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We need to do more



Dr. Philip Duffy
President &
Executive Director

The Biden administration is putting far more energy and resources into stopping climate change than any presidential administration before it. The private sector is beginning to take climate change seriously—thanks in part to our work—and philanthropic support for climate work is growing. These are encouraging developments and I am proud of what we're accomplishing at Woodwell Climate. However, the challenges humanity faces are imposing, to say the least, and the global situation demands that we do even more.

It is bad enough that humanity is making insufficient progress towards meeting our goal of limiting global warming to 1.5° or 2° C. Beyond this, however, I and other scientists increasingly feel that these goals are not sufficiently strict, and that the scenarios we have developed for meeting them are not realistic.

In 2020, climate impacts became impossible to ignore. Examples included fire in Australia and California, record tropical cyclone activity in the N. Atlantic, and extreme heat in the Arctic and elsewhere. Globally, 2020 tied for the warmest year on record, even though it was a La Nina year, which tends to make it cooler.

These impacts, and more, occurred at approximately 1.1°C of global warming. Consequences will be much more harmful at 1.5 or 2°C. Our work (and work by others) shows that parts of the world will be difficult to inhabit in that temperature range. This will have socio-economic impacts which are likely to be fundamental, rather than incremental. Perhaps most profound is that pressure towards mass migration will tend to cause political instability and conflict. This will make it even more difficult to mobilize the resources and to obtain the international cooperation needed to manage climate change.

Warming of 1.5 or 2°C also raises some important longer-term issues, including massive sea level rise over the next few centuries and the possibility that the climate won't be stable at 1.5 or 2°C of warming, even if humans stop all emissions of greenhouse gases. This is because greenhouse gas emissions from biotic sources like thawing permafrost may continue to drive global warming.

And yet, most scenarios which limit warming to 1.5°C, including those of the United Nations, ignore greenhouse gas emissions from thawing permafrost. We don't know very accurately what these emissions are today or will be in the future—that is a major focus of our work here—but clearly these emissions are enough to greatly increase the challenge of limiting warming to 1.5°C.

That challenge is made even greater by the fact that necessary emissions reductions haven't been happening. Delay results in accumulation of more carbon in the atmosphere, making the needed emissions reductions, when they do happen, even more

rapid. Furthermore, scenarios which limit global warming to 1.5°C assume removal of massive amounts of CO₂ from the atmosphere—more than can be accomplished via natural climate solutions like reforestation. We don't know how to do CO₂ removal at the scale needed, and incentives which would encourage large-scale implementation aren't in place.

We all must do more

Our current situation demands immediate action and a better plan. We need to go full speed ahead on the fundamental things we already know how to do: deploying low-carbon energy generation; implementing natural climate solutions, developing and implementing other forms (geologic and chemical) of CO₂ removal. There is no danger of doing too much, and great danger in doing too little.

In addition, we need to develop an achievable, science-based plan to preserve an acceptable future, taking into account the risks described above and giving due consideration to all our options.

Our mission—to provide science needed to inform policies and decisions addressing climate change—is more important and more urgent than ever. But the dire situation outlined above means that we need to make every effort to increase our impact. We can and will work to engage the new Administration and leverage growing private-sector involvement. Above all, we must be bold and take steps that will motivate action commensurate with the scope and scale of the crisis.

Humanity won't meet the challenge of climate change without more of us understanding what's at stake, and without those—like you—who do understand being part of the solution. Set an example in your daily life and help make environmental stewardship the norm. Engage politically, at the local, state or national level. And get involved with organizations (there are many) doing great work on every aspect of climate change.

This is a time for increased ambition. For Woodwell Climate, this means being willing to take risks and do things differently—differently from how we have in the past and from how other organizations operate. We should not fear controversy. George Woodwell was never afraid to speak truth to power, and the passage of time has proven his wisdom. The reason for that, and the reason he was able to foresee many of the consequences of climate change before nearly everyone else, is that his views were founded in science—physical principles which are timeless. If we go where those principles lead us, we'll succeed.

