Q MAGAZINE

Mosquitos Suck

Pests that have plagued humanity pose an even bigger risk as the planet warms

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More inside ...

The CLIMATE CHANGE ISSUE

Institute for Sustainability, Energy, and Environment
UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

VOLUME 6 / ISSUES 1 & 2
A PUBLICATION OF THE UNDERGRADUATE CERTIFICATE IN ENVIRONMENTAL WRITING

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Our Gracious Donor ...

A very special thanks to Janelle Joseph, who has continued her support of the Institute for Sustainability, Energy, and Environment (iSEE) with several generous donations to help *Q Magazine* student writers go on location and research their stories.

Her gifts have also funded the Janelle Joseph Environmental Writing Contest, which debuted in 2020 and offers U of I undergraduates the opportunity to submit articles for cash awards and publication in Q! The contest occurs each summer; so far, award winners have appeared in every issue since 3.2.

"Through my dear friend Joel Friedman, I became aware of iSEE's dedicated programs," said Joseph, pictured here with her dog Moonbeam. "The planet and the environment are where all things future begin. All needs and other great causes depend on where we live and are safe. After hearing about iSEE and *Q Magazine*, I felt HOPE, for the first time in many years, that brilliant young people are working on improvements and solutions."

With Joseph's funding, student writers are inspired to explore environmental issues up close and in person.

We are grateful!

About *Q Magazine*

Welcome to *Q Magazine*, a showcase for inspired environmental writing at the University of Illinois.

Q Magazine features outstanding articles by U of I students, most of them enrolled in the Undergraduate Certificate in Environmental Writing (CEW), a joint venture of the Institute for Sustainability, Energy, and Environment (iSEE), the School for Earth, Society, and Environment (SESE), and the English Department.

When enrolled in the CEW capstone course (ESE 498), students have the opportunity to submit their writing for publication in Q, working closely with instructors and production staff to develop their work to a professional, publishable standard.

The motto of the CEW is "turning data into narrative" — to absorb the latest environmental research and communicate that research effectively to the public. Certificate courses allow students to engage with the latest on-campus research in sustainability science and identify environmental issues they are passionate about.

Whether dropping in to take one of our courses or completing the full three-course sequence, students work with dedicated professors, meet enthusiastic students from disciplines all across campus, and build marketable skills in environmental communication.

Enjoy these student voices, broadcasters for change and a livable planet.

The Writers

Lucca Ammann

Helen Anil

Levi Beckett

Abby Culloton

Olivia Grubisich

Gabe Lareau

Erin Minor

Jenna Schaefer

Matt Troher

Sakshi Vaya

Rachel Weingart

Editor's Note:

In *Q*'s sixth volume, our authors take us around the world to see that climate change impacts much more than rising temperatures. From mosquito-borne disease to typhoons to high school science classes, this volume will leave you reflecting on the many symptoms of an overheated planet.

In our headline piece, Lucca Ammann regales us with her adventures from a summer working in a West Nile mosquito abatement lab, while Janelle Joseph prizewinner Abby Culloton introduces us to the amazing world of citizen science, where everyone can be a part of environmental research. Our special issue also asks how we talk about climate change. Matt Troher delves into how global warming is (or isn't) being taught in our schools, while your student editor, on a visit to the fire-ravaged Pacific Northwest, finds in the Douglas fir tree a symbol of nature's resilience in the face of climate doom and gloom.

Our Vol. 6 *Q* authors offer us a tour of climate impacts abroad as well. Helen Anil spotlights the cultural repercussions of rising sea levels in Kerala, India. In the western Pacific Ocean, Levi Beckett takes readers to the shores of Guam with his firsthand experience of a super typhoon while, further east, Jenna Schaefer brings us along on her study abroad trip to the Galápagos Islands to see its struggle with drought and environmental damage from overtourism.

Newsflash: Climate change solutions are edible. *Q* interviews Illinois professor Esther Ngumbi whose research grapples with food insecurity around the world as changing climates wreak havoc on traditional crops. Gabe Lareau investigates how our beef consumption impacts carbon emissions. And, back on campus, Sakshi Vaya tours the U of I cafeterias for answers to our endemic food waste problem.

There's cause for alarm in these richly varied stories, but also much to inspire. May the probing questions posed here by our *Q* authors spark conversations about the far-reaching impacts of climate change in your own communities.

Erin Minor
Student Editor
And the *Q* Editorial Team

ABOUT THE COVER: Illustration by Haley Ahlers using photo from Shutterstock.com.

ALL ARTICLE CITATIONS: Online at q.sustainability.illinois.edu

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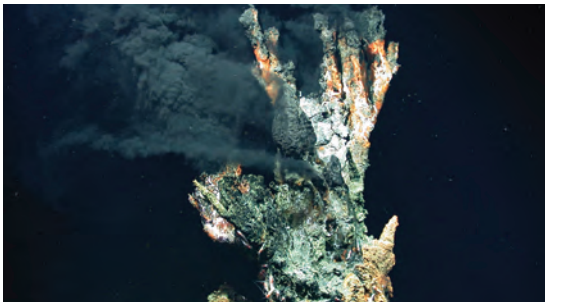

Animal Planet

Called the "Candelabra," this black smoker sits at a depth of 3,300 meters as a part of the Logatchev Hydrothermal Vent Field on the Mid-Atlantic Ridge. *Credit: MARUM Research Facility, University of Bremen*

OUT OF OUR DEPTH

By Olivia Grubisich

Just below the ocean's surface, water glows in sunlight's embrace. Diving deeper, the seafloor slopes, a chill replacing the residual warmth of the sun. Fading from cerulean to navy, the surrounding water thickens as the ocean presses heavily from above. Farther down still, the last remnants of blue vanish and suddenly, yet without grandeur, darkness extends in all directions. Despite the darkness, life exists. At mid-ocean ridges, jagged spires rise against the seascape. Plumes of "smoke" billow from these peaks — in some places thick and dark, in others wispy like white clouds. Along the exterior, yeti crabs scuttle between clusters of tubeworms and deep-sea mussels that cover the rock.

This unique scenery indicates the presence of our ocean's most ancient topography: hydrothermal vents. At these vents, cold seawater seeps through crevices in the ocean floor, where magma heats it at the Earth's center. It re-emerges, providing a tricky sort of chemistry that sustains vibrant communities of life at the bottom of the ocean. Discovered less than 50 years ago, hydrothermal vents revolutionized our understanding of the deep sea and the origins of life on Earth. But now these rare, precious deep-sea environments face threats of destruction from mining companies lurking miles above.

Not long after their discovery, scientists realized hydrothermal vents were full of valuable metals. With this knowledge the vents quickly went from being a new natural wonder to a potential source of materials and profit. Mining companies over the last four decades have explored extracting those minerals from the ocean floor. Now, as society pushes for clean energy and more efficient and sustainable technology built with these metals, they are more eager than ever — so eager, they're willing to begin mining without sufficient research or proper regulations.

The International Seabed Authority (ISA), a U.N. body that governs the business of the sea, met this past summer to solidify regulations for deep-sea mining exploitation. The meeting marked a new phase in a global industry, but even as Pacific island nations and corporations push to mine for undersea minerals, the ISA failed to finalize its rules. That hesitancy, and conflict among ISA members, represents a question that's been lingering for decades: Do the benefits of underwater mineral extraction outweigh the environmental costs?

The discovery of hydrothermal vents in 1977 changed the way scientists think about life on Earth. Until this point, consensus said sunlight was a necessary ingredient for survival. It shouldn't have been possible for so many organisms to live at the vents, thousands of meters below the sun's reach. The key, it turns out, comes from the vents themselves. On its journey back from the center of the Earth, the water releases metal and other inorganic materials into the surrounding area. Special microorganisms interact with the elements, creating energy in a process called "chemosynthesis." The micro-organisms survive and feed other creatures, fostering life at the vents.

Minerals not used up in chemosynthesis continue on a different path, one that lands them in the crosshairs of deep-sea mining. As the hot jets emerge from the seafloor, icy water turns the metals to solids, creating the spindly towers characteristic of hydrothermal vents. Alongside the chimneys, large collections of metals settle on the ocean floor, forming Seafloor Massive Sulfide (SMS) deposits. SMS deposits are full of metals such as iron, zinc, copper, lead, and sometimes other materials like gold, silver, arsenic, cobalt, molybdenum, calcium, and platinum.

While much remains unknown about hydrothermal vents and chemosynthesis, it's clear their unique features play a role in the ocean's viability far beyond the seafloor. Hydrothermal plumes rise hundreds of meters, distributing microorganisms throughout the ocean to interact with other systems. Additionally, vents are large sources of oceanic iron and manganese, two metals essential to the function of organisms like phytoplankton. And phytoplankton play a large role in undersea food webs, acting as primary food sources for a host of different creatures from micro-organisms to blue whales and a plethora of fish in between.

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Feasibility studies of mining SMS deposits began as early as the 1980s, although low demand for metal at the time made this work mostly theoretical. The growing reliance on technology in our ever-modernizing world has returned SMS mining to relevance. SMS deposits contain metals used in green technologies like electric vehicle batteries, solar panels, and windmill magnets. High concentrations of valuable metals make SMS deposits too alluring for mining companies to ignore, but altering the flow of minerals from vents could be catastrophic for ocean systems.

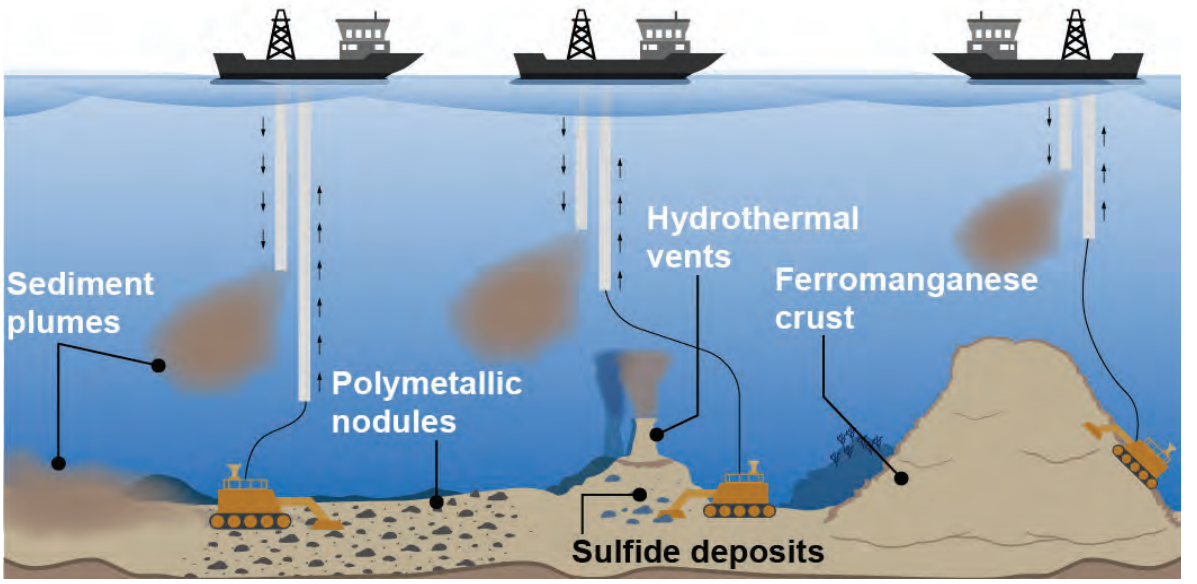
There are several ways mining disrupts ocean life. The sounds of equipment, harsh and alien to the creatures of the sea, reverberate far out into open waters. Deep in the ocean, sound plays a role in how organisms communicate, navigate, and detect prey. The scraping and grinding of metal on rock disturbs all these processes, leaving deep-sea creatures without use of functions they need to survive. Mining additionally hinders visual processes. Bright lights on survey equipment slice through the darkness, harming the sensitive eyes of deep-sea organisms created to live without light. Artificial light also interferes with bioluminescence, which is the only natural source of light at such depths.

Perhaps worst of all, the grinding tools and movement of collector vehicles create sediment clouds. Toxic particles like reduced metals and organic matter stirred up by the machines deplete oxygen from the surrounding area. As clouds resettle, their altered composition interferes with chemosynthesis occurring at the vents.

Even with those environmental consequences, the deep-sea mining industry is pushing ISA to take a stance. Formed in 1994, the ISA is made up of three separate bodies — the Assembly, Council, and Secretariat — that work together to make decisions about the parts of seafloor that lie outside any country's individual jurisdiction. Its primary function, according to ISA Secretary General Michael Lodge, is to regulate exploration for and exploitation of deep seabed minerals found in "the Area," which makes up just over 50% of the ocean seabed.

Mining groups "explore" survey areas they're interested in mining and "exploit" by actually removing metals from the seafloor. The ISA has had exploration regulations in place for years, and so far it's approved 28 exploration contracts in the Pacific, Indian, and Atlantic Oceans covering more than 1.3 million square kilometers of ocean floor. Poland

Shrimp, yeti crabs, and vent mussels gathered together atop hydrothermal vents. *Credit: NOAA Vents Program*



Mining industries set their sights on three main types of deep-sea mining: cobalt found in ferromanganese crusts, seafloor sulfide deposits at hydrothermal vents, and polymetallic nodules.
Credit: U.S. Governmental Accountability Office

"When in doubt, favor nature. Deep-sea mining is not the only alternative to meet the growing demand for minerals vital to new energy sources. It is clear there are doubts as to the effects that this activity might cause."

Edward Anibal Pérez

applied for the 29th contract in January 2017. With so much exploration under way, the desire to exploit grows. Yet despite discussions on exploitation rules dating back to 2014, the ISA still hasn't come to a resolution. Now it faces a deadline to reach consensus, set in motion by an unlikely source.

In 2021, the small Pacific island Nauru announced its intention to begin deep-sea mining, invoking a clause in the U.N.'s Law of the Sea called the "two-year rule" that gave the ISA an ultimatum: Mandate regulations by July 2023, or begin accepting mining applications anyway. A reasonably small player on the global stage, Nauru raised the stakes in a last-ditch effort to save itself. One of the wealthiest countries per capita just 40 years ago, Nauru now faces rising poverty from the effects of climate change and a dwindling supply of phosphate, its main export. Deep-sea mining could be an economic lifeline.

At the ISA meetings that began in March 2023, Nauru stood firm in its desire to mine as soon as possible, gaining support from fellow ISA member China. However, many other member states expressed doubt about exploitation, instead voicing support for precautionary pauses. The Dominican Republic went so far as to formally request mining delays.

"When in doubt, favor nature," Edward Anibal Pérez, the Dominican representative, said at the closing meeting. Deep-sea mining is not the only alternative to meet the growing demand for minerals vital to new energy sources, he said. "It is clear there are doubts as to the effects that this activity might cause."

Meetings resumed in July, giving the ISA one last chance to put together a unified message. But after two weeks of discussion, progress came to a standstill. With 22 total member states holding anti-deep sea mining positions and others pushing for action, the ISA decided it still needed more time.

In a news release, ISA officials lauded the progress made toward drafting regulations, but admitted that official regulations won't be put in place until 2025 at the earliest. It's simultaneously a victory and a dilemma. Delaying regulations could ensure more thorough protections given to hydrothermal vents and their environments. At the same time, the two-year rule deadline passed on July 9, 2023, meaning the ISA must accept exploitation applications. Although none has been submitted yet, Nauru remains eager to begin mining as soon as possible.

Deep-sea mining has boomed over the last few years, but decades ago Canadian company Nautilus Minerals hoped to be the first to successfully mine the deep sea. It began exploring waters near Papua New Guinea in 1997, and gave an Environmental Impact Assessment to the Papua New Guinea Government in 2008, seeking approval for its project called "Solwara 1."

From the start, Solwara 1 created problems for both local and global communities. The information Nautilus made

available to the public about the project failed to satisfy international standards for Free Prior Informed Consent, which are designed to provide indigenous peoples with information about how global endeavors could affect their communities. Without access to this information, people near and far were unsure what to expect once mining began. Unfortunately for locals, it didn't take long to see how deep-sea mining could impact their livelihoods, culture, and traditions.

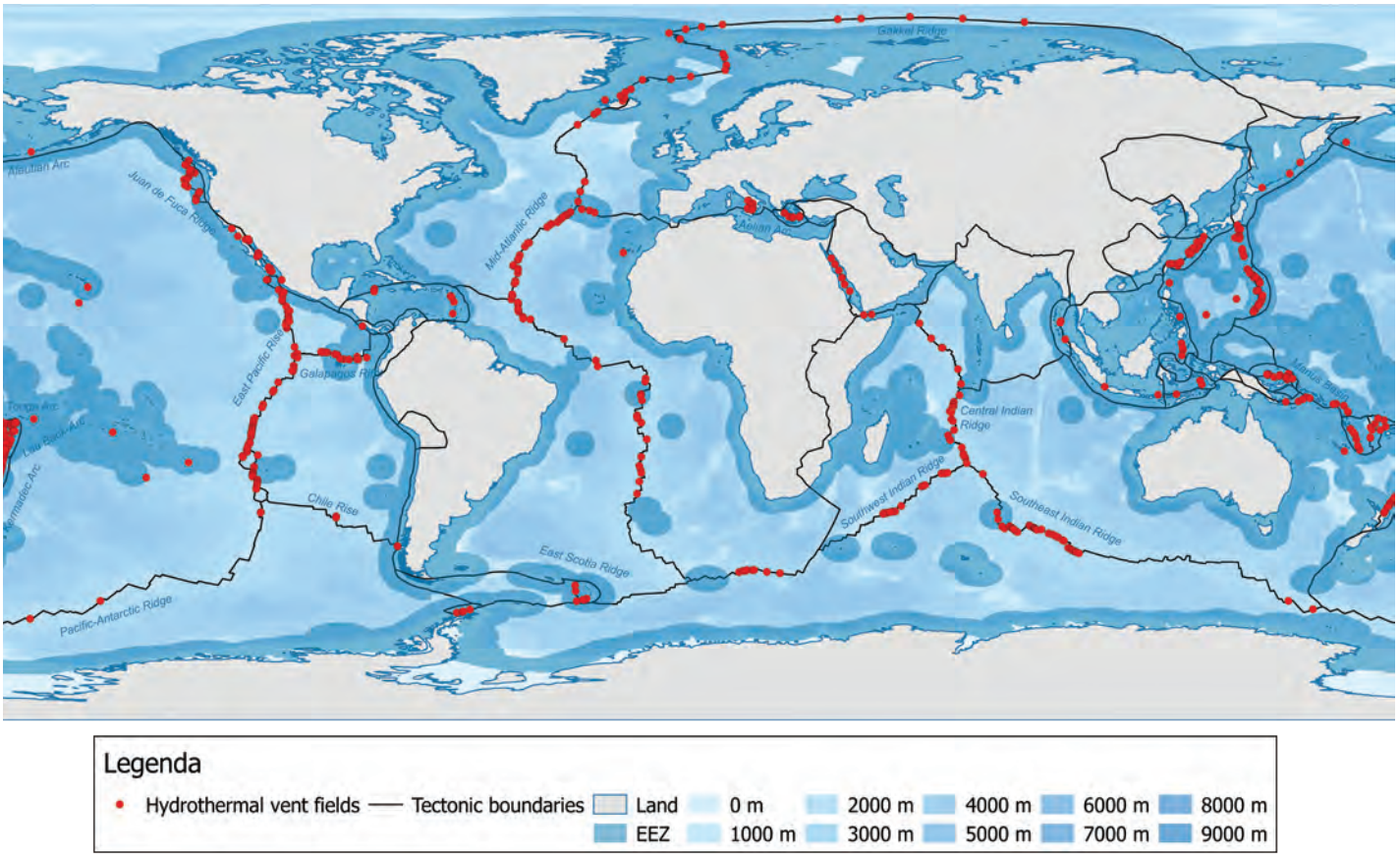
In an ancient practice of shark-calling, men of the native people in Papua New Guinea and New Ireland prepare for a shark hunt weeks ahead, fasting and limiting contact with the rest of their village. Donning traditional attire, they venture out to sea and begin to sing, calling the sharks to them. Catching them with bare hands, the hunters usually return to shore with one or two sharks to feed their village. But mining disrupts all marine life. Unnatural sounds and sediment disorient sharks and drive them away, far from the song of the shark callers.

"We can call sharks to our canoes," Jonathan Mesulam, a shark caller from the New Ireland Province, testified at a Mining Watch Canada Conference. "They are a major source of food for our people. When Nautilus started its exploration activities the sharks left our waters."

The impact on native peoples, their culture, and legacies may not be enough to spark outrage on its own, but concern over deep-sea mining stretches far beyond Papua New Guinea. Mining practices threaten other marine species, have the potential to cause earthquakes, and could create challenges we aren't yet aware of. Scientists across the globe argue deep-sea mining violates the "precautionary principle" — what you don't understand,

Barely 50 years since they first appeared on the human radar, hydrothermal vents have revolutionized the way we look at life, and our energy future. The ghost white crabs and bustling microorganisms represent the sometimes-unimaginable truth: No matter how much knowledge we think we have, our world remains full of mysteries.

The distribution of hydrothermal vents along the world's mid-ocean ridges. *Credit: DeDuijn via Wikimedia Commons*



you probably shouldn't mess with. Hydrothermal vents are still considered a new discovery. Without further study, there's no way to know the long-term consequences of deep-sea mining. The precautionary principle, and marine scientists like Beth Orcutt, say this fact alone should be enough to shut down the entire enterprise until scientists have more information.

"It is difficult to even convey the immense scale of our knowledge gaps." Orcutt explains in an article for *Nature*. "Deep-sea corals — like trees on land — are keystone species in their habitats, providing crucial structure for other forms of life. Scientists don't really know how these corals reproduce: Spawning has never been documented. How can we restore a baseline that we have never observed? We need research covering at least 10 years for each habitat to be able to make evidence-based decisions."

Nautilus continued exploring but started having financial issues before Solwara 1's completion. The project went bankrupt in 2019 and an Australian company called Deep Sea Mining Finance acquired all of the rights, interests, subsidiaries, and intellectual properties of Solwara 1. Its mission was simple: See the project through to completion. According to the Deep Sea Mining Finance website, it is currently working to send production support vehicles to the seabed sites. Eager to move forward, the company continues walking the trail Nautilus paved despite countless warning signs saying to go back. Now, it seems the lid to Pandora's box is likely to come off.

