



**Woodwell
Climate
Research
Center**



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Science or science fiction?

I'm not usually a fan of science fiction, generally preferring stories that are reality-based. One notable exception is Kim Stanley Robinson's *The Ministry for the Future*, which explores the impacts of climate change in the relatively near future, along with societal responses to those impacts. I liked the book in part because, while it is science fiction, the plot was one I could imagine playing out someday if we fail to get our act together. The book opens with a lethal heat wave that kills millions, a shocking scene set in a future I desperately hope never arrives.

Then, reading a *Washington Post* article on July 4, 2026, I had the strange feeling that I was reading science fiction, a milder version of the opening pages of *Ministry for the Future*. On the 250th anniversary of American independence, the celebrations meant to honor our freedom were being shut down, not by any government or enemy, but by the heat. In Washington, DC, organizers canceled the Independence Day Parade outright as temperatures climbed past 100 degrees. Philadelphia also scrapped its parade, expected to be among the nation's largest. Town after town followed suit.

We are fond of talking about American freedom in grand, abstract terms—liberty, self-determination, the pursuit of happiness. But freedom also lives in the ordinary, including the freedom to watch your child march in a parade. This year, the heat took that away for many people. The intensity of this heat and humidity would have been virtually impossible without climate change. This was not bad luck. This is the consequence of choices we have made.

In the weeks since, more extreme versions of this story have unfolded elsewhere, including wildfires sweeping across southwestern France and central Spain, fed by repeated heat waves that had left the landscape dangerously dry. Together, the two countries have seen hundreds of thousands of acres burn and hundreds of thousands of people forced from their homes. There have already been approximately 10,000 more wildfires in the U.S. so far this year than during the same period in 2016—an increase of 28%.

That the line between Robinson's fiction and our headlines has blurred should unsettle us. And what we experienced this Independence Day could be close to the best-case version of many summers to come, not the worst. This is not an anomaly; it is a preview.

So what do we do? We hold two truths at once, and we act on both.

First, adaptation. We cannot wish away the warming already locked into the system, so we must adapt to it. Adaptation is not surrender. It is the work of protecting lives and livelihoods, and the freedoms we still have.

But adaptation alone is a losing game, because there is a limit to how much we can adapt. This is why mitigation remains essential. Every ton of carbon we keep out of the atmosphere is a future parade that still happens, a future home that doesn't burn, a future summer our grandchildren can spend outdoors. Bringing emissions down is the only way to keep the preview from becoming the feature.

The freedoms we take for granted are already being curtailed by climate change.

The most patriotic thing we can do now is refusing complacency, adapting to the heat that is here, and fighting to reduce the heat that is coming.

At Woodwell, that has always been our goal—to apply our rigorous scientific research in pursuit of impactful and scalable solutions. As always, thank you for your ongoing support.

Onward.



Max

Dr. Max Holmes
President & CEO

Untangling climate science complexities

This month, two new research papers shed light on just how complex even simple climate science questions can be to answer. A new study from Dr. Brendan Rogers disentangles opposing warming and cooling dynamics to show that climate change is breaking down the natural balance of fire in northern forests. In the soils realm, Dr. Jon Sanderman and Colleen Partida's latest paper outlines the gaps in our knowledge about regenerative grazing. Just two examples of how Woodwell scientists continue to advance our understanding of climate threats and solutions.

Wildfire's natural balancing mechanism is breaking down

In Canada's boreal forests, climate change is impacting feedback loops that once regulated temperature rise

Natasha Heisenberg Science Writer Intern

In 2023, Canada experienced its worst wildfire season to date. Fires raged across all 13 provinces and territories, breaking national records for burned area and carbon emissions.

Fires have a complex impact on both the global and regional climate. While fires contribute to warming through the release of stored carbon from trees and soil, they also create an unexpected cooling effect. Postfire changes to vegetation composition and coverage have an impact on albedo—the amount of sunlight reflected by a surface. The absence of the tree canopy no longer conceals snow, thus reflecting more incoming solar radiation which can cool the local environment.

“If you have a more reflective surface, like ice or snow in particular, it's going to reflect more of that sunlight back to space, and so it's going to have a cooling effect compared to if it wasn't there,” says Rogers. “Because if it wasn't there, then the darker land or the ocean would have absorbed more of it and heated.”