Thank you for all you do in support of this cause. As I once heard Gina McCarthy say (movingly if not with syntactical perfection) “The world needs heroes, and you're it.”

Letter Regarding Use of Forests for Bioenergy

Hundreds of scientists affirm that trees are more valuable alive than dead — both for climate and for biodiversity

To President Biden, President von der Leyen, President Michel, Prime Minister Suga, and President Moon,

The undersigned scientists and economists commend each of you for the ambitious goals you have announced for the United States, the European Union, Japan and South Korea to achieve carbon neutrality by 2050. Forest preservation and restoration should be key tools for achieving this goal and simultaneously helping to address our global biodiversity crisis. We urge you not to undermine both climate goals and the world's biodiversity by shifting from burning fossil fuels to burning trees to generate energy.

For decades, producers of paper and timber products have generated electricity and heat as by-products from their process

As numerous studies have shown, this burning of wood will increase warming for decades to centuries. That is true even when the wood replaces coal, oil or natural gas.

The reasons are fundamental. Forests store carbon — approximately half the weight of dry wood is carbon. When wood is harvested and burned, much and often more than half of the live wood in trees harvested is typically lost in harvesting and processing before it can supply energy, adding carbon to the atmosphere without replacing fossil fuels. Burning wood is also carbon-inefficient, so the wood burned for energy emits more carbon up smokestacks than using fossil fuels. Overall, for each

kilowatt hour of heat or electricity produced, using wood initially is likely to add two to three times as much carbon to the air as using fossil fuels.

Increases in global warming for the next few decades are dangerous. This warming means more immediate damages through more forest fires, sea level rise and periods of extreme heat in the next decades. It also means more permanent damages due to more rapid melting of glaciers and thawing of permafrost, and more packing of heat and acidity into the world's oceans. These harms will not be undone even if we remove the carbon decades from now.

Government subsidies for burning wood create a double climate problem because this false solution is replacing real carbon reductions. Companies are shifting fossil

energy use to wood, which increases warming, as a substitute for shifting to solar and wind, which would truly decrease warming.

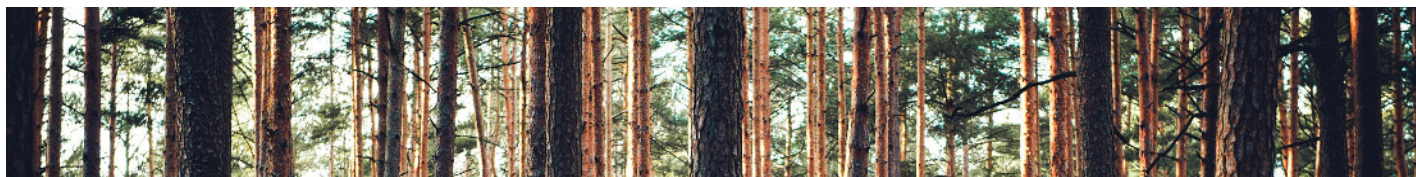
In some places, including Japan and French Guiana, there are proposals not just to burn wood for electricity but to burn palm or soybean oil. Producing these fuels requires expansion of palm or soybean production that leads to clearing of carbon dense tropical forests and reduction of their important carbon sink, both of which add carbon to the atmosphere.

“Sustainability standards” for forest or vegetable oil management cannot alter these results. Sustainable management is what allows wood harvest to eventually pay back carbon debts

wastes. This use does not lead to the additional harvest of wood. In recent years, however, there has been a misguided move to cut down whole trees or to divert large portions of stem wood for bioenergy, releasing carbon that would otherwise stay locked up in forests.

The result of this additional wood harvest is a large initial increase in carbon emissions, creating a “carbon debt,” which increases over time as more trees are harvested for continuing bioenergy use. Regrowing trees and displacement of fossil fuels may eventually pay off this carbon debt, but regrowth takes time the world does not have to solve climate change.





but cannot alter these decades or even centuries of increased warming. Similarly, any increased demand for vegetable oil adds to the global pressure to clear more forests already created by rising food demands.