Against the background of the ISA's meetings, the global Deep Sea Mining Summit took place in May 2023, uniting big names and advocates in the deep-sea mining industry. The industry stands on a precipice, yet in the aftermath of the conference there was very little coverage from mainstream media sources about what transpired during the three days of seminars and lectures in London. The only part of the summit flashy enough to garner media attention was a surprise appearance by the villainous trio of Thanos, Dr. Evil, and Darth Vader. During one session, Darth Vader paraded onstage as part of a Greenpeace protest saying, "I'm delighted to be here and learn more about deep-sea mining, because together we can destroy the oceans."

Much of the conference focused on manganese nodule extraction, a type of deep-sea mining that supporters argue is less invasive than traditional mining operations, but the same technology and government regulations apply. Summit discussion topics focused on technological advancements and economic opportunities on the horizon. Most eye-catching on the conference website, nestled nonchalantly between guest speaker head shots and flashy popup ads, were the six key topics of 2023. Naively optimistic, or just plain ironic, one stated the conference's commitment to "Achieving sustainable seabed mining projects in harmony with nature."

Images of large, concrete ships plaster the homepages of corporations attending the Deep Sea Mining Summit. Their mining boats sit in the middle of otherwise unimpeded blue horizons, as out of place as suburban roads across a watershed. Website galleries show robotic arms reaching into the sea and harsh lights illuminating normally dark places; these pictures certainly don't bring harmony to mind.

And yet, the world needs metals. As impacts of climate change continue to unfold before the planet's eyes, many scientists believe a technological revolution is the key to saving our planet. In defense of mining, advocates argue metals from the deep sea are not only profitable, but a necessary step in clean energy's war on climate change.

"Expected metal shortages will derail the energy transition," said Metals Company CEO Gerard Barron in an article for the online publication *Mongabay*. "We owe it to the planet and people living on it, to stay calm, consider all potential sources of metal supply and compare the lifecycle impacts of our options on a project-by-project basis."

To repair the damage done by our industrial footprint on the Earth, deep-sea mining calls for the human hand to reach farther than it ever has, once again taking what it does not own. Barely 50 years since they first appeared on the human radar, hydrothermal vents have revolutionized the way we look at life, and our energy future. The ghost white crabs and bustling microorganisms represent the sometimes-unimaginable truth: No matter how much knowledge we think we have, our world remains full of mysteries. Even in the face of this poignant reminder, we're still willing to justify destroying what's left of Earth's beauty. The ISA decisions are put on hold for now, but with both Nauru and Solwara 1 waiting in the wings to begin mining as soon as possible, there may be little else we can do but watch nature's oldest frontier disappear before our eyes.

Olivia Grubisich is a two-time U of I graduate from New Lenox, Ill. She completed her M.S. in Journalism in August 2023, and before that earned her B.S. in Chemistry. She now works as a Communications Specialist with the Department of Civil and Environmental Engineering at the U of I.

MOSQUITOES SUCK

By Lucca Ammann

***Culex* mosquito bite.**
Credit: Shutterstock

It's my first day of work, summer 2022. I've been hired as a lab intern for North Shore Mosquito Abatement District (NSMAD), a building 5 minutes from my house, unknown to me until my first day of work.

A blast of AC welcomes me into the building, followed by awkward confusion about where to go and what to do. After I waver a moment in the doorway, a few middle-aged male managers approach and take me on a quick tour of the building — the lab, break room, and enormous garage with every inch filled by rows of shiny red pickup trucks. In the corner closest to the lab I see industrial looking freezers and tables piled with equipment — nets, containers, microscopes, and tons of other equipment are stored on shelves. I am led from the hot, dark, concrete garage into the cool, white, and shiny lab.

Two cold tables, originally meant to be used in an ice cream store but cleverly recrafted, are on an island in the lab. A large freezer and PCR test equipment are nestled along the countertops. "PCR" might sound familiar — it's the same process used to test for Covid, and it stands for polymerase chain reaction. The test basically seeks out and amplifies the virus DNA we are searching for. One of my new coworkers is sitting at the island counting mosquitoes. Weird that I would soon know what the black pile of bugs is and what she's doing with it, and that the stranger sitting at the island would quickly become a good friend.

Back in the garage I am handed an assortment of gear, including, but not limited to, navy "NSMAD" T-shirts, which I'll be wearing every day, and an "NSMAD" bucket hat (later stolen by my mom), along with a yellow reflective work vest. Hot. The only truck left for me to claim for the summer is the oldest and largest in the garage, a Ford F-250 (and I have never driven a truck). Awesome.

Mosquitoes are the deadliest animals on Earth. Around 725,000 people are killed and millions infected by mosquitoes every year. Mosquito-borne diseases, such as malaria and Zika, have been ravaging the global south for centuries now.

Before I landed this summer job in a mosquito lab, outside of looking at bugs in the park as a kid, I had no interest in the subject. I had never studied entomology or cared about insects. But as a 21-year-old I was thrown into the wacky world of mosquito abatement and was forever changed by it. At that moment the lab seemed sterile and cold, but I would soon learn it is filled with warmth, curiosity, and often chaos.

Everyone hates mosquitoes. Their buzzing around you all summer long is infuriating, and their bites are itchy and painful, sometimes leading to sleepless summer nights.

Mosquito larvae form dense groups in standing water.
Credit: James Gathany via Wikimedia Commons

A gravid trap, used to catch mosquitoes. *Credit: Lucca Ammann*

But they are also a serious source of disease. Mosquitoes are the deadliest animals on Earth. Around 725,000 people are killed and millions infected by mosquitoes every year. Mosquito-borne diseases, such as malaria and Zika, have been ravaging the global south for centuries now.

For most of the past century, the U.S. hasn't had to worry about mosquito-borne diseases. We don't have to fear that our common mosquito bites will lead to getting sick from the innumerable vector-borne diseases in the world, thanks to mosquito abatement. Other parts of the world do not enjoy this luxury. Countries close to the equator are typically bombarded by mosquitoes and their diseases. Mosquito abatement programs have been a success in our country, but with global warming opening up more regions to mosquitoes, the battle is getting harder and harder to win, even here in the Midwest. African and Asian countries have malaria; the Chicago area faces the threat of West Nile Virus.

North American abatement first started in the early 1900s, when malaria was a huge issue. It was a normal summertime illness, unavoidable, for centuries. Now malaria is eradicated in the U.S. and an issue for most people in the global north only when traveling.

During my summer on the front lines, my contribution to mosquito abatement consisted of surveying a given area, reducing breeding sites, dropping larvicides, and testing adult mosquitoes for West Nile Virus. Every morning at 7:30 a.m., a stream of red pickup trucks filed out of the NSMAD parking lot.

We collected gravid traps — a tub of stink water with a battery-powered fan pushing air from above the tub into a net. Female mosquitoes (at least the ones we were after) lay their eggs on water, so as they were attracted to the water to lay their eggs, they get blown into the net. "Stink water" is aptly named. It is rabbit food and water placed in the sun to ferment in a huge tank and then divided up into containers to carry to the traps. One summer morning, I spilled a whole bucket all over the bed of my truck and the garage driveway. (I was not popular that day.) I was reminded of the apt name every day thereafter as our trucks perpetually wafted the foul aroma along the Chicago North Shore.

Later, after collecting the traps, we returned to the lab to organize and prepare nets for PCR testing. "Doing the nets" felt very labor-intensive at first; we hand-counted, gendered, and speciated each mosquito from every net. Picture me, hunched over the cold tables going "122, 123, 124..." as I moved around individual mosquitoes with tweezers. I later learned that we not only want to collect the mosquito that carries West Nile Virus, but also to use the nets as general surveillance of all species present in the area. There are 28 traps spaced out across the NSMAD district.

This process was organized by Christopher Xamplas, Vector Biologist at NSMAD for 13 years and my supervisor. He had the job of wrangling our team of four lab staff. Xamplas and my coworkers taught me everything I needed to know, from trap collection to PCR testing, and now, the history and future of mosquitoes and abatement.

NSMAD Vector Biologist Christopher Xamplas extracts DNA from a mosquito sample. *Credit: Lucca Ammann*

North American abatement first started in the early 1900s, when malaria was a huge issue. Xamplas explains that without mosquito abatement, "if you were to travel through Chicago in the late 1800s-early 1900s you were probably going to catch malaria." It was a normal summertime illness, unavoidable for centuries. Now malaria is eradicated in the U.S. and an issue for most people in the global north only when traveling. For example, I've had to take preventative malaria pills during a trip to Thailand. (Warning: They give you very weird dreams.)

The new threat, West Nile Virus (WNV), originally arrived in 1999 in New York and spread rapidly across the country. It is thought to have been brought over on a cargo ship carrying tires containing infected *Culex* eggs. Soon after the ship docked, birds at the New York Zoo started dying, and then humans became sick. By 2002, U.S. outbreaks were at an all-time high, including in Chicago.

"For a number of reasons the entire Chicago area is a hotbed for West Nile Virus," Xamplas says. Due to the area's swampy history, mosquito populations thrive. Standing floodwater, outdated sewer and drainage systems, and humid summers create a lovely mosquito oasis. The urban landscape of man-made water catch basins have exacerbated this mosquito environment, especially for the *Culex* mosquito.

The *Culex* genus of mosquito, especially *Culex pipiens*, spreads WNV. It is known as the common house mosquito because of its ability to seek out and breed in any urban standing water. Birds are a common vector. "The *Culex restuans*," Xamplas explains, "is primarily an avian biter," and the West Nile Virus prefers to harbor in robins. "So you have the *restuans* biting and then spreading WNV amongst the bird population. Then you get a mosquito like the *pipiens*, the house mosquito which lives around people. They will feed on birds while also having a preference to feed on humans. You get the mosquitoes bridging the WNV from the birds onto people."

As this description may suggest, most species of mosquitoes are, surprisingly, not primarily human feeders. They started feeding on us as we began forming larger villages and cities. With denser human populations and reliable water reservoirs, we became attractive. Some mosquito species basically "evolved" to rely on our urban water for breeding, and us for food, and hence became "specialized" to humans. *Culex pipiens* is a prime example.

In the lab, we collected females (the males don't bite) to test for traces of WNV. Every summer, when we first detect WNV the public is alerted and testing ramps up. Friends and family constantly asked how I avoided contracting the disease, but because of abatement, human cases are relatively low. There were only 1,035 reported U.S. cases in 2022, and 30 cases in Illinois. While looking through the years of national and NSMAD data on WNV,

The new threat, West Nile Virus (WNV), originally arrived in 1999 in New York and spread rapidly across the country. It is thought to have been brought over on a cargo ship carrying tires containing infected *Culex* eggs. Soon after the ship docked, birds at the New York Zoo started dying, and then humans became sick. By 2002, U.S. outbreaks were at an all-time high, including in Chicago.

I expected to see declining cases. Unfortunately, I was only partially correct. There is a huge correlation between high WNV cases and weather. After a summer storm, we spent more time hunting for breeding sites and occasionally using larvicide.

During my summer as a mosquito lab technician, we also aided in a research project on the breeding habits of *Culex restuans* and *Culex pipiens*. Whenever we had time, we headed off to explore our urban wonderland of abandoned tires and dirty buckets. Nine times out of 10, little larvae would be swimming around and looking back up at us. The number of breeding sites we found was shocking to me. Anything that can catch rainwater and sit for a few days can breed mosquitoes. Females can lay eggs in the water, which then turn to larvae, pupa, and eventually adult mosquitoes, who then fly away from the catch basin and terrorize your neighborhood. These mosquitoes are thriving in our urban world of waste.

Since mosquitoes require warm climates, the U.S. only sees them during the summer. But record-breaking warm summers are changing ecosystems and extending mosquito season. A longer mosquito season means more disease transmission and more time to crawl north. Zika virus is typical in this regard. Though the virus has been around for almost a century, its entry into the U.S. during the summer of 2016 caused a panic, and deaths. It is certain that globalization will continue to spread mosquito species, but so will global warming impacts.

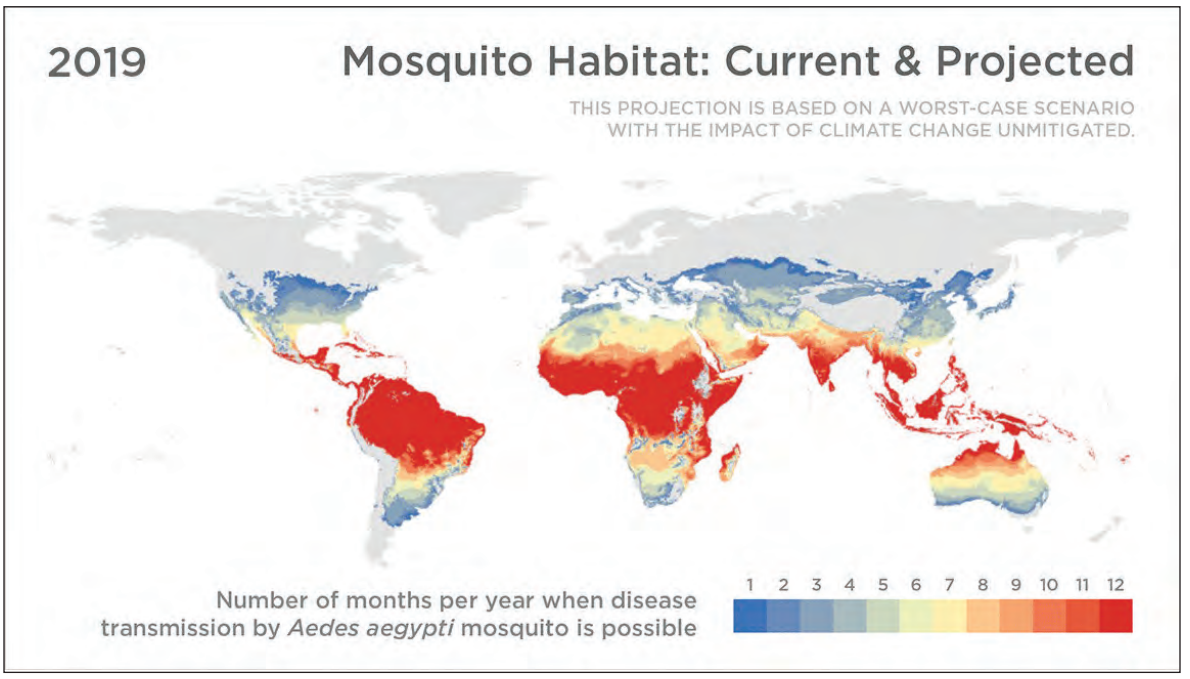
Hotter, wetter summers result in more mosquitoes, and therefore more WNV, and the weather is increasingly harder to predict. Low numbers one summer do not promise low numbers the next, which makes consistent abatement support and funding an issue. In 2012, after abatement funding in Dallas County, Texas, was reduced,

Record-breaking warm summers are changing ecosystems and extending mosquito season. A longer mosquito season means more disease transmission and more time to crawl north. Zika virus is typical in this regard. Though the virus has been around for almost a century, its entry into the U.S. during the summer of 2016 caused a panic, and deaths. It is certain that globalization will continue to spread mosquito species, but so will global warming impacts.

mosquitoes began to appear in relatively larger numbers than normal. WNV was detected in the first mosquito samples of the summer, so the county started routine larvicide applications until August, but it was already too late. Dallas County began to experience one of the worst WNV outbreaks since the disease originated in the U.S. Only after the outbreak was labeled an endemic would more extreme measures, such as truck and aerial pesticides, be used. A total of 1,763 illnesses were confirmed in the country that summer, and 81 people died. Prevention and WNV monitoring now starts in May, or right when mosquitoes begin emerging for the summer.

Brian Allan, a Professor of Entomology at Illinois, studies vector-borne diseases, especially how our environment and these diseases are affected by each other. I asked him if climate change is going to increase the threat of mosquito-borne diseases. His answer is complicated; it's a multifaceted problem. While "lots of scientists have made reasonable predictions that climate change will alter vector-borne disease risk," Allan says, "one of the big predictions is geographical shifts. Diseases we've always thought of as tropical diseases [are] suddenly occurring in the southern U.S." What's harder to tease out, though, is "how much are those changes in distribution being caused by change in climate, versus are they being caused by other things changing, like humans moving around and bringing mosquitoes to new areas." In other words, global population movements, climate change, and vector-borne diseases are inextricably linked.

Deforestation is another complicating factor. "Deforestation," Allan continues, "is probably a more major driver of disease emergence than is climate change right now." It affects the habitat of animals, which alters the "geographical distributions of vector-borne diseases." My boss also emphasized the risk of disastrous weather, especially hurricanes. "Imagine there's a hundred miles knocked out by a hurricane," Xamplas says. "Swimming pools are left to breed, flooded areas, places holding water are not taken care of." In places like Florida and Louisiana, mosquitoes can make it unbearable for search and rescue and rebuilding efforts.



Credit: Koko Nakajima via NPR

Summer rain in Chicagoland is often a precursor to swarms of mosquitoes.
Credit: Robert Lawton via Wikimedia Commons

Our mosquito problem can be exacerbated in many ways, but one thing entomologists know is that a new mosquito-borne disease is coming. "There's inevitably going to be another virus, another West Nile," Xamplas says, and Allan concurs. Over the past century of abatement there has been a pattern of diseases popping up. By the time one disease is under control in an area, a new one begins to emerge. Before WNV was St. Louis encephalitis, and before that, malaria. We still check for St. Louis encephalitis in our mosquito samples, just in case the next wave of vector-borne disease is one from the past.

My strange summer job ended up being an incredibly unique experience. The lab and the Ford F-250 became home, and I still think of the giggling of my coworkers as we count thousands of mosquitoes by hand with music playing in the background. I see Xamplas giving disapproving looks (always followed by a chuckle and a wave) as we pile into the truck to search for breeding sites, and probably ice cream. I never felt threatened or scared by mosquitoes or the diseases they can carry. It was all very controlled.

But behind my fond memories lies a darker reality. While *Culex pipiens* was by far the most abundant mosquito species collected, we saw many different species in the nets. The new species seemed to grow in abundance as the summer went on. To us, these discoveries were exciting. The whole office would fan-girl and take turns looking at them under a microscope. Alarmingly, in retrospect, we found an increasing number of *Aedes japonicus*. "I found 10 my first year here," Xamplas says, "and now we get over a thousand every year. (It) incrementally increased until it became the third highest numbered mosquito in our traps." *Aedes japonicus* is known for transmitting yellow fever, dengue fever, Zika, and chikungunya virus. Although Xamplas wavered over attributing their increasing numbers to climate change, he did admit that given "one mild winter they can survive long enough to inch their way north." Without intensive abatement, I now realize, our summers would be unbearable, and many more lives would be lost. While we may be winning our local battle, the future of the war is uncertain. Globally, the situation is much less controlled, while the threat of a new mosquito virus outbreak hangs over Chicago every summer like a humid cloud. The odds, after all, are in the mosquitoes' favor.

Lucca Ammann graduated from the U of I in May 2023 with a B.S. in Earth, Society, and Environmental Sustainability, and a minor in Urban Planning. She is from the Chicagoland area, where she has begun a year of service with AmeriCorps. She hopes to continue her career in the environmental nonprofit field.

The Unreliable Bestiary

By Erin Minor

During the first choreography run with the giant whale models, Deke Weaver (in green) works with the performers to time out a dramatic interlude when a whale mother and her child come under attack. The creative energies of Weaver and his wife Jennifer Allen are paired up with dancers, designers, and other creative specialists as they build the production for **CETACEAN.** *Credit: UI NEWS BUREAU/FRED ZWICKY*

In the depths of Central Illinois dwells "The Unreliable Bestiary," an ark of stories about endangered animals, our relationships with them, and the worlds they inhabit. Through environmental theater, performance artists Deke Weaver and Jennifer Allen have found a unique way to communicate their love for the natural world — and to help speak for the creatures and habitats that are disappearing because of climate change and other human factors. The latest exhibit in the Bestiary — "CETACEAN (The Whale)" — was performed Sept. 28 to Oct. 2, 2023, at the University of Illinois Stock Pavilion. The show was free and attracted crowds of 400-500 people for each performance during its five-night run. A smash hit for environmental theater at Illinois!

Deke Weaver is a Professor of New Media in the School of Art and Design at the University of Illinois. Outside of teaching, he co-creates multidisciplinary performance pieces with Allen, who is a choreographer and director when not working at her acupuncture practice in Champaign.

***Q Magazine* sat down with Weaver and Allen ahead of the "CETACEAN" premiere to discuss their careers, the development of their latest show, and the power of theater to dramatize ecological connectedness and crisis.**

How would you describe "The Unreliable Bestiary" to someone who has no knowledge of it?

DW: Jen and I met each other in performance. She has a history of dance and choreography, but for me, performance and storytelling came out of a visual arts background. I came up with the idea for "The Unreliable Bestiary" when I realized that most of the stories and performances I was creating always had some sort of animal involved. So it is a big project with a performance for every letter of the alphabet, each letter represented by an endangered animal or habitat. The animals are the obvious part of the story that get people in the tent. But once the audience is there, you realize the stories are not just about the animals but ultimately about us and our relationship to the animals. My goal with this project is to find and create stories that feel urgent and connect with people emotionally here in Central Illinois. Even though the animal might not exist here in the wild, I want to highlight the ways that we're all connected.

JA: What we do is multidisciplinary, meaning that it uses all of these different art forms. All the different ways you present the information is absorbed by the audience in different ways.

When we hear a narrative, we're explicitly being told what is happening, and when you see people dancing, it can be interpreted a lot of different ways. So it blows open the possibility for things to be more abstract and include other ways of feeling.

Why did you decide to use endangered species to tell this story of climate change?

DW: In some ways, it's Storytelling 101. If you're going to tell a story you want to have a threat. It's a way to build the scaffolding so that you can talk about these other things. And metaphorically you can talk about your own ideas of being under threat or pushed up against a wall where you don't have anywhere else to go. It's also connected to personal experience. My dad is an ornithologist and wildlife management guy. When I was a little kid, trumpeter swans had been hunted out of Minnesota. My dad was one of the people who helped bring them back to the region.

JA: I grew up in Oregon, so I spent a lot of time hiking in the mountains and visiting the ocean. Those experiences made the natural world very real to me, so I cared about it a lot. Then I moved to New York City and was exposed to people who grew up in an urban environment where a natural world experience didn't mean anything to them. Having grown up surrounded by trees and mountains, I think I value it more and see how the whole planet works as a system. As more people move to cities, they get more separated from caring about the environment because they never see it, don't experience it. So animals are one way to get people to care a little more. We started with the charismatic megafauna because it will get someone looking through the eyes of a creature like us, rather than something abstract like the erosion of natural ecosystems.