These changes in albedo have historically partially offset the warming caused by fire-induced emissions; however, in a newly published paper, co-authored by Woodwell Climate Senior Scientist Dr. Brendan Rogers, researchers found a 29% decrease of the regional climate-cooling impact of boreal wildfires since the 1960s. This represents one aspect of a critical shift in past ecosystem dynamics—not only is climate change responsible for



rising global temperatures, but it is also weakening the natural mechanisms that once regulated this rise.

“The consequences of retreating snow cover become especially clear at the scale of individual fires,” says Max van Gerrevink, lead author of the study and postdoctoral researcher at Wageningen University and Research. “Historically, nearly half of all Canadian wildfires reached a natural climatic break-even point, where snow-driven surface cooling fully offset the warming caused by fire-related emissions. Today, that proportion has fallen dramatically, to only about one in four or five fires.”

The study used remote sensing to map the predicted changes in surface albedo over a 70-year postfire period assuming carbon dioxide emissions maintain current levels until 2050, then decrease, eventually reaching net zero by 2100. For Canada's boreal forests, this means earlier snow disappearance rates, later snow onset and warming temperatures—all of which impact albedo.

When considered alongside a previous study co-authored by Rogers, the decreasing power of the cooling effect is projected to continue even further.

“Compared to pre-climate change, we’re talking about, over the next several decades... a 50% to 60% reduction due to earlier snowmelt,” says Rogers. “It’s important to be aware of this when you’re thinking about ‘What does this mean for the earth system,’ and ‘How might you manage these fires.’”

The implications of this finding are of growing concern, as warmer and drier weather conditions associated with continued climate change are subjecting Canada's boreal forests to more severe and longer fire seasons. During the 2023 Canadian fire season, an estimated 647 teragrams of carbon were released—a number comparable to the annual fossil fuel emissions of the largest-emitting nations and only exceeded by India, China and the United States.

With more carbon being released annually from worsening fire seasons and a diminishing climate-cooling effect, Canada's boreal ecosystems are facing an amplified threat from exacerbated warming. As the study found, the subsequent weakening of the climate-cooling impact implies that contemporary boreal fires are, on average, twice as likely to result in a net climate-warming influence.

“Fires both warm through greenhouse gas emissions and cool through changes to land surface albedo,” says Rogers. “The cooling impact is declining, but the carbon impact is not, and it might even be growing because we’re seeing more permafrost emissions after wildfires.”

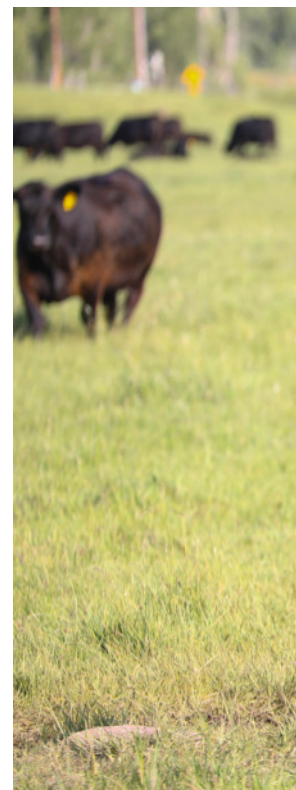
Rogers stressed the importance of considering albedo and carbon as two parts of a larger equation rather than two factors that act in opposition. This is due to the fact that albedo's impact is limited to the geographic area where these fluctuations occur and therefore is not as widespread. Furthermore, he emphasized the need for measures that directly target carbon emissions in order to comprehensively address climate change.

“The reality is the spatial footprint from the albedo changes in Canada have very little impact on us down here in the lower 48 or other parts of the globe,” says Rogers. “And I think that’s important, because the carbon impacts are global and do impact us and everyone else on the planet.”

Does regenerative grazing help sequester carbon? We don't know yet.

The practice holds potential, but the underlying science is sparse

Jonathan Sanderman Senior Scientist
Colleen Partida Research Assistant



Grazing lands are everywhere. These lands, used to raise domesticated animals like cows and sheep, span over 12 billion acres, comprising nearly 40% of ice-free land on Earth, and represent the largest category of human land use.