Making countries responsible for emissions from land use changes, although desirable, cannot alone fix laws that treat burning wood as carbon neutral because these national responsibilities do not alter the incentives created by those laws for power plants and factories to burn wood. In the same way, the fact that countries are responsible for emissions from diesel fuel use would not fix a law encouraging trucks to burn more diesel on the flawed theory that diesel is carbon neutral. Both treaties that shape national climate responsibilities and each country's energy laws that implement them must accurately recognize the climate effects of the activities they encourage.

Your decisions going forward are of great consequences for the world's forests because if the world supplied just an additional 2% of its energy from wood, it would need to double its commercial wood harvests. There is good evidence that increased bioenergy in Europe has already led to greatly increased forest harvests there. These approaches also create a model that encourages tropical countries to cut more of their forests — as several countries have pledged to do — undermining the goals of globally accepted forest agreements.

To avoid these harms, governments must end subsidies and other incentives that today exist for the burning of wood whether from their forests or others. The European Union needs to stop treating the burning of biomass as carbon neutral in its renewable energy standards and in its emissions trading system. Japan needs to stop subsidizing power plants to burn wood. And the United States needs to avoid treating biomass as carbon neutral or low carbon as the new administration crafts climate rules and creates incentives to reduce global warming.

Trees are more valuable alive than dead both for climate and for biodiversity. To meet future net zero emission goals, your governments should work to preserve and restore forests and not to burn them.

Peter Raven, Director Emeritus Missouri Botanical Society, St. Louis, Missouri USA,
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New study reveals formation of new gas emissions craters in the Arctic

Researchers using high-resolution satellite imagery and a geospatial algorithm to identify rapid and abrupt landscape change in the Arctic find additional indicators of ground collapse due to warming climate

by Maddie Rocklin

Communications Contributor

In 2014, workers on the Yamal Peninsula in western Siberia noticed a deep, mysterious crater within the permafrost that had seemingly exploded like a volcano. The discovery of the feature, now known as a gas emissions crater (GEC), energized international news coverage, as well as a flurry of scientific research to understand the phenomenon. Now, a new study by scientists at Woodwell Climate Research Center and colleagues, captures GECs in formation

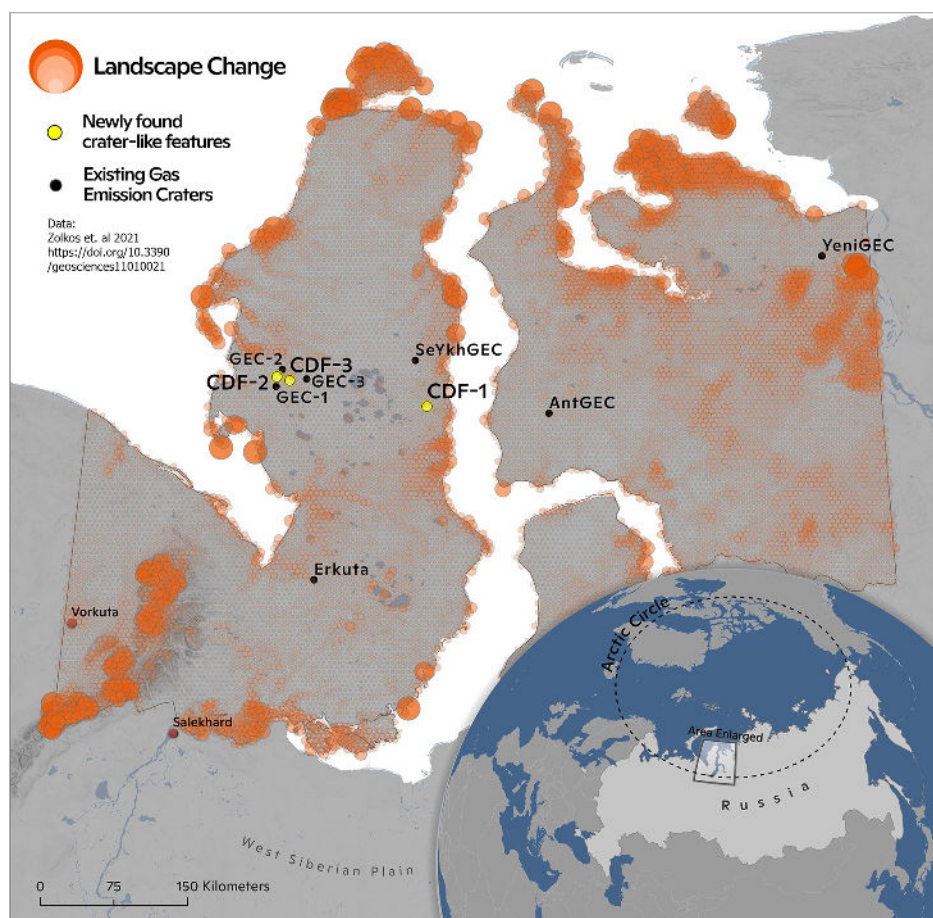
and reveals the magnitude of landscape change across the Yamal and Gydan Peninsulas using high-resolution satellite imagery and a novel geospatial algorithm.

