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Despite centuries of successful Indigenous management, the Xingu's fire regimes are changing

Sarah Ruiz Science Writer

What's new?

The first designated Indigenous land in Brazil, Território Indígena do Xingu (TIX), has been cited by studies for decades as a successful buffer against the deforestation, degradation, and fires that plague other parts of the Amazon. A recent study,

co-authored by Dr. Divino Silvério, Professor at the Universidade Federal Rural da Amazônia, and Dr. Marcia Macedo, Woodwell Water Program Director, shows that fire regimes are changing in the Xingu region, leading to more forest loss and degradation.

The paper shows roughly 7 percent of the TIX has

been degraded by drought and fire. Degradation is part of a feedback loop wherein damaged forests become drier and more susceptible to burning in future fires.

Understanding: Changing fire regimes

Indigenous communities in the TIX have been managing the rainforest for centuries with finely adapted slash and burn cycles that create space for agriculture and promote the growth of natural species used in construction, medicine, and cooking. These cycles can last three to four decades before an area is burned again. Traditionally, burns were well controlled and the rainforests surrounding burned areas were healthy enough to prevent flames from escaping.

But over the past two decades, the paper observed, escaped fires have occurred more often within the reserve and the likelihood that forest is lost post-fire is rising, particularly in seasonally flooded forests. Indigenous management practices have not

changed significantly, the paper explains, so why the increased prevalence of fire and degradation?

Climate change is drying out forests, making them more susceptible to escaped burning from management practices. The other factor driving degradation within the territory is growing population. Indigenous communities are becoming less nomadic, and village populations are rising, increasing the area of forest used for subsistence. Degradation was higher in areas surrounding villages.

What this means for Indigenous fire management

Climate change will force Indigenous communities within the reserve to adapt traditional practices to protect the forest against more frequent, intensifying fires—despite these communities not contributing to global emissions.

Previous attempts to manage increasing fires through prescribed burning have clashed with the needs of residents of the TIX. Burning at a different time of year does not cultivate the same species, and residents were concerned it was jeopardizing the growth of plants used for medicine.

Dr. Silvério is working with residents of the Xingu to understand how to integrate changes to fire management practices with traditional strategies in a way that supports community needs. One example, he said, could be shifting the primary construction material from grasses (that grow after fire) to palms.

Indigenous people will probably need to learn how to live in this new reality, an environment with more drought and more fires. We are trying to work in a participative way to construct solutions with them.

Dr. Divino Silvério



A warmer world means snow, rain will be much less predictable

Sarah Ruiz Science Writer

When and where precipitation falls can determine whether or not people have enough drinking water, aquifers can support agriculture, and rivers keep running. Climate change is breaking down the predictability of weather patterns across the globe. Two new releases this week, from the Woodwell Climate Research Center and Probable Futures, flesh out our understanding of how the shifting seasonality of precipitation might impact our future.

precipitation trends, showing how they will change with climate change.

The impact of a warmer world on precipitation patterns is not uniform—in some places dry spells will become more common, in others, intense storms, and some places will fluctuate between both. Rainy seasons may start earlier or later in different parts of the world, which will have impacts on growing seasons and agricultural yields.

“Climate change is reshaping both local precipitation patterns and the global water system—and everyone on Earth will be affected,” said Alison Smart, executive director of Probable Futures. “It may seem counterintuitive, but knowing that the future is less predictable is a valuable forecast. Communities need to be more resilient, adaptable, and prepared. It’s within our power today to prepare for the events that are probable, and prevent those with irreversible impacts.”

