

**Woodwell
Climate
Research
Center**

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Notes from the Field

Month in Review • June 2025
woodwellclimate.org



Dr. Max Holmes
President & CEO

Reflections on another Canadian wildfire season

The summer of 2025 is showing the effects of climate change, with severe storm activity, flash flooding, and heat waves all making national headlines in recent weeks. What has received less attention—and certainly less than it deserves—is the record-breaking wildfire season impacting Canada.

Already this summer, Canadian officials have reported more than 2,000 wildland fires, which is slightly above the ten-year average. But those fires have burned an area more than four times the average. Out-of-control fires have forced tens of thousands of people to evacuate their homes. And smoke from these fires has brought air quality and health impacts to communities both nearby and as far away as Europe.

These fires are part of an insidious cycle of escalating climate change. Rapid warming is extending the fire weather season, increasing lightning ignitions, and contributing to heat-stressed vegetation that fuels larger fires. And the fires further exacerbate the situation by releasing massive amounts of carbon from trees and soils. A recent synthesis led by Woodwell's Dr. Anna Talucci confirmed that the carbon impacts extend long after the fire is extinguished, increasing permafrost thaw and the associated emissions for up to two decades.

Throughout the summer, we will be sharing a wealth of information and perspectives about the rapidly shifting wildfire regime in the Arctic/boreal region—first-person essays, accessible explanations of key concepts, and immersive storymaps that bring to life our work and the impacts communities are facing. Boreal fire is an important piece of our climate puzzle that deserves to be recognized and understood.

For some (and I would put Woodwell's scientists in this category), recognizing the consequences of boreal fire and understanding the inextricable links to climate change leads to a sense of urgency and purpose that drives action. For others, it can lead to overwhelm and hopelessness. If you are in that camp—and all of us are sometimes—here's what I want you to know: there are things we can do.

While reducing fossil fuel emissions is the single most important step we can take to limit the risk of boreal fire in the long-term,

fire management can reduce impacts, including carbon emissions. In 2022, Drs. Carly Phillips, Brendan Rogers, and Peter Frumhoff led a study showing that fire suppression could reduce carbon emissions at a cost of just \$12 per ton, making it a highly cost effective climate solution. We launched a pilot project to test the feasibility of deploying fire suppression for emissions reduction and, as recently as this month, we have been working to raise awareness at the federal level about this pragmatic climate solution.

With active research at the fire-climate intersection in both the Arctic/boreal region and the Amazon, Woodwell Climate brings a unique array of experience and expertise to these issues. While there are many differences between what's happening in the Arctic and the tropics, there are also parallels. And both the similarities and the differences offer opportunities for insight and cross-pollination.

Of course, new Western science is far from the only source of solutions, and those solutions cannot focus on carbon alone. Indigenous knowledge and cultural burning practices reflect millennia of experience, relationship, and wisdom. We are working with Indigenous colleagues and collaborators to explore how fire management can better integrate climate, health, and cultural values. For a powerful perspective on this topic, I highly recommend Senior Arctic Lead Edward Alexander's essay in a recent special issue of Wildfire Magazine.

This is just one example of how our communities and our science are strengthened when we can come together to see our challenges from a range of angles, and when we can bring different ideas about the path forward to the table. Woodwell's network of partners and supporters is large, interconnected, engaged, and resilient. It is one of our greatest strengths, and an immense source of comfort and inspiration, especially when obstacles loom large. Thank you for being part of that.

Onward,

Max

The connection between boreal wildfires and permafrost, explained

How northern fires are threatening the Earth's "deep freezer"

Kate Petersen Arctic Communications Strategist



As the Arctic heats up three to four times faster than the rest of Earth, hotter temperatures have super-charged northern fires, causing them to burn more area, more frequently, and more intensely.

These fires have a range of harmful impacts on communities, ecosystems, and wildlife in the north. When it comes to carbon, they represent a unique now-and-future threat to the global climate. That's because much of the boreal forest, which circles the high northern latitudes, is underlain by carbon-rich frozen ground called permafrost. Stocked with carbon from dead animal and plant matter that's accumulated over hundreds to thousands of years, permafrost functions as Earth's "deep freezer," keeping the planet cool by keeping carbon out of the atmosphere.

