



BURN ZONE

SAVE THE LAKES

Aging pipelines threaten a catastrophic spill along the Great Lakes' picturesque shores.

— Page 30

PLANT-BASED FUN

Are new "green" LEGOs the Impossible Burgers of toys?

— Page 54

VOLUME 3 / ISSUES 1 & 2

A PUBLICATION OF THE UNDERGRADUATE
CERTIFICATE IN ENVIRONMENTAL WRITING
AT THE UNIVERSITY OF ILLINOIS
URBANA-CHAMPAIGN

WRITING CONTEST GRAND PRIZE WINNER: THE
AFTERMATH OF A WILDFIRE IN NEW MEXICO — Page 48



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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 donations of \$5,000 apiece 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 offered U of I undergraduates the opportunity to submit articles for cash awards and publication in *Q*! Several prize-winning articles are featured on these pages.

"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*, a showcase for inspired environmental writing at the University of Illinois.

The 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.



**Gwenna
Heidkamp**



**Peter
Davis**



**Jennifer
Coronel**



**Maria
Maring**



**Shelby
Cheyenne Job**



**Sarah
Gediman**



**Anneli
Cers**



**Lindsay
Albright**



**Andy
Sima**



**Brandon
Hausser**



**Nicole
Pinsky**



**Brooke
Witkins**



**Joshua
Reed**



**Jonah
Messinger**

The Writers

Editor's Note:

In *Q Magazine's* third annual print issue, our student authors invite you into their own personal relationships with environmental change.

In our headline piece, the grand prize winner of the 2020 Janelle Joseph Environmental Writing Contest, Andy Sima guides us through a New Mexico landscape ravaged by wildfire, an experience that revolutionized his understanding of the human footprint on nature.

If reading about fire burns you out, refresh yourself with our sparkling suite of *Q* articles on waterways throughout the magazine. You'll be surprised by the questions our authors come up with. Do sharks pose a threat to big data? Could a massive oil spill truly destroy the Great Lakes? Can our Illinois rivers be saved from the toxic legacy of coal? And how can studying the bodies of prehistoric crabs help us learn how to fortify our own?

Tough questions, too, about energy: from unreliable grids, to land clearance for mining, to coal ash. In her poignant memoir, Maria Maring shows how the desire to change hearts and minds about energy and climate can shape a life's very purpose.

Looking for answers? We have those, too. Read the piece by Brooke Witkins on the potential of nuclear fission to meet utility scale clean energy needs, or Joshua Reed on graphene, the world's thinnest known compound, which might just prove to be the holy grail of green tech.

In Volume 3, you'll find a diversity of subject matter befitting the planet we're desperately committed to saving. Sample, savor, and share with friends!

Sarah Gediman

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

IN THIS ISSUE:



4 SILENT KILLER



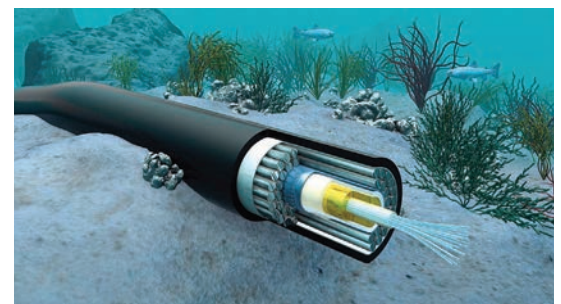
10 COAL'S DIRTY SECRET



15 END TO GREENWASHING



18 DISCUSSING CLIMATE CHANGE IN A FACT-FREE WORLD



24 A WATERY WILD WEST



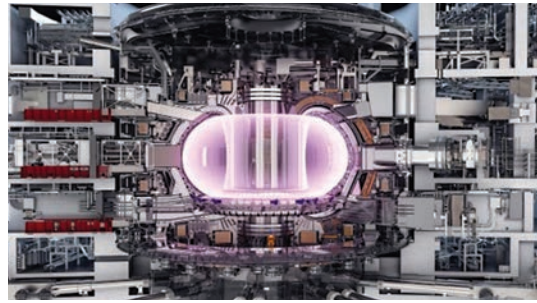
30 SAVE THE LAKES



58 ROMAN HOLIDAY



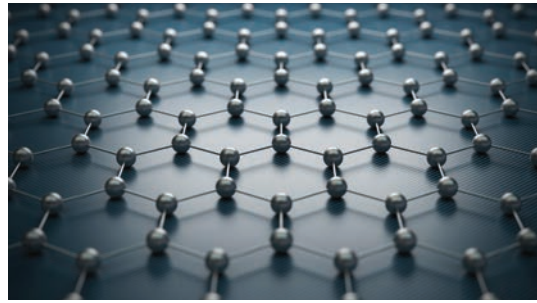
35 PROTECTING OUR WATER



64 HERE COMES THE SUN



41 BLUE BLOODS



67 SUPER CARBON



48 BURN ZONE



70 BLAME GAME



54 PLANT-BASED FUN



74 SOLASTALGIA



The Middle Fork of the Vermilion River in Fall. Credit: Rob Kanter

SILENT KILLER

By Gwenna Heidkamp

On a balmy summer day in early July, a few friends and I rented kayaks and moseyed our way down the Middle Fork of the Vermilion River, enjoying Illinois' only officially designated national scenic river. As hawks circled overhead, small fish followed us along the current. Closing our eyes, we could hear birds chirping in the trees and laughter from fellow explorers as we floated along the water, soaking in the amazing vistas. So much biodiversity and life surrounded that tiny patch of heaven: turtles popping up every so often between the lush grasses along the riverbank; rocks big and small rising above the water; small fish swimming under the kayaks; and birds perched on branches hanging over the river, hunting for food.

But as we meandered along, I saw something that didn't fit with the idyllic scenery: an orange liquid seeping out of an eroded bank. Oozing like venom, the unnatural liquid was flowing freely into the water. The vibrant river seemed dead around that spot; no life could be spotted anywhere near the polluted bank. Where had this life-killing seepage come from?

Not easily seen from the Middle Fork, about a half a mile away, is a retired coal-fired power plant, Vermillion Power Station, with three coal ash ponds.

What is coal ash, and why is it so dangerous?

After coal is burned for fuel, the coal byproduct is placed in surface impoundments called coal ash ponds. While the intent is to prevent ash from entering the atmosphere, an unintended consequence has slowly emerged: dangerous chemicals leaching into our natural water systems. Dug in the river's floodplain, the ponds contain toxic byproducts such as mercury, cadmium, and arsenic. Compounding multiple chemicals together can bring catastrophic results, creating cancer-causing toxins that leave deformed fish and death in their wake. These toxins are contaminating groundwater, rivers, lakes, and streams throughout Illinois and across the country.

In late November 2018, four environmental advocacy groups jointly released a report stating that 22 of the 24 Illinois coal-fired power plants that publicly reported groundwater monitoring data on their websites (because of new transparency requirements imposed by 2015 federal coal ash regulations) have contaminated groundwater with unsafe levels of toxic pollutants. All over Illinois, it's the same story: chemical runoff at rates greater than the legal limit.