Snow is melting earlier

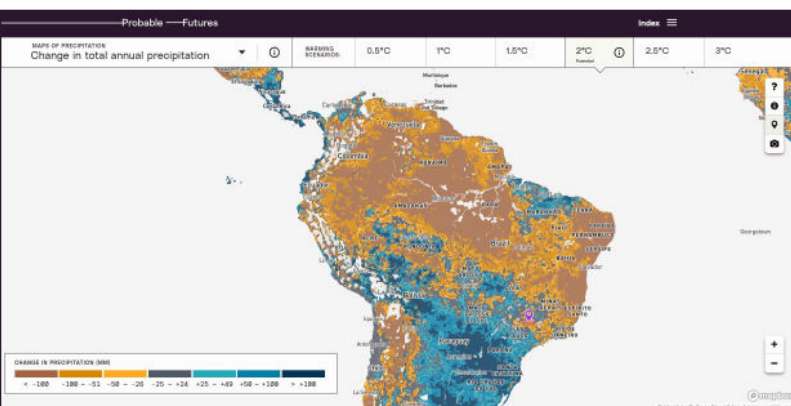
Woodwell Associate Scientist, Dr. Anna Liljedahl and Assistant Scientist Dr. Jenny Watts, were co-authors on a paper also released today that documents the impacts of earlier snowmelt in the Arctic. The Arctic is warming more rapidly than anywhere else on earth, which has led to earlier snow melts and longer growing seasons in the tundra.

Conventional hypotheses have predicted that lengthening summers would allow more time for vegetation to grow and sequester carbon, perhaps offsetting emissions elsewhere.

“Our results show that the expected increased CO₂ sequestration arising from Arctic warming and the associated increase in growing length may not materialize if tundra ecosystems are not able to continue capturing CO₂ later in the season,” said Dr. Donatella Zona, lead author on the paper from the University of Sheffield’s School of Biosciences and the Department of Biology at San Diego State University.

Dr. Liljedahl says that the results highlight the fact that the impacts of climate change will be complex across ecosystems.

“This work shows how important it is to continually assess our assumptions and terminology on how the Arctic system will respond to warming. We often say that warming will lead to a “longer growing season”. We need to be more careful in making that connection,” said Dr. Liljedahl.



Rainy seasons are fluctuating more

A new volume of maps, data, and educational materials recently launched on the Probable Futures platform (www.probablefutures.com). The volume provides information that helps readers better understand local, regional, and global

above left: Burn scars in the forest of the Território Indígena do Xingu. / photo by Divino Silvério

above top: Teenagers play soccer in the rain in São Paulo, Brazil. / photo by Marlon Dias

above: Probable Futures platform shows the change in precipitation for Brazil predicted if the world warms 2 degrees celsius.

A regional approach is essential for high-quality soil carbon credits and durable climate benefits

Woodwell Climate and EDF make the case for better measurement and a regional crediting framework

Soils have the potential to store substantial amounts of carbon and help slow climate change. There is growing interest in carbon markets that would enable investment in—and revenue from—soil carbon capture and storage. In a paper published today in the journal *Science*, researchers from Environmental Defense Fund and Woodwell Climate Research Center recommended creating a regional crediting framework to strengthen the integrity of the voluntary soil carbon market.

The recommendation followed a scientific review that revealed widely disparate approaches to measuring, reporting, and verifying among the 12 published protocols used to generate soil carbon credits through carbon sequestration in croplands. This variation could lead to credits that aren't consistent or comparable.

“To know whether the voluntary soil carbon market is driving down emissions, we need to know that one ton of carbon equals one ton of carbon, regardless of the protocol used. A regional approach would help make this possible, which is good for farmers, businesses and governments working toward climate solutions,” said Dr. Emily Oldfield, lead author and scientist at EDF. “This is the defining decade for slowing climate change. We need to get this right.”

Measuring progress at a regional scale instead of at the project or individual

field level provides the following benefits:

- **Improved accuracy of net greenhouse gas mitigation estimates:** Models are the key to measuring progress and reducing verification costs for farmers and project developers. Existing models that are used to estimate soil carbon sequestration across different soil types and climates work better at regional scales, and developing regional baselines and methodologies would improve measurement and accounting of net greenhouse gas changes, including nitrous oxide, to provide a more complete picture of overall climate impacts.
- **Better visibility into how crop yields and land use are changing:** Accounting across a region and viewing changes both within and outside of project boundaries ensures that the pursuit of soil carbon doesn't jeopardize food security or shift climate pollution from one region to another.
- **More equitable market access:** Public investment in a regional crediting framework can provide financial and technical assistance programs targeted to increase market access.
- **More consistent and comparable credits:** A regional approach would set unified standards for high-quality credits, which would boost confidence and transparency in the voluntary market.