Weaver and Allen.
Credit: Deke Weaver

You are also a professor here at the U of I. How does this work influence your teaching and vice versa; do your teaching and experiences in the classroom have any impact on your performance art?

DW: My performance work impacts who I am, and that's going to come out in classes. At this point I haven't taught a specific art/ecology class, but there is a performance art class I've been teaching for years. It's my favorite class. It takes people away from the screen and gets them to be physical. I watch people embrace things they haven't tried before. Get them out of their ruts and assumptions and start to become confident with things that might have been scary. That's something art can do — question the status quo. And it's exciting to watch that happen in real time.

Briefly walk me through your career paths. What's led you here?

JA: I went to New York University to study in the dance department at Tisch and graduated with a BFA. Then I went right into dancing professionally in New York and touring around Europe for many years. But it was a different time. I was able to work on the side (temping in offices, restaurants) to cover my cost of living so that I could dance for choreographers who didn't have much money to pay me. Because of the way the economy is now I think that's harder and harder for kids to do. Since our country doesn't fund artmaking like it used to, there's less of a safety net for artists, putting more pressure on them to work more full time at something else.

DW: Out of college I spent a year working odd jobs before going to grad school in Boulder, Colo. I went for photography, but our teacher encouraged us to try video and performance — which I realized I really liked a lot. So I took a hard turn there. At that point I decided to move to San Francisco, where I lived for 10 years working jobs that allowed me to have access to equipment, taking evening shifts so I had time during the day to do my own stuff. When I moved to New York I was working at Showtime, the cable network, which paid pretty well and allowed me to be around smart, interesting people and learn a lot on the job. After a while, I decided I should make the jump to try to teach. There were lots of teaching opportunities at that time. I ended up at the U of I, which was great. From the start the people were interesting, there was funding for research, and now we've been here for 18 years.

The Unreliable Bestiary productions were inspired by the literary concept of the unreliable narrator and the medieval bestiary, which gave every living thing a spiritual purpose. These productions share stories about animals, our relationships with them, and the worlds they inhabit. *Credit: UI NEWS BUREAU/ FRED ZWICKY*

How do you make use of the community in Champaign-Urbana? Is there a way for students or community members to be involved in your performances beyond being an audience member?

DW: Yeah, definitely. Students work with us on all different levels: Sometimes they're in the show, sometimes they're making the art that's in it. For CETACEAN we're going to need so many people. In particular, the Whale is a big endeavor, we'll be trying to string 3,000 bottles up into the air — it'll be a challenge.

It sounds like you've been working on the Whale for a while. What does your process look like in between performances?

DW: This one has been longer, and the reason is probably because of COVID. We gave it a little bit more time because a lot of research opportunities had shut down. Usually, it's about three years between each one. This gives time to raise money and figure out a venue — which is important because it's often a site specific to the human-animal story. They're often hosted in unusual spaces, which is really fun and interesting but adds a challenge to make things work in spaces that are not set up for performances.

JA: We're making these alternative spaces into a theater: bringing in lights and projections that would already be set up in a regular theater.

DW: In terms of writing the story, for the first year I'm doing a lot of reading and having back-and-forth conversations with Jen, getting excited about certain things. For Whale, it turns out that there's not that many spots on a boat for whale research and a lot of people want to go on those boats. I had a residency in Washington and while I was there Jen's mom was constantly keeping an eye out for things related to whales. She told me about a whale that had beached about four hours south of me. So I jumped in the car and drove down to see the beached whale.

JA: It's more than just seeing the animals, though. Part of the experience of going to places where the animals are is that he's filming them. This footage then becomes video used in the performances. Which becomes another layer of storytelling, like a memoir.

DW: It doesn't always work though. I went to a national park in India for TIGER. The park was advertised like "Come see the tigers." I was there for a week and didn't see a single tiger. But you find ways to make that part of the story.

Over the more than a decade you've spent on this project, what have you taken away from this about the role that humans play in the environment?

DW: All these different beings have a reason for being here. That's the whole definition of a bestiary. A bestiary is the idea that every single thing on the planet has a spiritual purpose — a reason for being part of the planet. And I mean spiritual as systems all interconnecting. All these different things have a purpose. Aldo Leopold has a famous quote, "To keep every cog and wheel is the first rule of intelligent tinkering." You don't throw anything away, even if you don't know what it does.

JA: All the parts are important even if you don't understand them. There's a hubris in our thinking, "Well, just because I don't understand it, it must not matter."

DW: The message of the shows has also changed a bit over time. The first one we did was in 2009 with MONKEY, then ELEPHANT was right after in 2010. Those two were less about climate change, and I feel like as we've gone on, they've become more and more about the interconnection of systems causing climate and habitat destruction.

Tell me about CETACEAN. How do you get audiences in central Illinois to relate to these animals that maybe they've seen in a zoo before but don't have any obvious impacts on our ecosystem?

DW: That is the trick in trying to write stories. For example, with ELEPHANT there's actually plenty of stories in the Midwest about elephants in zoos and circuses. But when you go back 5,000 years, there's also mammoths and mastodons. It's not just about real-life interactions with the animals; these animals exist in our imagination — in our stories, cartoons, and fairytales.

CETACEAN has been a longer project that included people all over the community. I ended up going into 45 different classes at high schools in Champaign-Urbana and on campus doing workshops with over 800 kids. There were conversations about how water and waste from our houses and farmland runs down the Mississippi and contributes to the dead zone in the Gulf of Mexico. So we're introducing students to these ideas of connected systems. These conversations aren't in the final show, but they've been in the project through the workshops and the knowledge that gets built up making these shows.

One of the things we did in these workshops were writing exercises. I asked kids to write down what they're afraid

> One of the things we did in these workshops were writing exercises. I asked kids to write down what they're afraid of over different periods of time, crumpled those papers up and burned them. Then we took that fear-ash, mixed it with sand, and put it in the water bottles. Then we did a similar thing with hope, made six origami stars, and put those stars of hope in the bottle with the fear-sand. Now we're making a sea of these bottles and telling these stories under a sea of hope and fear. So it allows for the idea that something can be there in the show and add a layer of meaning without explicitly being talked about.
>
> Deke Weaver

A sea of water bottles.
Credit: Erin Minor

Wood whales.
Credit: Erin Minor

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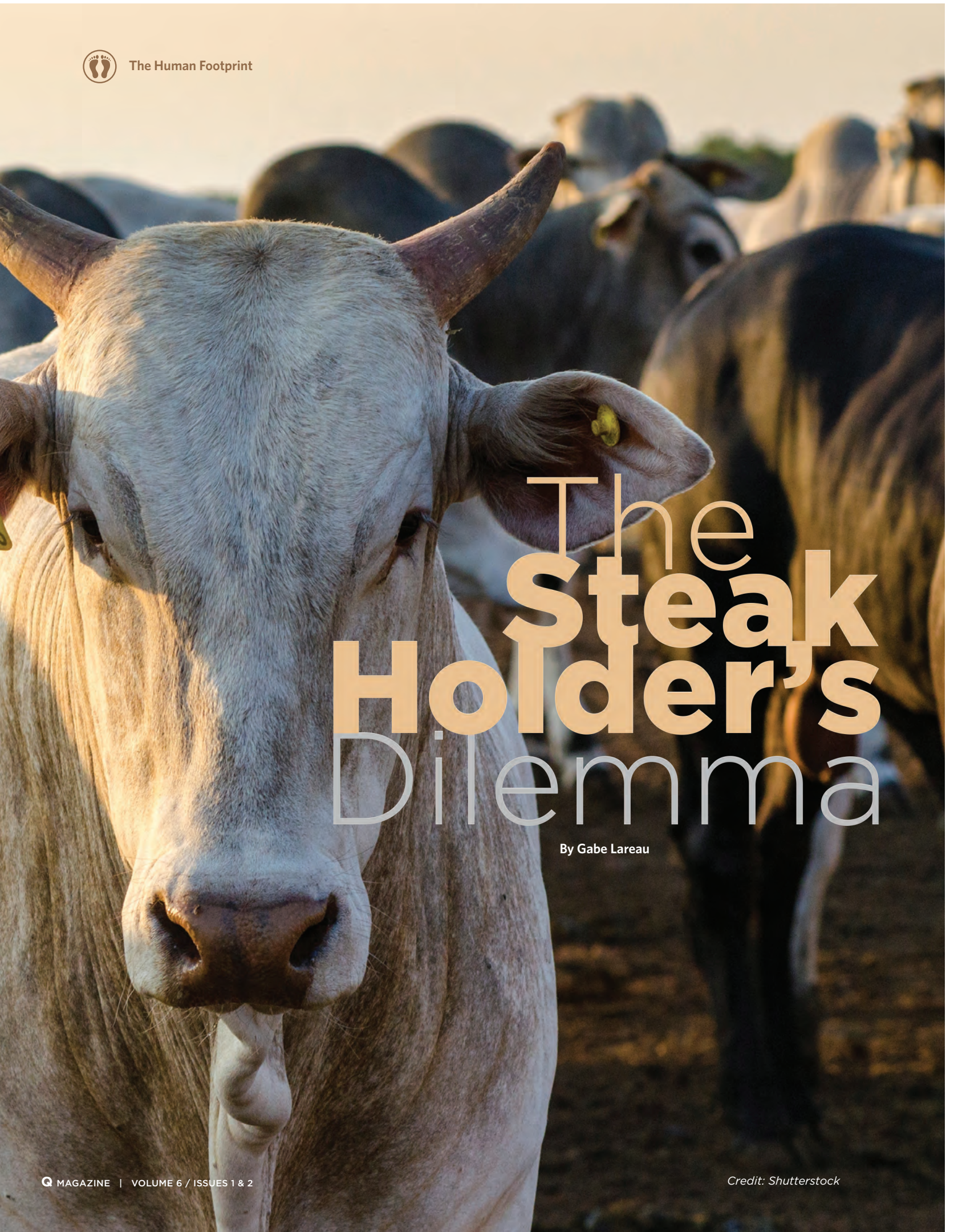
What do you hope people take away from "The Unreliable Bestiary" performances?

DW: These issues are becoming more urgent. Sometimes when people are doing work like this one of the criticisms you get is that you're preaching to the choir; everyone there already holds the same opinion about the issues. Maybe so. I don't think it's a bad thing to gather in community and to feel that sense of urgency as a group. A lot of people feel this sense of panic waiting for others to wake up and realize the climate problem is happening right now. I want people to feel that connection in a way that makes them feel less alone.

JA: You can be given permission to care about how the world is changing within a group of people. There's a power in that that is different from watching something on a screen by yourself, which can feel very isolating. This came out of COVID where there was not that much going on in person, and since both of us are performing artists, we really care about live performance. Humans are physical creatures and when we're in a room together there's a resonance that happens around the room with each other. Everyone has their own private feelings but also experiences a feeling that comes from the group itself. That is really different than being in your head watching a flat screen. Obviously, the specific information in the show is something we both care about — talking about the relationship of plastics in the water and all the creatures including whales that are affected by that. But at the end of the day, it's about this phenomenon of getting to bring people together and share an experience together.

Erin Minor is *Q Magazine's* Volume 6 Student Editor. From Urbana, Ill., she earned degrees in Political Science and Earth, Society, and Environmental Sustainability as well as the Certificate in Environmental Writing. She also served as a Communications Intern with iSEE.



The Steak Holder's Dilemma

By Gabe Lareau

Credit: Shutterstock

At the start of 2022, the world took part in its yearly tradition of adding new data to all the graphs tracking our ongoing environmental catastrophe. Previous forecasts turned out to be pretty accurate: 2022 would become the hottest year on record for the ninth year in a row. A heat wave in Europe caused 20,000 excess deaths and global coal use reached a new high, surpassing 8 billion tons.

In light of all this bad news, I decided it was time to treat 2022 differently — the reckless personal environmental choices I knew were wrong but still committed would be things of the past. With a bike as my main transport, laundry often clothesline-dried, and lightbulbs mostly LEDs, I'd checked almost every box an individual can in order to live a sustainable lifestyle. But there was one thing I'd willingly ignored for too long: meat. Its production, consumption, and disposal all contribute significantly to climate change and other ecological problems, so I decided that 2022 would be the Year of No Beef. During this year, I would deliberately avoid any red meat from animals that burped greenhouse gases, like beef and lamb. Special dispensations would be seldom to maximize my carbon impact.

Spoiler alert: I failed the Year of No Beef twice over.

Why was not eating beef so difficult? For an entire nesting doll of reasons. There are the complex structures of our global economy and food systems, built by powerful corporations wielding cash stores to fund biased "science." And then there are the cultural influences that have impacted my tastebuds from the outset. Old habits, especially societally expected ones, die hard. Like most Americans, I was taught from an early age that a meal was incomplete without an animal on the plate, and cow was often the animal of choice. People grill beef with relative ease, chumming around with a beer in their hand while they do it. Its endless cuts are easily integrated into casseroles, curries, Reubens, and roasts. It's so delicious. It has fueled a decades-long addiction I could not simply quit cold turkey — or cold beef, rather.

As an American, at least I knew I was not alone. We prodigal Americans slaughter the fattened calf. Often. Our World in Data reports that, in 2020, Americans consumed 37 kg (81 lbs.) of beef per capita — the second most in the world behind only Argentina and more than four times the global average. The United States is also

A herd of Nelore cattle in Goiás, Brazil.
Credit: Carlos Ebert via Wikimedia Commons

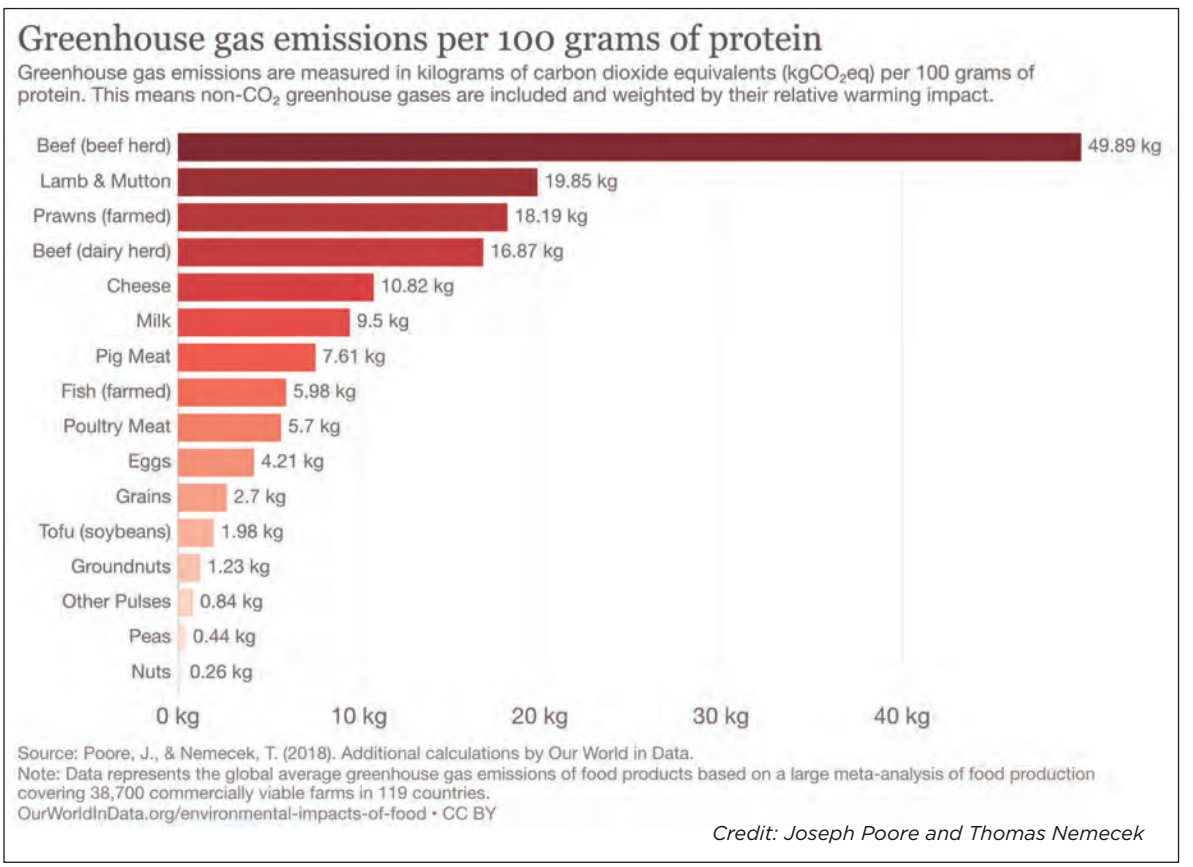
tied for first place in overall meat consumption with Portugal, totaling 149 kg (328 lbs.) per person per year, well over twice the world average.

This meat culture runs deep. There is a certain, quintessentially American character to the Memorial Day or Fourth of July cookout and the football tailgate. Beef equals freedom and family. It defines the American identity. *À la* the recent controversy surrounding gas stoves, pro-environment messages of mitigating meat consumption have been convoluted into a false but provoking message of, "They want to take away our burgers!" For many, abandoning meat is equivalent to debasing our national character.

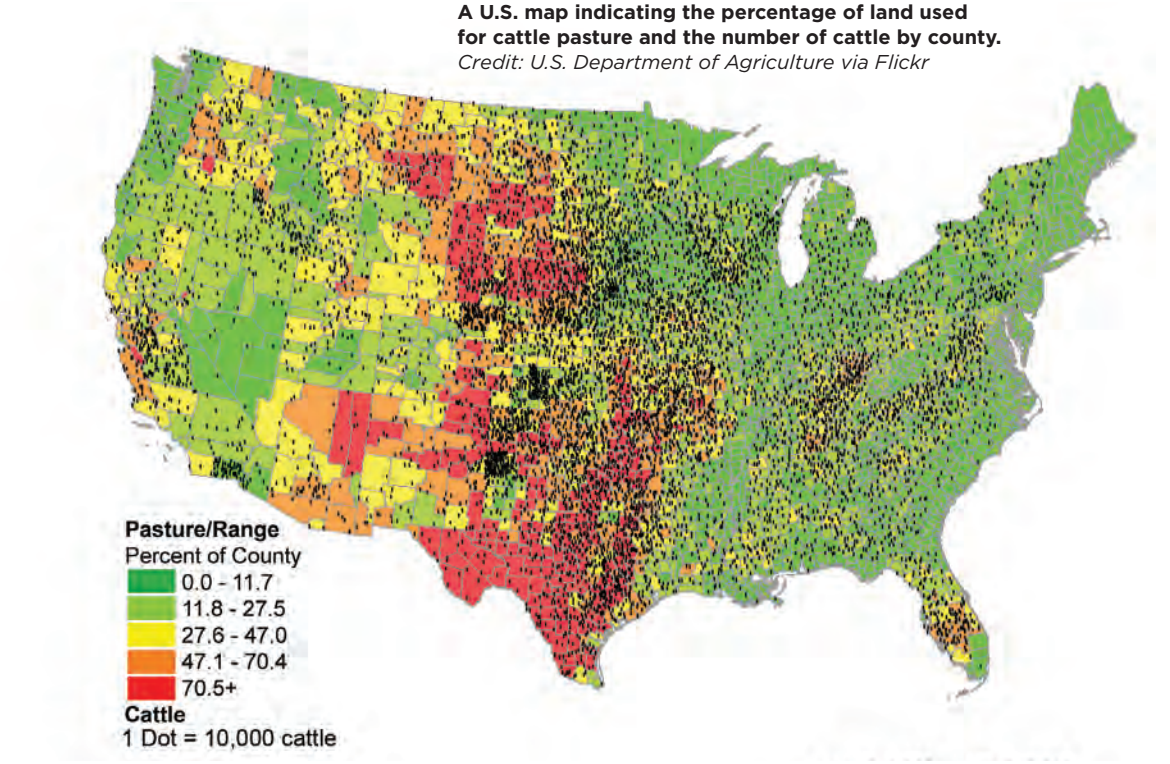
But loving meat is hardly just an American thing. It spans the globe and goes back deep into human history. Over 2.6 million years ago, our earliest hominid ancestors — perhaps out of hunger-driven desperation or inspiration from our own predators — began to sneak smackerels of this calorie- and protein-dense animal flesh into their diet. We didn't really stop. Every ancient society, from the Han Dynasty to the ancient Romans, regarded meat as a fine delicacy, even if it did purportedly give the latter the runs. With the advent of industrial farming, the price of meat plummeted as its popularity skyrocketed. Instead of consuming a mostly plant-based diet, where we capture the sun's energy in chlorophyll, industrial meat production rerouted that energy from plants into animals on an unprecedented and unsustainable scale. Americans' obsession with meat has made livestock an unwilling, and inefficient, middleman in the food energy transfer system. That one extra step has become a vacuum for resources and a vent-pipe for emissions.

Put another way, meat is as environmentally destructive as it is delicious. Meat production currently accounts for around 15% of global greenhouse gas emissions, according to *Science*, and beef is by far the worst offender. One kilogram of beef emits about 100 kilograms worth of CO_2 equivalents. For comparison, pork clocks in at about 12 kg, while chicken is at 10.

A variety of factors is at play here. Most notable (and pungent) is the fact that a cow's digestive system produces methane, a greenhouse gas 23 times more effective at warming the planet than carbon dioxide. Despite its much shorter lifespan within the atmosphere compared to CO_2 — "around 12 years compared with centuries" according to the International Energy Agency — its presence is still bad for the climate. "Methane is responsible for around 30% of the rise in global temperatures since the industrial revolution," according to the International Energy Agency.



Credit: Joseph Poore and Thomas Nemecek



A U.S. map indicating the percentage of land used for cattle pasture and the number of cattle by county.
Credit: U.S. Department of Agriculture via Flickr

Things compound when you realize that nearly 194.7 kg of beef — nearly 780,000 cattle — are wasted in the United States every year, mostly due to discoloration of the raw meat. If those cows had never been made, the U.S. would have saved nearly 581,000 tons of carbon dioxide. Instead, by wasting them, on top of all of the emissions associated with beef production, the discarded meat ends up emitting more than if we had eaten it.

This is in part why, in 2011, the Food and Agriculture Organization of the United Nations published a report saying that if food waste were a country, it would take the bronze medal in emissions. Meat contributes "to over 20% of the carbon footprint of total food waste," meaning all of those emissions to make it were wasted only to put more greenhouse gases into the air.

