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What science for solutions means in 2025

A special message of resolve from President and CEO Dr. R. Max Holmes

2025 has opened with stark reminders of why we do the work we do, and its particular importance in this moment.

For weeks, we have watched the situation in Los Angeles with horror and heartbreak. Members of our Woodwell Climate community—staff, collaborators, supporters—are among the many who have been displaced, and lost their homes, schools, and entire neighborhoods.

This tragic event is the latest in a growing list of devastating disasters in recent months that, together, have killed hundreds and displaced tens of thousands. Helene. Valencia. Now L.A.

What is most disturbing is the knowledge that none of them are natural—each of these unprecedented events was made possible by climate change which we, collectively, have failed to halt. These are the consequences.

Even as the news cycle moves on, we are well aware that the work of assessing the damage and beginning to recover is yet to come. And that these will not be the last such disasters. Woodwell Climate's teams are working with partners around the globe to both curb unchecked warming and prepare communities to cope with the unique suite of risks they face.

This sobering reality steels our resolve to work ever harder and smarter. Even more so in the face of a federal political landscape in which we expect to face significant headwinds. We know that the true energy emergency is not one of limited fossil fuel production, but of unlimited carbon pollution; that the Paris Agreement is not an undue burden, but a critical template for international cooperation; and that science and innovation must be at the table as we confront the greatest challenge of our lifetimes.

We will not be distracted or deterred. We will continue to do the cutting-edge research we have always done. We will deepen our partnerships on both sides of the aisle, in the private sector, and in communities around the globe to develop the solutions this moment so urgently demands. We will forge even stronger connections to sustain this work.

Onward,

Max

Five things to know about the U.S. withdrawal from the Paris Agreement

What President Trump's executive order does—and does not—mean for federal and international climate action

Matti Goldberg Director of Government Relations - International

Dave McGlinchey Chief of Government Relations

One of President Trump's first actions this past week—and also in his first term—was to announce the withdrawal of the United States from the Paris Agreement. It is a step that is both misinformed and misguided. But how much difference will it make? Here's what you need to know.

① Significance of the Paris Agreement

The Paris Agreement was adopted by 197 countries in December 2015 and has been the underpinning of international climate action for nearly a decade. The goals and strategies it sets out are critically important to maintaining a stable climate, which is the foundation of successful societies and economies. The Parties to the Paris Agreement are legally obliged to submit national climate plans, known as Nationally Determined Contributions (NDCs) every five years. However, the content and level of ambition of those NDCs are (as the framing “nationally determined” makes clear) up to the Party itself.

② Immediate legal implications

The Paris Agreement stipulates that any nation's withdrawal takes effect one year after an official notice has been submitted to the Secretary-General of the United Nations. In the case of the United States, the earliest effective date of official withdrawal is, therefore, sometime in January 2026. After that, the country will not be bound by its obligations under the Paris Agreement. Those include the submission of NDCs every five years, accounting of progress toward commitments, the submission of biennial transparency reports, and the general obligation to provide climate finance. The United States will also lose, in particular, its right to vote on decisions within the governing body of the Paris Agreement, to nominate members to institutions serving the Paris Agreement, and to participate in emission trading under the Paris Agreement. However, as the United States submitted a new NDC and a biennial transparency report in December 2024, it is currently in compliance with the key obligations under the Paris Agreement.

③ What withdrawal from the Paris Agreement doesn't do

The executive order of January 21, 2025 does not withdraw the US from the UN Framework Convention on Climate Change (UNFCCC), the 1992 treaty that established the international climate negotiation process. The language of the executive

order indicates that this is deliberate—the US will retain its right to vote in the Conference of Parties, as well as its reporting obligations under the UNFCCC. This is possibly due to the fact that a withdrawal from the UNFCCC, a treaty ratified by the U.S. Senate in 1992, requires a two-thirds majority in the Senate. It is also notable that no action has been taken to withdraw the NDC submitted by the Biden Administration in December 2024.

④ The policy impact

The United States' withdrawal makes maintaining—let alone enhancing—the ambition of emission reduction efforts across the world significantly more difficult. When a major emitter “free-rides,” it de-motivates ambition by others. However, although the U.S. has the second-highest GHG emissions in the world, and has always been a key player in global climate collaboration, it is important to bear in mind that 194 other countries representing approximately 90% of global emissions have not withdrawn from the Paris Agreement.