A Threat to Water and Wildlife

One nasty side effect of coal ash pollution is the ecological damage to wildlife in the local rivershed. Aquatic Biologist Alison Stodola from the Illinois Natural History Survey (INHS) says coal ash may form "toxic cocktails," resulting in a "stronger impact (on wildlife) because these elements are together." The base standard levels set by the U.S. Environmental Protection Agency (EPA) are determined by single-element exposure, so the safe limit on this combination of coal ash pollutants has never been tested. With this exposure comes an often-overlooked danger in a natural system: bioaccumulation within organisms. Put simply, toxins spread through the food chain as organisms eat one another.

A study in North Carolina addressed the ecotoxicological implications of aquatic disposal of coal combustion residues (CCRs), or coal ash, in the United States. Researchers found that when CCRs seep into waterways, toxic chemicals branch out into many different environments. Trace amounts of mercury or arsenic are toxic to embryonic fish and amphibians. These

After coal is burned for fuel, the coal byproduct is placed in surface impoundments called coal ash ponds. While the intent is to prevent ash from entering the atmosphere, an unintended consequence has slowly emerged: dangerous chemicals leaching into our natural water systems.

toxins can also be eaten by macroinvertebrates when they dig for food in the bottom sediment. Eventually, these macroinvertebrates will be eaten by the small fish populations, which are then eaten by bigger fish. At each level of predation, more and more toxins accumulate. The fish are then eaten by humans or birds, which can lead to lethal consequences higher up the food chain. Furthermore, these chemicals are persistent. Mercury, cadmium, and arsenic are metals, so they can never be broken down into natural compounds. Together, these factors create the strong possibility for serious damage to fish, amphibians, reptiles, birds, and mammals. The North Carolina study projected a 75 percent mortality rate for aquatic organisms with prolonged exposure to leached coal ash.

Back in Illinois, Alison Stodola predicts coal ash could have a serious impact on the state-protected species of bluebreast darters and wavy-rayed lampmussels if toxic levels drastically increase in the Middle Fork River. As benthic species, these tiny fish and mussels that burrow into the bottom river sediment are "very vulnerable as juveniles and larvae," as the heavy metals from coal ash that settle to the bottom can accumulate in their cells and tissues. If a coal ash spill occurs, the small-bodied fish and mussels can't escape because of their inability to move more than a short distance. It could prove fatal for those endangered species — a definite cause for concern in the long-term health of our food chain and natural environment.

Yet the negative impacts of coal ash pollution do not stop at our food chain. From the coal ash ponds next to the Vermillion River, the toxic water can percolate through the layers of soil and rock into the groundwater. This can be catastrophic for the local aquifer. In central Illinois,

the Mahomet Aquifer supplies more than 50 percent of drinking water to 15 counties. Any contamination of the aquifer will leave many counties — and their residents — with no clean drinking water.

Another major issue is flooding. Vermillion Power's coal ash ponds lie within the floodplain of the Middle Fork River. In a torrential downpour, the coal ash ponds could be overwhelmed and spill over into the river. Likewise, the Middle Fork could flood and sweep the ponds, pulling the toxic sludge into the river. There are 46.1 miles of biologically significant stream along the Middle Fork. Any contamination there would flow down the Vermillion River, then into Indiana via the Wabash River, then head toward the Ohio River, which joins the Mississippi River and eventually empties into the Gulf of Mexico. Although a small amount of contamination in one small scenic river in Illinois might not seem disastrous, it can affect a large

In late November 2018, four environmental advocacy groups jointly released a report stating that 22 of the 24 Illinois coal-fired power plants that publicly reported groundwater monitoring data on their websites have contaminated groundwater with unsafe levels of toxic pollutants.

section of the country and cause aquatic life to suffer far downstream.



Coal ash at the Cross Generating coal-fired power plant near Pineville, SC. Credit: J Henry Fair/SouthWings for the Environmental Integrity Project

Too Little Regulation Too Late?

Unfortunately, coal contamination isn't limited to just the Middle Fork. Coal pollution is happening all over the state and nationwide.

Since 1811, when Abraham Lincoln was a small boy, Illinois has had a storied history of mining and burning coal for energy. The state currently has 24 Coal Combustion Residual Surface Impoundments, and many do not have proper lining due to their age. When the pits aren't lined, the toxic chemicals often filter down through the soil during a heavy rain and end up in the groundwater, creating unsafe drinking water conditions, causing deformities in fish, and degrading biodiversity in the region. The Illinois EPA has required new ash pits to be lined since the 1990s to prevent those unintended consequences. Coal ash ponds must now have a composite liner consisting of a geomembrane and a 2-foot layer of compacted soil or an alternative equal in performance.

In Vermilion County, resident activists have fought for stricter measures to contain the now-inactive Vermilion Power Plant next to the Middle Fork River. Originally run by Illinois Power Co., the plant came online in 1955, providing reliable energy and stable jobs, while also actively dumping coal ash into three different ponds. Dynegy took over the plant in 2000 before closing it in 2011. Despite the closure, the coal ash ponds remained haphazardly buried near the banks of the Middle Fork. To date, Dynegy has been cited twice for groundwater violations by the Illinois EPA. The company has conducted studies that found the ponds will fail eventually, yet it still has refused to remove the coal ash or prevent contamination of the nearby waterway. Dynegy opponents are continuing the fight to force the company to clean up the ponds.

Unfortunately, waiting to act until an environmental disaster has already occurred is a recurring theme in environmental regulation. In 2008, a dike failure at Tennessee Valley Authority's Kingston Fossil Plant released more than 5.4 million cubic yards of coal ash into a pond and river channel. This caused destruction of property, miles of ruined shoreline, and ecological ruin. The cleanup cost more than \$1.1 billion and took more than six years to complete. Tragically, out of the nearly 900 laborers who worked to clean up the disaster, 30 workers died and more than 250 are known to be chronically ill from toxin exposure.

Due to coal ash spills like the one in Tennessee, the

From the coal ash ponds next to the Vermillion River, the toxic water can percolate through the layers of soil and rock into the groundwater. This can be catastrophic for the local aquifer. In central Illinois, the Mahomet Aquifer supplies more than 50 percent of drinking water to 15 counties.

EPA created new guidelines for coal ash disposal. In 2015, a final rule was established on the proper disposal of coal combustion residuals in order to reduce the risk of catastrophic failure, protect groundwater, and define operating criteria, record-keeping, and closure procedures. In the case of Tennessee, these measures came too late. And what's worse, in October 2020, the EPA changed the 2015 regulation to loosen the rules on linings, allowing companies that own the 65 percent of coal ash ponds that are unlined to argue their method is effective. This deregulation creates a clear and immediate danger, as many coal ash ponds won't be required to modernize disposal technology and protocols.