This massive waste was also, in part, why my Year of No Beef met such a quick end. In the unique situation of a university dining hall, I didn't have any say over what the cooks would serve on any given day. I was faced with a conundrum: On the one hand, I didn't want to drive up demand whenever they served beef. But, on the other, having it go to waste would have been arguably worse. Most days, I figured that a burger I didn't request is better than one wasted. They also smelled really good.

While many have managed it successfully, trying to abstain from meat for the sake of the environment as an American — for reasons of taste, culture, economy, systems of food provision, and more — is still just hard, and it often just feels futile. Everything we do, from the planes we ride to see our families to the meat we eat to sustain our bodies, carries an environmental cost, but obsessively micromanaging our personal actions would ultimately eliminate only a small slice of the pie and would distract from larger, systemic carbon emitters.

While there's some truth to the argument that individual choices are insignificant in fighting climate change, it's worth pausing to think about it when one of the meat industry's biggest advocates uses that insignificance as a selling point. Frank Mitloehner — a professor at the University of California, Davis with well-established connections to the cattle industry — has made the insignificance of individual food choices a central talking point. As Jenny Splitter writes in *Undark*, "The quintessential Mitloehner take" is this: "Worry less about the burgers and more about Big Oil. He praises what animal agriculture gets right … but he staunchly rejects the idea of telling anyone to eat less beef for the planet."

It seems that Mitloehner counters every environmentalist argument against meat with a canned rebuttal claiming either innocence or insignificance. In fact, he did exactly this in an interview on the YouTube channel *What I've Learned* and its video, "Eating less meat won't save the planet. Here's why" — which drew nearly 5 million views.

Mitloehner's cornerstone example cites a 2017 study that showed that if 10% of the U.S. population went vegan, emissions would be reduced by 0.26%, adding, "We're talking about changes that aren't even measurable." And he is correct. However, what Mitloehner gets wrong here is not in his answers but in his presentational framework.

The title of the video and Mitloehner's whole philosophy are factually true but steeped in flawed logic. Of course eating less meat won't save the planet — no one thing or person will. Ending internal combustion engines alone

won't save the planet. Transitioning away from oil alone won't save the planet. Mixing less concrete alone won't save the planet. All of those combined (and so, so much more) *will*.

Instead, what many will take away from Mitloehner, especially in the *What I've Learned* video, is that it's OK to continue on with business as usual; your choice of whether or not to eat beef will have nearly zero effect on climate change. After all, you're only one person. World Resources Institute analyst Jessica Zionts puts it this way: "By framing emissions as smaller than sectors like transportation, which [Mitloehner] frequently does, the livestock industry can continue to say, 'Look how small agricultural emissions are anyway.' … And by that reasoning, dietary changes won't make much of a difference to combating climate change."

The fact that Mitloehner's research frequently produces pro-meat conclusions is less surprising when we take into account that much of it is funded by the dairy and cattle industries. As Matthew Hayek, a New York University scholar specializing in food production's relation to climate change, explains it, "Industry influences the types of questions you're going to ask." Take for example, a 2019 UC Davis study conducted by one of Mitloehner's colleagues, Ermias Kebreab, and funded in part by a dairy company. Its findings are quite remarkable — the paper "implies" that "methane emissions could potentially be halved by using seaweed as a feed additive to dairy cattle." Producing more efficient cows, via seaweed or not, will be a necessary step to curbing emissions. The paper, and Mitloehner's teachings, though, carry the "implication" that cows are irreplaceable. If one truly was concerned about reducing emissions, why research a compromise on the old method when newer, more effective solutions like plant-based or lab-grown meat are available? Why opt for natural gas instead of solar for energy; why a more fuel-efficient car instead of an electric one? Sure, you'll be better off smoking this cigarette instead of eating mercury, but it'll still poison you.

The cigarette analogy doesn't end there. Scientists who conduct dairy and meat industry-friendly research could arguably be included in the parade of corporate villains in *Merchants of Doubt* — a 2010 book by science historians Naomi Oreskes and Erik Conway. The book describes how, for decades, Big Tobacco-funded scientists

Angus and Charolais cattle in a pasture in central California. *Credit: Carol M. Highsmith via Flickr*

defrauded the public, playing down health risks and even going so far as to say that cigarettes have health benefits. An article published by UC Davis celebrating the seaweed-cow paper is similar to an unsettling degree. Its penultimate subheading: "Cows as part of the climate change solution." Focusing mostly on ranchers — and ignoring the fact that 70% of American cows reside in ecologically unsustainable and destructive factory farms — the UC Davis article hails the practice of "maintaining healthy root systems" to help offset the greenhouse gases emitted by cows, a practice that, if adopted *en masse*, "could sequester 16 gigatons of carbon dioxide by 2050." I cannot help but think that such a future is as much a pipe dream as Mitloehner's 10% vegan "what if" scenario.

Speaking of land use, Mitloehner doesn't. Half of the entire world's habitable land is used for agriculture. A majority of that space is used to grow feed for livestock, not humans, according to a 2021 paper by two University of Illinois professors, Xiaoming Xu and Atul Jain. Beef production requires a great deal of space and, as a result, farmers have also had to increase their pasture sizes. That's partially why beef is so environmentally toxic: Bovines are bigger, so they require more space. Unfortunately, farmers make that space by destroying natural woodlands. Again, we see another installment of a pattern environmentalists encounter all too often: If the problem can get worse, it usually does.

According to most estimates, around 20% of the Amazon Rainforest has been razed. In every country that the Amazon covers, 80% of deforestation efforts are to make way for cattle ranching. Scientists estimate there would be an irreversible "tipping point" for the jungle at 20-25% deforestation. In 2021, deforestation in the Amazon reached a 15-year high when the forest lost 5,100 square miles, an area nearly the size of Connecticut. If trends continue, more than 10,000 different plant and animal species could go extinct — a dispiriting death-blow to one of the most biodiverse regions on Earth, the so-called lungs of the planet.

The way these forests are cleared, largely by combustion, not only transfers the carbon stored in the trees into the atmosphere, but also transforms former carbon-sink regions into meaty emission factories. The feeding, raising, and production of beef have created an environmentally destructive feedback loop: The more greenhouse gases we release from cut-down forests, the easier it is to emit even more through cows. This is what beef apologists like Mitloehner deliberately overlook: Even if beef's direct greenhouse gas emission output is negligible, we're shrinking the "lungs of the earth" to make way for its methane-spouting production.

So, how do we proceed?

Things are going to have to change, obviously. Whether they will or not depends on how much we're willing to sacrifice. Today, the way we make our meat is not sustainable, no matter how you slice it. "The World Counts" reports that meat consumption has more than doubled in the past 30 years. By 2050, it is expected to double yet again. Enthusiasm for plant-based alternatives, like Impossible or Beyond Meat, is slowing to a crawl. All the while, our planet is set to breach the 1.5 degrees centigrade warming threshold by 2027.

A possible solution may lie in an alternative philosophy. A 2017 book by Brian Kateman started the "Reducetarianist" Movement. Their self-purported mission is a triple-threat: human health, environmental sustainability, and animal welfare by way of a 10% (or more) meat reduction in diets. In addition to the original source text, the Reducetarians have a documentary and book titled "Meat Me Halfway," a foundation, podcast, fellowship, and cookbook.

Food is tricky, environmentally speaking. Unlike international travel or lighting up the exterior of your house at night, it's not exactly optional. The dilemma between going hungry or emitting greenhouse gases isn't a choice, no matter the diet — you're biologically programmed to choose the food every time. But unlike switching away from a gas-powered vehicle or hopping off the grid by installing solar panels, food is far easier to turn sustainable. It's simple: Eat less meat.

The Reducetarians present a compromise — a half-solution that both acknowledges the dire need for people to change their diets, while keeping in mind how hard

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We inhabit systems where the big, structural decisions are already made for us. Like it or not, our economy runs mostly on fossil fuels, and our culture expects our bodies to run on meat. Wanting to do better, how do we reconcile our limited personal power?

Overcoming our addiction to meat is no simple task, individually or collectively. *Credit: Peachyeung316 via Wikimedia Commons*

that is. One of their cornerstone studies, published in the *Journal of Environmental Psychology* in 2021, notes how the Reducetarian message can nearly lead to that 10% meat-reduction number. This was most effective among those within the "younger, more liberal, more educated, and lower income" demographic — one that you could say this author generally inhabits. The Reducetarian outreach has proved effective, too. Since moving out of a university residence hall and into my own apartment, I've nearly abandoned eating beef altogether, save for the occasional indulgence. What became a twice or thrice weekly meal has been relegated to maybe once a quarter. Reducetarianism's main focus is on education and communicating its message of a better world, for good reason, too — because the hard data for the 10% meat reduction figure shows little impact.

According to a 2019 study published in *Nature*, if every single American reduced their meat intake by a quarter, we'd save a little more than 1% of our greenhouse gas output. It is a depressing figure, and one that reminds us of our original conundrum: We inhabit systems where the big, structural decisions are already made for us. Like it or not, our economy runs mostly on fossil fuels, and our culture expects our bodies to run on meat. Wanting to do better, how do we reconcile our limited personal power?

Enter what University of Illinois Nobel Prize-winning Professor Donald Wuebbles has called the most important weapon in our arsenal for fighting climate change: communication. A lot can come about by simply engaging with an issue and voicing our concern, and environmentalists everywhere are echoing a similar message. *Grist* contributor David Roberts has advised the best way to communicate about climate change is to "Pull up a barstool." A 2020 paper in *Climatic Change* argued that the narratives we need today are ones that are "positive and engaging" and "empower people to act." Author John Green, while managing the construction of a mass-funded hospital in Sierra Leone, often thanks his followers above all for their attention — what he calls everyone's "central resource."

The true value of my bungled Year of No Beef was to shape my ability to communicate the problem of beef consumption, and to actively champion the Reducetarian philosophy I embraced out of that failure. The value of our choices, however small, is not in how much carbon is expended, but in how we promote a position that goes against the flow of our structured systems. With our diets, that means trying to eat less meat — but more importantly, keeping on talking with your mouth full.

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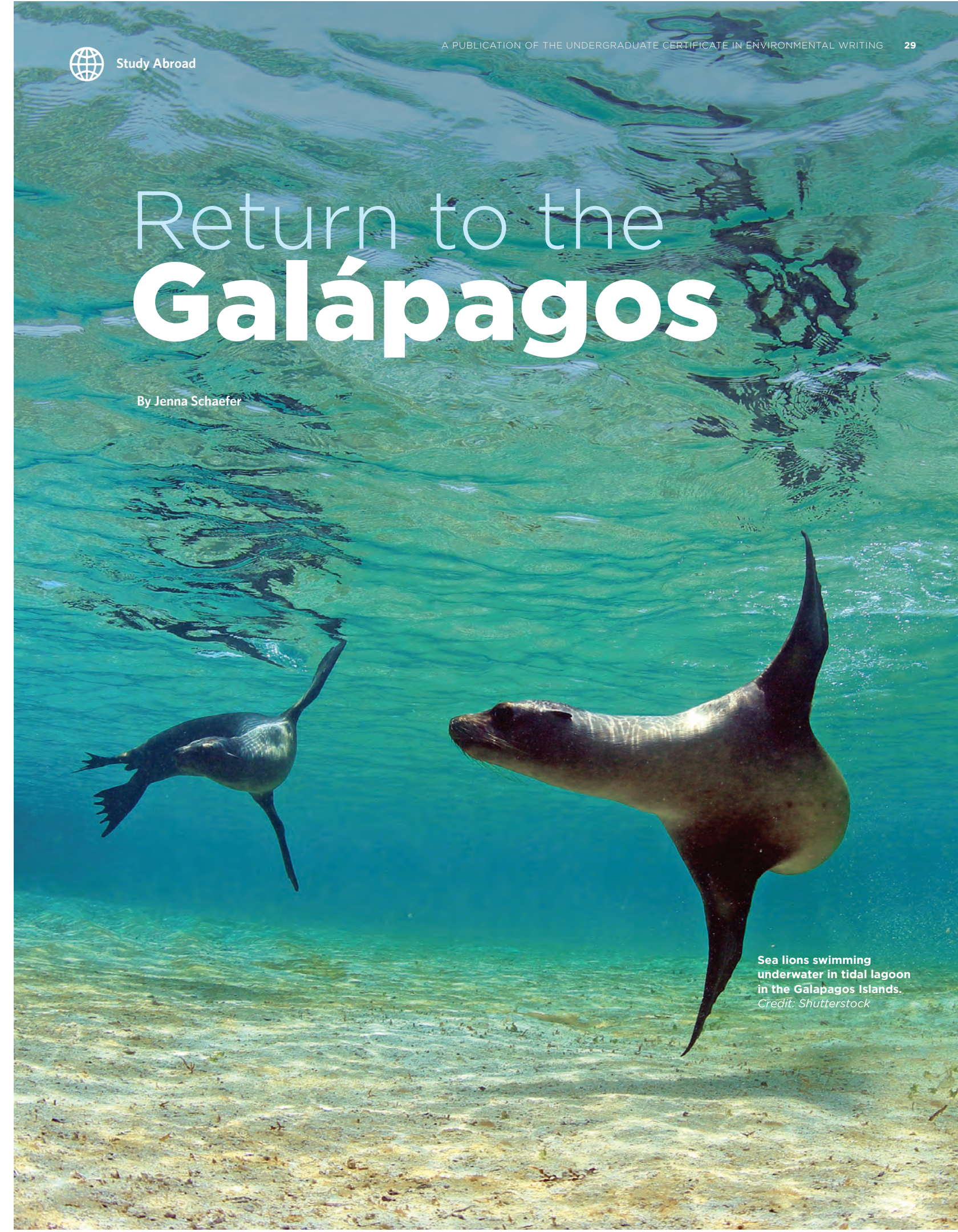
Study Abroad

Return to the Galápagos

By Jenna Schaefer



Sea lions swimming underwater in tidal lagoon in the Galapagos Islands. *Credit: Shutterstock*

I had many incredible experiences during the six weeks I spent studying abroad in the Galápagos Islands during the summer of 2022. Our group of 11 students worked on sustainable agriculture and economic development projects that supported local livelihoods and conservation efforts. While I had an incredibly positive experience in the Galápagos, I also learned firsthand how the islands are facing environmental threats exacerbated by high levels of tourism. Across the archipelago, invasive species threaten native species, and residents and visitors face water insecurity. The islands are increasingly being developed to support more tourism and human activity, simultaneously harming delicate ecosystems. This creates a complex dilemma: How can the unique island environment be protected without threatening the livelihoods of native Galapagueños?

The Galápagos Islands are approximately 600 miles off the coast of Ecuador and are home to around 30,000 people and 2,000 endemic species. Their first recorded human discovery was in 1535 by Fray Tomás de Berlanga, but scientist Charles Darwin is most responsible for making the archipelago a household name. While Darwin saw the value of the Galápagos Islands as a case study in species evolution due to their remoteness, the islands have significantly changed since Darwin's time there in the 1830s. The Galápagos are a growing tourist destination, with 270,000 visitors in 2019, which brings both benefits and challenges.

Decades ago, tourism to the Galápagos was mainly in the form of cruise ships that could be strictly regulated. However, between 2006 and 2017, the number of hotels skyrocketed from 65 to 317. This increase in supply led to affordable prices and more land-based tourism, which is harder to regulate. The increasing tourism is a vital part of the islands' economy, totaling 80% of jobs and making the average salary higher than in mainland Ecuador. Good-paying jobs are created as more hotels, restaurants, and tourist attractions are developed. Additional revenue is generated from the $100 fee charged for entry into Galápagos National Park, which encompasses 97% of the area of the Galápagos Islands. Through this fee, tourists raise millions of dollars to fund critical conservation projects and protect the environment, including invasive species removal.

While tourism brings economic benefits to the Galápagos, it also puts stress on the very species that made the islands famous. Over 1,700 invasive species have been introduced by tourists and colonizers. One significant threat to the Galápagos ecosystem has been goats. Brought to the Galápagos by settlers in the 1800s, goats began to consume all the native vegetation on the island – the same vegetation that is a food source for tortoises and other native species. To protect the ecosystem from invasive goats, Project Isabela was developed in 1997. At this point, an estimated 100,000 goats lived on the northern part of Isabela Island alone. To help control the

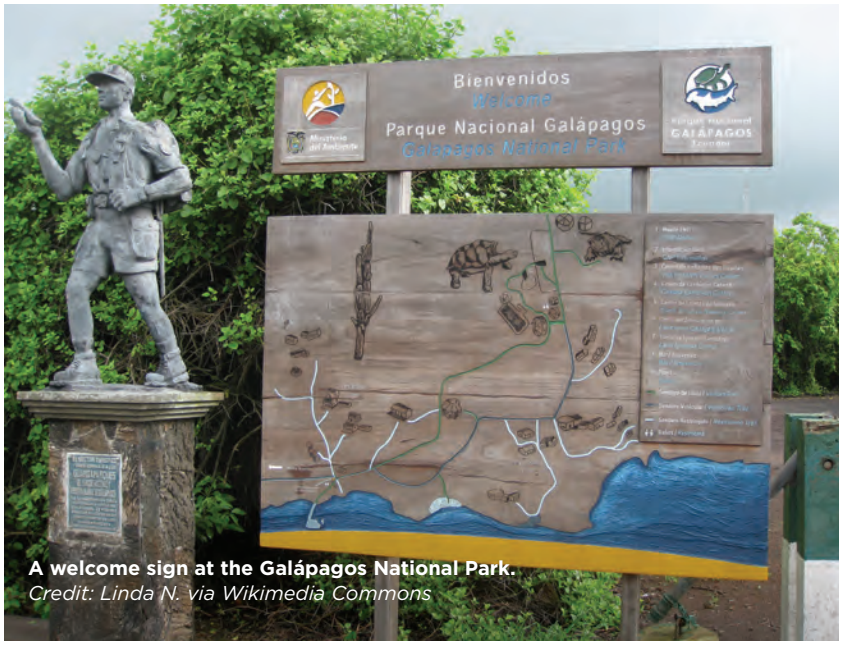
The small port village of Puerto Villamil can be spotted along the beautiful beach on the southeastern edge of Isla Isabela.
Credit: Jenna Schaefer

The cumulative impacts of water insecurity and invasive species make one wonder how Galápagos tourism can be made more sustainable. The government has implemented some regulations, such as the requirement for guides to accompany visitors in Galápagos National Park. For example, on our hike up and around the Sierra Negra Volcano, a guide accompanied us for the entire 10 miles to ensure the protection of the islands. While this is a useful first step, it's critical for the government to put more regulations in place to limit the number of tourists and, thus, the environmental impact of tourism.

goat population, park rangers, including my host father, initially hunted them on the ground, then from the air. Sterilized goats were released with radio collars. These sterile goats would seek out other goats, which helped rangers find more secluded populations. With $20 million invested in the project, goats had been eliminated in Northern Isabela by 2006, and native vegetation was able to recover. Unfortunately, not all invasive species have been managed so successfully and continue to spread across the Galápagos.

Due to the spread of invasive species and the continued development of the islands to support the growing tourism industry, the population of some endemic species has declined. One scientist at the Charles Darwin Foundation estimates that at least 10,000 finches are hit by cars each year. Predation by invasive rats and cats has led to the pink land iguana being listed as critically endangered, with a population of 211. It is just one of at least 150 species in the Galápagos classified as endangered or critically endangered, including the Galápagos sea lion and Galápagos fur seal.

Despite the chronic problem of invasive species, the Galápagos Islands remain an ecological paradise due



A welcome sign at the Galápagos National Park.
Credit: Linda N. via Wikimedia Commons

to their remoteness, tiny human population, and lack of commercialism. To protect the islands from greedy foreign investors and excessive tourism, el Consejo de Gobierno, the government council, enforces a rule that businesses must be at least half owned by native Galapagueños. You won't find chain restaurants, big box stores, or excessive billboards on Isabela Island. The island's largest store, which sold food, housewares, and cosmetics, was a fraction of the size of a Walmart. Somehow, such a small store still had all the essentials, plus more. Everything in town is also within walking distance, so most people travel by foot or bike.

But in the Galápagos, the limited water supply on the islands is an additional hurdle for human coexistence with the islands' native species. The climate is very dry on the coast, where most people live and tourism infrastructure is most developed. Unlike the maze of underground pipes that magically make water come out of the tap in the United States, in the Galápagos, individual water supply

The Ecuadorian government committed to a zero-growth tourism model by 2018, but as of 2021 the government still had not created an action plan to follow through. In fact, the number of flights to the Galápagos increased after 2018.

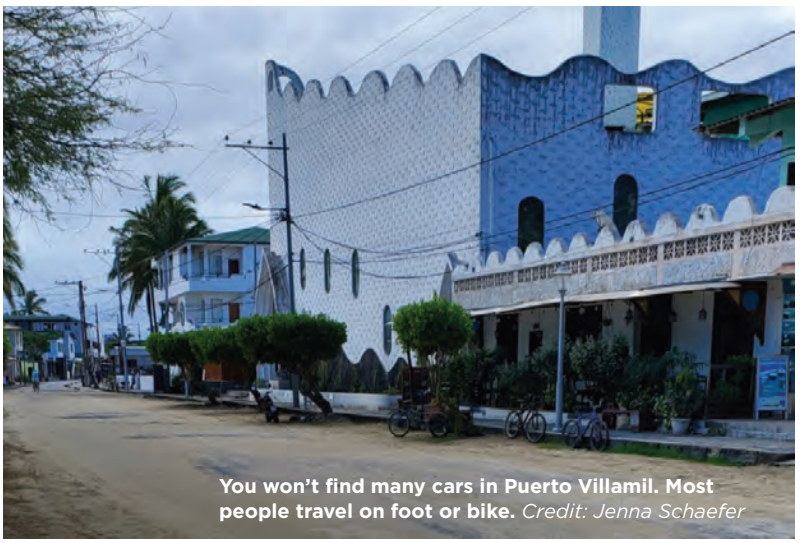
Environmental protection and endemic species usually dominate conversations about the Galápagos, but it's also important to acknowledge the needs of the residents, who understand firsthand the importance of conserving such a special place.

is more visible. Tap water is not safe to drink, so drinking water must be purchased in large jugs, or a water filter must be installed. Despite these measures, it's easy to consume trace amounts of unsafe water. As tourists, we weren't accustomed to their water, so we all felt its effects at the beginning of the trip.