The latest science suggests that GECs form when subterranean methane accumulates beneath ice-rich permafrost, which can over-pressurize, deform the land-surface, and explode catastrophically. This activity is associated with warmer air temperatures, so as the climate warms and

temperatures rise in western Siberia, that may in turn accelerate GEC formation in the region, increasing greenhouse gas emissions and posing a risk to humans and infrastructure. Understanding these risks however, has been hindered by limited capabilities for detecting and mapping GECs.

The new study identified the process by which the seven previously reported GECs had formed, and explored the extent of additional landscape changes taking place. The findings revealed the formation of three new GEC-like features, as well as a number of previously undetected abrupt landscape changes occurring across an area of 327,000 km². These changes included a 5% change in landscape from 1984 to 2017, an abundance of retrogressive thaw slumps (ground collapse features due to thaw of ice-rich permafrost), evidence of erosion along stream and river bends, and thawing of permafrost in upland areas.

“Thanks to recent advances in cloud computing and new geospatial data products, the algorithm we developed pushes the boundaries of landscape change detection,” said Dr. Scott Zolkos, a co-author of the study. “It allows us, for the first time, to quantify and map landscape change at high-resolution across the Yamal and Gydan Peninsulas, where GEC formation, abrupt permafrost thaw, and lake drainage are among the striking changes occurring in this vast region. These tools can be further developed to assess rapidly



Above: map by Greg Fiske



changing permafrost terrains across the circumpolar north, to better understand and perhaps even mitigate the effects of climate change.”

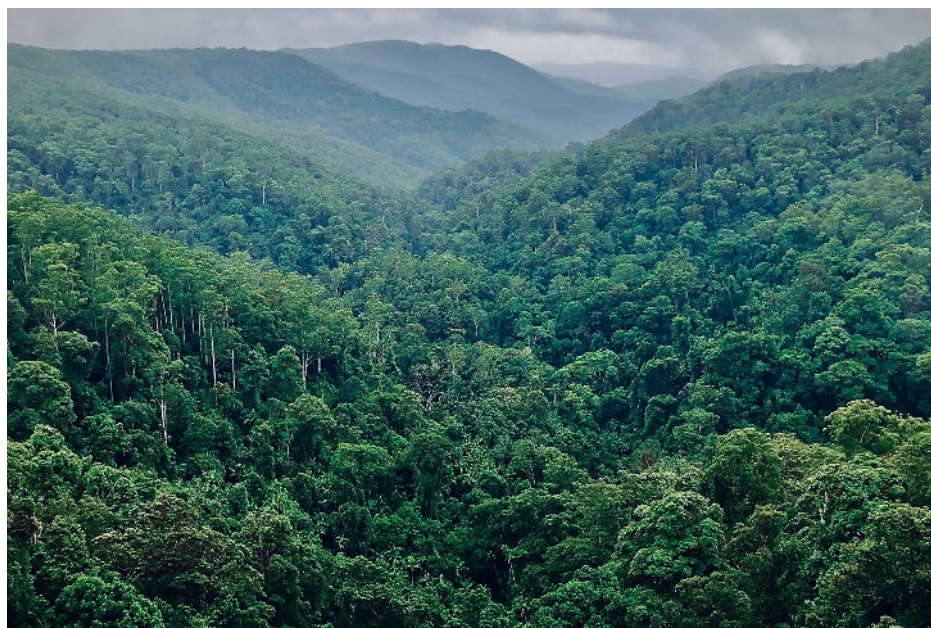
The Arctic is warming two times faster than the global average and the permafrost thaw that comes with these changing temperatures has significant implications for the region and our global climate. Potential impacts of the changes identified in the study include an increase of greenhouse gases being released from the microbial breakdown of organic matter within thawing permafrost and a threat to infrastructure and people as hundreds of cubic meters of ground material is displaced.

