



**Woodwell
Climate
Research
Center**

New support for a prediction by George Woodwell / 02

New McKinsey report advises climate action for US state and local leaders / 03

A productive first year of work with McKinsey & Company / 04

Global Carbon Budget 2020 finds record decrease in emissions / 05

River data shows evidence of permafrost thaw / 06

In the news: highlights / 07

Notes from the Field

Newsletter • January 2021
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New support for a prediction by George Woodwell



Dr. Philip Duffy
President & Executive
Director

Biological processes are sensitive to temperature. That's why we keep food in the refrigerator. That's also why, as the planet warms, we worry about biological processes adding more CO₂ to the atmosphere—above and beyond what humans are adding through fossil fuel use and deforestation.

George Woodwell warned about this biological amplification of climate change in his 1986 Senate testimony. One manifestation of this is greenhouse gas emissions from thawing permafrost. At the time of George's testimony this idea was purely hypothetical, but work at the Center and elsewhere has shown that these emissions are now quite significant.

The problem is bigger and broader than that, however. I'll quote George's testimony at some length because, as usual, he states things very effectively:

"In the normal circumstance, over long periods of time, there is an approximate equivalency between processes that fix carbon dioxide out of the atmosphere, referred to as photosynthesis, and the processes that break down that fixed carbon, the carbon compounds of plants and soil, into carbon dioxide, heat, and water. That series of processes is respiration. The products of respiration, I emphasize, are carbon dioxide, heat, and water, the same products as those of fire. The products of photosynthesis are fixed carbon compounds. In the normal course, those two processes, photosynthesis and respiration, are approximately in balance over the Earth.

We think that is true, but there is no absolute proof of it. A change in the climate has the potential for changing the balance between photosynthesis and respiration over very large areas. The experience of ecologists who think about such topics leads them to believe that the factor which affects the balance most is temperature. ... The best guess at the moment is that warming will affect respiration considerably more than it will affect photosynthesis. The effect will be the release of additional carbon dioxide, methane, and probably carbon monoxide from the vegetation and soils.

So here is a positive feedback system: a warming makes the problem with carbon dioxide and trace gases worse."

Like greenhouse gas emissions from thawing permafrost, this more broad-based reduction in the ability of the biosphere to store carbon was just an idea in 1986. That's still true, but a new paper co-authored by Christopher Schwalm, who leads Woodwell's Risk Program, suggests that major changes may be coming soon.

Right now, land reservoirs like forests and soils remove from the atmosphere an amount of CO₂ equivalent to about 25% of human CO₂ emissions. Oceans do the same. In total, then, only about half of the CO₂ which humans emit every year accumulates in the

atmosphere. Nature kindly disposes of the rest. If this changes, that would result in an acceleration of global warming, just when we need urgently to slow it down. Research at Woodwell suggests that this is starting to happen, via emissions from permafrost. Schwalm's work suggests that, on top of this, land may soon completely stop removing carbon from the atmosphere, and instead become a source.

If this is true, it is terrible news for humanity. It would make it much more difficult to meet the internationally agreed-upon goal of limiting warming to 1.5 or 2°C.

What is even more concerning is that these "carbon cycle feedbacks" are not represented in models and so are not part of humanity's plans for controlling climate change. Specifically, these effects are not considered in emissions scenarios which limit global warming to 1.5 or 2°C, or in national commitments as part of the Paris agreement. This means that limiting global warming to a tolerable level may be much more difficult than is widely thought. That's not welcome news, of course, but if it's true we need to know it.

Worst of all, it is conceivable that these biotic emissions of carbon may become strongly self-reinforcing, resulting in out-of-control global warming—a loss of control of our planetary destiny. That may sound like a science-fiction nightmare, but geological evidence suggests that this may have happened in the distant past.

These "carbon cycle feedbacks" are a major risk to the future of humanity, yet they get minimal attention in the scientific community and virtually no attention outside of it. A major focus of our work at Woodwell is to improve understanding of these issues, and also to give them more prominence in the policy world and in the public conversation.