In the past, power plants provided essential jobs and energy for the local community, but now, as power



Champaign yard sign. Credit: Julie Wurth



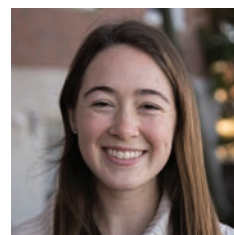
A public meeting of concerned citizens on the Middle Fork. Credit: Jack Brighton

For every moment of delay, this national scenic river in the Illinois heartland becomes more and more susceptible to environmental disaster — like the catastrophe that unfolded in Tennessee. If we want to preserve the Middle Fork River not only for ourselves but for future generations, we must urge our state and national governments to act quickly to protect our precious waterways. I hope my next kayak trip down the river is filled with the lush beauty and captivating wildlife

I saw that balmy July day, and that I'll be spared the sight of toxic runoff poisoning one of the most pristine and biodiverse regions in central Illinois. The hawks circling overhead, the turtles sunbathing on the rocks, the fish darting to and fro, and the birds nesting along our majestic waterway need clean water to survive.



As rivers and water are a common good, the most economically feasible way to deal with the coal ash threat is to have the company responsible clean it up. Harm is almost certain to happen down the line, and requiring future generations to pay for it is unacceptable.



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COAL'S DIRTY SECRET

By Peter Davis

If you're like most people, you care a great deal about the fine print on products you buy. You might prefer foods with easily pronounceable ingredients rather than indecipherable lists of chemicals. You might go out of your way to buy fair-trade and ethically sourced products. But have you ever considered the source of your electricity? Chances are, you will not find this information anywhere on your power bill. Most of us are completely in the dark as to how we turn on the lights, and the coal industry is doing its best to keep it that way.

Coal power accounts for 24 percent of all electricity generated in the United States and upwards of 72 percent in developing nations like India. Even as coal becomes more expensive than solar energy, the industry refuses to loosen its stranglehold on our energy system. The United States burns the equivalent of 500 train cars of coal each hour, enough to span five miles of railroad track. Like a pack-a-day smoker, our energy system fights an addiction to a carcinogen it should have quit long ago.

Just as the tobacco industry historically denied the health risks of smoking, the coal industry continues to dismiss the dangers of its product, prioritizing profit over human and environmental health. Lobbyists and politicians have gone so far as to promote the laughably oxymoronic phrase, “beautiful clean coal.” Coal is intrinsically filthy. It contains a swath of toxins including mercury, lithium, arsenic, and lead. Due to naturally occurring deposits of uranium and thorium, coal is radioactive, leading coal plants to release more radiation into the air than nuclear plants.

While filters in coal plants can capture toxic pollutant particles, one major detail is seldom addressed. The debris that is scrubbed from coal’s fumes does not disappear — it must go somewhere. These particles of ash, collectively referred to as “coal combustion residuals” or “coal ash,” are one of coal’s many overlooked byproducts. These substances present an immediate danger that has quite literally been creeping up on us. Had we read the fine print on coal’s warning label, we would not have been so easily tricked.

Coal’s Warning Label

Coal combustion residuals, commonly known as coal ash, are non-combustible components of coal — powdery substances accounting for roughly 10 percent of the weight of coal burned. This includes airborne particles caught in the smokestack filters (fly ash) and material left over in the furnace after coal is burned (bottom ash and boiler slag). Coal is an extremely impure fuel, and the toxins and carcinogens it contains are concentrated into coal ash when it is burned.

Coal ash poses an undeniable human health hazard. It contains particles up to 30 times smaller than the width of a human hair, so it is easily ingested or trapped in the lungs. Once in the body, its chemical cocktail can lead to cancer, heart damage, lung disease, kidney disease, and

birth defects — with especially severe damage to children. The EPA found that living within a single mile of a coal ash disposal site causes a 1-in-50 lifetime risk of cancer.

This raises the crucial, life-and-death question: Where is coal ash stored?

Storage and Disposal: Finding an Ashtray

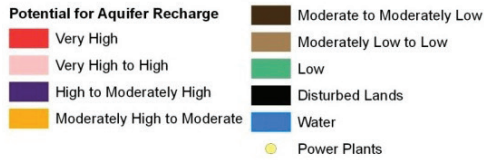
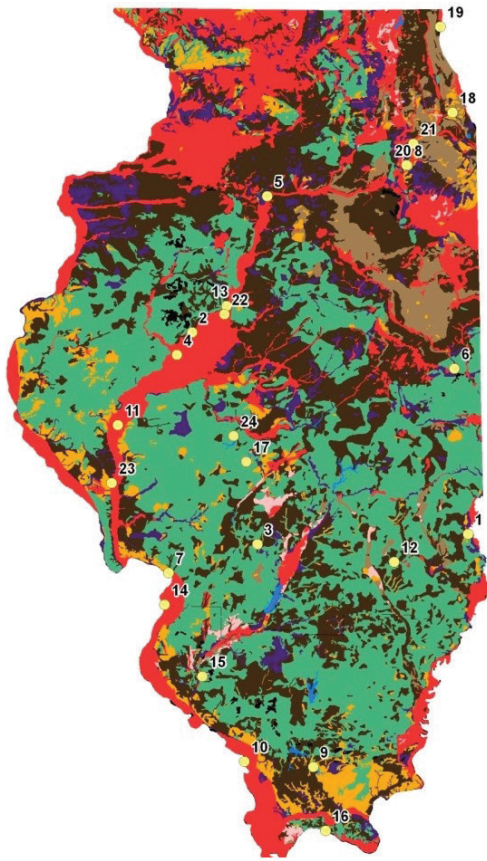
More than 100 million tons of coal ash are produced annually in the United States, making its disposal an unavoidable problem. Currently, this hazardous waste is stored at 1,400 facilities across 45 states. In Illinois alone, coal ash is stored at more than 80 sites, 10 of which pose a high risk of contaminating drinking water.

Options for coal ash disposal are bleak at best. The best case is to use coal ash as a filler in concrete or wallboard. Within the industry, this is known as a “beneficial use.” This way, harmful contaminants are encapsulated in a form where they cannot leak into the surrounding environment. However, this “beneficial” use only accounts for 60 percent of coal ash disposal, leaving us to question what happens to the remaining 40 million tons each year.

If the ash is not recycled, power companies have two options for disposal: dry storage in landfills or wet storage in ponds. In dry storage, coal ash is either filled into a designated unit (monofilling) or mixed with other municipal waste in landfills (cofilling). While monofilling is the better option to keep coal ash contained and prevent leakage, this requires a costly, specially designated storage space. Owing to its high cost, monofilling accounts for a minority of coal ash disposal sites. Instead, power companies opt for the cheapest way out: wet storage in large, man-made ponds formally known as “surface impoundments” where coal ash is mixed with water. There are 1,000 such ponds in the United States and close to 9,000 globally. The vast majority of these ponds are unlined, meaning that there are no real measures to prevent gradual seepage into groundwater.