Separate from drinking water is water for household use. My host family kept a huge barrel of household-use water outdoors. Water is pumped into this barrel from underground pipes, and my host mom told me they use about a barrel's worth of water daily. In the United States, it's hard to visualize the approximately 82 gallons of water we use per person per day. While the size of the barrel divided by the 10 people living at my host family's house yields a relatively small amount of water per person per day, multiplying that water use by the 1,800 inhabitants of Isabela Island adds up to a large amount of water, especially in a place with a limited supply. Now, add the water consumed by hundreds of thousands of tourists each year, and the result is extreme water insecurity. When we first arrived, we found out that they didn't have water the previous week, and our host moms were afraid they still wouldn't have water when we arrived. Luckily, we did, but a small mistake, such as leaving the faucet running, could leave a family without water. There simply is not enough safe water to sustain more than a small population.

The cumulative impacts of water insecurity and invasive species make one wonder how Galápagos tourism can be made more sustainable. The government has implemented some regulations, such as the requirement for guides to accompany visitors in Galápagos National Park. For example, on our hike up and around the Sierra Negra

One of the farms the author encountered on Isabela Island, named Finca Bellavista or "beautiful view."
Credit: Jenna Schaefer



You won't find many cars in Puerto Villamil. Most people travel on foot or bike. *Credit: Jenna Schaefer*

Volcano, a guide accompanied us for the entire 10 miles to ensure the protection of the islands. While this is a useful first step, it's critical for the government to put more regulations in place to limit the number of tourists and, thus, the environmental impact of tourism. The Ecuadorian government committed to a zero-growth tourism model by 2018, but as of 2021 the government still had not created an action plan to follow through. In fact, the number of flights to the Galápagos increased after 2018.

Environmental protection and endemic species usually dominate conversations about the Galápagos, but it's also important to acknowledge the needs of the residents, who understand firsthand the importance of conserving such a special place. On top of challenges stemming from the remoteness of the islands, such as limited health care, residents' livelihoods would be threatened if tourism were severely limited. Taking measures to protect the variety of needs of the residents of the Galápagos — plants, animals, and humans — is certainly a balancing act, but it's incredibly important if this archipelago is going to survive in the face of global climate change.

During my stay on Isabela Island, I saw many positive signs of environmental care. I visited diverse farms using the practice of polyculture, such as one farm where coffee was grown under the shade of tropical fruit trees. On our farm tours we saw no large pieces of gas-guzzling agricultural machinery. We learned from farmers that their crops and livestock were rotated regularly and that synthetic fertilizers were used infrequently. After seeing the water catchment systems farmers used to irrigate their crops sustainably, we enjoyed a meal made from farm-fresh food. This agricultural landscape could not have been more different from the intensive production of acres upon acres of corn and soybeans in Illinois.

Aside from the sustainable agriculture, I was pleasantly surprised to find a community where the mindset of

Taking measures to protect the variety of needs of the residents of the Galápagos — plants, animals, and humans — is certainly a balancing act, but it's incredibly important if this archipelago is going to survive in the face of global climate change.

endless overconsumption was absent. Each day, I walked where I needed to go, just like everybody else. We visited restaurants that offered reusable plates and silverware instead of disposable plastic or Styrofoam. After finishing the academic projects we were working on each day, we would visit the beautiful beaches, with few people and little trash in sight. Each night, I returned home to my host family's house, which was simpler than most American homes but still very comfortable.

Watching the sunrise from our boat, we left Isabela Island to begin the long trip back to Illinois. Dolphins swam with our boat and jumped out of the water as if to say farewell. It was a bittersweet goodbye, leaving the place I was lucky enough to call home for the previous six weeks. Visiting the Galápagos Islands was an absolute dream, an experience that felt like stepping into a completely different world — one facing extreme challenges, but for whose lucky inhabitants environmental protection takes precedence over the degradation and waste so visible in consumer societies like the United States. If Darwin's island paradise can be saved by a more eco-conscious worldview, perhaps we can save our home, too.

Jenna Schaefer is a U of I graduate and a first-year M.S. student from St. Joseph, Ill. She studies Agricultural & Applied Economics with a concentration in Environmental & Natural Resources Economics. She also acts as Assistant Campus Sustainability Programs Coordinator at iSEE.

Child exploring a park. *Credit: Shutterstock*

NATURE IS THE BEST SCHOOL

By Rachel Weingart

From a sea of masks to a sea of nervously smiling faces, much has changed these past few years. Education has always been an important part of our society, but the pandemic pushed us to find new, innovative ways of educating ourselves and our children. Hugs and high fives were exchanged for waving hands and a few brave elbow bumps. Social distancing was a must. Brightly colored crayons and glitter glue activities with a friendly teacher were abruptly exchanged for Zoom lessons. Much of the in-person interactions so crucial to our development were replaced by blurry screens, delayed audio, and family pets stealing the show. It's far from an ideal way to learn, especially during a child's formative years.

What was true for the pre-K crowd was true for college students as well. Sitting in my archaic apartment building, painted in garish orange with accents of gray, my peers and I experienced how higher education was transformed by the pandemic's forced virtual learning; previously in-person laboratory courses were exchanged for recorded YouTube videos. The result? Poorer student performance and mental health crises across the board.

The historic Covid pandemic illuminated the cracks in our education system. It's no surprise that a global crisis would cause significant decreases in learning and test scores over the pandemic's three main years. But when the pandemic ended, we collectively assumed that the best course of action would be to go back to our brick and mortar classrooms. But what if keeping education indoors isn't the best answer? While major research focused on the impact of Covid on traditional classrooms, little attention has been paid to learning outcomes in nontraditional spaces both pre- and post-pandemic.

To explore the post-pandemic landscape for education, I spoke with Julia Kolt, M.Ed., to hear her firsthand experiences teaching both in a traditional, city classroom and at a suburban, nature-based preschool. I listened to her stories while strolling through the Chicago Botanic Garden's prairie and woodland areas. We would stop conversing every so often to point out and observe the wildlife — as natural learners ourselves.

While she would go on to teach in a nature-based classroom, Kolt's career in education started as a fourth-grade teacher in Chicago Public Schools (CPS) right before the pandemic struck the United States. During her first semester of teaching in autumn 2019, Kolt and her fellow teachers spent 11 days on strike. On top of that rough start, her school was forced to be fully remote in March 2020 due to the pandemic, where she would remain fully remote until April 2021. At that time, she returned in-person, where she taught half of her students remotely and the other half simultaneously in her classroom, personally experiencing up close how virtual learning impacted children. Kolt commented on how difficult it was to obtain "hands-on learning resources" that would be meaningful for students both at home and in-person. She constructed activities separate from the CPS curriculum to create more impactful learning opportunities, "often raising money through GoFundMe to purchase materials such as playdough to make landforms, magnifying lenses to look at insects, and owl pellets to dissect." Even though CPS only funded materials directly related to the assigned curriculum, Kolt fought to make sure her fourth-graders had formative learning experiences. She went above and beyond, prioritizing the educational quality of her classroom over strictly adhering to the assigned curriculum.

But it wasn't enough. The problem was, she decided, her students had no opportunity to venture outside the classroom and overbuilt recess area, dominated by blacktop. As a result, she explained, "students reported they were often afraid or uninterested in the natural world." There was one boy whose love of the outdoors was cemented through family camping trips in Michigan's Upper Peninsula "where he learned how to survive in the wilderness with his family and Mother Nature as his guide." But the rest of her students were repulsed by greenspaces, and eventually Kolt knew she was ready for a nontraditional educational space. So she took a new job as a Nature Preschool teacher at the Chicago Botanic Garden, where she is able to enrich the lives of children through daily, direct access to nature.

> In the words of Julia Kolt, M.Ed., "Giving children the opportunity to learn, play, make mistakes, and explore their curiosities outdoors" is essential to solve the lack of nature education in our society.

As a Lead Teacher in Early Childhood Programs and the Nature Preschool at the Garden, Kolt brings her science knowledge from her B.S. in Biology to provide meaningful science-based nature education. She was thrilled about this shift from teaching in a traditional classroom to a nature-based program where developmental play in the Garden's natural spaces is at the program's center: "We spend 80 to 100% of our day outdoors, encouraging natural exploration and developing grit." That's a sharp contrast to the measly amount of recess time her fourth-graders spent outside.

I was curious about the evidence behind nature-based educational spaces being a better alternative to traditional education. For generations, we've known that playing outside is important, but scientific data on the topic has yet to meaningfully capture public attention. For a researcher's view, I turned to Andrea Faber Taylor, a Teaching Assistant Professor at the U of I, to learn more about the benefits of nature so I could better understand

Families play in a willow branch castle called "The Rookery," created by Patrick Dougherty for the Chicago Botanic Garden. *Credit: Rachel Weingart*

why nature-based education programs are superior to traditional classrooms. As I sat down to speak with her, my eyes were drawn to a poster of an American Buffalo standing among flowering prairie plants: a piece of the past rural Illinois landscape that made me nostalgic for a time long before industrial America.

Throughout our interview, Faber Taylor shared her holistic, community-oriented view of nature. She emphasized that the restorative power of greenspace isn't just a way to enrich our adult lives; it begins at the early stages of our development. Scientists have long known that increasing connection to nature through greenspace benefits human health. The definition of greenspace is incredibly variable, which is part of why communicating the science behind its benefits can be so challenging. Faber Taylor believes greenspace is more than just the color green: "Nature is more than plant material; there's rocks, water, soil." She stresses that greenspaces must be "low in human-made materials" to create a "less built" feeling. Human-created elements such as concrete should be a small percentage of the landscape compared to plant material and natural elements, such as rocks and waterfalls.

> Faber Taylor and her colleagues have conducted studies about physical activity and found that children become more active in greenspaces compared to built playgrounds or blacktop spaces. Since exploring greenspaces is the key to nurturing our health and wellbeing, it is especially important during our formative years.

How can we find greenspaces? At the macro-level, scientists can locate greenspaces by recording the number of green pixels in a satellite image. Since many of these pixels are inaccessible natural spaces, there's a push to increase greenspace access. "A person might live near acres and acres of wetland," Faber Taylor explained, "but they're not experiencing it because they can only stand on the edge and see a small amount of it. It's not a space they can pass through or recreate in." Spaces like this improve ecosystem health but don't have the same restorative benefits for people as accessible greenspaces.

Our conversation progressed to discussing the specific educational benefits greenspaces provide. Simon Nicholson's landmark book Theory of Loose Parts was among the first to define the relationship between childhood cognitive development and greenspace. Nicholson expands the definition of greenspace beyond parks and gardens to include outdoor spaces where children can interact with

sticks, rocks, pine cones, and leaves. Nicholson discovered that playing with "loose parts" is a foundational part of cognitive development. Children engage in self-guided learning when playing with the odd detritus of nature. In a regimented world filled with highly engineered playgrounds, Nicholson urges us to reexamine our outdoor educational spaces to include plentiful loose parts.

In my interview with her, Kolt spoke avidly about how teachers can introduce nature to children. Playing outside with peers allows children to problem-solve, teach, and learn from each other. As such, nature education programs foster more teamwork and collaborative activities to solve the unique challenges posed by learning outside. In addition to group learning, Kolt adds that, while supervised safely from afar, "Children benefit from quiet, solo time while outdoors, as they are able to think deeply, explore their own curiosities, and experience what it is like to be alone with nature." Connections can also be formed through hands-on lessons, such as those about local species. "A teacher could introduce bird songs to students and help them to memorize the call of a black-capped chickadee" which sounds like "cheeseburger," Kolt explains. From then on, when children are outdoors and hear the "cheeseburger" call, "either with others or alone, they will be able to identify the bird and feel a sense of belonging in nature." The consequences of this, as she describes, cannot be understated. "Because the child has learned to listen and identify, they may feel less fear or trepidation

> Scientists have long known that increasing connection to nature through greenspace benefits human health.

Loose parts come in all shapes and sizes! Autumn offers a bounty of fallen leaves for children to enjoy. *Credit: Ian Poellet via Wikimedia Commons*

while spending time outdoors," Kolt says, contrasting her earlier description of her fourth-graders as "afraid or uninterested in the natural world."

The proof of the power of connections to nature are even seen on paper, since access to school greenspaces also results in better test scores, even when accounting for income disparities. This is especially important since the pandemic caused a rapid, national decline in test scores, meaning that nature-based education programs can serve as a meaningful way to help increase national test scores in the wake of the pandemic. We all want to ensure everyone has a high-quality education, and access to nature is the missing puzzle piece.

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There have been some shifts toward successfully incorporating greenspaces into traditional school settings. Faber Taylor shared the story of a greenspace program designed by her landscape architect friends Robin Moore and Nilda Cosco at North Carolina State. Moore and Cosco design greenspaces for early child care centers, and "succeeded in altering the legislation in North Carolina so that all early child care centers must have an outdoor space accessible to the children during the day." These spaces are mandated to incorporate natural elements, so they won't just be composed of a grassy lawn without natural "loose parts." The legislation stipulates that educators must use the greenspace for daily nature play activities. This law could serve as a model for future legislation to increase children's access to greenspace.

At the community level, another way to increase greenspace access is through the Natural Learning Initiative. Faber Taylor explained how this initiative works to provide research summaries in layman's terms, sharing how greenspace positively impacts development. A program like this could be additionally helpful to educators without a natural science background looking to implement hands-on, nature-based learning activities. Faber Taylor and her colleagues have conducted studies about physical activity and found that children become more active in greenspaces compared to built playgrounds or blacktop spaces. Since exploring greenspaces is the key to nurturing our health and wellbeing, it is especially important during our formative years.

Zinnias bloom at the University of Illinois Idea Garden.
Credit: Rachel Weingart

For all these isolated examples of progress in nature education, there are many barriers to American children accessing greenspace. Faber Taylor described how her children's recess time was limited to the blacktop. Teachers "did not want to deal with the complications of wet shoes, any potential mud." While weather can be a concern, changing outdoor conditions can actually provide meaningful learning opportunities. For Kolt, "At Nature Preschool, we are able to use what is going on outdoors as our guide, often switching lesson plans or activity ideas based on student interest or natural phenomena that is currently ongoing." Since her lessons already structure themselves around seasonal changes, inclement weather conditions are treated as just one more seasonal phenomenon for her preschoolers to learn about. "For example, if it begins to rain during our lesson on butterflies, we may take a short hike in our rain coats and boots to discover what insects do during rainy weather," Kolt explains. "We may even go visit our Butterflies & Blooms exhibit here at the Garden, to see the butterflies in action during the rain." In a traditional classroom setting, this flexibility and access to multiple facilities are simply not possible. This same flexibility made it vastly easier

for the Nature Preschool to continue safely operating during the pandemic while traditional school systems floundered.

Knowing all of this, I wondered why we haven't done more to embed the importance of greenspaces into the common consciousness and into school curricula. In Faber Taylor's opinion, it is because there are more pressing traditional concerns, such as school budgets and the emphasis on test scores. "Schools are always strapped for funding. And there's just a lot of pressure. They're getting evaluated on test scores, so they're going to put all of their funding into the traditional ways of trying to boost scores." For her, the organic approach to test scores is to give children time to rest their attention throughout the day by giving them a more supportive environment that includes nature. But, she conceded, getting away from worksheets and fancy technology is "a hard sell."

Both educators I spoke with believe that early and repeated exposure to nature, especially during early childhood, is of great importance. In the words of Kolt, "Giving children the opportunity to learn, play, make mistakes, and explore their curiosities outdoors" is essential to solve the lack of nature education in our society. In situations where those opportunities are not possible, Kolt suggests advocating for the use of federal funding in public schools to go toward outdoor education programs. The Nature Preschool received funding from the Illinois State Board of Education which is used to help provide resources and scholarships for families with financial need. This can help nature education programs become more accessible to all families, regardless of their economic status.

So, what can we do if people are interested in nature education but feel that it's a financially irresponsible pursuit? Increasing access to greenspaces and overall knowledge of the natural world can help us prepare for the next global crisis. Kolt firmly believes that "time spent outdoors is a strong introduction to all scientific fields, such as physics (leaves falling), chemistry (pond water solutions), meteorology, biology, ecology, and even mathematics (noticing patterns in nature)." Thus, increasing scientific literacy and nature education go hand in hand. "By piquing a child's interest at an early age and exposing them to different scientific topics, they will have a stronger understanding of the natural world and how it works," she says. This understanding can improve scientific literacy, which can help children prepare for a world of pandemics and climate change, and envision a more sustainable future.

Returning to the Chicago Botanic Garden, I stroll past rolling hills and lilypad-filled shorelines to watch screeching red-winged blackbirds peeking out from spindly, native prairie grasses. We cannot let nature's rich, living tapestry

Built pathways allow children to explore otherwise inaccessible greenspaces. *Credit: Teaneck Creek Conservancy*

fade into the pages of an archaic textbook. The benefits of greenspaces are abundantly clear: Depriving anyone of them means denying a basic human need. With tall, brick buildings peeking out from behind the greenery, I close my eyes and revel in the feeling of being cradled by the natural world. The contrast of greens helps me breathe as I am reminded that I can escape the oppressive walls of industrial society to take time for myself. I am reminded that I am alive, entangled in the ecosystem.

Nature-based education ensures children retain a lifelong love for and desire to protect the planet. Covid has caused many irrevocable changes, but we can ensure that the pandemic's damage to our already fragile education system is not permanent. A life without access and connection to nature is not a life worth living. We can start by teaching the kids about it.

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By Matt Troher

The ABCs of CLIMATE CHANGE

I don't remember being taught about climate change. Are today's teachers working to make sure students learn?

Rosie Jurasas, a 22-year-old senior at Loyola University Chicago, sits at the front of her classroom of 20 second-graders. She's holding a book; its cover is a cartoon seascape with aquatic animals living in a plastic-riddled ocean. It's titled *What a Waste: Trash, Recycling, and Protecting our Planet*.

Jurasas is student teaching at Jordan Community Elementary, a bilingual school located in Chicago's Rogers Park neighborhood, 2 miles from Loyola's lakeshore campus. The North Side neighborhood is often cited as the most diverse neighborhood in Chicago, with roughly 34% of Rogers Park residents being foreign-born. Most of Jordan Community's students hail from non-English speaking households

Second grade is when students at Jordan Community start the gradual transition from learning in Spanish to learning in English. This week, the class is using picture books to practice English reading and speaking skills. The school's administration gave Jurasas a set of picture books pertaining to the environment — particularly the negative impacts humans are having on our climate — to read to her students.

Afforestation for better future.
Credit: Shutterstock.

As Jurasas begins her lesson, she notices an unexpected barrier to her students' comprehension. They don't really know what they are reading about: "The books were assuming that they had a background knowledge about climate change, but I don't think they did, to be honest."

To supplement her lesson, Jurasas took it upon herself to give her students a fundamental understanding of climate change and the role we have in creating it. She found YouTube videos for kids about global warming and fostered discussions about waste production. The unit culminated with a dialogue about the changes individuals can make to reduce their environmental impact.

"It was interesting to see their faces and their reactions when we would read facts about how, literally as of right now, in 100 years we will have no rain forests, or how plastic doesn't actually really go away even if you recycle it," Jurasas said. "I think that really shocked them."

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As I spoke with Jurasas, I thought about my own educational experience. No matter how I racked the farthest corners of my brain, I could not recall ever being taught about climate change. I evidently learned about it at some point, but I cannot pinpoint a moment in my educational experience where I first encountered climate change the same way I can pinpoint when I first learned how to find the average of a set of numbers (third grade), understood what a preposition was (fourth grade), or read *The Great Gatsby* (10th grade).

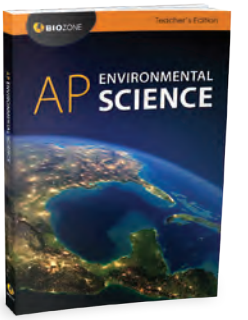
When I was in the shoes of Jurasas's second-graders 14 years ago, I learned about the life cycle and the states of matter, but nothing about the climate or environmental degradation. Instead, I think my knowledge of the topic came from non-curricular sources: the TV, the radio, and the internet.

When I was in the shoes of Jurasas's second-graders 14 years ago, I learned about the life cycle and the states of matter, but nothing about the climate or environmental degradation. Instead, I think my knowledge of the topic came from non-curricular sources: the TV, the radio, and the internet.

While it was heartening to hear about Jurasas introducing her students to such an important topic, I couldn't help wondering if her intervention was closer to the

Elementary students in a classroom.
Credit: Arthur Krijgsman via Pexels.

exception than the rule. What if today's students are still left to their own devices to learn about climate change? With younger generations growing up under the sway of social media, riddled as it is with misinformation, how will we be assured that their knowledge of the most pressing issue of the current age is correct?



To see where social media sits in the realm of climate education, I opened a new tab on my laptop, pulled up YouTube, and searched the words "climate change." I made sure to use an incognito tab to minimize the influence of my previous search history on the results. The first result was a brief news clip from *Good Morning America* titled "Community Relocates due to Climate Change Displacement." The second result was an hour-long documentary "Climate Change: What Will Our Lives Look Like in 2050?"

The third result, however, was a 4-week-old video with more than100,000 views titled, "NASA Engineer Tom Moser Reveals the Truth About Climate Science." I looked at the channel. As it turns out, the third result YouTube returned for a search about climate change was from The Heartland Institute — a conservative and libertarian think tank *The New York Times* described as "the primary American organization pushing climate change skepticism."

Children are naturally curious, and the first step a child of any age takes to satisfy any unbridled curiosity nowadays is — for better or for worse — social media. As climate change becomes a more prevalent topic, young people will become curious. I can't help but fear that if this curiosity stems from a lack of coverage in the classroom, there's a very real chance that children will get their information from unvetted, politically motivated sources.

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From a moral standpoint, our education system has a duty to prepare children for the world they're about to enter. As climate change's effects on our world become increasingly severe and experts urge immediate action, today's students must be provided with accurate information about a changing world. As Rita J. Turner, a lecturer at the University of Maryland, Baltimore County, sums up in her book *Teaching for EcoJustice*, "One of the most essential skills that education can help to cultivate in students is the ability to imagine possibilities that are different from those presented by the dominant culture."

Before I dug any further, I wanted to make sure that this lack of climate change education was a far-reaching

Little Girl Drawing Our Beautiful Green Planet Earth. *Credit: Shutterstock*

As climate change's effects on our world become increasingly severe and experts urge immediate action, today's students must be provided with accurate information about a changing world.

problem, not just a product of my own forgetfulness. I wanted to see if other people my age had similar experiences. I found that I am not alone.

I spoke with Scarlett Hoffer, an undergraduate at the U of I in the Earth, Society, and Environmental Sustainability program. We met on the last day of March 2023 and sat on the outdoor patio of the Illini Union. The temperature peaked at 72 degrees; the strong central Illinois wind kept blowing the pages of my notebook into disarray.