When permafrost thaws, microbes begin to access and break down the once-frozen carbon, releasing it into the atmosphere where it contributes to warming. Wildfires accelerate this process by burning off the organic soil layer that protects permafrost—opening the door on the freezer. And as temperatures in the north rise and boreal forests dry out and experience greater climate stress, the fires these forests evolved with have become more frequent and severe, with consequences for both permafrost and our climate.

Why are boreal forests important to climate?

The boreal forest, the largest forested biome on Earth, covers large stretches of North America, Europe, and Russia and stores 25% of the planet's terrestrial carbon. Roughly 80% of this carbon is stored belowground in the form of soil organic matter and permafrost. So when the forest burns, the carbon released from the trees is just the tip of the iceberg. Eighty percent or more of carbon emissions from boreal fires in North America and in central Siberia come from belowground combustion of soil organic matter.

Boreal forests have been reliable safekeepers of this belowground carbon historically by providing an insulating soil organic layer that protects permafrost. But increasingly severe fires are changing that picture.

What happens to permafrost when the boreal burns?

Wildfires threaten carbon in boreal forests in multiple ways, both during and long after the fire itself.

As a fire burns, it combusts the carbon stored in trees and plants, releasing it into the atmosphere along with smoke and harmful pollutants. Intense fires also burn through duff and soil layers that carpet the forest floor.

Burning these insulating layers exposes the permafrost below to warmer temperatures for years after a fire. A recent synthesis study led by Postdoctoral Researcher Dr. Anna Talucci of

Woodwell Climate found that in burned sites across the boreal and tundra regions, the depth of seasonally thawed ground increased for two decades after a fire.

That means that long after a fire is extinguished, permafrost is still thawing and releasing carbon in the form of carbon dioxide and methane. Where this ground is rich in ice, it can sink and collapse after a fire, causing ponding, erosion, and creating bogs and wetlands that release methane.

All of this carbon released to the atmosphere contributes to further warming, which in turn contributes to drying forests, hotter temperatures, and more lightning ignitions in the boreal forests. That's because warming has boosted both lightning ignition efficiency, or the likelihood that lightning starts a fire, and the number of lightning strikes in the region.

Average yearly burned area across Alaska and Canada has roughly doubled since the 1960s. Emissions from Canada's 2023 fire season exceeded total fossil fuel emissions from every other nation except the U.S., China, and India for that year. And the frequency of extreme wildfires across the circumpolar boreal region increased seven-fold from 2003 to 2023.

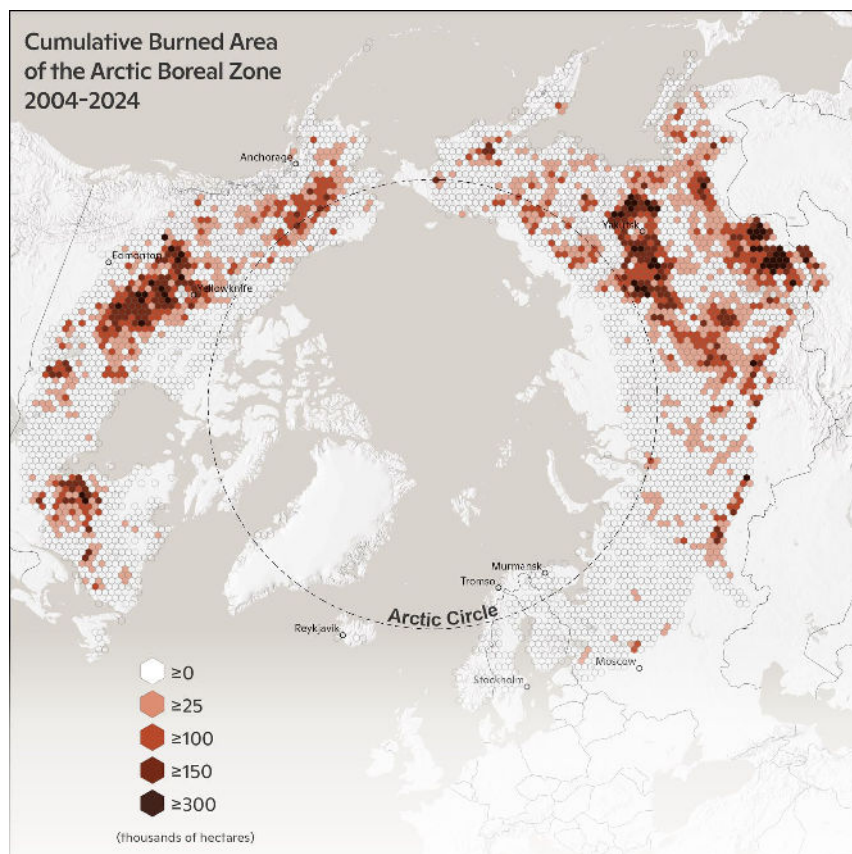
These trends, amplified by the permafrost-fire feedback, worsen both Arctic impacts and global emissions and could hamper our ability to meet agreed-on climate goals.