Grazing lands are not just working lands, they are also critical grassland, shrubland, and woodland ecosystems that provide important ecological benefits like carbon storage. Poor management practices like overgrazing have resulted in the degradation of these ecosystems. In the United States, over half of rangelands are considered degraded, resulting in the loss of 50 billion tons of carbon that would otherwise be stored in soils. Grassland species are in decline, and the productivity of these lands has dropped, with economic consequences for ranchers.

What is regenerative grazing?

Regenerative grazing is the practice of moving livestock between pastures to allow more time for vegetation to rest and re-grow, and it is often touted as an antidote to degradation. The technique is intended to emulate the movements of wild grazers like bison and elk and can maximize grass growth and help incorporate more plant biomass into the soil, two factors that are key to increasing soil carbon. Regenerative practices can also improve the quality and diversity of food for grazing animals.

Because of its potential, regenerative grazing practices have generated much buzz, particularly in the world of carbon credits. Current proposed grassland management projects on the Verra Registry—the world's largest public database on



carbon credits—estimate that in total they will remove as much as 40 million tons of CO₂ per year. Despite these claims, there have been few conclusive scientific studies to verify. Accurate soil carbon estimates are crucial to right-size expectations for producers, policymakers, and financial markets supporting regenerative grazing practices as a potential climate solution, yet this lack of conclusive evidence leads to the need for more rigorous analysis.

Why is it so hard to study rangeland carbon?

An ideal study of the carbon storage potential of regenerative practices requires before and after measurements on comparable fields using both conventional and regenerative techniques. This is hard to do for a couple of reasons.

First, rangelands are complex systems with many different factors, including soil type, vegetation and land use history, playing into how much carbon gets locked away in soils. Second, the grazing practice changes are individually tailored to work with each rancher's operation, adding complexity. Third, expected changes in soil carbon are small relative to the large and variable background carbon stocks in rangelands, often leaving scientists looking for a needle in a haystack.

A review assessing the quality of existing evidence, led by Woodwell Climate researchers, found 70 papers that attempted to answer this question. Of those 70 papers, only 10 were found to make scientifically robust comparisons of soil carbon between conventionally and regeneratively managed sites. These 10

studies showed an average result of no change in carbon. Most of these 10 studies used small experimental plots that allow researchers to control for confounding effects, but can simplify the system past the point of recognition for a rancher. Two studies even used lawn mowers instead of grazing animals, raising questions about the applicability of these findings to real, working ranches.

A large subset of the 70 studies compared soil carbon levels at ranches already under regenerative management with nearby conventionally grazed ranches. These studies suggest that, on average, regenerative grazing can sequester 0.7 tons of CO₂ per acre per year more than conventional grazing. However, this approach makes the assumption that the present-day soil carbon level on a conventionally grazed site is equivalent to the baseline level of the regenerative site prior to change. This assumption requires careful pairing of vegetation, soil type, climate, and land-use history that was not documented in most of the studies.

The variable quality of existing studies leaves us no closer to understanding the benefits of regenerative grazing, and scientific study is still needed.

Woodwell's rangeland carbon projects are working to fill the data gap

The flurry of attention on regenerative management practices means funding and executing long-term studies that can generate high-quality data is an urgent priority. Projects on the Verra Registry are claiming to sequester more than twice as



much carbon as the Woodwell analysis was able to estimate based on existing data. Left unverified, this could result in greenwashing ranching operations and carbon credit programs.

Woodwell researchers are actively exploring ways to fill this knowledge gap. Soil spectroscopy, a method that measures the interaction between light beams and soil particles to determine their chemical composition, offers a lower-cost option for analyzing a large number of soil samples to determine carbon content. Easier and cheaper soil analysis options will facilitate future research into the benefits of various land management practices, with applications for farms, ranches, and other landscapes.

Woodwell scientists have also developed RangeSTAR, a system for tracking changes in plant productivity and soil carbon at a land management scale with a high level of detail. RangeSTAR combines computer simulations with remote-sensing data and field measurements of rangeland-health indicators. As the project progresses, researchers hope to get a clearer picture of the role rangelands can play in combating the climate crisis.