Hoffer described herself as an outdoorsy kid, spending her childhood catching frogs in the creek near her house and running from the garden snakes that resided in her backyard. "Every time I was bored, I'd go outside," she told me. But Hoffer's experience in nature was not matched by education in the classroom. "I definitely don't remember the topic of the climate or climate change [being brought up] in high school," Hoffer said. "I never got any sort of explanation from the teacher."

Instead, once Hoffer first encountered the term "climate change," she turned to outside sources to satisfy her natural curiosity. As she was born before the advent of social media, Hoffer turned to books and conservationists to learn about the topic.

"I was a big bookworm as a kid, like reading encyclopedias type of kid, and I went to the zoo all the time," Hoffer said. "I'd read, or hear from workers at the zoo, that because of climate change these types of animals are losing their habitats."

Other students noted this climate-related gap in their education as well. Halie Collins, a senior studying civil engineering, spent part of her childhood in Japan. When she entered the American school system in middle school, she noticed a striking lack of environmental content in both the curriculum and in the broader American culture.

"I grew up in Japan where they're very waste conscious," Collins said. "It's a really small country, and they don't have a lot of space for waste, so they have a very well-planned and executed waste management plan. When I went to middle school and high school in the United States, it was really easy to identify things where the United States is lacking in terms of sustainability."

Cecilia Milmoe, a senior in the creative writing program, put it more bluntly: "I don't remember that happening at all in middle school or high school. I cannot think of a time where climate change was talked about."

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To get a sense of what the state of climate education in today's high schools really is, I met with Cyndi Smyser, a science teacher at the University of Illinois Laboratory High School. Commonly known as Uni High, the laboratory school serves just over 300 students in a gothic-revival building in the midst of the university's engineering campus. As I walked through the front doors, I felt as if I had walked into a promotional brochure. Nearly every one of the school's tan lockers was personalized with drawings, posters, and magazine clippings. Murals adorned the hallways. A cartoon dragon was painted on the door to the library. To the left of the library's entrance was a poster of Greta Thunberg accompanied by the phrase: "You are never too small to make a difference."

Smyser teaches organismal biology and scientific research methodology while serving as the executive teacher for the school's science department. Her classroom door is covered with posters and flyers for the different clubs she runs: Healthcare Club, Biology Club, Psychology Club, and Women in STEM. She's the faculty sponsor for the sophomore class, serves on the school's crisis team, and mentors for the Worldwide Youth in Science and Engineering program held at the university. I was surprised she had the time to meet with me.

After our brief tour, we settled in Smyser's classroom on the school's third floor.

Smyser taught the school's Environmental Science class for three years before handing the course off to an incoming teacher. Since Uni High receives most of its funding through the university instead of property taxes, teachers aren't bound to school board standards like most public schools. Instead, teachers have free reign to construct their own curriculum.

Smyser used this freedom to structure her Environmental Science course around Rachel Carson's influential *Silent Spring*, a book about pesticides perhaps best known for helping spark the broader environmental movement. Her students would read a chapter, then do a project relating to its concepts. For one unit, her students were to redesign Disney World after studying the effects that developing Florida's swampland had on the local ecology.

As a self-described environmentally minded person, Smyser saw the importance of teaching about climate change,

According to a recent poll conducted by Gallup and the Smithsonian Science Education Center, 83% of American teachers believe that teaching about sustainability-related topics — such as clean energy, responsible consumption, and climate action — would have a positive impact on the world.

both its causes and the effects it will have on human populations. But, year after year, when it came time for the class to focus on climate change's effects, Smyser ran into a challenge. Formerly engaged and passionate students would, almost suddenly, lose all interest.

"Students have just been inundated with it," Smyser said. "I really did find that they were just so done with hearing about climate change."

When describing how students typically react to a lesson on the effects of global temperature changes on various species, Smyser let out a long, exasperated sigh. "I feel like I depress them for an entire semester. And, you know, as a teacher, I want to uplift them and teach them how to make things better."

When asked about the causes behind the students' disengagement from climate change in the classroom, Smyser cited the unique demographics of Uni High. The high school's admission rate is 32%. Many students are children of professors at the university or come from academically minded households that encourage their children to meet the rigorous admission standards. These households are more likely to foster conversations about current issues such as climate change. To generalize, these aren't the students who need to be taught about climate change.

Prior to teaching at Uni High, Smyser taught in Danville, a city of just under 30,000 residents roughly 40 minutes east of Champaign, right along the Illinois-Indiana border. Smyser encountered a similar resistance to lessons about climate change in Danville, but the reasons were far different from those at Uni High.

Handprints on the side of the Junior/Senior Lounge at Uni High.
Credit: Exceed College Ruled Notebook via Wikimedia Commons

"The high school I taught at before this one was in a very conservative evangelical Christian community, and many of [the students] were just flat out with like, 'The weather seems fine to me,' " Smyser said. "When people are basing their ideas on something other than data, it's really hard to use data to convince them otherwise."

Smyser is not alone in wanting to integrate climate education into the classroom. According to a recent poll conducted by Gallup and the Smithsonian Science Education Center, 83% of American teachers believe that teaching about sustainability-related topics — such as clean energy, responsible consumption, and climate action — would have a positive impact on the world. However, only 17% of American teachers reported receiving the necessary support to successfully implement these topics into their curriculum, with the biggest impediments being a lack of time, instructional materials, and expertise. While some states, such as Washington, New Jersey, and Connecticut, have passed legislation requiring and funding lessons on climate change, such statewide initiatives are much more likely to be passed in states with legislatures already friendly to climate-positive initiatives.

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It was time for me to bring the issue of climate education in American schools back home. The locker-lined hallways and school-event posters of Uni High reminded me of my high school years at Downers Grove North, a school of just over 2,200 students situated in the heart of the politically moderate western suburbs of Chicago.

When I went to North, the options for science courses were clear-cut. Freshman year you take biology, sophomore year you take chemistry, and junior year you take physics. Three years of science were all that was required by the school board, but a variety of electives were available for interested seniors — one of which was Advanced Placement (AP) Environmental Science.

I'll be forthright; I was not a science kid in high school. My interests centered around literature and the arts, so when I slogged through physics and finished my third year of science, I instantly opted for no elective. However, I remember hearing rave reviews from my more science-minded friends about AP Environmental Science (known as APES), likely the most popular science elective at my school, and its teacher, Mr. Heinz.

APES covers a variety of topics pertaining to the natural sciences, including ecosystems, biodiversity, Earth systems, and atmospheric pollution. The course's last unit, the largest in the AP curriculum guide, focuses on global change. The APES curriculum not only focuses on the effects of climate change, but also the underlying Earth systems that contribute to climate change.

AP Environmental Science is a popular course. Just over 160,000 U.S. students took the AP exam in 2021, making it the second most popular science course behind AP Biology. Yet, limiting climate education to an AP course, albeit a popular one, is not enough to foster wide-reaching knowledge on the topic. Those 160,000 students who took the APES exam constitute just over 1 percent of all students in American high schools. AP courses are often sought out only by those with a preexisting interest in the subject, and counselors often promote AP course offerings only to high-achieving students. According to the College Board, the organization behind the AP program, only 35% of high schoolers graduating in 2022 took an AP exam during their time in high school.

A further gap arises when you consider that students must pay an exam fee — currently set at $98 — to take the course's culminating AP exam. While it is possible to take the class without sitting for the AP exam, this financial barrier can disincentivize low-income students from

I met with Cyndi Smyser, a science teacher at the University of Illinois Laboratory High School. Commonly known as Uni High, the laboratory school serves just over 300 students in a gothic-revival building in the midst of the university's engineering campus. As I walked through the front doors, I felt as if I had walked into a promotional brochure. Nearly every one of the school's tan lockers was personalized with drawings, posters, and magazine clippings. Murals adorned the hallways. A cartoon dragon was painted on the door to the library. To the left of the library's entrance was a poster of Greta Thunberg accompanied by the phrase: "You are never too small to make a difference."

considering the class in the first place. And because students who score highly enough on the course's AP exam can earn college credit, AP courses appeal to already college-bound students, far from the entirety of American high school students.

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When I spoke with Mr. Heinz — whose first name I learned is Michael — I was pleased that our conversation about climate change in the classroom extended beyond his AP Environmental Science class. He told me that, at the beginning of the 2023-24 school year, an Earth and Space Science course will be implemented into the district-wide curriculum, encompassing both North and our cross-town rival, Downers Grove South.

"We'd have kids that were your best students in biology, chemistry, or physics, but they couldn't explain why there were tides or why there were seasons," Heinz said. "We realized that kids, parents, societal members, citizens, whoever they were, they couldn't understand the nuances of the difference between weather and climate. By bringing this class back, we feel really good about the direction that we're headed."

An Earth and Space science class was last offered in the district seven years ago but was reserved as an option for students who didn't have the math skills needed to take chemistry or physics. Now, the district plans to hold eight different sections of the course on three different tracks: remedial, on-grade, and honors. The Earth and Space Science course will cover the district's physical science requirement and can be taken during a student's freshman, sophomore, or junior year. By broadening the curriculum and offering a class that focuses intently on the systems that shape our climate, the school district is ensuring that a greater diversity of students – not just those likely to seek it out on their own – will receive direct education about the most important issue of our time.

After 33 years of teaching, Heinz is two years away from retirement. Despite standing so close to the finish line, his eyes are set on evaluating science education's place in the future of combating climate change.

In February, Heinz and several retired teachers received a National Science Foundation grant to develop a climate change education conference to be held at North. Slated for March 1, 2024, "The Climate of H.O.P.E. (How Our Planet is Evolving)" centered on developing curriculum about climate change.

"We're going to have teachers teaching teachers about better ways to teach climate science," Heinz said. "You asked about the challenges, and some of it is not having the curriculum in place. This will be a way to solve that."

With less than a year until the planned conference date, Heinz estimates anywhere from 300 to 500 science educators will attend. Featured speakers already on the guest list include Kenneth Miller, the president of the National Center for Science Education, and Mary Albert, a professor at Dartmouth College and executive director of the U.S. Ice Drilling Program.

Many science educators have cited a lack of existing curriculum resources as a primary barrier to teaching about climate change. The National Research Council held the first notable climate change education workshop in 2011, and an informal survey presented there found that 78% of teachers required instructional materials to better implement climate change education in their classrooms. "The Climate of H.O.P.E." seeks to solve this glaring problem.

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It's important to realize that in no way were my conversations with teachers and students representative of the state of science education in Illinois, let alone America. Education is rife with inequities, and educational quality often depends simply on how well-funded a school district is. In terms of funding, the two schools I've highlighted fall above the national average. Yet, I was left with a sense of hope that, despite all the challenges baked into teaching about a complex, controversial topic, some teachers are working to prepare the next generation for a changing world.

"At my age — I'll be 54 next week — I'm fine," Heinz said. "I'm going to be OK. My world isn't going to change. But what's gonna happen to my daughters and my grandchildren? It's existential, but it's what will my daughters and their families have to deal with. I think it's important to see that can we get back to a societal good based around confronting climate change."

Matt Troher graduated from the University of Illinois in May 2023 with a B.A in English and a B.S. in Journalism. He lives in Westmont while reading, writing, running, and working as a due diligence analyst in Chicago.

Climate Change

SMOKE SIGNALS

By Erin Minor

Witnesses watch the Eagle Creek fire from the Columbia River Gorge two days into the fire. *Credit: U.S. Forest Service via Wikimedia Commons*

Background: View of a coniferous forest fire. *Credit: Shutterstock*

During Labor Day weekend 2017, Eagle Creek Trail was busy. Located in the Columbia River Gorge just outside of Portland, Oregon, this scenic area is a popular hiking destination. The trail bustled with families hiking to the Punchbowl Falls swimming area about 2 miles from the trailhead. Unfortunately, these hikers had no idea that their afternoon would be interrupted by a 15-year-old boy setting off fireworks, starting a fire that would ravage this stretch of forest for the next three months. The fire started about halfway up the trail and trapped more than 150 hikers, who were forced to stay in place overnight. In the following days, westward winds blew ash on Portland, causing school closures and disrupting traffic along the highway and the river. By the time authorities deemed the fire contained three months later, almost 50,000 acres of forest had burned. The U.S. Forest Service has announced that many of these trails will remain closed until late 2024 because damage to soil composition after a forest fire creates instability that causes rock slides.

When I visited Eagle Creek for the first time in January 2021, the trail I hiked had only been reopened to the public for about a week and a half. Driving through the Columbia River Gorge, it became clear to me that this ecosystem was very different from any I'd seen before. Most of the trees were conifers, their thick trunks and pointed tops covering the hills as far as the eye could see. Along the trail, the understory was thick with ferns that made me feel like I'd stepped into *Jurassic Park*. Fog hung low in the air and the roar of the creek only 10 feet below overwhelmed the chatter of the many visitors we passed. As we slid on the muddied trail, walls of rock arose on the left-hand side – slick and covered with moss. Almost immediately, we came across a large fallen tree — a Douglas fir — blocking the trail and putting us face to face with one of the casualties of the 2017 fire.

A Douglas-fir cone displaying the "mouse tail" bracts. *Credit: Walter Siegmund via Wikimedia Commons*

The Douglas fir is a common conifer species in the Pacific Northwest and is resilient to fire. Indigenous cultures from the area have folk stories about the hardiness of these trees. As a wildfire moves through the forest, the mice living in the forest look for a place to hide. They run to the maple tree and the red cedar tree for help, but neither can protect the mice from the fire. Finally, they get to a Douglas fir, which tells them to use its fire-resistant bark to run up the tree and hide inside its cones. This story serves two purposes. In one way, it's a fun tree identification tool. Douglas fir cones have three-pronged bracts (a different kind of scale that only some types of conifers have) that protrude between the scales, resembling a mouse's tail and legs sticking out. The story also exemplifies the Douglas fir's fire resilience — something that has served it well for centuries both before and after the arrival of settlers during the westward expansion.

Standing on that trailhead on a misty gray winter afternoon, this story and the recent damage to this landscape were fresh on my mind. The trail was busy and covered in the sloppy kind of mud caused by hundreds of feet trudging through wet dirt for the first time in three and a half years. While the damage from the fire was clearly visible in the bare tree stumps and fallen logs, the beauty of this little landscape still took my breath away. Those fire scars seemed to fit in, with moss growing over charred logs like they'd been there all along. I wondered if they had. I wondered what this trail had looked like four years ago, before the most recent fire, but also wondered what it had looked like 300 years ago, when this path didn't exist. With the threat of climate change lurking in the back of my mind, I was heartened by the longevity of the fir trees. Standing so massive and all-encompassing, the Douglas firs looming over me seemed eternal survivors of whatever the Anthropocene had thrown at them.

Found throughout the Cascades Mountain range from Northern California to British Columbia, Douglas firs generally live anywhere from 400 to 1,000 years and are the second-tallest conifer in the world, after the Redwoods, reaching average heights of 200 to 300 feet. Their large size impacts the surrounding ecosystem. Douglas firs are the primary home for the spotted owl and the red

A Douglas-fir in Eagle Creek shows burn marks on the bottom of the trunk but new growth in the canopy.
Credit: Erin Minor

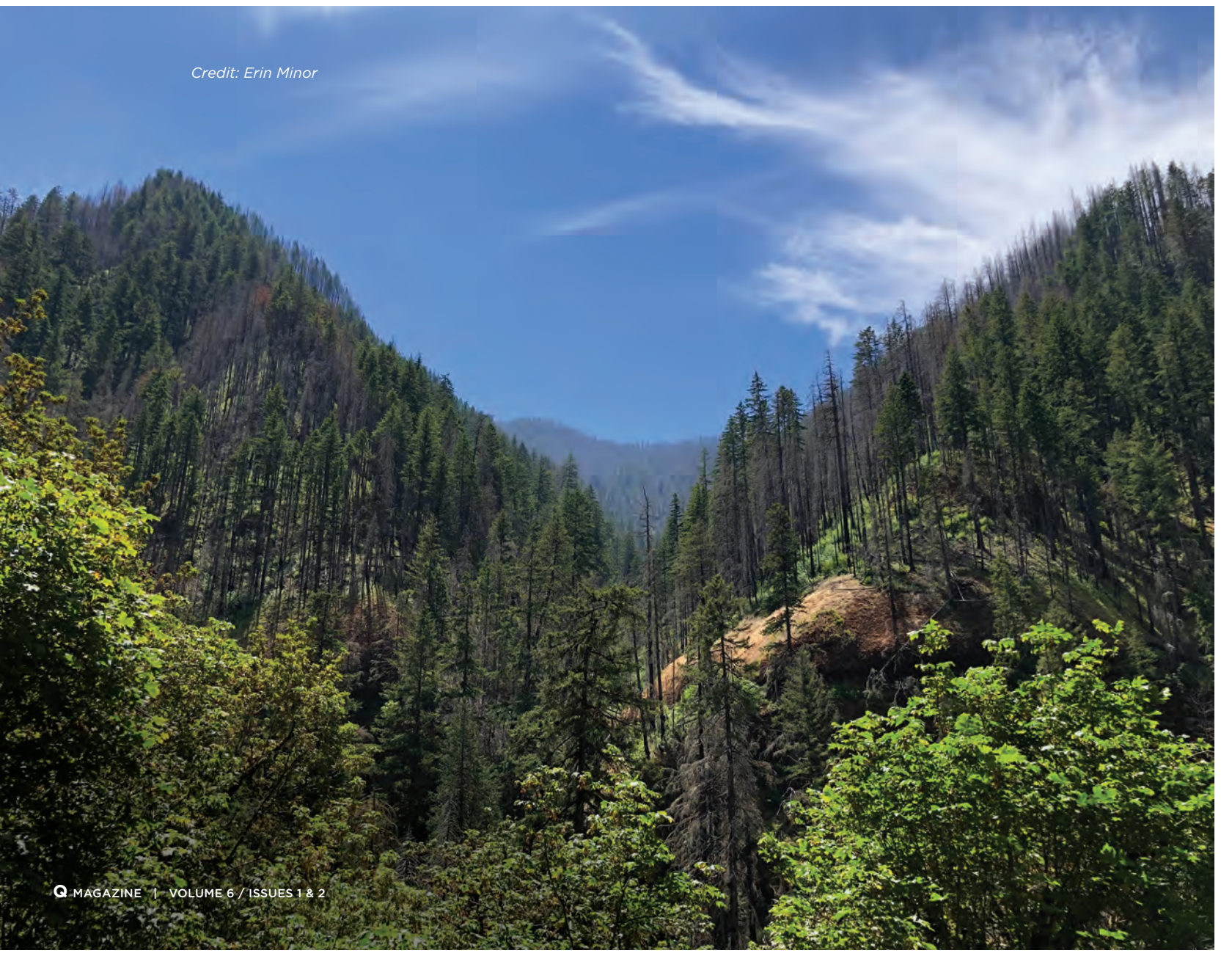
Moss-covered trunk.
Credit: Shutterstock

A fallen tree blocks the trail along Eagle Creek.
Credit: Erin Minor

tree vole, and the seeds found in their cones are a major source of food for many small mammals, including those fabled mice that hide inside.

The bark that saved the mice in the legend is thick and cork-like. This protects the cambium — the layer of the tree directly underneath the bark where new growth occurs — from mild- and medium-intensity fires. Prior to westward expansion, a Douglas fir in the Pacific Northwest would see low-intensity fires in its area as frequently as every six years. These fires were not only low intensity but also geographically small, which scientists can determine by matching scars on the trees and the years they occurred. These temporally matching scars rarely occur in samples across different sites in Washington and Oregon, indicating that 50,000-acre fires like Eagle Creek were not the historical norm. However, around the end of the 19th century, the length of time between fires quadrupled. Without regular fires to thin out the brush, the forests became denser with more material to burn. As a result, when fires *did* occur, they were higher intensity. As climate change worsens in coming years, higher temperatures and drier conditions will exacerbate this problem — the drier the vegetation, the more flammable it becomes.

In the wake of a wildfire, regrowth varies with the intensity of the fire. If the fire wasn't strong enough to damage the highest canopy layer of trees in an area, the new growth after the fire will mostly contain trees that grow well in shaded areas, like the western hemlock. On the other hand, extensive fire damage to the forest canopy opens room for direct sunlight on the forest floor, allowing Douglas fir seedlings to take root and become the dominant tree species in that area. Throughout their lifetime, the thick bark on the Douglas firs along the Pacific Coast can bear the scars from as many as 10 fires.



Credit: Erin Minor

Across the creek, hills rolled into the distance with gray patches of bare trees peeking out through the sea of evergreen. While I was heartened by the forest's tenacity, I had to wonder how these trees would endure the monster heatwaves that rising temperatures will bring in the next century.

On my hike, those bark scars were visible all around me. The bark was charred black, damp to the touch, and left inky black residue on my fingers where I touched it. Some were stumps, ranging from two to seventy-five feet tall, their tops splintered off like broken toothpicks stuck in the ground. Some still stood tall but with all the needles singed off, looking naked in a way that conifers, which normally keep their needles all year, rarely do. Yet most were charred only at eye level, greeting me with a beautiful full canopy above my head. Across the creek, hills rolled into the distance with gray patches of bare trees peeking out through the sea of evergreen. While I was heartened by the forest's tenacity, I had to wonder how these trees would endure the monster heatwaves that rising temperatures will bring in the next century.

I soon had my answer. Just six months after my first visit to Eagle Creek, in June 2021 the Pacific Northwest was hit by a heat dome — a high-pressure system trapping hot air across the region. This led to record high temperatures ranging up to 120 degrees Fahrenheit. Many of the conifers in the area, including the coastal Douglas fir, struggled mightily in this heat. The Pacific Northwest has wet winters and dry summers, and most conifers in the area have a root system that allows them to draw moisture from the ground during the summers. This helps them with drought, but not high temperatures. All over the Pacific Northwest, Douglas firs showed signs of scorching: Their needles turned orange, visible across stretches of forest from aerial photos. Foliage scorching happens when high heat or drought damages the process through which water vapor is absorbed and transported throughout the tree. One study has demonstrated conclusively that it was high temperatures, not drought, that caused this ghastly scorching — similar to scarring from the extreme heat of a wildfire's flames.