“There's growing momentum behind voluntary soil carbon credits, and it's urgent that we ensure the market is able to deliver lasting climate benefits. Measuring and quantifying net soil carbon and greenhouse gas changes across regions reduces the risk of climate benefits being overstated and creates a stable, long-term foundation for the voluntary market,” said Dr. Jonathan Sanderman, contributing author and senior scientist at the Woodwell Climate Research Center.

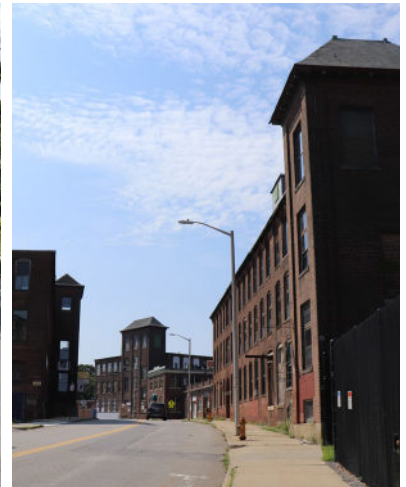
The regional approach recommended in the *Science* paper takes inspiration from the jurisdictional approach that is gaining traction for generating high-quality carbon credits for tropical forest protection. The paper recommends basing a regional approach on existing land classifications used by the United States, European Union, India and China to group together areas with similar soils, climates, and agricultural potential and constraints.

Implementing the recommendations will require public and private investment and ample stakeholder engagement, but the benefits of a regional crediting approach are worth pursuing. This is the best way to ensure the voluntary soil carbon market generates measurable, reliable, long-term climate solutions.

Unequal heat

A visit to Worcester, Massachusetts in the heat of summer highlights the inequities of rising temperatures

Sarah Ruiz Science Writer



It's a hot, humid day in late August and we're all already sweating as Arman Bajracharya begins to tell us about his project.

Bajracharya is a second year Ph.D. student in the geography department at Clark University in Worcester, MA, where we're standing now. He pulls out a green and orange map of the city and points to our location on one of the orange blocks that signals industrial land use and impervious land cover.

We're standing in the sparse shade of some trees ringing the edge of an old millpond, but we had to walk across a hot, cracked parking lot to access it. The neighborhood is called Webster Square. It is located in the southern reaches of Worcester, which was once a vibrant epicenter of the industrial revolution.

That industrial heritage is evident both on the maps Bajracharya shows us as well as in our surroundings. Truck beds and spare pvc piping and gravel piles rest at the edge of the water. It's also scorching hot.

Temperature varies with land cover. In cities, the presence of impervious surfaces like asphalt, concrete, and metal trap heat, while natural surfaces—water or vegetation—can help buffer it. The distribution of these hotspots and heat buffers in Worcester, as in many cities, is not equal. Some neighborhoods endure

much higher temperatures than others during the summer months.

Bajracharya's research during the Summer of 2021 made possible by the Edna Bailey Sussman Fund employed remote sensing and census data to determine what features make a neighborhood more susceptible to extreme heat. He mapped temperature, land cover, and land use onto areas of greatest social vulnerability in Worcester, as well as two other post-industrial cities in Massachusetts, Haverhill and New Bedford. The results show that as climate change warms cities, the communities that have already experienced environmental inequities are likely to face more.

A gateway to the American dream

Worcester, Haverhill, and New Bedford are designated as gateway cities. These places, often important centers of the industrial revolution, have served as "gateways to the American dream," offering job opportunities and housing for many who immigrated to the region.

Worcester began its industrial life as a mill town but soon grew into a manufacturing center for a variety of goods. It was also a crossroads of canal, and later, rail thoroughfares connecting the rest of Massachusetts with Providence and New York. Today, at the edge of the millpond in Webster Square,

the remnants of an old rail bridge are still visible and active trains can be heard traveling the present day rail lines in the distance.

Industrial neighborhoods built to serve mills and factories often filled in with minority populations, and over time, wealthier families moved to quieter and more suburban areas of town. In the case of Haverhill, some communities also suffered the consequences of redlining, a discriminatory Federal Housing policy during the post-Depression era that limited financial services available to people, overwhelmingly African-American and people of color, deemed "hazardous to investment," limiting social mobility and enforcing racial housing segregation. These factors often intensified the overlap between areas of high social vulnerability and industrial infrastructure.