Gaps in boreal fire research

Wildfires in boreal forests are already weakening the region's carbon storage capacity, signalling a crucial shift in the global climate system. Addressing critical gaps in our understanding of the fire-permafrost feedback will help prepare for such shifts and their local and global implications.

Research teams, including Permafrost Pathways and collaborators, are refining tools to predict what increasing fires mean for regional and global carbon emissions and climate targets. Such insights are needed to inform the Intergovernmental Panel on Climate Change's (IPCC) inventory of global emissions, which does not yet include fire emissions or fire-caused permafrost thaw emissions. Efforts to better model and predict the complex interactions between permafrost and fire are also critical to informing adaptation and management responses.

The region's vastness, as well as geopolitical conditions, presents challenges to collecting field data. Here, modeling can help scale the insights from what field data is available. And developing more accurate fire maps in Alaska and Siberia, where less burned area satellite data exists, could equip researchers and communities with better near-real-time information. Long-term monitoring efforts that study pre- and post-fire conditions, such as those led by Łííldłıı Kúę First Nation at the Scotty Creek Research Station, are providing critical insights about fire's acute and long-term effects on permafrost.



What we can do: solutions that support resilience

The impacts from widespread severe northern wildfires transcend boundaries, affecting health and ways of life for communities living in the Arctic and around the globe.

But there are solutions at hand. Cultural burning, an important practice for many Arctic Indigenous communities, can help boreal forests build resilience by removing fuels with low-intensity seasonal fire. And collaborative management approaches that suppress fires in permafrost regions have been shown to be a cost-effective climate mitigation tool that has co-benefits for human health and the global climate.

But the most important solution to help keep the global wildfire-permafrost feedback loop in check is to reduce greenhouse gas emissions. Lowering overall emissions will slow rising temperatures in the north and give communities, boreal forests, and other ecosystems a better chance to recover and to adapt.

Where in the world is Woodwell Climate?

June has been a particularly impactful month with more than a dozen of Woodwell Climate's scientists and policy experts participating in several high-profile events around the globe—nurturing ongoing partnerships, building new relationships, and bringing our world-class climate science to decision makers. / map by Christina Shintani



Life in the lab—a lesson in trial and error

For **Research Assistant Marly Bartkus**, lab work can be both tedious and chaotic, but they wouldn't have it any other way

My first attempt at using Woodwell's new Total Organic Carbon (TOC) analyzer began with a week of performing potassium chloride (KCl) nutrient extractions on 120 soil samples, and abruptly ended when the analyzer immediately failed to accurately measure total nitrogen correctly. While this disruption was frustrating, experiencing setbacks is a common part of lab work.