The impacts of extreme temperatures were visible when I returned to Eagle Creek a year later, in July 2022. The increasing heat of the Pacific Northwest summer was palpable, even for a Midwesterner used to heat and humidity. The trail was sunny, with clear blue skies showing off the distant rolling hills that were previously hidden by the low-hanging fog that seems to permanently cover the forest all winter. We hiked the 2 miles to Punchbowl Falls, the same way those 150 hikers did five years earlier before getting trapped by the fire. Standing on the rocky shore of the river with my toes in the icy water, I thought of the families who'd been there doing the same thing, not knowing a reckless teenager would extend their short nature walk into a tense, sleepless night in a fire zone. Looking at my own family wading into the river current, a chill ran down my spine as I imagined how easily the same thing could happen to us.

The semester just before my initial visit to Eagle Creek, I'd taken an atmospheric sciences class on climate change. I was committed to learning how to interpret the reports of the United Nations Intergovernmental Panel on Climate Change (IPCC), with its dire projections. It was difficult to see the reality of the future of our planet laid out in hard science. Confronted by the data on climate change, I felt pessimistic.

But standing on that muddy trail, the famous fir trees told a story of resiliency I had forgotten was possible. Yes, the scars of the fire were everywhere: conifers with needles missing from their limbs, fallen trees across the trail and in the distance, charred tree trunks lining the trail. But also, there was so much greenery: in the moss-covered trunks, the ferns in the undergrowth, and the green conifer needles above our heads. There was so much life: the little wildflowers peeking through the ferns, a squirrel scurrying up a tree, and the salamander on a rock next to the trail. The cycle of life continues both because of and in spite of the damage from our human footprint on the world.

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A Pookalam flower carpet made for the Onam festival in Kerala, India.
Credit: Vijayanrajapuram via Wikimedia Commons

A SONG TO THE DRAGONFLY

By Helen Anil

When my mother was young, the arrival of Onam, a harvest festival, transformed our ancestral home nestled amidst the lush emerald green of Kerala, India. Celebrated in the month of Chingam, it wasn't just a festival; it was a symphony of local traditions, with elaborate feasts known as Onasadya.

Tables adorned with banana leaves showcased a dazzling array of culinary delights. Traditional snake boat races called Vallamkali took place on the shimmering backwaters. The intricate art of Pookalam, in which vibrant floral carpets were meticulously crafted on the courtyard, connected us to the essence of Kerala's natural beauty. At the heart of this celebration was the thumba flower, which symbolized the purity and vibrant spirit of Onam.

As a child, I watched my mother's nimble fingers lovingly weaving garlands of thumba flowers, their pristine white petals evoking the purity of freshly fallen snow. Dressed in the traditional kasavu saree, she gracefully placed thumba garlands all around the home, their vibrant petals mirroring the laughter that filled our hearts.

In the midst of these memories, I hear the echo of a song: "Thumbi vaa thumbakudathin thunjathu aayi oonjaal idaam." *Come, O dragonfly, alight on the stem of the tender plant, let's swing on the swing.* The dragonfly is invited to sip nectar from the thumba plant, as though nature itself composed the song, calling us to taste its sweetness.

Now, I celebrate Onam in my American home, but am forced to fashion garlands from artificial thumba blooms, their plastic petals mimicking the vibrant hues of memory, a stark reminder of the world we've had to recreate. Although I sometimes get back to my lush homelands and am able, like my mother, to weave garlands with real flowers, I have a lingering fear that thumba flowers may one day become as rare as solace in a storm.

Climate change impacts precipitation patterns globally, affecting the timing, intensity, and distribution of rainfall. In the case of India, changes in the all-important monsoon are contributing to rising sea levels, making coastal regions more susceptible to flooding. Kerala, with its extensive coastline, is especially vulnerable to an amplified monsoon, with storm surges that lead to destructive flash flooding.

The construction industry has made matters worse with sand mining, especially on the eroding coastline. The serene coastal village of Alappad, for example, once almost 90 square kilometers in size, has shrunk by 90%. Homes have vanished, and local communities now face eviction. Fish and other local animal populations are also in decline.

Rivers that once flowed with gentle grace now surge and swell, carrying devastation with them. Kerala, my beloved homeland, has felt the wrath of these changing tides, the floods a reminder of nature's capricious temperament. We rebuild or relocate our homes, but the scars on the land run deep, echoing the turmoil of a planet in flux. Amidst these altered rhythms, the konna trees of Kerala stand with a muted splendor, their gold now tinged with worry, like sentinels guarding the secrets of a vanishing world. The once-thriving, delicate shoreline is being transformed into a broken monument to human greed.

In a not-too-distant future, my daughter, born into a world profoundly altered by the relentless march of climate change, will experience a different life from mine, or my mother's ...

A white thumba flower with an ant crawling across it.
Credit: Rameshng via Wikimedia Commons

As she flips through the holographic pages of our family's digital album, she encounters images from my mother's time, a period when Onam was a celebration of nature's abundance. She gazes upon the thumba flowers, their colors and shapes unfamiliar, like relics from an alien world.

"Amma," she inquires, her eyes wide with curiosity, "what are these vibrant blossoms in the pictures?" With a heavy heart, I narrate tales of a time when ecosystems thrived in harmony, when Onam's pookalam was a testament to nature's artistry.

For this child, the Kerala landscape has altered beyond recognition. Oceans have swallowed the shores her mother and grandmother cherished, and the skies are a permanent shade of gray. The seasons have lost their rhythm, and the gentle monsoons are a distant memory.

For me, the invitation we sang to the dragonfly serves as a haunting reminder of what once was — a world where nature's sweetness flowed freely. It will be the next generation's duty to preserve what little remains and to envision a future where thumba flowers and the resplendent tapestry of nature once again grace the festivals of Kerala.

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Not Waving, Drowning

By Levi Beckett

Credit: Shutterstock

On the island of Guam, some 1,600 miles off the coast of Japan, the sky looked clear, the water looked safe, and I had just bought a snorkel. We got lost several times on the road to the beach and ended up not quite where we intended. But the locals were swimming just off the shore, so I got into the water with a few others. All Illinois natives, we reveled in the unfamiliar wonders of the ocean. We floated on top of salt water without moving and let the waves carry us into the air like a roller coaster, always depositing us back safely near the shore.

As we ventured farther out, I was surprised to feel the water tug me toward the incredible expanse that was bigger than I was comfortable comprehending. I avoided looking at the vast horizon. The waves got just a little taller every few minutes, and the pull became stronger. Still, I didn't leave the water; if the waves got too high, I could just go back. By the time I realized how helpless I was, I was being dragged underwater by an undertow that snuck beneath me like a snake. When I was able to force my head above water again, the shore was considerably farther away.

In September 2022, Super Typhoon Nanmadol gathered in the Pacific Ocean halfway between Tokyo and Guam. It began as a low rumbling of thunderstorms scattered across the water. The storms coagulated in the Pacific sky and then slammed into the coast of Japan. With heat energy ripped from the sea surface, the storm system exploded in size, leaving a trail of eerily frigid ocean in its wake. Winds over 185 kph whipped across Japan's heavily populated coastline. Nanmadol had abruptly metastasized across a warming ocean and ultimately became one of the strongest typhoons ever recorded in Japan, forcing millions to evacuate and wreaking over $1 billion of damage.

The entire ocean rocks when a hurricane forms. During Typhoon Nanmadol, 60-foot waves punished slow-moving animals and shellfish beds in the Pacific Ocean. These creatures could not survive the rapidly changing salinity and temperature and the brutal undertow. Sharks and whales fled the apocalyptic conditions, while most coral reefs were badly damaged or destroyed. Two Japanese citizens died and about 90 others were injured in the destruction. One man was submerged in his car while sitting in a parking lot, waiting for the storm to pass. Another was caught in a landslide and never came home.

Hurricanes gain power in warmer atmospheres. Water expands as it gets warmer, which produces more moisture in the air. The result is an increase in rainfall and a higher frequency of Category 4 and 5 hurricanes. Rising sea levels and melting glaciers add even more fuel to storm surges and floods. A warming climate, influenced directly

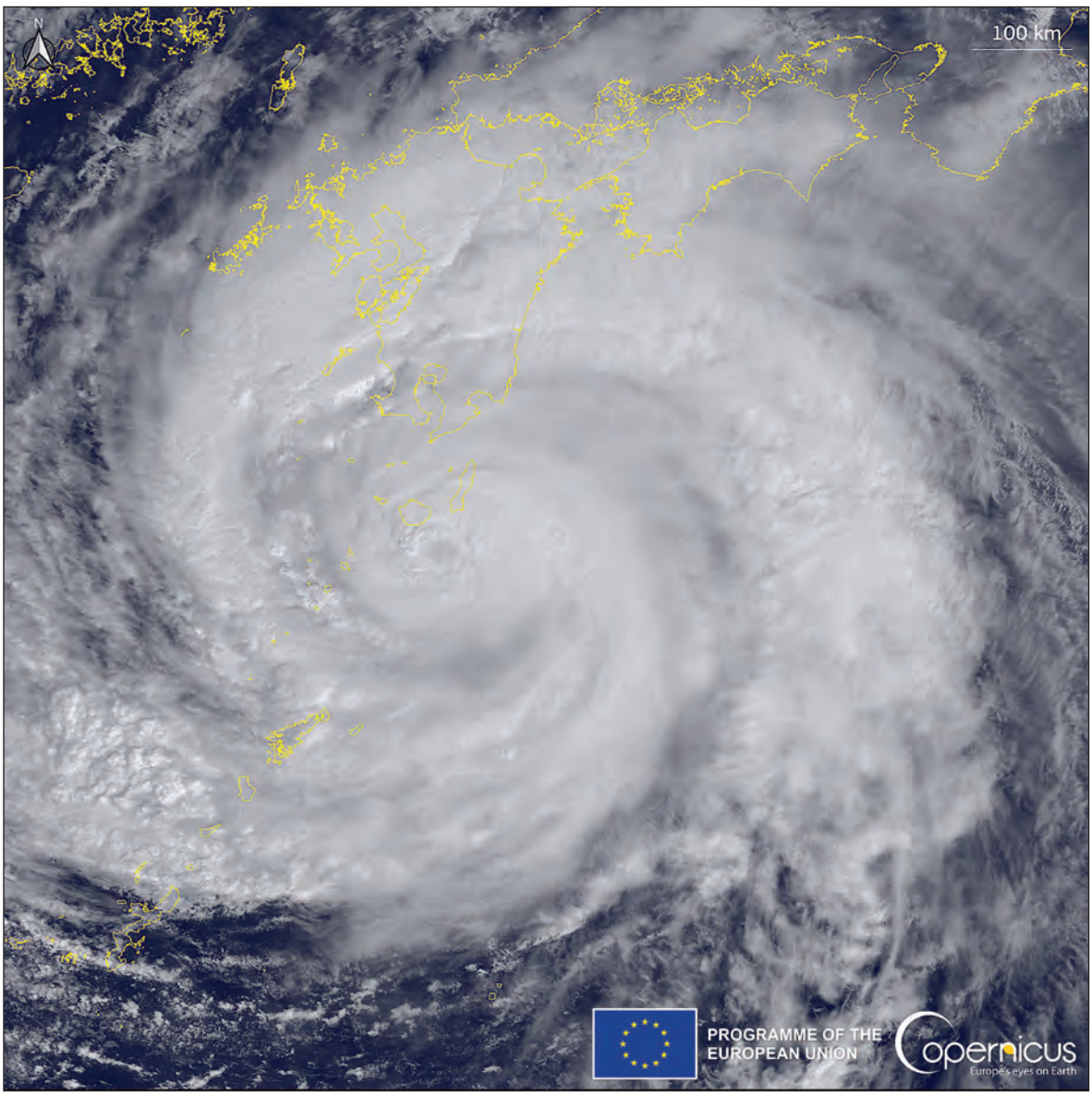
Waves from Typhoon Nanmadol break along the coast in Izumi, Kagoshima prefecture on September 18, 2022.
Credit: Yuichi Yamazaki via Getty Images

by human behavior, also contributes to much stronger tropical storm winds, causing hurricanes to intensify faster and driving powerful waves against vulnerable coastlines.

Decades ago, this size and severity of tropical storm activity did not exist. Simple math dictates that a 1,000-year flood has a 0.1 percent chance of occurring every year, but in just five months of 2016, four of these floods racked Texas, West Virginia, Maryland, and Louisiana. Heavy rains today are estimated to dump 71% more rainfall onto the mid-Atlantic and northeastern United States than they did just 60 years ago. While natural forces create varying degrees of storm and flooding intensity, man-made climate change exacerbates these weather disasters.

Hurricane Katrina, one of the most costly tropical storms in recent history, caused massive damage not only because of its severity, but because it made landfall on one of the most economically valuable coasts in the country. Shifting housing prices and migration in response to rising sea levels, as well as sheer destruction in high-value areas, will rise alongside sea surface temperatures. One Yale study estimates that storm damages will increase by 0.08% of GDP annually due to rising CO_2 levels in the atmosphere.

Storms are increasing in frequency as well as size. The number of Category 4 and 5 hurricanes has doubled since the 1980s. Hurricane Harvey, which made landfall in Texas in 2017, broke records with a 60-inch rainfall. Scientists estimate that the warming climate increased



A satellite photo of Typhoon Nanmadol hitting the southern tip of Japan.
Credit: European Union via Wikimedia Commons

this rainfall by 15-38%. Storm surges, possibly the greatest danger for human lives during a hurricane, also drastically increase in warmer waters. Hurricane Ian, which flooded Fort Myers, Fla., in 2022, drowned 30 people with a surge of 15 feet. Though restored wetlands can help alleviate the brutality of these storms, a significant reduction in global carbon dioxide emissions and methane pollution is the only way to properly protect humanity from this worldwide onslaught of extreme weather.

Then there's El Niño, generated by warmer sea surface temperatures in the Pacific Ocean, resulting in more extreme rainfall and a higher likelihood of hurricanes, floods, and landslides in some regions, and crippling drought in others. In the past 100 years, the periodic El Niño phenomenon has turned monstrous as sea surface temperatures artificially rise. A record-breaking Texas flood in May 2015 was driven by El Niño conditions, as was Nanmadol, a typhoon so powerful that a U of I student was left flailing in the ocean hundreds of miles from the eye of the storm.

In the blink of an eye, the waves had become goliath. I was thrown onto rocks, bloodying my feet and legs while I turned somersaults in the water. I couldn't tell where the ocean stopped and I began. My stomach churned with the waves. The skin holding my body together suddenly felt thin and fragile, barely an afterthought to the power of the sea. All I knew was I wanted air. I didn't know which way was up, but I kept clawing for that precious air, praying I was going the right way. I remember the water was salty and burned my throat. How much I swallowed I don't know. When I finally found the surface again, I screamed out. The waves were too high to see anything around me, and my shouts were muffled by the walls of water. A mountain of ocean surrounded me. Panic coursing through my veins, I tried to float on my back until the waves subsided.

As I watched the indomitable height of a wave coming to force me under again, I suddenly understood myself as never before. I was a collection of molecules that happened to organize into a person-shape, a monkey descendant that could easily be scrubbed away like the dinosaurs. I thought about the flat plains of the American Midwest, and about the fireflies I used to see during the summer nights of my childhood. I thought about my mom and I silently apologized to her. I understood, probably for the first time, that I am no different from every person who has died before me.

The waves relaxed. I was exhausted, but an ancient instinct to hack through the water and rescue myself from drowning drove me on, no matter how useless my limbs felt. It took about an hour to swim back to safety. I arrived on the shore shaking, bleeding, and vomiting. Having been stripped down to my barest animal instincts, I felt simultaneously like a monkey unadapted to swimming and like Adam from the Bible, exiled from the garden.

As a Midwest native, the danger of a hurricane had been distant to me before I nearly drowned in one. But the economic damage dealt by hurricanes will soon be brought home to all of us. Long-term data on tropical storms is restricted to the availability of satellites, which only came about 60 years ago. But it is undeniable that the annual number of hurricanes has increased, especially since 1980. The massive storm surges that typically accompany tropical storms are a powerful threat to major economic centers with low elevations. In the United States alone, the coasts of Miami, New Orleans, Houston, and Tampa are hugely vulnerable. Hurricane Katrina was only the beginning.

Looking back, it was my arrogance that carried me out to sea. Ego is an ocean of another sort. I'm sure that for those who study the forces of nature, the power of a super typhoon, the oceans, and climate change is obvious. But for the rest of us living in a hyper-artificial society, the illusion of individual agency is comforting and becomes the unquestioned norm, as invisible as a virus or a microplastic particle or the hurricane winds that nearly killed me back in 2022.

The Earth doesn't recognize self-made billionaires or kings. That fateful day off Guam, it also didn't recognize an Illinois kid who had disregarded the ocean's power and just wanted his mom. The damage of climate change already disproportionately affects people of lower income and poorer countries. But no one is immune to a super typhoon, and eventually, if there is not a significant effort to reduce global warming, we'll all be equal. Death keeps no record of wrongs. It has no marketplace or meritocracy to distribute suffering fairly. All we can do in the face of it is reach out to each other, and be there when someone reaches out to us. To strive to save ourselves and each other, no matter how hopeless it feels.

Levi Beckett completed his Bachelor of Science in media and cinema studies with a minor in political science in December 2023. While an undergrad, he was an active member of ecological restoration RSO Red Bison and a marketing intern with the University of Illinois Foundation. He is passionate about conservation and currently seeks a career in non-profit communication. He maintains a website at lkbeckett25.wixsite.com/levi-beckett.

BLIND ME WITH (CITIZEN) SCIENCE

By Abby Culloton

"Look at me — I'm a chemist!" my teammate enthusiastically declared as she tipped a test tube full of bright blue liquid back and forth. The blue liquid in question was a test for dissolved oxygen in water: an important chemical parameter for determining the health of an ecosystem. Our lab was contained in a backpack that we carried to the grassy overbank of the Iowa stream where we used an empty milk jug to collect our water sample. We then tested the water for different chemical pollutants and recorded its clarity, color, and smell. None of my teammates had much experience or knowledge on water testing when the day began, but by the end, we were proud to call ourselves hydrologists-in-training.

Taking a water sample.
Credit: Shutterstock

University of Illinois students participating in a mussel survey with the Upper Sangamon River Conservancy. *Credit: Abby Culloton*

Efforts like these to gather environmental data are part of the ever-growing field of citizen science: the involvement of the public in the collection of scientific data. Public-collected data is used in countless scientific studies across numerous fields. From helping NASA collect data on Aurora Borealis sightings to keeping a rain gauge in your backyard to record precipitation data for state climate studies, there are so many ways for anyone to get involved in scientific research. Environmental science in particular is a field where citizen science is heavily used. Many environmental studies have large data needs, which can be time intensive or cover a large geographic range, making volunteer participation essential to collecting adequate data. Citizen science provides a unique opportunity for communities to engage with research and learn about environmental issues, all while collecting crucial information.

On that summer morning when my teammates and I got to play chemist for the day, we experienced the importance of citizen science firsthand. We were participating in an annual event called "Summer Snapshot," hosted by the Partners of Scott County Watersheds (PSCW) in Davenport, Iowa. PSCW is a nonprofit organization that hosts four "snapshot" events each year, where the community comes together to gather water quality data on local streams. Some teams collect chemical parameters, such as nitrates and nitrites, chloride, dissolved oxygen, pH, and more, using various tools and testing kits. Other teams collect biological data by identifying aquatic organisms present in a stream. All volunteers are provided with training on how to conduct these tests, then are sent off to visit two to five different sites around the county to collect their data. Afterward, the information is entered into a publicly available database. Volunteers can see the final data they helped gather, community members can gain a better understanding of what's in their water, and environmental agencies like the Iowa Department of Natural Resources can use this information for their own studies and projects.

Volunteer-collected snapshot data is also used directly by PSCW to identify polluted streams, develop projects to remediate impaired waterways, and write grants to secure funding. One such initiative is the Robin Creek biofilters project. Snapshot data indicated an elevated *E. coli* presence in the Duck Creek watershed in Davenport, likely due to fecal pollution from pets, wildlife, and livestock in the area. One location on Robin Creek, just downstream of a dog park, was identified as a pilot location to install three biofilters, with the goal of reducing *E. coli* and enhancing the aquatic habitat. The biofilters are mats made of recycled plastic fibers, which allow water to pass through while filtering out fine particles. The filters are currently in use in Robin Creek and help determine the feasibility of implementing similar devices in other streams. This project would not have been possible without volunteer-collected snapshot data, which informed PSCW about the water quality issue in the area and provided the organization with the foundation on which to build the project.

Citizen science is also crucial in large-scale environmental studies where it would be impossible for researchers to gather adequate data on their own. The Globe at Night project, an initiative of the National Science Foundation's National Optical-Infrared Astronomy Research Lab (NSF's NOIRLab), is one example of this type of effort. This international campaign aims to quantify light pollution across the globe. Artificial illumination from streetlights and buildings floods the night sky, interfering with astronomical research and — more importantly — disrupting the nocturnal rhythms of plants and wildlife.

The Globe at Night project allows anyone to submit their observations of the night sky from anywhere on

Earth. Whether using sophisticated telescopes or just the naked eye, people are invited to use an app to submit their observations and the conditions in which they were recorded. Those who are especially interested in the project can even purchase a Sky Quality Meter — a device that quantifies light pollution in a given location — and report their readings to the database. This allows scientists to maintain a comprehensive database of night-sky observations across thousands of locations and under different meteorological conditions. Crowdsourcing allows for a much wider set of data than a small team of experts would be able to collect on their own. The database can then be used for light pollution studies and awareness campaigns.

As an added bonus, the project actively gets people interested in the issue of light pollution and encourages them to go outside and engage with their environment in a new way.

Environmental education and awareness are important aspects of citizen science. A 2016 report from the U.S. Environmental Protection Agency presents citizen science as a core tenet of environmental protection, stating that "citizen science is more than the participation of volunteers in research. It is a model for the democratization of research and policy making. In addition, it is an environmental movement that is changing the way the government and institutions interact with the public." Citizen science actively makes environmental research and policy making more accessible by meeting people where they are. When educational background can be a barrier to involvement in the technical aspects of scientific research, citizen science allows anyone, regardless of background or experience, to get involved.

I asked PSCW Coordinator Liv Humphrey about the impact of events like Summer Snapshot on the people who participate. She explained that "this is a day that most of them wouldn't get to experience if it wasn't for this event. Being able to work with water-monitoring tools is something that people don't really get to do. Not only does it benefit the volunteers — it benefits them to get out there — but it also submerses them into their environment in a way that they might not have the ability to do."