The executive order is targeted at stopping any U.S. climate finance contributions. This will mean that the new global climate finance goal of \$1.3 trillion per year by 2035, agreed upon in Baku, has become much harder to achieve. This will impact the poorest countries directly, as well as degrading the international community's trust in the effectiveness of the process.

⑤ What happened last time

President Trump also withdrew the U.S. from the Paris Agreement during his first administration. Then, as now, one of the primary impacts was to create a leadership vacuum. In that case, that vacuum was largely filled by other nations, plus state, local, and business leaders. The resulting groundswell generated momentum that carried into the Biden Administration and the U.S. re-entry into the Paris Agreement. While much of that foundation remains strong, trends in the private sector have shifted, with a growing number of major corporations and financial institutions backing away from their climate commitments. Global geopolitics has also evolved, raising questions about what role other governments, in particular China, might play in reaction to the United States' withdrawal from the international governance structures.

Arctic hotspots study reveals areas of climate stress in Northern Alaska, Siberia

Kate Petersen Arctic Communications Strategist

Ecological warning lights have blinked on across the Arctic over the last 40 years, according to new research, and many of the fastest-changing areas are clustered in Siberia, the Canadian Northwest Territories, and Alaska. The analysis of the rapidly warming Arctic-boreal region, published in *Geophysical Research Letters* this week, provides a zoomed-in picture of ecosystems experiencing some of the fastest and most extreme climate changes on Earth.

Many of the most climate-stressed areas featured permafrost, or ground that stays frozen year-round, and experienced both severe warming and drying in recent decades.

To identify these “hotspots,” a team of researchers from Woodwell Climate Research Center, the University of Oslo, the University of Montana, the Environmental Systems Research Institute (Esri), and the University of Lleida used more than 30 years of geospatial data and long-term temperature records to assess indicators of ecosystem vulnerability in three categories: temperature, moisture, and vegetation.

Building on assessments like the NOAA Arctic Report Card, the research team went beyond evaluating isolated metrics of change and looked at multiple variables at once to create a more complete, integrated picture of climate and ecosystem changes in the region.

“Climate warming has put a great deal of stress on ecosystems in the high latitudes, but the stress looks very different from place to place and we wanted to quantify those differences,” said Dr. Jennifer Watts, Arctic program director at Woodwell Climate and lead author of the study. “Detecting hotspots at the local and regional level helps us not only to build a more precise picture of how Arctic warming is affecting ecosystems, but to identify places where we really need to focus future monitoring efforts and management resources.”

The team used spatial statistics to detect “neighborhoods,” or regions of particularly high levels of change during the past decade.

“This study is exactly why we have developed these kinds of spatial statistic tools in our technology. We are so proud to be working closely with Woodwell Climate on identifying and publishing these kinds of vulnerability hotspots that require effective and immediate climate adaptation action and long-term policy,” said Dr. Dawn Wright, chief scientist at Esri. “This is essentially what we mean by the ‘Science of Where.’”

The findings paint a complex and concerning picture.

The most substantial land warming between 1997-2020 occurred in the far eastern Siberian tundra and throughout central Siberia. Approximately 99% of the Eurasian tundra region experienced significant warming, compared to 72% of Eurasian boreal forests. While some hotspots in Siberia and the Northwest Territories of Canada grew drier, the researchers detected increased surface water and flooding in parts of North America, including Alaska’s Yukon-Kuskokwim Delta and central Canada. These increases in water on the landscape over time are likely a sign of thawing permafrost.

Among the 20 most vulnerable places the researchers identified, all contained permafrost.

“The Arctic and boreal regions are made up of diverse ecosystems, and this study reveals some of the complex ways they are responding to climate warming,” said Dr. Sue Natali, lead of the Permafrost Pathways project at Woodwell Climate and co-author of the study. “However, permafrost was a common denominator—the most climate-stressed regions all contained permafrost, which is vulnerable to thaw as temperatures rise. That’s a really concerning signal.”

For land managers and other decisionmakers, local and regional hotspot mapping like this can serve as a more useful monitoring tool than region-wide averages. Take, for instance, the example of Covid-19 tracking data: maps of county-by-county wastewater data tend to be more helpful tools to guide decision making than national averages, since rates of disease prevalence and transmission can vary widely among communities at a given moment in time. So, too, with climate trends: local data and trend detection can support management and adaptation approaches that account for unique and shifting conditions on the ground.