“These craters represent an Earth System process that was previously unknown to scientists,” added Dr. Sue Natali, an Arctic ecologist and co-author on the study, “The craters and other abrupt changes occurring across the Arctic landscape are indicative of a rapidly warming and thawing Arctic, which can have severe consequences for Arctic residents and globally.”

The paper was co-authored by Woodwell Climate Research Center scientists and researchers, Drs. Zolkos and Natali, Greg Fiske, Gabriel Duran, and Tiffany Windholz, as well as colleagues from the U.S. Forest Service and Trofimuk Institute of Petroleum Geology and Geophysics (Novosibirsk, Russia), and is available online at: doi.org/10.3390/geosciences11010021

Scientists investigate present and future of land carbon sinks

by Anabelle Johnston
Communications Intern



As global decision makers prioritize combating climate change in the coming decades, there is a growing need to understand how much carbon dioxide forests and other land-based ecosystems can absorb and store. While many forest carbon monitoring systems have been developed for various regions, differing techniques, methodology, and assumptions have made it difficult to accurately and consistently measure mitigation performance on a global scale. Additionally, climate change itself may alter the efficacy of land carbon sinks, as the basic biological processes of plants that absorb and release carbon dioxide respond to changing environmental conditions. To meet these challenges and facilitate better forest management decisions, Woodwell Climate scientists have created maps of global forest carbon flows and investigated the sustained potential for land carbon sink mitigation.

Land carbon flux is the flow of carbon back and forth between terrestrial

ecosystems and the atmosphere, influenced by land use, soil type, the species present, and environmental conditions. Plants convert carbon dioxide (pulled from the atmosphere) and water into energy via photosynthesis. In respiration, that energy is used and carbon dioxide is released back into the environment. Bacteria and other microbes can also absorb and release carbon dioxide and methane as a result of their metabolic processes. All of these biological processes are influenced by environmental conditions, including temperature, moisture, and the amount and type of carbon available. And, of course, cutting trees or otherwise disturbing an ecosystem can result in the release of previously stored carbon.

The new maps show that, globally, forests currently absorb twice as much carbon as is emitted by deforestation and disturbance. Drs. Richard Birdsey, Richard (Skee) Houghton, and Alessandro Baccini collaborated with

other scientists to create a monitoring framework that integrates satellite imagery and ground data. By creating a consistent international standard, the team hopes to increase transparency and improve communication among different regions.

“There has been a steady evolution of forest carbon flux monitoring methods over time and our work builds off methodology that has been proven effective,” explains Birdsey. “Scientists have begun integrating remote sensing and satellite data into their calculations but it is our map-based approach that makes all the difference. Not only do maps provide lots of important data—including information about forest regrowth and changes in carbon density—but they are also incredibly accessible. Our findings are public because we believe everyone should have access to this data, and it should be presented in a way that doesn’t require a supercomputer or PhD to understand.”