Citizen science events like Summer Snapshot engage community members in environmental efforts and provide educational opportunities that they might not otherwise have. They also allow people to become more aware of the environmental issues that are most directly impacting them and can inspire individuals to find a new interest in conservation. Humphrey went on to say that summer snapshot "really slows [volunteers] down and makes them look at what's in their water." In today's world, it is more important than ever to bring continued awareness to environmental issues, and getting as many people involved in efforts that will generate this awareness is key to generating sustainable solutions.

In East Central Illinois, the Upper Sangamon River Conservancy (USRC) strives to promote diversity in citizen science and inspire young people to find a passion for the environment. One way the USRC does this is through mussel survey events, which bring community members out to the Sangamon River to help collect freshwater mussels, then participate in identifying,

A biofilter spans Robin Creek, using recycled plastic mats to filter fine particles out of the water. *Credit: Partners of Scott County Watersheds*

Summer Snapshot participants conducting chemical water tests in Davenport, Iowa. *Credit: Abby Culloton*

measuring, and tagging them.

In the short documentary "Mussel Grubbing: A Citizen Science Treasure Hunt," USRC Citizen Science Coordinator Bruce Colravy says "one of the goals of citizen science with the Upper Sangamon River Conservancy is to offer opportunities to young people who might then take that enthusiasm that they have out here for the surveys into a more long-term goal of theirs."

Dr. Danelle Haake, USRC River Watch Director then goes on to describe the wide diversity of participants in the mussel surveys: "We've had volunteers who were 5 years old, we've had volunteers in their 70s. We've had volunteers who were legally blind. You can't usually see the mussels anyway, you use your hands to find them, so being blind wasn't necessarily a hindrance to participating in the citizen science project."

Furthermore, USRC volunteer Nina Carmichael discusses her passion for increasing participation of underrepresented communities in outdoor spaces and how citizen science events like the mussel survey help her achieve this. "One of my biggest passions is to bring people outside, and in particular black and brown people, and to make it less scary of an experience and a really exciting opportunity," she says. "I think citizen science does that inherently where you're able to come out, things are structured, you learn what things are, and what to look out for."

Citizen science is truly a space for everyone, and it is an important step in making scientific communities more accessible and inclusive.

Through both PSCW's Summer Snapshot and the USRC's mussel surveys, I've experienced the magic that happens when community members of all ages and backgrounds come together over a shared interest in conserving our local water resources. The feeling of being immersed in nature and surrounded by a community is inspiring — in fact, it has motivated me and many of my peers in environmental majors to pursue careers in conservation.

When I started my Civil and Environmental Engineering program, I didn't have a clear direction for what I wanted to specialize in or any idea of how I would use my major after graduation. The mussel survey with USRC was my first real opportunity to contribute to a hands-on environmental project, and after spending the day learning about river ecosystems ... something clicked. I began to turn my focus toward water resources engineering, and my experiences with Summer Snapshot further affirmed that this was a direction I loved. Thanks to these citizen science projects, I found my passion in water resources conservation and aquatic ecosystem restoration, as well as a newfound desire to make a difference out in the world.

Humphrey echoed many of these sentiments: "The more we get our volunteers out in nature, the more they can connect with it, relate to it, and that will all build the relationship to then preserve and care for it."

Citizen science initiatives helped me find my path in college, and this is only one example of the reach these types of events can have. When children engage with citizen science initiatives, they learn the importance of being good environmental stewards, and may even be encouraged to pursue an environmental field from a young age. When adults engage with scientific efforts in their communities, they may learn about environmental issues they weren't previously aware of, sparking them to use their voices and voting power to influence policy and encourage conservation in their own backyards.

Citizen science reminds us that anyone can be a scientist, and by meeting people where they are and making science more accessible, we are creating communities that are more engaged, informed, and inspired to take action for a better, more sustainable future.

Abby Culloton is a recent U of I graduate from Bartlett, Ill. She completed her B.S. in Civil and Environmental Engineering in December 2023 and earned the Certificate in Environmental Writing. She now works at the U.S. Army Corps of Engineers in Rock Island, Ill. as a Hydraulic Engineer where she works on flood management and ecosystem restoration projects on the Mississippi River.

Waste Not, Want Not

By Sakshi Vaya

Have you ever been to a landfill? I'm not talking seeing one from 300 meters away sitting in a car. I'm talking up close, face to face with it, standing in the middle of endless hills of everything that humans deem garbage.

I recently had the dubious pleasure of doing so, and let me tell you: It is far more real than the images you find on Google. It is a living, breathing, growing, snarling creature seeming to engulf all that is thrown at it. It stinks beyond belief — you'll faint should you stand there more than 10 minutes. As you walk, you must watch your step, for black fluids mixed with melting plastic and rotting food scraps leak through the disgusting body of this monster and puddle on the ground. You look at its ugly, oily plastic skin and fear to touch it, for it might just suck you in. The bodies of these horrifying creatures are made primarily of rotting food.

Credit: Shutterstock

In the United States, food waste makes up the biggest chunk of landfills, about 24 percent. And yet, more than one in five U.S. adults faces food insecurity. The numbers only get worse when you look at the student population, with 29% of students in four-year colleges facing food insecurity at some point while they're at school, according to the Hope Center's 2020 Student Basic Needs Survey.

The dichotomy between the over-abundance and crippling shortage of food is a salient feature of many college campuses in the U.S., with 22 million pounds of food being wasted each year. Our own Urbana campus is no stranger to this issue. Similar to the trends in the United States at large, we waste 30% to 40% of all food, both on and off campus — the fault of student behavior as well as institutional mismanagement.

Even as the university administration makes efforts to remedy the problem, food waste management at the U of I cries out for student engagement: first, because of high levels of food insecurity in the student population; and second, because students are best situated to fix the problem. It is thus crucial for Illinois students to understand food management at the university — a story that begins in our dining halls.

U of I dining halls greet you with a wide variety of options: many cuisines, diverse dietary preferences, and several options for each course of a meal. With a regular meal plan or the standard cost of one meal, you swipe your card to get in and then your only limit is how much you can fit on a tray. In this all-you-care-to-eat model, there is no limit on the number of plates, bowls, or servings. Result? Food waste.

As an undergrad, I have seen first-hand students put way more on their trays than they can consume, often taking multiple plates per person. I've routinely seen trays full of untouched food in the trash bins. It made me wonder how such a glaring waste issue went unaddressed. To learn more about the problem, I spoke to the Food Service Supervisor at the Ikenberry Dining Hall, Anthony Sanders.

He walked me through the doors into the kitchens and prep areas. "It's not just students. A big reason for food waste in dining halls is excess production," he said.

In a university this size, with over 35,000 undergraduate students from across the globe, the dining services must accommodate all cultures and dietary preferences. With such a wide variety, it is hard to predict on a daily basis how much of what dish will be consumed. There are bound to be errors in these projections, which lead to more than 25 tons of perfectly good fresh food being thrown into trash bins each month.

"So where does all of this unused food go?" I asked, looking for hope. Sure enough, there was some. Sanders led me to the waste disposal system at the back of the dining hall, called Grind2Energy.

Since 2019, the university has been using food waste from dining halls to produce energy through the Grind2Energy system. Food waste in several dining locations is churned through commercial-grade grinders before being filled into storage tanks. From there, the slurry is transported to the Champaign-Urbana Sanitary District, where it enters anaerobic digesters. These digesters convert the energy from the waste into biogas, and the remaining sludge acts as a fertilizer for agricultural fields. This system allows for almost all of the food waste from university dining to be diverted from landfills and instead be put to use, either as energy or fertilizer.

While I was relieved to learn about this solution, I wondered if the problem of food waste on campus was limited to dining halls. It only took a couple of student interviews to reveal that was certainly not the case.

Food being sent to the Grind2Energy system at a University Dining facility. *Credit: Mark Herman*

A campus Grind2Energy system.
Credit: Mark Herman

After their freshman year, many students move to off-campus housing options and start cooking their own meals. Junior Raunak Bansal expected his food waste to decrease when he moved to a private apartment, since he would only be making what he needed. Not so. "It was a slow and hard realization that responsible grocery shopping, cooking, and storing food were skills that took a good while to learn," he said. Like Raunak, most young people have little to no food management skills when they first start living by themselves, which means significant amounts of spoiled food and extras end up in trash cans.

It is important to see the food waste issue on a college campus in a national context.

Almost all of the food waste in the United States makes its way not to a recycling machine like the Grind2Energy system, but rather to a landfill. It is a common misconception that food waste that reaches landfills decomposes there and thus causes no damage. In reality, food in open landfills rots over long periods, releasing greenhouse gases like methane and mixing with other toxic substances seeping into the soil.

Food waste is also an enemy of recycling. Like the U of I campus, many municipalities around the country have a two-bin system of segregating waste into recyclable and non-recyclable components. With this system, rubbish like plastic bottles, metal cans, paper, and cardboard can be diverted from the landfill and recycled instead. But there is a lack of education surrounding the proper segregation of waste. Many of us throw plastic and cardboard containers with food waste straight into recycling bins. Oil, water and other substances from such containers leak and contaminate other recyclable materials in the bin, ruining them for recycling.

To better understand this recycling-and-food-waste conundrum, I visited the Waste Transfer Facility on the U of I campus. There I saw with my own eyes the foul mix of things people throw into recycling bins, from used tissue paper to bad coffee to oily takeout that someone forgot to eat, all mixed with cups, cardboard, and paper. The contents of recycling containers are extremely contaminated, primarily by food waste, to the extent that only 30% of all potential recyclables are actually salvaged.

Here's the most jarring part. While tons of food are wasted on our Urbana campus every day, many in our community struggle to secure two square meals a day. Despite university initiatives like the Food Assistance and Well-being Program — a food pantry for students — many remain helpless and hungry. Social, mental, or emotional issues may prevent them from seeking the help they need. The COVID-19 pandemic only added fuel to the fire, pushing thousands more to the brink of food insecurity. This is what makes the conversation around food waste more urgent now than ever before.

As an international student, I'm able to participate in this discussion as both an insider and an outsider. I come from India, a country with a far bigger hunger problem than the United States. In developing countries like mine, we're raised with values that surround respecting, preserving, and judiciously using food, irrespective of your socioeconomic status. Wasting even a morsel of food is considered a sin. It is thus a huge shock to me to see that the contemporary culture around food in the U.S. normalizes throwing away leftovers if you "do not like it" or find it to be "too much work to store it." The elevation of personal convenience to a sacred principle disregards the fact that individual behaviors impact food security in entire communities.

That said, these same cultural differences can be used to bring about change. A robust exchange of diverse views around food in our university setting can help educate people about hunger in the community as well as the environmental impacts of food waste across the globe. A campus-wide conversation about food values and food waste might also inspire individuals and groups to positive action. Unlike many other social issues, food waste is one that students have the direct power to solve through their personal decisions. We can *choose* to waste less, to be mindful of our portion sizes, and to be responsible with leftovers. We can also push new collective initiatives, such as the introduction of student-managed composting units, which could provide compost to green our campus.

So much better, after all, than a reeking landfill!

Sakshi Vaya is from India, and received her degree in Earth, Society, and Environmental Sustainability as well as the Certificate in Environmental Writing. She was part of the Environmental Leadership Program as well as the Global Leaders Program, and she served as a Zero Waste Intern at Facilities & Services. She plans to devote herself to Jeevatva, a waste management startup based in India.

LET THE SUN SHINE IN

By Gabe Lareau

Sustainability begins in the soil.
Credit: UI NEWS BUREAU/FRED ZWICKY

On paper, Esther Ngumbi is a multiple award-winning Professor of Entomology and African American Studies at the University of Illinois Urbana-Champaign, a food security advocate, and a science communicator featured in venues such as *NPR*, *Scientific American*, *Al Jazeera*, and *The New York Times*. She's also the recipient of a shelf-full of awards: the 2017 Emerging Sustainability Leader Award, the 2018 President's Medal from the Society for Experimental Biology, and the 2021 Award for Public Engagement with Science by the American Association for the Advancement of Science, to name just a few.

In person, Ngumbi makes those, and every other line of her biography, seem like an understatement. Like most in Kenya's southern Kwale County, Ngumbi was born a farmer, and poor. After graduating from Auburn University in 2018, Ngumbi became the first person to earn a Ph.D. from her village, Mabafweni. Ngumbi has played an integral part in Mabafweni's recent transformation, founding a school (Dr. Ndumi Faulu Academy) and a lab (the only item on her bridal registry).

Ngumbi manages her own lab at the University of Illinois, which specializes in studying plant-insect chemical relationships as part of an overall effort to build better climate-resilient "muscles" in crops like tomato and maize. When not in the lab, Ngumbi is busy writing about anything under the sun: climate change's impact on food security among the world's poorest; how scientists need to rethink their communication strategies; and the exclusion of African scientists on the world stage.

Q Magazine's Gabe Lareau sat down with Ngumbi this past fall semester to discuss the many threads of her work, her upbringing in Kenya, climate change, and how she can't help but stay joyful amidst it all.

Esther Ngumbi.
Credit: UI NEWS BUREAU/FRED ZWICKY

Q: You grew up in the small village of Mabafweni, Kenya, where you lived with your parents and four siblings. What was it like growing up in that community?

We went to school like every other kid, but a large part of growing up was agriculture. We would farm with our parents; we had to do that to kind of subsidize or enhance our ability to feed ourselves. We would go out to the field in the morning and tend to the crops — maize, beans, vegetables — go to school, and then go back again to the garden. Some of us girls would go out to get firewood for cooking and then prepare the meals. But when we were not at school or on the farm, we were just playing with other kids.

Q: And your parents particularly stressed your education, right?

Yes, absolutely. My mother and father were both teachers. Just looking at the surroundings, you know, poverty was a real thing and they themselves were brought up in homes that were not well off. They emphasized that the way out of poverty, the way out of having not much to eat, the way out of not having not a lot of wealth, was education.

They would say, "I can't give you anything because you're not going to inherit anything. But what I'm going to give you is education. So, do the best that you can." They definitely sacrificed anything and everything to get us in school.

It was truly a sacrifice because, on payday, they would leave in the morning, go into the city, and divide their paychecks. As children, we always told them to spend their money in the city, but they would say, "If we do that, that means you're not going to go to school."

Q: Was science something you always loved in school or did you learn to love it?

Well, I've always been a curious person. Growing up, I was always asking questions. But the reality was that I was growing up in a place where you don't have access to a lot of people who did different things and had careers to facilitate broader thinking in kids.

So, for most of my early childhood, I wanted to be an accountant because I would go to the banks with my parents. It looked like the best career — they were working in air-conditioned rooms, wearing suits and ties and looking so well dressed. I wanted to be like that. But with that, there's this dilemma: I also wanted to be curious every day and not see the same things. And I found that especially with growing crops. I was always curious, thinking things like, "How do all of these insects find all of our plants?"

I did well in high school, and during undergrad I did a lot of science. I went to the lab for the first time and was like, "Wow, here I am. This is the profession that truly satisfies my curiosity." It was just question after question after question which I get to find the answers to. So then I flipped. I was like, "OK, I am definitely going the science route."

Q: Science is heavily collaborative, and you take advantage of that at every opportunity. Why does collaboration bring you so much joy?

I can never do it alone. I like science that is collaborative because when we work together, that's when we get close to the answers. We can also tap into the strengths of different experts and then things can always become a hybrid and interdisciplinary project. It's so much better than somebody doing things by themselves.

Q: What made you want to go into entomology specifically?

It had a direct impact on our lives as children. It had a direct impact on food security and just poverty at large. The effect that insects have had on my family and my community have been huge when you realize that when insects take away crops, families go hungry. That lack of food then opens things up to poverty.

There's this interrelationship between insects, food, and poverty that each feed on one another. It becomes this combined issue that escalates to other things. A lot of aspects of poverty originate in food insecurity.

Q: Has food insecurity gotten better in spite of, or worse because of, climate change?

As we've gotten better at development, food security frequently goes forward and then goes behind us. We keep thinking we make progress, and then climate change brings another wave of challenges. So it's been a lot of "one step forward, five steps backward." It has just been this zig-zag line.

Some governments can teach people how to be resilient when climate stressors come in or step in and allow people to move altogether. But for many families, when climate change pushes them, it means that it takes so many years for them to get back to normal. All the monumental good that we do just quickly gets wiped away.

Q: Many people overlook how climate change, environmental justice, and the education of young women are all related. How are those things important and intertwined?

First of all, education broadens your understanding: your understanding of nature, how it is changing, how we've changed it, and how we, as much as we are the problem, can also be the solution. By learning and by educating yourself, you broaden not only your thinking but also the solutions which we can use to tackle these challenges.

It's all so interconnected. Some of these challenges can be tackled by education. And so when you go out and educate people, most importantly young women, then you're also educating families and you're educating societies. When these young women succeed and go back to their families, their educational upbringing becomes part of the fabric of their society, and it never goes away. That's why we need to kind of stitch in the lack of education as an aspect of all of these environmental problems.

Q: You're also a science communicator and have stressed the importance of clear science communication for the public. How do you balance educating a more general audience with being a major contributor to the scientific community?

When I was part of the Aspen Institute New Voices Fellowship, we had a training that was focused on empowering us to be advocates from the Global South.

The Dr. Ndumi Faulu Academy (founded by Esther Ngumbi) in Mabafweni, Kenya. *Credit: Esther Ngumbi*

And in my training, it was clear that scientists are not communicating at all.

And most of the time, yes, I write manuscripts. But available research shows that less than 10% of people are reading a lot, especially manuscripts. That's because of the way we write our manuscripts. The language is so dense that nobody can understand what's going on. Second, most of the time we are publishing in journals that are not open access.

We have a lot to gain when scientists translate and try to use accessible language that not only just reaches your peers, but a wider audience. Those audiences consist of policy makers, business owners, and people who can translate what we are doing into products that can immediately start taking on the challenges humanity is facing.

Q: What's the Ngumbi Lab up to these days?

Our work is heavily focused on agriculture. We focus on tomatoes and maize, which is a staple in my country and many other African countries. To grow it, we must learn about its biological faculties.

In my lab, we are guided by chemistry first. Chemistry is the way that plants can communicate with insects and pollinators. Beneficial microbes below the ground all communicate with plants that are being eaten; they can call for rescue from natural enemies. That's all chemistry.

My lab tries to understand how that chemistry changes when the plants themselves are being stressed out, whether it's biotic stress — biotic means insects — in the fields or abiotic factors. In my Ph.D. I was studying drought. When I came to Illinois in 2018, the next year saw a big flooding event, and it was clear that farmers did not know what to do.

All of their crops died, and they had to replant. There was no scientific evidence on what was going on or how the plants would respond to climate stressors. My lab quickly started investigating how flooding, as a stressor, influences not only plant chemistry, but its physiology, its relationship to the microbiome, and ultimately soil health.

We wanted to see how long the impacts of flooding events last and how we can start integrating everything we are learning from my lab into knowledge that will help mitigate this. We wanted to find out what defensive traits give the plants their muscles to perform well and be resilient, no matter the stress.

When we really understand what's going on, then we can use that to work with leaders and other experts to equip our crops and our farmers' systems.

Q: Are there any specific examples or discoveries of what a plant needs to gain those "muscles"?

For me, I think the greatest discovery has to do with plant growth-promoting rhizobacteria. When these microbes associate with plants, they form a relationship that becomes a decoy system for the insects. It's almost like saying, "No, there are already people who are eating me. I don't need anyone else! Why would you choose me when I'm already being eaten?"

This happens in maize and tomatoes — it's quite a harmonious collaboration that ends up strengthening the plant. The beauty of it all, though, is that it's natural. This is a relationship that has already existed. We're amplifying these benefits as opposed to just spraying chemical pesticides that impact our ecosystems, our health, the health of the soils, and all of the good insects that stick around.

I mentioned flooding earlier: Once plants have been flooded, farmers will usually put nitrogen in the soil. In 2024, we're going to have an experiment where we test soil with nitrogen and soil with beneficial microbes. Because nitrogen is not good, leading to algae blooms, we're going to build on this harmonious relationship that plants have with these soil microbes to find their muscles.

Q: How do you stay so joyful amidst so many environmental catastrophes?

I feel very privileged to be where I am. Every time I reflect where I came from and where I am now, I realize I'm probably in the 1% of people that are privileged to have been able to overcome all of these hurdles. Because of that, I can use that privilege; for those who much has been given, much is also expected.

But again, you know, why be sad? Comparing how I grew up to what I have access to now, I have everything! Why would I be sad?

I'm doing science I'm on the frontline of discovery. If I want to find something out, I say, "OK, what's your chemistry?" I can even wake up in the evening and say, "OK, I'm coming to the lab. I have a question I need to solve!"

Q: Have you ever done that?

Yes, yes, I've done that. I've been here on Christmas Day. I've been here on New Year's Day.

You know, I'm only here for such a short time. Time is not on my side. I don't ever want to say why I didn't do something.

Q: What's something that people often overlook about climate change?

As I said, when stressors like droughts, flooding, insects — things that I'm studying — happen, it means that affected countries, especially in the Global South, will have citizens that are even more food insecure. Without a support system, resilience becomes impossible. These people are poor: Any climate disaster quickly thrusts them into poverty. And that's hard to bounce back from; it takes generations. Then these communities have even more trouble sending their children to get the education that they need.

It's all interconnected: poverty, lack of education, lack of health care. It's just a continuous spiral of people being thrust back down into poverty without any hope for the future. In the process, we're losing contributors to challenges that impact, not just them, but all of us. We are losing the talent and the brainpower that is important for us to work together. It slows the world trying to progress forward. Today, our world is so interconnected, meaning that these losses will find a way to impact you one way or another.

We have to work together. We have to have a world where we feel safe and happy.

Q: Are you hopeful that world might come about?

Yes, yes. I am a hopeful person. Despite it all, I always think there's a way. As an example, my country had a national tree planting day recently. *That* is one way to take the right steps forward. We're thinking of ways to handle climate change.

I can't wait for the day where the world is not suffering. Poverty … it's the worst. That is something I wouldn't wish on anybody to go through.

I'm always hopeful that we can move towards a brighter future. A future where everybody leads a happy life because everybody deserves a happy life defined by themselves in whatever way they choose.

Q: You've done so much already; what's next for you?

Science, science, science all the way. Finding solutions to problems. Always asking, "What is that? What does that mean?" That's what's always going to be next.

Gabe Lareau is from Moline, Ill. He received a degree in English with a concentration in Literature and Science and the Certificate in Environmental Writing. Gabe, who will serve as the *Q* Student Editor in Fall 2024, also works as a Communications Intern for iSEE, has blogged for Let's Move Quad Cities, and successfully advocated for a $30,000 grant for World Bicycle Relief in "The Project for Awesome." He hopes to join the Peace Corps.

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