Woodwell Climate Research Center has four labs used by researchers to prepare and analyze soil, plant, gas, and water samples. In the preparation labs, scientists spend hours filtering,

treating, extracting, and grinding samples, usually hundreds at a time. My job involves doing biogeochemical analyses on soils and water to understand how nutrients and greenhouse gases are affected by different land management practices. The projects that I have worked on include studying the role of cover crops on soil health, exploring the impacts of tropical agriculture on reservoir dynamics, and the impacts of burning of Arctic tundra on nutrient availability. As a result, I have become extremely familiar with the breadth of complex assays that Woodwell Climate's labs offer.

Performing these tasks can feel tedious, and facing boxes upon boxes of samples can be daunting. But when I put on some R&B and dig in deep, I'm able to transform the work into more of a meditation. Suddenly the rhythm of the music aligns with my pipetting, or how I change out samples while weighing, or my pace when cleaning and preparing materials for the next batch of samples. Recently, I spent an entire week grinding 500 soils for Carbon Program Director Dr. Jon Sanderman's Rangeland project. In the beginning, it was a little awkward finding the best approach to the grinding/cleaning dichotomy, which involves filling capsules with dirt, loading them onto a shaking instrument for grinding, storing the ground samples, then spending a decent amount of time cleaning up for the next set. With time, though, I caught a groove and the work became almost muscle memory.

Once the preparation steps are complete, the samples are ready for analysis on our sophisticated instruments, which measure greenhouse gases, nutrients, carbon and nitrogen levels, and other soil and water qualities. Analysis might seem like the more complex aspect of our work, but between automation and well-

developed methods, data collection can be as simple as loading samples into the apparatus and pressing start.

However, sometimes the instruments misbehave, and that's where my biggest challenges begin. Troubleshooting is a very open ended process, so knowing where to start requires experience and in-depth understanding of the instrument. The answer to a problem can come from the manual, other lab users, or tech support, and often encountering an unfamiliar error can be the best way to learn the intricacies of equipment, and ultimately new skills. Since joining this lab, I have learned a good deal about electronics by having to check the performance of, and occasionally replace, components such as fusion boards, distribution boxes, and fuses. Similarly, software engineering has become less elusive to me. Familiarity with these and similar aspects of our instruments allows lab members the ability to restore harmony when they begin to misbehave.

Despite the challenges, lab work is really fulfilling. Watching the seemingly endless queue of samples dwindle down to nothing is gratifying, and the data produced can provide long-anticipated answers to some of our biggest research questions. Trial and error is a tried and true way to learn, so needless to say, a lot of learning occurs in the lab. Lab results are rewarding by nature, because they drive the important work done at Woodwell Climate, but after an uphill battle, they become much more gratifying. Struggling with an instrument only increases my appreciation for smooth sailing and working through so many samples reminds me of the thorough research that all our scientists are doing every day. My work may seem aggravating at points, but it is very much worthwhile for the greater mission of mitigating climate change.

Meet the lab instruments

The center boasts four lab spaces that hold instruments designed to analyze water, soil, and gas samples brought back from field expeditions. Here are just a few of the core machines.

Shimadzu TOC This machine is used to analyze the amounts of organic carbon and total dissolved nitrogen present in water and soil extract samples.

Seal AQ400 Also called the discrete nutrient auto-analyzer, this instrument uses chemical reactions to identify nutrients present in water samples. As the nutrients are detected, the liquid within changes color—for nitrate and nitrite it becomes pink, and for ammonia, phosphate, and silica it changes to different shades of blue.

Elementar Vario Max Cube This instrument measures carbon and nitrogen levels in soil samples, and in particulates from filtration of water samples.

Bruker Vertex FTIR Another soil sampler, this machine uses laser light to detect characteristics of soils like pH, clay content, and total organic carbon.

Gas Chromatograph The chromatograph can identify key greenhouse gasses, including carbon dioxide, methane, and nitrous oxide in gas samples collected in the field.