One recent step in that direction is the release of five short videos about these and other climate feedbacks, featuring Woodwell scientists, including George himself. Created by Northern Lights Productions, these are available online, and were recently featured in a conversation including two Woodwell scientists, Greta Thunberg, and the Dalai Lama.

This new science reminds me that the more we learn about climate change, the worse it looks. It is also a reminder that, even though we already know that climate change is a problem and that we need to do a lot more to address it, it's essential to continue research into what happens when we add greenhouse gases to the atmosphere. Only with that understanding can we begin to formulate and implement a viable plan to contain the threat.

Thanks as always for your interest and support.

New McKinsey report advises climate action for US state and local leaders

by Anabelle Johnston
Communications Intern

Unless dramatic action is taken, global temperatures will continue to rise in the coming decade and, in turn, increase the frequency and intensity of physical climate risks across the United States. In their latest climate action report, McKinsey & Company, with analyses conducted by Woodwell Climate scientists, finds that state and local leaders have an opportunity to prevent billions of dollars in damage and human health catastrophes by curbing carbon emissions and investing

When precipitation does fall, it is expected to accompany extreme weather events. While the frequency of moderate rainfall will decline in the coming thirty years, the frequency of extreme weather events is expected to increase by at least 50% across the country. The report also incorporates an examination of tropical storm risk by Dr. Kerry Emanuel of MIT. That work projects stronger and more destructive hurricanes, raising the risk of coastal flooding.



in resilience. Already, states and cities have begun to set greenhouse gas emission reduction goals and are developing programs to ease this transition. This report identifies the physical threat posed by climate change, the short-term benefits of climate action, and opportunities for state and local leader responses in 2021.

Woodwell Climate provided extreme heat projections that point to a variety of risks in different regions of the country. The number of lethally hot days will increase across the country, posing the greatest health threat to the elderly. Extended heat waves are projected to impact counties across Texas and Florida. McKinsey researchers also report increased potential for a multi-decade long drought in the Southwest and Central Plains. Woodwell Climate scientists found that by 2050, superimposition of extreme heat and drought will add three to four weeks of severe wildfire risk along the West Coast.

“All of our calculations are conducted on the time horizon of large capital expenditures,” says Woodwell Climate Risk Program Director Dr. Christopher Schwalm, who has worked closely with the McKinsey team on more than a dozen projects over the course of the past year. “Instead of looking towards the end of the century, we’re focusing on the next thirty years, which is important in the field of climate policy given the constraints of the Paris Agreement and goal of achieving net zero emissions by 2050.”

With these risks in mind, climate mitigation and adaptation are

essential to protecting labor productivity and coastal properties. Adaptation protects against the physical threat of unavoidable flooding, wildfires, extreme storms, and prolonged droughts, with the potential to save the country 2.5 billion dollars in climate-related damages. However, dramatic reductions in greenhouse gas emissions are needed to stop the escalating physical and socioeconomic risks. And while many state and local leaders may be hesitant to prioritize climate response in the wake of the COVID-19 pandemic, McKinsey & Company urges immediate action, arguing climate change response could help rebuild economies weakened by the COVID-19 pandemic and provide infrastructure for healthier and more equitable communities.

Strategic climate action could help stimulate the economy, as low-carbon investments, such as renewable energy projects, have been found to create more jobs than environmentally

neutral or harmful construction endeavors. Additionally, public transportation projects have been found to create 70% more job-hours than highways. Overall, climate action projects have been found to have a 1.5-fold multiplier effect on economic productivity and to create ten jobs per million dollars invested. McKinsey & Company also note that decarbonization efforts can support health and environmental justice by mitigating the disproportionate impact of air pollution on low-income communities. Phasing out fossil-fuel power generation and internal combustion engines could save over a million American lives in the coming 20 years while lowering healthcare expenses and increasing labor productivity.