Already, the method used here has become useful for decision makers in the U.S. Using scaled down maps developed by Birdsey and Dr. Nancy Harris of the World Resources Institute, 25 counties and communities across the United States are developing strategies for land use modifications to reduce greenhouse gas emissions and maximize efficiency, and access to spatial data about forests and carbon flux has been key to that effort.

However promising these strategies are, scientists are uncertain about the ability of land carbon sinks to continue to mitigate anthropogenic carbon emissions at the rate (~30%) they do today. Climate change poses a distinct threat because plants’ metabolic processes are dependent on temperature. Risk Program Director Dr. Christopher Schwalm was part of a team, led by a former graduate student, that used data from a continuous carbon flux monitoring network to determine the temperatures at which

photosynthesis and respiration peak. The work revealed that without drastic changes in emission rates, respiration could soon outpace photosynthesis in many ecosystems, cutting the total global land sink strength by nearly 50% by 2040.

“Seeing such a strong temperature signal globally did not surprise me,” Schwalm told *Inside Climate News*. “What I was surprised by is that it would happen so soon, maybe in 15 to 25 years, and not at the end of the century.”

In order to limit climate change, it is critical to understand how much we can rely on forests and other natural systems to absorb and store carbon. For decades, Woodwell Climate researchers have played key roles in integrating understanding of basic biological and ecological processes into global accounting of carbon sources and sinks. We continue to collaborate with key stakeholders to develop effective land use practices on both the local and global scales.

Understanding Land Carbon Fluxes

While working respectfully in northern regions Woodwell Climate researchers should abide by these principles:

- Land carbon flux is the flow of carbon back and forth between terrestrial ecosystems and the atmosphere, influenced by land use, soil type, the species present, and environmental conditions.
- Plants convert carbon dioxide (pulled from the atmosphere) and water into energy via photosynthesis. In respiration, that energy is used and carbon dioxide is released back into the environment.
- Bacteria and other microbes can also absorb and release carbon dioxide and methane as a result of their metabolic processes.
- All of these biological processes are influenced by environmental conditions, including temperature, moisture, and the amount and type of carbon available.



Woodwell Climate researchers kick off 2021 with star power

by Heather Goldstone
Chief Communications Officer

Addressing climate change requires action at all levels, all of it informed by science. Toward that end, Woodwell Climate researchers work with leaders across all sectors of society. That reach has been on display in recent events featuring household names with moral, political, and popular influence—from White House National Climate Advisor Gina McCarthy, to “The Office” star Rainn Wilson, to His Holiness The Dalai Lama.

A GROUNDBREAKING CONVERSATION

On the evening of January 9, 2021, Arctic Program Director Dr. Sue Natali and Dr. Bill Moomaw, a director and distinguished visiting scientist, took part in a conversation with Greta Thunberg and His Holiness the Dalai Lama (mindandlife.org/events/event-history). The event marked the first time the Dalai Lama and Greta Thunberg had met, and they were brought together by a shared sense of alarm at the prospect of runaway warming driven by climate feedback loops—natural processes

that are kicked off by warming and also exacerbate warming.

Dr. Natali focused on perhaps the most pressing of these feedbacks—greenhouse gas emissions from thawing Arctic permafrost—while Dr. Moomaw highlighted the potential for forests (if protected and restored) to act as a cooling force for the planet. Following strong calls to action by both Greta Thunberg and the Dalai Lama, the event's moderator Diana Chapman Walsh wrapped up the evening by exhorting those watching to set off a social feedback loop of spreading climate awareness and action.

Mind & Life Institute, who hosted the event, issued a statement that “we had nearly 775,000 live views across streams in 14 languages, and a week later, we've had over a million views including replays.”

The event launched a new series of educational films, *Climate Emergency: Feedback Loops*, mentioned recently in *People Magazine*, *The Independent UK*, and Bloomberg Radio. These films originated from a conversation between the producers and then Woodwell Board Chair, now Distinguished Visiting Scientist, Dr. William Moomaw. They feature several Woodwell Climate scientists, including founder Dr. George Woodwell, Arctic Program Director Dr. Sue Natali, Tropics Program Director Dr. Michael Coe, and President Dr. Philip Duffy, among others.