Types of coal ash: Fly ash (left), bottom ash (middle), and boiler slag (right). Credit: American Coal Ash Association



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The EPA found that living within a single mile of a coal ash disposal site causes a 1-in-50 lifetime risk of cancer.

Left: Risk for coal ash seepage into aquifers. Credit: Illinois Environmental Protection Agency (EPA)

Below: One of 40 homes affected by Tennessee's Kingston ash spill in 2008. Credit: News Sentinel.





Coal ash sludge near a power plant. Credit: Wade Payne, AP via The New York Times

While financially and logistically convenient for the coal industry, these storage options present a lose-lose situation for human and environmental health. Regulatory requirements for these facilities are weak, and since the utility has no financial incentive to track its waste products, these systems are devised hastily and typically suffer from engineering lapses. In the best case, contaminants from coal ash slowly leach into the surrounding environment. In the worst case, coal ash spills result in disaster.

Disasters: More Than Secondhand Smoke

The world received a harrowing reminder of these disasters on Dec. 22, 2008, when the dike failed on a coal ash pond at the Kingston Fossil Plant in Tennessee. This failure released more than 5 million cubic yards of coal ash into the pond's surroundings, extending for 300 acres outside of the designated storage area and contaminating the Emory River. Cleanup efforts lasted for 45 months and involved over 900 workers, many of whom were not provided with basic safety equipment such as masks. Workers became reliant on inhalers due to lung damage, and many developed severe cancers in subsequent years. Within 10 years of the accident, 36 employees had succumbed to leukemia, brain cancer, or lung cancer.

At the time of the Tennessee disaster, there were no federal regulations specific to coal ash — it was not even classified as hazardous waste by the EPA. However, after the catastrophe, the EPA began to formulate a “Coal Ash

Rule” to regulate its disposal. A draft was completed in 2010 — yet thousands of affected lives were evidently not enough to convince politicians, and the bill was shelved.

A second wake-up call occurred on Feb. 2, 2014, when a major spill occurred at a Duke Energy facility in North Carolina. A 70-mile stretch of the local Dan River turned to gray sludge; Duke's initial cleanup effort only recovered 8 percent of spilled ash. Consequently, the state sued Duke in 2019, and Duke recently announced that it will excavate 80 million tons of coal ash and retire its ponds over the next 15 years.

Regulation and Pushback

After the second disaster, the EPA Administrator signed the Coal Ash Rule in December 2014. Officially known as the “Disposal of Coal Combustion Residuals from Electric Utilities,” this rule created location restrictions, design standards, groundwater monitoring programs, and cleanup requirements for coal ash ponds. A major victory for environmentalists was the requirement for coal ash ponds to be composite-lined. The 65 percent of existing coal ash impoundments that are unlined were ordered to close by 2019 as a result of this requirement, as these ponds contribute to coal ash leakage and are at high risk for disasters.

Under the Trump administration, however, the EPA aggressively rolled back regulatory measures, allowing coal plants more time to conduct business as usual. Revisions

in 2018 extended the closure deadline for unlined ponds to 2021 — and certain unlined impoundments were permitted to operate until 2028. The revision removed the requirement for state regulators to enforce groundwater monitoring and permitted facilities to operate barring explicit proof of leakage. In other words, regulators were not required to check for pollution in our water supply, and facilities could not be shut down until inevitable damage was already done. Following these revisions, the D.C. Circuit Court ruled that EPA protections were inadequate and ordered that the regulations be revised.

In response, the EPA finalized new regulations in August 2020; like a poisoned apple, they seemed wholesome at first glance but were in fact rotten to the core. While unlined facilities were finally ordered to close, the definition of “lined” was expanded to include alternative liners with no track record. In effect, this allowed unlined facilities to continue operating, masquerading under the guise of “alternative” lining.

While the EPA has spent two years dissolving existing regulations, there are still problems that were never regulated in the first place. For example, the Coal Ash Rule has never required the testing of drinking water wells near coal ash sites. Even worse, “legacy” ponds that stopped receiving material prior to 2015 are not regulated at all.

Breaking the Addiction

Despite this alarming trend, there is hope for change at the state level. For example, Illinois passed the Coal Ash Pollution Prevention Act in 2019 and is one of four states with similar laws. Under this act, Illinois utilities are required to pay for coal ash cleanup rather than taxpayers. Furthermore, standards for coal ash ponds are elevated beyond federal requirements. This legislation is crucial; available data shows that 90 percent of coal ash dumps in Illinois cause local groundwater contamination as they are nearly all unlined.

In some states, the issue of coal ash disposal has led to the immediate retirement of coal plants. In August 2020, the owners of the San Juan Generating Station in New Mexico unanimously decided to retire the plant within two years after a damning report on the impact of coal ash at the site. The million tons of ash produced annually by the plant had been backfilled in an adjacent mine shaft since 1973 and were expected to leach into the water table by 2022.

The San Juan Generating Station is also a powerful case study in industry transition from coal power, as it will be replaced by the new construction of 650 megawatts of



The San Juan Generating Station near Farmington, N.M.
Credit: Sierra Club, courtesy of Ecoflight

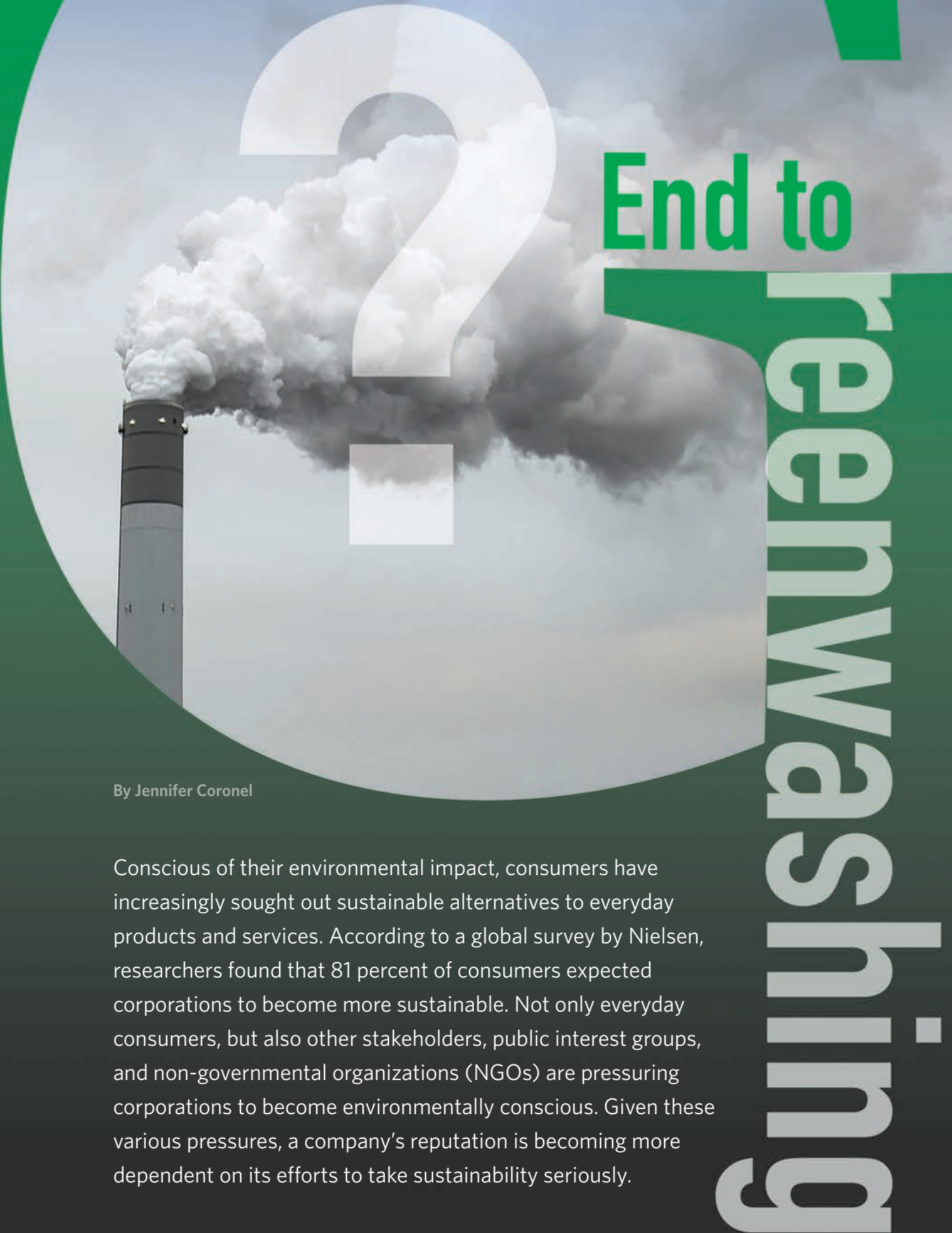
solar power and storage. This project ensures that the local community will continue to have jobs and that the power needs of local industries will continue to be met.