The report offers best practices for planning climate response strategies, recommending that state and local leaders develop a thorough understanding of relevant physical risks and transition challenges. Additionally, collaboration between public and private sectors could be critical to offset competing interests while lowering climate-risk exposure. Because low-income and minority communities suffer the most from climate hazards, McKinsey & Company suggests that programs are developed to identify and eliminate disproportionate risks, both physical and socioeconomic. Finally, the report deems that societal costs and benefits, job growth, and feasibility should be quantified and taken into account for all potential adaptation and decarbonization pathways.

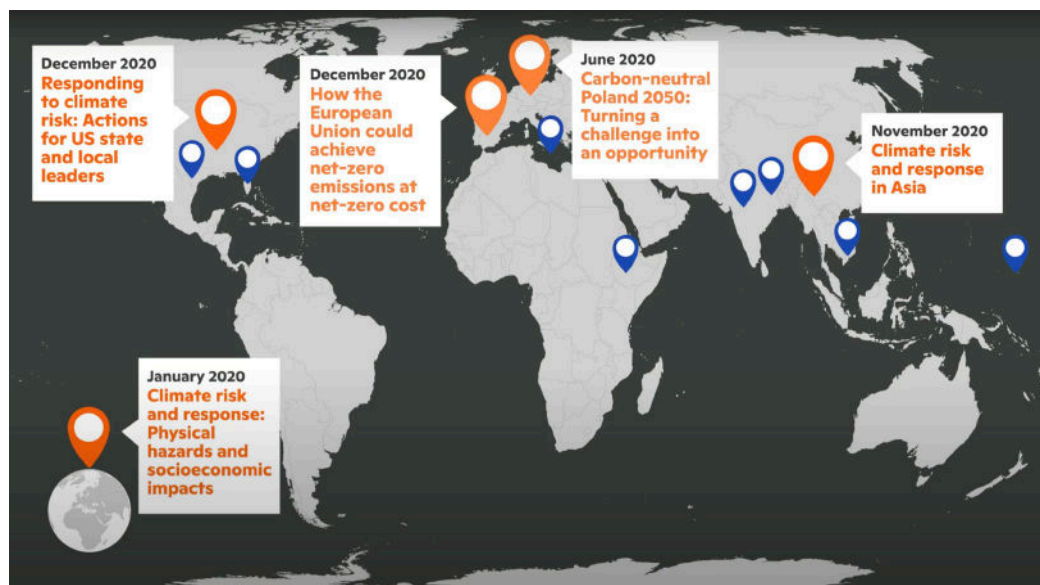
As rising temperatures and climate change accelerate, Woodwell Climate continues to partner with McKinsey & Company to present the socioeconomic impacts of climate change to stakeholders and decision-makers in industry, policy, and investment sectors.

A productive first year of work with McKinsey & Company

Five landmark studies and nine detailed case studies

by Anabelle Johnston
Communications Intern

The ongoing partnership between McKinsey & Company and Woodwell Climate Research Center produced thirteen groundbreaking climate reports over the course of 2020, including climate risk and response examinations, decarbonization pathways, and detailed case studies.



LANDMARK STUDIES

The first global report produced by this partnership identified seven key characteristics of physical climate risk, noting that risk is increasing, spatial, non-stationary, nonlinear, systemic, regressive, and far in excess of current preparations. The report also identified that climate change is already posing substantial threats to regions with lower per capita GDP levels and global socioeconomic impacts will likely be substantial, destabilizing livability and workability of certain regions, global food systems, physical assets, infrastructure services, and natural capital. The work went beyond simply identifying problems, developing

suggestions for decision-makers to curb risk in the coming decades.

The partners have not only investigated the near-future impacts of climate change, but also present-day challenges. In November 2020, McKinsey & Company released a report surveying climate risk and response in Asia, highlighting the importance of prioritizing climate resilience as the world works to recover from COVID-19. This paper is part of a larger ongoing series considering the Future of Asia, with flood, fire, and agricultural yield risk assessments contributed by Woodwell Climate scientists Dr. Christopher Schwalm, Dr. Zach Zobel, and Dominick Dusseau.