MAKE EARTH COOL AGAIN

More recently, the Arctic science outreach group Arctic Basecamp hosted a livestream event focusing less on the moral imperative and more on the cool factor of climate action (arcticbasecamp.org/events/davosagenda). Dr. Jen Francis was one of several climate scientists featured alongside pop culture stars including Rainn Wilson, Parisa Fitz-Henley, Ariel Winter, Billie Eilish, Andy Grammer,

Robert Downey Jr., and the Property Brothers, Jonathan and Drew Scott.

Make Earth Cool Again was a five-hour-long parade of high-profile individuals, with musicians, actors and actresses interspersed with royalty, CEOs, environmental activists. Co-host Rainn Wilson also indulged in periodic comedy breaks featuring Chuck the Polar Bear, an actor dressed in a polar bear costume. As the event progressed, youth voices played a larger role. And a panel discussion on sustainable fashion drove home the message that climate action is the stylish thing to do.

It's not the first time Dr. Francis has worked with Rainn Wilson. She is also featured in Wilson's *Idiot's Guide to Climate Change*. The star of “The Office” has made climate change his signature issue over the past two years.

FOCUSING ON CLIMATE JUSTICE

On February 9, 2021, Natalie Baillargeon, a Polaris Project alumna currently working with Woodwell's External Affairs team, took part in a panel discussion with White House National Climate Advisor Gina McCarthy (facebook.com/pg/smithcollege/videos). McCarthy delivered the Smith College Presidential Colloquium, with comments focused on the intersection of climate action and social justice. Baillargeon was one of two students selected to participate, along with a handful of faculty members, in a small group question and answer session.

“Gina McCarthy is a dedicated public servant in public health and the environment. It was an honor to speak on a panel with her and pick her brain about related topics,” Baillargeon said. “It was refreshing to hear that the Federal government is prepared to take environmental issues, such as climate change, seriously again. In particular, it was inspiring to hear her speak about how climate policy will be incorporated in all sectors of government from energy to education.”



Unlearning Racism in Geoscience combines information with action

by Anabelle Johnston
Communications Intern

When Gabriel Duran first began developing the curriculum for URGE, *Unlearning Racism in Geoscience*, neither he nor his collaborators had any idea that the project would become as popular and well-respected as it is now. The program, an eight-part series running from January to May 2021, was designed to replicate an anti-racist book club structure while also delivering actionable frameworks for substantial longterm change in one of the least diverse fields in science.

“It’s kind of daunting in a way. Our initial meeting had over 1200 attendees, some of them spearheading really impressive research institutions,” says Duran. Although he was never formally trained in social sciences or education development, Duran has utilized his experience as a geoscientist and passion for equity to make the project a success. “I think part of the popularity is that we haven’t really seen anything like this before in this field. There are similar systems out there that educators use, but nothing that directly addresses the specific challenges and history of geoscience while crowdsourcing anti-racist policies and data.”

Duran’s interest in this work stemmed from a conversation he had while conducting fieldwork as a part of Woodwell Climate’s Polaris Project.

Finding that many members of the geoscience community have faced the challenges of working within a predominantly white and male field, Duran was inspired to deepen his own understanding of the racist and colonial history of earth science when returning to the Falmouth campus. After forming a Diversity Book Club with other members of the Woodwell staff, Duran began collaborating with Vashan Wright—a postdoctoral researcher at Woods Hole Oceanographic Institution—and other members of the URGE team.

URGE has three primary goals: to broaden and deepen the community's knowledge of the effects of racism on the participation and retention of Black, Brown, and Indigenous people in geoscience; to draw on existing literature and personal experiences to develop anti-racist policies; and to share, discuss, and modify these strategies within a dynamic community network on a national level.

“We acknowledge that this is one of the least diverse scientific fields, and we are working to make it a more accepting, inclusive, and equitable environment,” Duran says. “At the end of the day, anti-racist policies will only be as good as the data that inform them, the people who uphold them, and the resources that go into supporting them.”