It's time to break our addiction to coal. The emergence of renewable technologies such as solar energy presents an increasingly viable escape route. Natural gas might even serve as a “nicotine patch” — presenting a safer option than coal, yet only as a transitory solution. Just as a smoker's lungs are affected long after quitting, coal ash will have serious consequences even after coal plants cease operations. Coal plants must be decommissioned as soon as possible, and utilities must take responsibility for their waste products, ensuring that storage ponds are properly lined and resilient against floods and accidents. With communities across the country being physically poisoned by coal ash, regulations must curtail the profit-seeking recklessness of energy utilities to safeguard public health and a clean environment. Nothing less than our lives, and the lives of future generations, are at stake.



Peter Davis is a junior from Naperville, Ill. He is pursuing a B.S. in Mechanical Engineering and is active in the Illinois Solar Decathlon

as well as the Energy Sustainability Working Advisory Team. He is interested in pursuing solutions to sustainably meet increasing global energy demands.



By Jennifer Coronel

Conscious of their environmental impact, consumers have increasingly sought out sustainable alternatives to everyday products and services. According to a global survey by Nielsen, researchers found that 81 percent of consumers expected corporations to become more sustainable. Not only everyday consumers, but also other stakeholders, public interest groups, and non-governmental organizations (NGOs) are pressuring corporations to become environmentally conscious. Given these various pressures, a company's reputation is becoming more dependent on its efforts to take sustainability seriously.



'Green' cleaning products. Credit: DIY

Many companies have responded to this demand. An increasing number of products claim to be environmentally friendly, from everyday necessities to carbon-neutral services, while companies claim to have reformed their business models toward sustainability. Companies have placed "sustainability reports" on their websites that show the world how they are doing. These reports often display exemplary results of environmental stewardship. So, why would this not be reason to celebrate?

Unfortunately, many corporations have taken the surge of environmental consciousness as an opportunity to engage in greenwashing; that is, conveying a false image of sustainability for a product, service, or the corporation itself. This can be seen in a variety of forms. Buzzwords like "natural" or "organic" on nonfood items are not regulated by the U.S. Department of Agriculture (USDA). This means that these labels can be misused to portray "greenness" in a product without proper certification. And the practice is not limited to labeling consumer goods. Companies have long put on a front of corporate sustainability through marketing efforts and environmental pledges, creating a guise of environmental stewardship in their commercials. While proclaiming their dedication to sustainability, many continue to participate in environmentally destructive behaviors.

A prime example of corporate greenwashing in recent history is Chevron Corp. In the 1980s, the company released an array of advertisements to show off its dedication to the environment. The "People Do" campaign consisted of Chevron employees frolicking in nature, meant to convince the public that they were the "good guys." And it worked. The campaign won awards and was even studied at Harvard Business School. It also worked in another, more sinister way: as a smokescreen to hide the fact that Chevron was violating environmental laws, settling lawsuits for unbelievably high toxic air emissions, and other acts of environmental degradation. Corporations have only gotten worse as time has passed. The major Australian bank Westpac received an industry

sustainability award in 2019. However, a deeper look revealed that the bank invests billions of dollars in fossil fuel companies. Unfortunately, this is common practice among all industries worldwide. The stain of greenwashing is even more concerning when we consider that 71 percent of carbon emissions come from just 100 companies. To combat environmental calamities like climate change, corporate greenwashing needs to be tackled.

Why does greenwashing happen? Within the business community, sustainability is often viewed as unprofitable. This is a result of the relatively long onramp of sustainable ventures. While they do prove more profitable than traditional, unsustainable ventures over the long term, a preference for short-term profits has prevented many companies from adopting a more sustainable business model. "Short-termism," as it has been appropriately labeled by Harvard researchers, is pushed by the expectation of constant profit by stakeholders and investors. In turn, this has led companies to greenwash to appease growing consumer demand without risking their short-term profits. In short, as more consumers display preferences for all things environmentally conscious, companies continue to seek opportunities to profit. This is capitalism in its most basic form: maximizing profits as much — and as quickly — as possible.