“We looked at rainfall, streamflow, and coastal flooding in the general Tokyo area and modeled all three together to estimate how extreme rainfall events will change compared to our historical data. This region is important because it is an economic center for the region, holds one of the largest metropolitan populations in the world, and is at a significant flood risk due to a combination of typhoons and rainfall,” explains Dusseau.

Most recently, McKinsey released a report for state and local leaders in the United States, with Woodwell research on heat and wildfire risk.

DEEP DIVES

Following widespread support from financial and policy sectors, McKinsey & Company dove deeper into risks specific to particular regions and economic sectors. Utilizing nine key case studies and different regional reports, the partners presented strategies for both climate mitigation—preventing additional greenhouse gas emissions on a relevant timescale—and climate adaptation—assessing present risks and potential responses.

One of the first case studies looked at the numerous climate hazards plaguing Florida, including tidal flood risk and storm surge calculated by Woodwell Climate scientists, to evaluate real estate loss over the next 30 years. Storm-induced property damage, declining property value, and increased insurance rates will have substantial economic impacts on the state and national level. Another case study examined the impact of rising temperatures, water stress, and volatile precipitation on the Mediterranean basin’s tourism and agriculture industries. McKinsey & Company also identified the compounding threat COVID-19 and climate change pose to the global food system. Lack of variety in grain type and origin leave the global food system vulnerable to rising temperatures and extreme precipitation, causing the

likelihood of multiple breadbasket failures to increase dramatically in the coming decade. Additionally, a case study found that the increasing frequency and severity of climate hazards have the potential to interrupt global supply chains.

DECARBONIZATION PATHWAYS

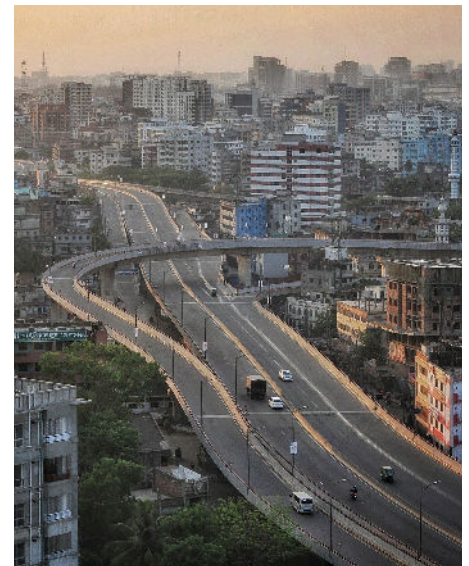
In December 2020, McKinsey & Company released a plan to help the European Union achieve net-zero emissions at a net-zero cost. The report outlining EU decarbonization expands upon a plan for decarbonization in Poland, released in June 2020. The report offers suggestions for emissions reductions within the power, transportation, building, industry, and agriculture sectors, combining renewable energy with carbon offset and natural climate solutions.

Woodwell Climate’s Dr. Richard “Skee” Houghton reviewed proposed land use changes, including reforestation of agriculture areas and conversion of unproductive land to bioenergy plantations. These carbon offset pathways repurpose unused land as forests and fuel sources, which falls in line with Houghton’s work in natural climate solutions. Houghton communicated with authors of the original studies utilized in McKinsey’s calculations and reviewed carbon budget estimations alongside Dr. Wayne Walker.

LOOKING FORWARD

The partnership between Woodwell Climate and McKinsey & Company allows the Center to reach audiences that were previously inaccessible and increase impact in the private sector.

“Working with McKinsey [& Company] allows us to gather a diverse group of people in the same virtual room and brainstorm how to present the climate risks to various stakeholders,” says Schwalm. “We’re prepared to support them as they navigate the climate space and already have seen this partnership expand our reach.”



Global Carbon Budget 2020 finds record decrease in emissions

by Anabelle Johnstn
Communications Intern

For the past 15 years, the Future Earth research initiative on global sustainability, in conjunction with the World Climate Research Programme, has produced an annual Global Carbon Budget. This project aims to present a complete picture of the global carbon cycle and carbon feedback loops over time. This year’s update, released in early December, includes multiple noteworthy elements.