The URGE team plans on accomplishing with a series of eight focused sessions, presenting information from experienced panelists and fostering guided discussion. The first session, hosted on January 18th, provided key definitions and working principles to lay the groundwork for further discussion. The second session explores personal identity, offering participants an opportunity to share experiences and better understand individual relationships to larger systems of oppression. The third session is focused on the history of racism in geoscience, the fourth on issues

of environmental racism, the fifth on accessibility of entry into geoscience, the sixth on inclusivity. Understanding that, although many institutions are putting in necessary work, racism won't be stopped overnight, the seventh session offers self-care practices and coping strategies for people of color. The final session asks how participants can best implement the goals, policies, and strategies developed over the course of the program, and continue to hold themselves accountable after URGE is complete.

“I'm hopeful that people will take something meaningful away from URGE and bring it back to their institutions to affect change. We've already gotten requests to continue the program past the scheduled run date. I'm not sure what comes next but this feels like a really good start,” says Duran.

To learn more, visit the URGE website: urgeosience.org

In the news: highlights

A letter from climate scientists urging action against biomass was mentioned in *Politico's* Morning Energy column (under Mail Call): Biden, China dance around fossil fuel funding, February 12; and in *Mongabay*: 500+ experts call on world's nations to not burn forests to make energy, February 15

Dr. Jennifer Francis is quoted on *Gothamist* in a piece on warming winters, which was quickly picked by publications in Europe: Why New York's Snowstorms Are Growing—Along With Warming Winter Temperatures, February 14

The study about temperature-driven tipping points in the land carbon sink co-authored by Dr. Christopher Schwalm has drawn attention over the last few weeks, including in a *Forbes* feature: Climate Catalysts: The Pairs Trade Of The Century, February 9, and on *Skeptical Science*, How close are we to plant temperature tipping point?, January 18

Board member John Le Coq penned an op-ed commending Pres. Biden's executive order on protecting 30% of land and ocean by 2030: It's time to implement history's most ambitious conservation agenda, February 7

Dr. Linda Deegan weighs in on new work showing differential impacts of climate change on birds and mammals in *Science Magazine*: Study shows winners, losers as desert warms, February 5

Dr. Phil Duffy is quoted in the *Financial Times* on the long-term view of extreme weather: Climate graphic of the week:

Storms intensify in the Atlantic, January 31

Dr. Jen Francis explains how Arctic warming affects New England's winter weather on CBS Boston: Climate Scientist Says Disrupted Polar Vortex Is Causing New England's Frigid Temps, January 30; and in the *New York Times*: Forecast: Wild Weather in a Warming World, January 30

Drs. Phil Duffy and Bill Moomaw are quoted in the *Washington Post's* analysis of President Biden's early climate actions: The Energy 202: Biden stokes hope among climate scientists, January 29

Drs. Rich Birdsey and Ale Baccini's work with WRI and others on an interactive global map of deforestation emissions was published in the latest issue of *Nature Climate Change* and received extensive media attention: New Maps Show Forests Absorb Twice as Much Carbon as They Release Each Year - The Sustainability Consortium, January 29;

Dominick Dusseau appeared in Chris Gloninger's latest story for NBC Boston, a look at the impact of sea level rise on vulnerable populations: Climate Change Threatens Homes of Boston's Most Vulnerable, January 28; the story also appeared on NECN the same day

Greg Fiske and Dr. Scott Zolkos feature in an article in *Discover Magazine* on gas emission craters: Massive Craters in Siberia Are Exploding Into Existence. What's Causing Them?, January 27

cover: Dr. Jon Sanderman led a study showing that soils in tropical mangrove forests, like in Bangladesh and India pictured here, hold 4.5 billion tons of carbon per year. The study's database of soil carbon measurements is meant to provide tools to governments to help protect and restore these valuable carbon sinks as natural climate solutions for mitigating greenhouse gas emissions. / map by Greg Fiske

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