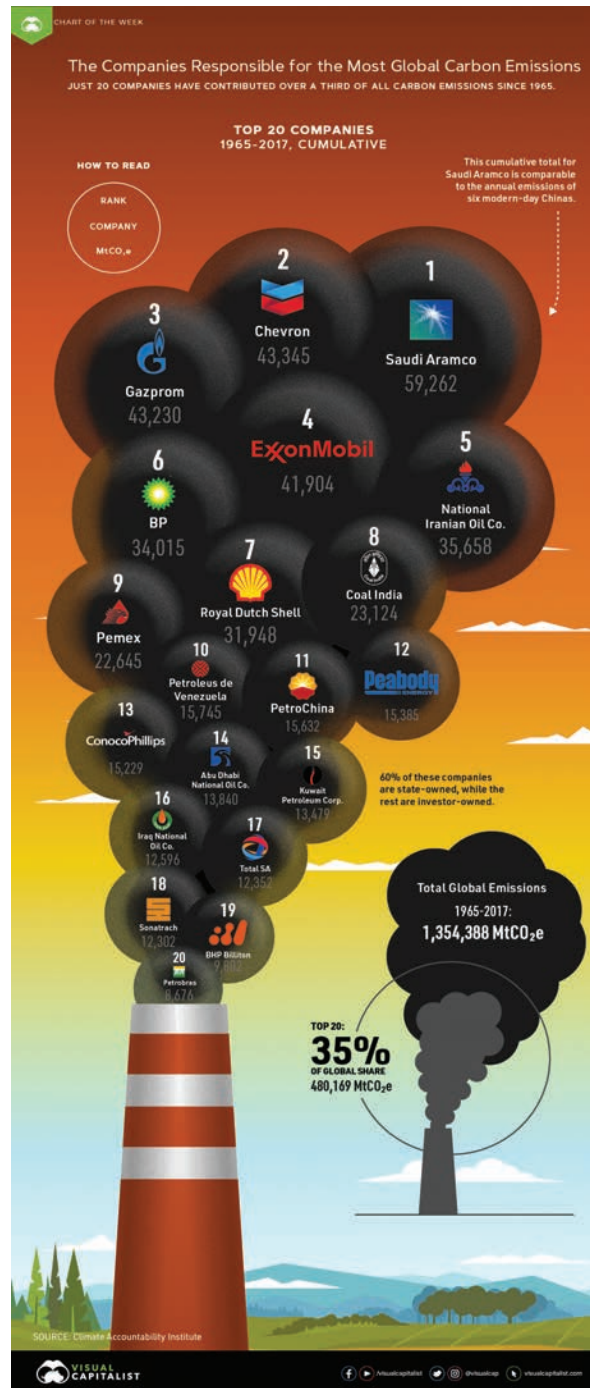
How can we even begin to change this? First, we need to fundamentally alter how we do business. Companies must pursue transparency in their business practices and investments alike; that way, consumers who are concerned about sustainability can choose whether or not to support them. Investors and shareholders must also demand sustainability from corporations. Likewise, CEOs should align themselves with investors and shareholders with similar views on sustainability.

To avoid shallow commitments to environmentalism and reduce the chances of greenwashing, sustainability must be integrated from top management down to all managers and employees, to instill environmental values

at all levels of the company. Clear strategies to move toward sustainability are the best way to build internal engagement and instill these values within employees on every level. There is no one “right” strategy, but frameworks exist that can be tailored to individual industries. Corporate Social Responsibility (CSR) and “environmental, social, and governance” (ESG) goals can inspire businesses to adopt ethical business models.

A shining example is Ørsted, a green energy company from Denmark. Ørsted has aligned its goals with the Paris Climate Agreement, operating as a carbon-neutral company. The Danish company also provides an investor list on its website, transparently including shares and debt. Another look at the website provides readers with countless opportunities to educate themselves on sustainability and the company’s efforts along the way. Shockingly, Ørsted used to be one of the most fossil fuel-intensive companies in Europe. Now, after remodeling its business plan, it has been named the Most Sustainable Company in the world by Corporate Knights Global Sustainability Index, a Toronto-based company dedicated to “clean capitalism.” As one can see from this example, it is possible for corporations to switch from carbon-intensive practices and investments and rebrand themselves as environmental stewards.

As we continue our shift toward a more sustainable society, we must realize that the burden of climate change should not only be on the shoulders of the individual. Oftentimes we see people pointing fingers at each other for not recycling or not being as sustainable as they could be. While it is important to promote individual environmental stewardship, it is even more important to recognize that the impact of the individual does not compare with the impact of a multinational corporation. Corporate sustainability is something we should all demand from businesses. While these industries are typically profit-driven, there is a way for consumers to leverage this in their favor. A global survey performed by Nielsen in 2015 found that 66 percent of respondents would pay more for products and services from companies that were committed to positive social and environmental impact. From that same population, they also found that 73 percent of millennials feel the same way. Right now, millennials are the largest consumer group. The fact that nearly two-thirds of the largest consumer market group would be willing to pay a higher price for sustainably sourced products is a huge incentive for corporations to pursue sustainability. However, to avoid more instances of greenwashing and to keep corporations accountable, consumers will need to be both vocal and well-informed. While it has been profitable for corporations to greenwash in the past, the risk of losing a huge portion of their future share of an eco-conscious market is a gamble not even the most ruthless corporations can take.



Top 20 Companies Responsible for Global Carbon Emissions, 1965-2017. Credit: Visual Capitalist, Climate Accountability Institute



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Discussing

Climate Change

in a Fact-Free World

By Maria Maring

Katharine Hayhoe ranks among the most prominent voices today advocating for open conversations about climate change — not just conversations between scientists and politicians, but you and me.

A native of Canada with a Ph.D. from the University of Illinois Urbana-Champaign, Hayhoe is the Political Science Endowed Professor in Public Policy and Public Law at Texas Tech University. As an atmospheric scientist, Hayhoe evaluates climate models to predict and prepare for the future; but she is also a master communicator, as evidenced by her popular YouTube channel *Global Weirding*.

Through years of experience having conversations, giving public talks and lectures, and fielding questions on climate change, Hayhoe has developed a comprehensive philosophy for how to talk about this polarizing issue. She identifies significant barriers to constructive conversations — including our nation's identity politics and pervasive complacency that “it won't affect me” — as well as three solutions to overcome these barriers: bonding, connecting, and inspiring.

Hayhoe argues that it is not celebrities, health care workers, or even scientists who need to be doing the talking on climate change. Rather, our friends, family, and neighbors are the most effective communicators. “According to social science research, politicians are the ninth most effective messengers on climate change. Health care experts are third. Scientists are second. Who's number one? You. And that's why using our voices to advocate for climate change is the most effective thing that every single one of us can do today. That is what gives us hope,” Hayhoe explained in her Charles David Keeling Lecture for the U of I's 2020 Earth Week celebration.

I followed up with Hayhoe in May 2020 to talk about her philosophy, her career, and her thoughts on the future. You can hear more in Hayhoe's TED Talk, “The most important thing you can do to fight climate change: talk about it,” and her Keeling Lecture, “Climate Science in a Fact-Free World.”



Groundbreaking climate scientist and communicator Katharine Hayhoe. Credit: Artie Limmer, Texas Tech University

Q. What drew you to atmospheric sciences?

As an undergraduate, I studied Astrophysics at the University of Toronto, but looking around for an extra breadth requirement to finish my degree, I found a brand-new class on climate science over in the Geography department. I thought to myself, “Well that looks interesting!” and the rest is history.

I had always thought of climate change as an environmental issue: environmentalists care about environmental issues, they work to fix them, and the rest of us wish them well. But the first thing I learned in this new class was that climate change is a threat multiplier. It takes all the issues we care about and makes them worse: poverty, hunger,

lack of access to clean water, basic health care, resource scarcity, civil conflict ...