The 2020 report found a record decrease in carbon dioxide emissions, attributed to COVID-19 interruptions of regular business practices. Global carbon dioxide emissions declined by approximately 2.4 billion tons (7%) from the previous year, bringing global fossil fuel-derived CO₂ emissions to 34 billion tones. This decrease is most pronounced in the US, EU, and India, where COVID-19 restrictions were most prominent and prolonged. Due to previous rebounds in emissions following crises, the authors

predict that long-term trends will be influenced by the actions taken to stimulate the economy following pandemic restrictions on activity.

Much of the media and public response to this report has centered around the relationship between COVID-19 and carbon emissions, as this moment presents a unique opportunity to prioritize a sustained decrease in global emissions. In order to meet Paris Agreement goals, global emissions must be cut by one to two billion tonnes each year between now and 2030.

In addition to emphasizing the significance of this critical juncture, this report is the first Global Carbon Budget to include gross emissions from land-use in addition to the typical net calculations. For years, Woodwell Chair for Global Ecology Dr. Richard “Skee” Houghton has called for the inclusion of this measurement, which provides information about emissions from clearing land for agriculture and wood harvesting, as well as carbon uptake by regrowing forests.

“Knowing the net emissions from land use change is great for calculating the overall budget but isn’t very helpful for making decisions about land management,” says Houghton. “The gross emissions from land use are much higher than the net, which helps us understand how management of forests could help meet carbon emissions goals.”

Gross emissions from land-use change in 2020 accounted for approximately 16 billion tonnes of CO₂ and were partially offset by forest regrowth, which accumulated 11 billion tonnes. These findings underscore the importance of making informed land management decisions in the coming year as health and safety restrictions on development begin to lift.

River data shows evidence of permafrost thaw

by Anabelle Johnston
Communications Intern



Long-term ecological monitoring doesn’t always look like typical scientific experimentation. There isn’t always a single hypothesis being tested, and it’s often unclear what might be learned. However, these projects, and the constant streams of data they provide, can yield discoveries that would otherwise be missed. Since 2003, the Arctic Great Rivers Observatory (ArcticGRO) has sampled six of the largest Arctic rivers, generating an archive of essential data about the rivers’ biological, chemical, geological, and physical processes, which can indicate changes in the surrounding watersheds and impact the ocean. Those data have revealed new evidence of the remarkable changes taking place in Arctic ecosystems, specifically the release of ancient carbon from thawing permafrost.

“Many of us are interested in the Arctic because we know there are vast amounts of carbon stored in the permafrost,” Woodwell Climate’s Dr. Robert Max Holmes says. “As the Arctic warms and permafrost thaws, we expect to see signals of that carbon release in the rivers.”

The team took many measurements, including the radiocarbon age of

dissolved organic carbon. Dissolved organic carbon (DOC) is a form of carbon often derived from vegetation that is deposited in rivers by smaller streams or overland flow. DOC has the potential to rapidly oxidize to carbon dioxide, furthering carbon feedback loops and amplifying global warming. Measuring the age of DOC in rivers provides a picture of the severity of surrounding permafrost thaw, as older DOC indicates deeper release and further thaw. Typically, DOC found in these rivers has been characterized as young, resulting from modern plant growth and surface soil. However, a new study released in late 2020 found older DOC in the Mackenzie River, marking a departure from trends measured over the course of nearly twenty years.

The study collected young DOC from the Mackenzie river and two connected tributaries in summer 2017 and summer 2019. In summer 2018, Holmes and other scientists reported aged DOC, previously only found in small streams and tributaries of thawing regions. This measurement was taken following a warm summer and the second warmest winter on record, indicating that high temperatures may be responsible for a deeper permafrost thaw and subsequent

Above: Dr. Max Holmes taking a water sample from the MacKenzie River in Canada.

release of aged DOC. This was the first time this phenomenon was recorded in a large river.