The significant changes the team detected in the Siberian boreal forest region should serve as a wakeup call, said Watts. “These forested regions, which have been helping take up and store carbon dioxide, are now showing major climate stresses and increasing risk of fire. We need to work as a global community to protect these important and vulnerable boreal ecosystems, while also reining in fossil fuel emissions.”



After millennia as carbon dioxide sink, more than one-third of Arctic-boreal region is now a source

Kate Petersen Arctic Communications Strategist

After millennia as a carbon deep-freezer for the planet, regional hotspots and increasingly frequent wildfires in the northern latitudes have nearly canceled out that critical storage capacity in the permafrost region, according to a new study published in *Nature Climate Change*.

An international team led by Woodwell Climate Research Center found that a third (34 %) of the Arctic-boreal zone (ABZ)—the treeless tundra, boreal forests, and wetlands that make up Earth's northern latitudes—is now a source of carbon to the atmosphere. That balance sheet is made up of carbon dioxide (CO₂) uptake from plant photosynthesis and CO₂ released to the atmosphere through microbial and plant respiration.

When emissions from fire were added, the percentage grew to 40%.

The findings represent the most current and comprehensive assessment of carbon fluxes in the ABZ to date. Drawing on a library of CO₂ data four times as large as earlier upscaling efforts gathered from 200 study sites from 1990–2020, the analysis captures both year-round dynamics and important recent shifts in climate and northern fire regimes that have altered the carbon balance in the north.

These data are stored and analyzed in a comprehensive and growing library dubbed “ABC Flux,” which Virkkala helms. ‘Upscaling’ refers to the process by which these individual site-level readings are knitted together with climate, soil, and vegetation records to produce living maps of Earth’s otherwise invisible exhalations and inhalations.

“We wanted to develop the most current and comprehensive picture of carbon in the north, and to do that, we knew we needed to account for fire’s growing carbon footprint in this region,” said Dr. Anna Virkkala, a research scientist at the

Permafrost Pathways initiative at Woodwell Climate and lead author of the study. “While we found many northern ecosystems are still acting as carbon dioxide sinks, source regions and fires are now canceling out much of that net uptake and reversing long-standing trends.”

The study is a robust record of how land in the northern latitudes is breathing—measuring the gasses it releases and pulls down from the atmosphere. Data are gathered at carbon flux monitoring towers and chambers, which track gas exchange between the land and the atmosphere.

By tracking monthly records over three decades, the *Nature Climate Change* study helps illustrate the “why” behind the trends: for instance, carbon uptake in the summers has increased over the 30 years, but more carbon emissions are being released from the tundra during the non-growing season months.

Another advantage this study offers is relatively high resolution—1km x 1km for 2001–2020—allowing the researchers to map the “where” shaping these trendlines.

“The high resolution of these data means that we can now see how variable the Arctic is when it comes to carbon,” said Dr. Sue Natali, a co-author on the study and lead of Permafrost Pathways at Woodwell Climate. “That variability isn’t surprising because the Arctic isn’t one single place—it’s a massive area with diverse ecosystems and climatic conditions. And now we have the capability to track and map carbon processes at a spatial resolution that can reveal what’s happening on the ground.”

“We are seeing that longer growing seasons and more microbial activity in winter are gradually shifting carbon trajectories,” said Dr. Marguerite Mauritz, assistant professor at the University of

Texas-El Paso and co-author of the study. “Highly collaborative efforts like this are critical for understanding how shifting seasonal dynamics and disturbance patterns can have regional and even global impacts.”

The latest findings add to a growing ensemble of recent studies that show how carbon budgets in the North are changing after the region’s historical role as a sink. While this study focused on CO₂ fluxes on land, other recent results that count CO₂ and methane (CH₄) emissions from lakes, rivers, and wetlands also found the permafrost region to be a carbon source.

But the recent cache of upscaling results tells similar stories: namely, that trendlines in the northern latitudes are beginning to turn, and a warmer, greener Arctic does not reliably translate to more carbon storage there—in part because warmer has