In a nutshell, climate change is a human issue. To care about climate change, the only thing we have to be is a human living on this planet because climate change affects every aspect of our lives. You don’t have to be an environmentalist to care about climate change — all you have to be is a human.

I also was surprised to learn that atmospheric science is all physics — the very same physics I’d been learning throughout my undergraduate years. I thought to myself, “I serendipitously have the skill set needed to study climate change, which is disproportionately affecting the most vulnerable people of the world. How can I not do



Katharine Hayhoe discusses how climate change is affecting Texas during a 2018 lecture at the LBJ Library.

Credit: Jay Godwin, LBJ Library

everything I can to help fix this global problem? It's so urgent that surely we'll fix it soon, and then I can go back to astrophysics."

That was over 25 years ago.

Q. How did you end up at the U of I?

As I was looking for graduate programs in atmospheric sciences, I knew I wanted to work with an advisor who did policy-relevant science. After all, I was switching fields to do science that could help inform decisions, right?

When I visited the University of Illinois to be interviewed by prospective advisors, I met Don Wuebbles and I immediately knew he was the advisor I was looking for. He was extremely involved in policy-relevant research, helping chemical companies figure out how to make chemicals that wouldn't destroy the ozone hole, and he was just transitioning his work to look at how to reduce GHG emissions as well. Not only was he doing cutting-edge research, but he was very aware of the importance of that research informing sound decision-making.

Coming to the University of Illinois and working with Don Wuebbles was one of the best choices I've made in my entire life.

Q. Can you tell me a little bit about your YouTube series *Global Weirding*?

Global Weirding is a PBS Digital Series that arose out of three very different experiences I had.

First, I had stepped on the carbon scale and seen that travel was one of the biggest parts of my carbon footprint. Because of that, I wanted to cut down on my travel and transition to more online talks.

Second, Brian Webb from Houghton College in New York state contacted me to run an experiment to determine whether attending one of my talks actually made a difference in students' opinions. When the students were arriving, he directed them into one of two rooms: in one room, they got me live in-person; in the other room, they got a video of me. The experiment found their opinions on "does climate change matter?" and "should we be fixing it?" changed significantly after attending the talk: but it didn't matter if it was a video or a live talk! That's when I decided to invest more time in online videos.

Shortly afterward, my local PBS station reached out to me. They said, "Wouldn't it be great to have a digital series on climate change coming out of West Texas?" I replied,

"Yes, it absolutely would be! I've found that people have a ton of really good questions, and there's nowhere that they can look to find those answers. So, let's use the *Global Weirding* to do that."

Q. Now I want to shift gears to some topics you talked about in your Keeling Lecture. Drawing upon historical context, why is America so politically polarized right now?

Americans have a lot of fear that the world is changing too fast — that who I am, what I represent, and what I care about is being disregarded. As a result of that fear, we tend to cling more closely to what is more familiar to us, thus drawing deeper lines in the sand, dividing ourselves from people and ideas that we feel might differ from us.

One of the major factors contributing to this is the monetization of the internet. We get our news now from customized sources, businesses who know that we are more likely to click on headlines that make us alarmed or frustrated or angry or fearful, and stories that confirm what we already believe rather than challenging our biases and ideologies.

Social media also contributes to our polarization. For example, social science researcher Zeynep Tufekci was watching a simple political video, but she noticed that after three or four recommended videos from YouTube, she arrived at a video of an extremist rally. Curious, she ran an experiment and determined that the algorithm YouTube uses tends to feed people more radical information; not because they have a political agenda, simply because it pays.

The fact that industry plays a huge role in determining political policies is also part of polarization. Organizations that have everything to benefit from keeping us addicted to fossil fuels for as long as possible have chosen to use the tools of political lobbying. And there can be a vicious feedback between industry, politics, and the media. A message that comes from an industry-funded small organization might get picked up and transmitted by a larger news organization because it's consistent with the political agenda that it supports.

This isn't just about climate change: We see the same factors at work with issues of immigration, gun use, race, and many other hot-button politicized issues. But climate change is one of the largest casualties of this polarization.

Q. You said the most important thing we can do to mitigate climate change is talk about it with our loved ones. Why is that so crucial, and how do you have a climate conversation?

Many people feel that we need to educate people on science, but we've been telling people about the science for decades — literally, decades. Yet, today, we're more politically polarized on climate change than ever. And it turns out that sharing more and more doom-laden information that people don't accept enhances, rather than decreases, this polarization.

The real problems people have are identity politics, psychological distance, and solution aversion. Let's unpack those a bit.

So first, identity politics: Today, where we fall on the political spectrum is the most important predictor of who we'll marry. So it's no surprise that it's also the number one predictor in the United States on whether we agree with the simple facts that the climate is changing, humans are responsible, and the effects are serious.

Second, psychological distance is the belief that climate change won't affect us here and now. Even in places where public polling reveals that people agree with science, the majority of them say, "It matters to future generations, it affects plants and animals, it will affect people in developing countries, it might affect people in the United States, but it won't affect me." We see climate change as an issue that is distant in time (in the future versus now) or in space (affecting people that live far away but not here).

And finally, solution aversion is, in effect, why we have such political polarization over climate change. People

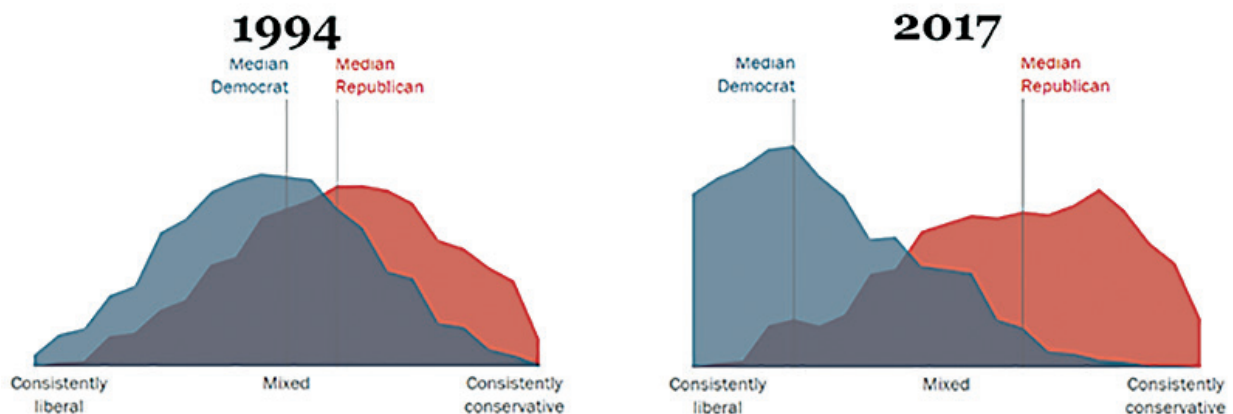
have been told that the only solutions to climate change are negative, harmful solutions that run counter to their values or ideologies; people are told that the only way to fix climate change is to destroy the economy or let the U.N. or China take over the world. I've even had people tell me that the only solution to climate change is abortion. So, if you're pro-life and you're told the only solution to climate change is abortion, then you can't support climate solutions. Many of these objections are being cold-bloodedly manufactured by people who have everything to lose from us as a society weaning ourselves off of fossil fuels. Unfortunately, they're falling on receptive ears because they're enhancing identity politics.