“We know that these findings are important because of the long-term data we have,” explains Holmes. “Sampling annually since 2003 allowed us to recognize a pattern. So, when we saw the aged dissolved organic carbon, we knew something was up. As a climate scientist, this is both exciting and scary. We’re now seeing evidence of the changes

we’ve been predicting for years, which is exciting, but those changes are ones that we’d much rather avoid.

This 2018 anomaly supports previous evidence that the age of dissolved organic carbon can be a sensitive indicator of changes in the watershed and permafrost thaw. ArcticGRO will continue to date DOC from all six large rivers using samples already collected. To learn more about this work and further research, visit arcticgreatrivers.org.

RECORDED EVENT

The Dalai Lama with Greta Thunberg and Leading Scientists: A Conversation on the Crisis of Climate Feedback Loops

This event, hosted and livestreamed by the Mind & Life Institute on January 9, 2021, was recorded and is available to watch on our website at: woodwellclimate.org/stories/videos

In the news: highlights

Phil Duffy was interviewed on WCAI's *The Point: How Will A New Presidential Administration Impact Our Region?*, January 19

Christopher Schwalm was interviewed on WCAI's *The Point: Nearing the Climate Cliff: Study Warns Plants Are Decades Away From Absorbing Less Carbon*, January 17

Woodwell Climate Research Center was mentioned in numerous stories about new work finding that the land carbon sink may hit a tipping point and decline sharply in the next few decades, including: *Nature World News*, January 16; *Ecowatch*, January 14; *ClimateWire*, January 14

Christopher Schwalm is quoted in an *Inside Climate News* article: *Many Overheated Forests May Soon Release More Carbon Than They Absorb*, January 13

Bill Moomaw was a guest on *Cheddar Climate: Cheddar Climate: Scientists Share Strategies for Mitigating Global Warming*, January 12

Jen Francis was quoted in a *National Geographic* article on the polar vortex: *The polar vortex is coming—and raising the odds for intense winter weather*, January 11

Sue Natali was quoted in the *Washington Post* in two articles: *2020 rivals hottest year on record, pushing Earth closer to a critical climate threshold*, January 16; *2020 tied with 2016 for Earth's hottest year, as global warming overpowered La Niña*, January 8

“The Dalai Lama with Greta Thunberg and Leading Scientists: A Conversation on the Crisis of Climate Feedback Loops” received pre-event attention in outlets ranging from *Millennium Magazine*, to *Tampa Bay Indian*, and *The Tribune India*, with perhaps the highest-profile piece in *People*: *Greta Thunberg Hopes 2021 Brings a Climate ‘Awakening’: ‘We Have Failed’ Thus Far*, January 6

Jen Francis was featured in a *ScienceLine* podcast about extreme weather, climate change, and meteorologists: *More than just a weather forecast*, January 6

Rich Birdsey and Bill Moomaw co-authored a piece in *CommonWealth Magazine* highlighting the flawed logic of wood burning for electricity generation: *Baker is wrong to subsidize wood burning*, January 4

Max Holmes and Board Member Johny Le Coq, founder and owner of Fishpond, are interviewed by *Flylords Magazine*: *Organization of the Month: Science on the Fly*, December 30

Max Holmes was quoted in *The Economist* in an article on Sergei Zimov and his Pleistocene Park: *One Russian scientist hopes to slow the thawing of the Arctic*, December 19

Jen Francis talked to the *New York Times* about climate change connections to winter weather: *How climate change is affecting winter storms*, December 17

NOTEWORTHY ACTIVITIES

Jennifer Watts recently participated in an invite-only roundtable discussion with NASA Associate Administrator Thomas Zurbuchen about the important contributions of early career scientists within NASA Earth Science.

Foster Brown was awarded the Baron of Rio Branco's medal for merit in helping with the Civil Defense of the city over the past several years. He notes: “This was a fourth award from different state and municipal entities since 2006 to recognize the contribution that science and scientists have made in dealing with extreme climate events—droughts and floods—in southwestern Amazonia.”

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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