"In the 1930s, these practices delineated which areas were defined to be good for financial services like loans," Bajracharya says. "Which is why there is a historical divide between which areas are favorable and which areas are not. That can impact how we see the land being used today, especially where the greenspaces are."

Mapping the heat

Bajracharya used available satellite data to show the relationship between land cover and social vulnerability. Examining

the imagery, he created an index of relative heat in the city. Areas with high tree cover correlated with lower land surface temperatures. He then overlaid social vulnerability and environmental justice datasets that index communities

Roy Chowdhury have brought us out onto the streets of Worcester. A few blocks away from the millpond, a grassy field rolls out behind a chain-link fence. In Bajracharya's maps, this appears as a patch of vegetation interspersed among

and provide recreational opportunities. Bajracharya and Dr. Roy Chowdhury emphasize the importance of field trips like this one, along with more in-depth work to ground truth satellite image analysis in local realities.



in Massachusetts based on socioeconomic status, minority status, primary language, and other demographic information.

"Throughout many or most U.S. cities, neighborhoods facing greater environmental risks (such as from heat waves, urban flooding, and hazardous wastes) were historically settled by poorer families or racial and ethnic minorities," Bajracharya says. "And there really is a lot of evidence for communities of color, or low-income communities, continuing to be disproportionately exposed to risk."

According to Bajracharya, the analysis showed a startling overlap between the hottest areas of the city and the most vulnerable. Neighborhoods classified as Environmental Justice Communities tended to have a lower percentage of green vegetation (especially tree cover), with higher average temperatures. The most vulnerable areas are clustered in the core of the city.

The satellite maps only tell part of the story, however, which is why Bajracharya and his advisor Dr. Rinku

the developed land uses. The field sits under metal towers belonging to a nearby power station.

Often, Roy Chowdhury reminds us, the "green" and "blue" spaces that do exist in vulnerable areas may be inaccessible to residents, either cordoned off as private property or unsuitable for use due to safety concerns or an absence of trails or paths. The sign on the chain-link fence here warns of danger from high voltage.

This is where the distinction between land cover and land use becomes important. Land cover refers to what is currently on the land—whether that's forest, grassland, or concrete. Land use data shows how humans are interacting with an area of land. For example, an area of grassy land cover could be used for conservation, residential or commercial purposes.

When natural land covers such as trees and water bodies are present but inaccessible, it limits potential social co-benefits that green and blue spaces can offer. Beyond regulating temperature, these spaces can reduce air pollution

"There's a really interesting mix of industrial and commercial uses interspersed with areas important for conservation and recreation, that could also potentially help in bringing down surface temperatures," Dr. Roy Chowdhury says. "Tree cover and water are really helpful for buffering against the urban heat island, but so much more needs to be done to understand and steward such 'ecosystem services,' especially in underserved areas of cities."

Building an Emerald City

With climate change accelerating, every patch of green and blue on the map will become indispensable in regulating city temperatures. To prevent a crisis of infrastructure failures and heat-related illnesses and even deaths from unfolding during brutal summers, cities like Worcester are going to have to get greener, faster—and do so in a way that benefits residents equitably.

Dr. Roy Chowdhury and Bajracharya are interested in investigating further to figure out the most promising pathways towards greener, more equitable cities. Questions still remain around finding the best proportion and distribution of land cover and implementation strategies that will improve environmental equity and encourage citizen participation. Woodwell's Dr. Chris Neill has been collaborating with Dr. Roy Chowdhury and Clark University over the last decade to analyze land cover and ecological structure of urban vegetation in several U.S. cities.

"Every tree makes a difference, but there are scale effects as well. What is the minimum threshold to make a difference? What's the mix in different cities or neighborhoods? What do local residents value and want? These are really

interesting and important questions to ask,” says Dr. Roy Chowdhury.