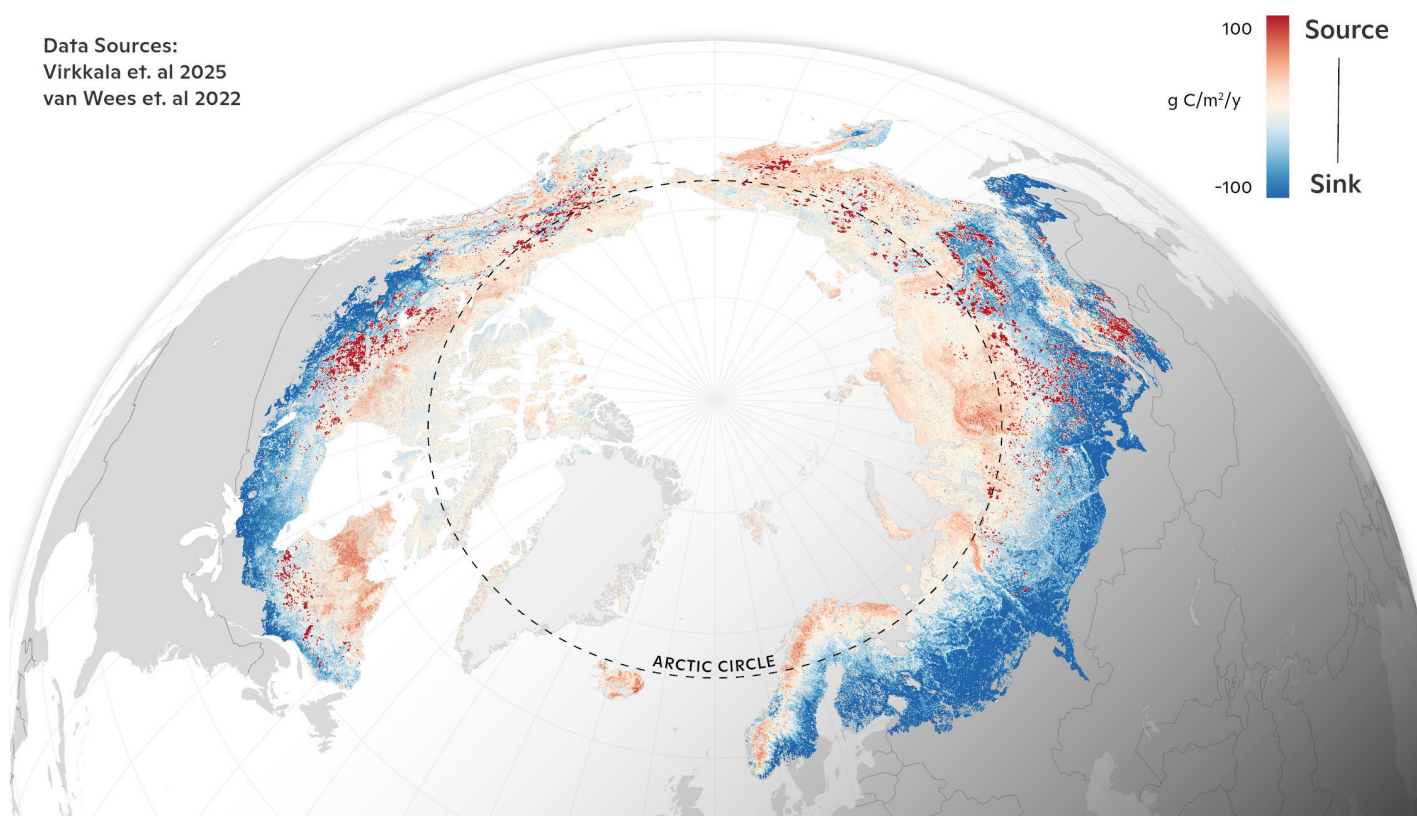
meant emissions from permafrost thaw and greener, more carbon to combust.

For example, the *Nature Climate Change* study found that while 49% of the ABZ region experienced “greening”—in which longer growing seasons and more vegetation means that more carbon can be photosynthesized and stored—only 12% of those greening pixels on the map showed an annual increasing net uptake of CO₂.

“Carbon cycling in the permafrost region is really starting to change,” Virkkala said. “Our study may act as a warning sign of bigger changes ahead, and offers a map of places we’ll need to better monitor in the coming decades.”

This work was funded by the Gordon and Betty Moore Foundation and funding catalyzed through the TED Audacious Project for Permafrost Pathways: Connecting Science, People, and Policy for Arctic Justice and Global Climate.

Data Sources:
Virkkala et. al 2025
van Wees et. al 2022



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In the news: highlights

Drs. Anna Virkkala and Sue Natali were quoted in articles around the world, including in *The Guardian*, *BBC*, *The Canadian Press*, *Discover Magazine*, and *Alaska Native News*. The stories covered their recent research published in *Nature Climate Change* showing that one third of the Arctic is now a source of carbon emissions.

