1% of Earth's land surface, fires in intact extratropical forests emit more than 8% of the total CO_2 emissions from fires globally.

It's estimated that fires may amplify emissions of greenhouse gases from permafrost thaw by 30% by the end of the century, following a moderate emissions scenario.

Dr. Jones, a Research Fellow whose work focuses on the carbon cycle and climate change, said, "Extratropical forests are globally important because they lock up dense stores of carbon in vegetation and soils, helping to keep CO_2 out of the atmosphere and moderate global warming.

"However, when fires occur in these regions, they emit more CO_2 per unit area than virtually anywhere else on Earth.

"Our research highlights that extratropical forests are vulnerable to the combined effects of a warmer, drier climate and a heightened likelihood

of ignitions by lightning strikes.

"Future increases in lightning ignitions threaten to destabilize vast carbon stores in extratropical forests, particularly as weather conditions become warmer, drier, and overall more fire-prone in these regions."

The research is particularly timely given Canada's record-breaking fire season in 2023, when fire emissions were more than four times greater than the 2003-2022 average. Preliminary reports have indicated widespread lightning ignitions in Canada this year.

VU's Dr. Thomas Janssen, lead author of the study, said, "While our research did not focus specifically on this year's extreme fire season in Canada, it does help us to understand this year's events. Extreme fire seasons in boreal forests, like the one we saw in Canada this year, will be more likely in warmer climates due to hotter, drier weather and more lighting strikes.

"The fires in Canada this year closely follow record-breaking fire seasons in the Siberian boreal forests in 2020 and 2021."

The authors warn that greenhouse gas emissions from fires can contribute to rising concentrations of carbon in the atmosphere and drive additional warming, further exaggerating the likelihood of fires and other adverse impacts of climate change in future.

Prof Sander Veraverbeke of VU said, "Increased greenhouse gas emissions from wildfires reinforces the problem of climate change, with more fires occurring as the climate warms and more greenhouse gases being emitted by fires.

"This 'reinforcing feedback' is particularly important in boreal forests, most of which are underlain by carbon-rich permafrost soils that take

many hundreds of years to form if they are lost to fire."

Dr. Jones said, "Our work has shown that the risk of lightning ignitions increases substantially as the planet warms, meaning that every tenth of a degree of warming that we can avoid will translate directly into a reduced risk of wildfire.

"Curbing emissions of greenhouse gases from fossil fuel use and land use change is critical to avoiding the worst additional risks of wildfire in many regions, but especially in the boreal forests where fires are so sensitive to warming."

More information: Extratropical forests increasingly at risk of lightning fires, *Nature Geoscience* (2023). DOI: 10.1038/s41561-023-01322-z

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