Incoming and departing board members

A welcome to incoming board members



Aimée Christensen is CEO of Christensen Global where she leverages deep expertise to build a resilient world by advising innovators, global businesses, multilateral institutions, and philanthropists. She is the founder and curator of the Sun Valley Forum and recently served as Senior Adviser for Climate Finance at the Milken Institute.



Karen Olcott is a seasoned strategy advisor and investor with more than 30 years of executive leadership experience across Fortune 100 technology, telecom, and media sectors. She held pivotal roles at T-Mobile, Microsoft, Pinnacle EFX, Showtime Networks, and ABC Sports.

She holds a U.S. patent for Wireless Coverage Verification, has won over 45 industry awards, and is a two-time Emmy winner in sports television.



James Socas has invested in, advised, and financed leading growth companies throughout his career. He is currently launching a new investment fund and previously served as managing director in private equity at Blackstone and Investcorp and in investment banking at Credit Suisse First Boston and Donaldson, Lufkin & Jenrette. He began his career at Goldman Sachs.

Thank you to departing board member Georgia Nassikas

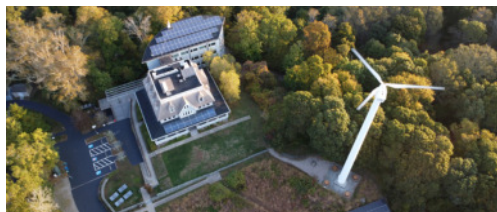


Georgia Nassikas joined the Woodwell board in 2017 and held a number of leadership positions during her tenure, including chair of the Nominating and Governance Committee and as Vice Chair for a term. Nassikas is a Woodwell ambassador and champion in the truest

sense. Not only does she connect with donors, board prospects, and Center partners, she and her husband have opened their home and workplaces to Woodwell for many events over the years.

Upcoming events

Woodwell Climate Conversations



TUESDAY, August 11 ■ 5-7 pm *in-person and livestream*

Hope, science, and solutions

Charting the future of U.S. climate policy

Join Joseph P. Kennedy III and Max Holmes for a forward-looking discussion about the opportunities emerging from the climate transition—from clean energy and technological innovation to stronger communities and healthier ecosystems.

woodwellclimate.org/hope-science-solutions

supported by Chris and Lisa Kaneb



Woodwell Climate Conversations



WEDNESDAY, August 12 ■ 5-7 pm *on the road*

Advancing climate-resistant food systems on Martha's Vineyard

With Island Grown Initiative, we'll discuss how regenerative farming practices can deliver better outcomes for farmers, ecosystems, and communities, and how local agriculture, grounded in rigorous science, can deliver tangible climate impacts across Martha's Vineyard and beyond.

woodwellclimate.org/mv-food-systems

supported by Chris and Lisa Kaneb



In the news highlights

Dr. Jen Francis was interviewed on *Living on Earth* to explain how greenhouse gases from burning fossil fuels, the loss of reflective ice and snow, and other changes are increasingly causing the Earth to retain extra heat energy from the sun.

The *Boston Globe* featured a front-page story by journalist Sabrina Shankman who wrote about her trip to Howland Forest, covering Woodwell Climate's methane research and interviewing Kathleen Savage.

Mongabay quoted Dr. Manoela Machado on how new FireSat data has the potential to help Indigenous communities and fire brigades in the Brazilian Amazon.

Dr. Max Holmes was quoted in a WBUR piece on proposed changes to an OMB regulation that would undermine scientific research in the United States.

Dr. Brendan Rogers provided his wildfire expertise and is quoted in a *Marin Independent Journal* article on a study that finds wildfire smoke is eroding clean-air progress in the U.S.

Past events



Esri User Conference

Woodwell Climate's Permafrost Pathways was well-represented at the Esri User Conference in San Diego last month. In addition to a booth, there were award-winning maps by Jackie Dean & Morris Alexie and Dr. Heidi Rodenhizer, and presentations by Tiffany Windholz and Lucy Martin and Christina Shintani.

cover: Associate Scientist Dr. Jennifer Watts samples plants growing on grazing fields in Colorado. / photo by Dave Nagel

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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