Dr. Manoela Machado was quoted in an article from *Le Figaro* about wildfires in Brazil, which last year burned an area the size of Italy (French).

ContilNet wrote an article featuring an interview with Dr. Foster Brown about climate change in Acre, Brazil. He was also quoted in two different stories about the air monitoring program he started in Acre, one published in *A Gazeta do Acre*, and the other in *A Gazeta.net* (Portuguese).

IPAM quoted Dr. Ludmila Rattis in an article about a proposed law that would convert land designated as Amazon forest to Cerrado, decreasing the amount required to be conserved (Portuguese).

Newsweek published an article highlighting a recent publication on northern hotspots of change, quoting Drs. Sue Natali and Jenny Watts, and featuring maps by Christina Shintani. The paper, published in *Geophysical Research Letters*, had many Woodwell Climate contributors, including Natali and Watts, Stefano Potter, Dr. Brendan Rogers, Dr. Anna Virkkala, Greg Fiske, Dr. Kyle Arndt, and Dr. Arden Burrell.

World Resources Institute published an article highlighting recent updates to the LEARN tool (the Land Emissions and Removals Navigator), developed in collaboration with Woodwell Climate.

BBC quoted Dr. Zach Zobel on how scientists have been warning about increasing extreme weather events for a long time.

The Boston Globe shared Dr. Max Holmes' thoughts about the 1.5° C average temperature goal, which was exceeded by last year's average temperatures.



LISTEN *Living on Earth* produced a tribute episode for Dr. George Woodwell, who helped inspire the broadcast. The episode aired on public radio stations across the country.



WATCH ICCI's COP29 Video of the Week was the panel discussion, "Slow Onset, High Impact: What Permafrost Means for the Global 1.5°C Target," featuring Drs. Jenny Watts and Elchin Jafarov.

The *Cape Cod & Islands Roundup* newsletter featured the Just Access project's climate risk assessment for Barnstable, MA.

With the frigid temperatures across much of the U.S. and the L.A. County fires, Dr. Jen Francis had a banner month for media mentions:

AP News quoted her on how continuous "alarm bells" of climate change impacts may be starting to numb people to the urgency of the problem, even as those impacts become more severe.

WCAI interviewed Francis about how warmer water temperatures will impact storms and flooding in New England.

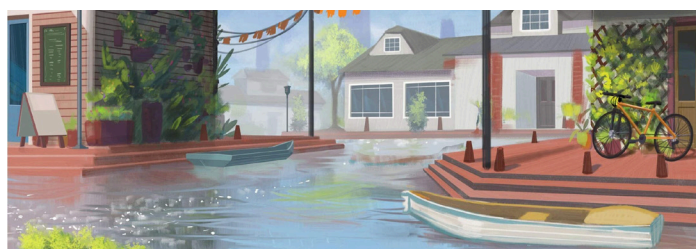
New Scientist quoted Francis in an article about the links between climate change, the jet stream, and extreme weather.

A quote of hers about how ocean heat waves are connected to persistent and unusual weather patterns was also republished in *Smithsonian Magazine*.

She was quoted in four widely-syndicated *AP News* articles: on the storms that hit much of the US with snow and cold weather, on how such "cold blasts" could be more frequent with global warming, on Greenland's role in the AMOC (Atlantic Meridional Overturning Circulation), and validating a study that concluded climate change added 41 days of dangerous heat around world in 2024.

The Boston Globe also quoted Francis describing how rapid Arctic warming is impacting the jet stream, and in turn, intensifying cold weather in the northern hemisphere. A *Vox* article covering winter storm Blair quoted Jen giving a similar explanation, as did a NOAA Research article.

Bloomberg quoted Francis on long-lasting weather regimes in an article about the Los Angeles wildfires. She was also quoted in another article, describing how the dry fire conditions and Santa Ana winds in California are becoming increasingly more likely due to climate change.



above: Illustration by João Queiroz, from the *Climate Action Almanac*.

FEBRUARY WEBINAR

Our Climate Future: Fact + Fiction

Kick off the new year with a forward-looking virtual event that will explore how science—and science fiction—can help us envision the future and motivate action today.

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cover: A depiction of the Kuskokwim River at the confluence of the Kwethluk River in Alaska. Three of the Permafrost Pathways partner communities are within this image: Kwethluk, Akiachak, and Akiak. The Kwethluk River is also a major focus for Science on the Fly. / map imagery by Greg Fiske

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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