Multi-plexer Built by Research Assistant, Zoë Dietrich, adapted from previously published designs, the multiplexer is a complex nest of tubes and circuits that auto-samples the gases emitted by microbes incubating in soil samples.

photo by Rose Lincoln/Harvard



Gina McCarthy
First White House National
Climate Advisor
and former U.S. EPA
Administrator

WOODWELL CLIMATE CONVERSATIONS SERIES

Thursday, July 17 • 5-7 pm

Turning the tide Climate progress, peril, and the path ahead

Join two leading voices in climate science and policy for a timely conversation on how bold, science-based action drove historic progress—and what's at stake as that progress faces new political threats.

PLEASE NOTE Pre-registration for this in-person and livestream event.

Learn more: woodwellclimate.org/mccarthy



The recording of last month's **Enduring Impact** conversation with Drs. John Holdren and Max Holmes is now available to watch and share:

youtube.com/watch?v=MfMbAoec1yM



Selected news coverage

FIRST PERSON

Dr. Jon Sanderman co-authored an editorial article in the journal *Biogeochemistry* highlighting concerns about the rapid dismantling of the inquiry-based scientific enterprise in the United States.

Drs. Kayla Mathes and Peter Frumhoff wrote an article about using targeted boreal fire suppression as a climate solution in Alaska, which was published in the spring issue of the Society of American foresters' *Western Forester*.

Dr. Glenn Bush contributed to an article authored by research collaborators and published in *The Conversation* about the Democratic Republic of Congo's plan to establish a green corridor the size of France that follows the Congo River.

EVENTS

Eae Máquinas mentioned Dr. Ludmila Rattis' participation in a panel at BioSummit 2025, titled "How to scale regenerative agriculture and what are its bottlenecks?"

Brooke Woods was among the "groundbreaking leaders" spotlighted in *Telluride Daily Planet's* coverage of a "power-packed symposium" on Indigenous leadership in conservation at Mountainfilm.

CLIMATE IMPACTS

Associated Press News turned to Dr. Jen Francis for context on a new study, which found that over the past 75 years climate change has made atmospheric wave events linked to extreme summer weather three times more likely to occur.

Center for Science in the Public Interest quoted Dr. Brendan Rogers for a high-level explanation of the connections between climate change and Arctic permafrost in their May/June issue of *Nutrition Action*.

Sea Change podcast interviewed Morris Alexie about the impacts of permafrost thaw on Nunapitchuk for an episode on tribal relocation and resistance.

The Independent quoted Dr. Jen Francis on how sea ice loss in the Arctic is one of the clearest indicators of climate disruption. *Mongabay* also interviewed Jen for their series on the world "beyond 1.5," where she discussed changes in the Arctic and how they are impacting the jet stream.

The Provincetown Independent interviewed Dr. Chris Neill about the unique ecosystems in Cape Cod's human-created sandplain grasslands.

RESEARCH ADVANCES

NSF's Arctic Data Center featured the Permafrost Discovery Gateway in their June 2025 Collaborator Highlight.

Research on the impact of gold mining on Peruvian Amazon forests, led by Dr. Abra Atwood during her doctoral studies, was highlighted in articles from *Earth.com*, *R7*, and in a press release published to *EurekAlert!*

MIT Sea Grant asked Dr. Zhongqi Chen five questions about the FishEye project, which uses AI to monitor river herring populations. *The Falmouth Enterprise* also covered the project, both online and in print.

EurekAlert! published a press release from Cornell University announcing the publication of a new study with Woodwell Climate collaborators evaluating trade-offs of regenerative farming practices.

A new story from IPAM shares the organization's 30-year history, beginning with its inception as a union of multiple organizations and initiatives, including Woodwell Climate (then Woods Hole Research Center).

cover: Woodwell Climate welcomes over 20 interns this summer! At left, a small group of interns is conducting field work in western MA, here using laser rangefinders/hypsometers to measure tree height on the South Taconic Plateau (photo by Colleen Partida). At right, Woodwell Climate and Buzzards Bay Coalition interns are collaborating to deploy and monitor sensors in Buzzards Bay (photo by Kristin Huizenga).

Donations play an important role in securing the future of Woodwell Climate Research Center's work—and help safeguard the health of our planet for generations to come.

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