Research into the interactions between these green spaces and rising temperatures could help city planners make more conscious decisions about climate adaptation. Baracharya’s future projects may also examine flooding risk in cities, which adds another dimension to potential inequities in climate risk. Future research could also incorporate social interviews in different neighborhoods to understand residents’ concerns regarding their environment, climate change, and quality of life.

The last stop on our Worcester tour is Beaver Brook Park—an example of what’s possible when a city decides to reinvest in its natural spaces. The neighborhood surrounding the park was a primary destination for Black Americans moving north after the Civil War and has a history as a vibrant minority community. The titular brook had been paved over years ago, running in darkness under the city until 1990, when it was daylighted again to serve as a central feature of the park.

The area is now a green haven for recreation in the neighborhood and a stop on Worcester’s East-West trail, which

Dr. Roy Chowdhury describes as “an emerald necklace” running through Worcester—one of the ways the city and numerous environmental stewardship organizations are working towards broader greenspace protections and access.

The feel of the air here contrasts sharply with where we started the day—a hint of the power urban greenspaces hold. Despite the heat warping off the street pavement, in the shade of old oak trees by the gurgling brook, it’s easy to stop sweating for a moment and just feel the breeze.

In the news: highlights

Dr. Wayne Walker and Dr. Mike Coe were both quoted in an article from *The Guardian* that described results from their research released today, which found that forests are holding back warming. The work was also featured in articles from *Phys.org*, *MSN*, and *Yahoo!*

Dave McGlinchey was quoted in a *MarketWatch* article on the SEC’s proposed rules regarding climate change disclosure for publicly-traded companies. The article was also published to *MSN*.

Work by Haydee Hernandez-Yañez on species’ life history and their risk of extinction was featured in an article from *MSN*, *Science Alert*, and an *MSN* article in Czech as well.

Dr. Jen Francis and her work on the relationship between the polar vortex and extreme weather were featured in a story on *Scienceline*.

Dr. Anna Liljedahl was quoted on her work using satellites and deep learning in an article from *Government Technology*.

An article from *IG Último Segundo* quoted Dr. Ludmila Rattis on how changing precipitation regimes in Brazil may harm agricultural productivity (Portuguese).

An article in *The Atlantic* was adapted from John W. Reid and Dr. Thomas E. Lovejoy’s upcoming book *Ever Green: Saving Big Forests to Save the Planet*—and also quoted Dr. Mike Coe on forest fragmentation.

Dr. Sue Natali put Arctic seafloor sinkholes in the broader context of climate change for a story for *CNN*, also picked up by *MSN* and *9News Australia*.

A paper co-authored by Dr. Jon Sanderman and Dr. Rachel Rubin on regional soil carbon accounting was published

yesterday in *Science* and featured in a blog post on the Environmental Defense Fund’s website.

An article from *Vrije Universiteit Amsterdam* shares findings from a study published in *Nature*, performed in collaboration with Woodwell scientists—drawing up a new time series for global carbon emissions from deforestation. The publication was also featured in an article from Columbia Climate School, as well as *Phys.org*.

Dr. Sue Natali commented on the implications of the conflict in Ukraine for Arctic research in an article from *Time*, also syndicated to *Yahoo News* and *MSN*.

An article by Dr. Jen Francis on the role of water vapor in fueling hurricanes and rising temperatures was published in *Spektrum* (German).

Dr. Max Holmes commented on U.S. climate misinformation and maladaptation in an article from *The Independent*, picked up by *Yahoo News* and *NewsBreak*. He was also quoted in a *Quartz* article about the lack of response to IPCC report findings, which was picked up by *Yahoo Finance*.

A *Reuters* article on physical climate risk mentioned Woodwell’s partnership with Wellington Management and quoted Wellington’s Chris Goolgasian. The article was syndicated widely to outlets including *Daily Mail*, *Investing.com*, *Yahoo Finance*, *US News Money*, and *NewsBreak*.

Drs. Linda Deegan and Christopher Neill’s cranberry bog restoration project was featured in an article on *UConn Today*.

An article from *The Star* (Malaysia) on re-carbonizing South-East Asia’s blue carbon ecosystems mentioned Dr. Jonathan Sanderman’s research on soil carbon and mangrove deforestation.

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