When we talk about climate change, it's important to directly address these three problems, and here's how.

The solution to identity politics is bonding. Begin conversations by bonding over shared values — something we genuinely agree about. It can be something as simple as our family or the place that we live or something we enjoy doing.

Psychological distance can be solved by directly connecting climate change to the values we already have. How is climate change affecting the things we already care about? Not things that other people care about, but things we care about here and now. Making the impacts present and relevant has also been shown to decrease political polarization.

And finally, to address solution aversion, we must talk about real solutions that are positive and beneficial. People are often surprised to find out what real solutions actually look like, and may find those easier to get on board with than the highly politicized science. Then, after a while — it might take a couple of weeks, months or even years — they'll agree with the science, too. But it's the solutions that really matter.



The U.S. is more polarized than ever, but close relationships are the key to productive discussions on climate change.
Credit: Pew Research Center

“ We must talk about real solutions that are positive and beneficial. People are often surprised to find out what real solutions actually look like, and may find those easier to get on board with than the highly politicized science. Then, after a while — it might take a couple of weeks, months or even years — they’ll agree with the science, too. But it’s the solutions that really matter. ”

Q. How did you develop this approach?

Trial and error — with lots of error. Soon after moving to West Texas, where people are very politically conservative, I got my first invitation to speak to a women’s group. They weren’t necessarily on board with climate science, but they had a lot of questions. So, I did my best to explain the science — just the science. Then I got more questions like, “How do you know it’s not volcanoes or the sun or natural cycles?” so I revised my next presentation based on the questions I had gotten the first time, to answer those questions. After that, I started getting questions like, “Why does this matter to me? I thought this was about the polar bears.” So I did my best to talk about why it matters. Then I started getting questions like, “What am I supposed to do about it if the only solution is to shut down the economy?” so I knew I had to talk about solutions, too!

My approach evolved by sharing what I thought was the most important information (which it turned out was not), then listening very carefully to the questions and feedback that I got, and trying to make sure the information I was providing was actually what people wanted to know rather than what I thought they did.

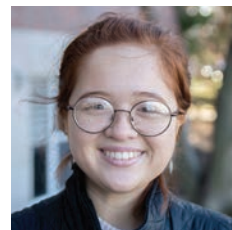
Q. Can you provide some optimism that our voices can actually make a difference?

For so long, we’ve been told that changing our light bulbs and recycling are the solutions to the greatest crisis that our world currently faces. Clearly, there is a mismatch of the scale of the problem versus the solution. That’s why it’s so important to offer real solutions. And although all of these things do help, I’ve become increasingly convinced that changing our light bulbs is not the most important thing we can do; neither is stopping flying, becoming vegan, or living a carbon-zero life.

The most important thing we can do is talk about it, because if we don’t talk about it, why would we care? And

if we don’t care, why would we as a society ever fix it? We need system-wide change, but the system is made up of people. And how we as people interact with each other and make decisions with each other is through communication.

Five years ago, there was a young girl who was really, really concerned about climate change. She was so concerned that she became anxious and depressed. She persuaded her family to stop flying, change their diet, and significantly reduce their carbon footprint, but she still felt like it still wasn’t enough. So, she decided to do one simple thing that nothing to do with reducing her carbon footprint. She took a piece of white cardboard, painted a few words on it, and sat outside a building. Of course, the words on the sign were “School Strike for Climate,” and the building was the Swedish Parliament, and her name was Greta. Now, the entire world knows her name, and she has inspired thousands of people around the world to use their voices to advocate for change as well. The impacts that she has had are profound, and that has all come about because she used her voice.



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One hundred eighty-five years after Charles Darwin's famous expedition on HMS Beagle, the Galápagos Islands are still bursting with discoveries, only the science looks a little different. For one thing, researchers like Craig Venter have traded in the Beagle for more comfortable research vessels. Venter is a biochemist who, among other things, helped complete the first sequencing of the human genome. He has spent his career leveraging 21st century tools like big data for cutting-edge scientific research. But he is still drawn to the Galápagos. Aboard his personal yacht, Sorcerer II, Venter set sail in 2003 to circumnavigate the globe in a route inspired by Darwin's voyage.

AWATERY WILD WEST

By Shelby Cheyenne Job

While anchored in the Galápagos, the Sorcerer II's mission was to secure hundreds of ocean water samples, as the crew had done all over the globe. The samples were then frozen, analyzed, and cataloged in massive computer databases. From there, "high-speed sequencers and supercomputers" employed the whole genome shotgun technique, reassembling genome sequences over and over again until sections of DNA were fully mapped. The result was the discovery of thousands of unknown bacteria species that have aided our understanding of marine microbiology. Venter's work has not only put him at the forefront of ocean science; it has also exposed the bald fact that while big data is changing the world, it's changing the oceans along with it.

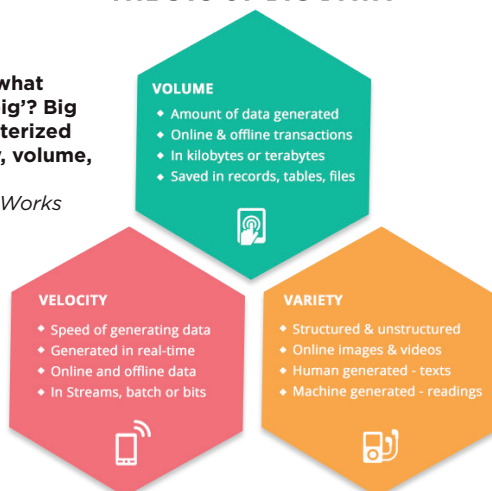
The grand irony here? Venter's big data ocean research would not be possible without thousands of miles of deep sea data cables that threaten the very marine ecosystems he studies.

In data-based research such as Venter's, we see how global data infrastructure has become the backbone of modern science, replacing the scrawling field notes and finch sketches of Darwin's 1830s expedition. Science is no longer slow thanks to our ever-expanding digital knowledge bank, which holds far more data than anyone could hope to analyze in a lifetime. One of the big buzzwords in tech, "big data" can seem a daunting concept. Brian Jefferson, an Associate Professor of Geography at the University of Illinois Urbana-Champaign, explains big data to his students through the three "Vs": velocity, volume, and variety. Your regular, run-of-the-mill data can qualify for a promotion to "big data" once it's big enough (volume), fast enough (velocity), and diverse enough (variety). An easier way to determine if you are dealing with "regular" data or big data is to ask whether you could feasibly manage the dataset yourself. Would analyzing the data take years, decades, centuries, or even longer? If so, it's likely big data.

THE 3Vs OF BIG DATA

Confused on what makes data 'big'? Big data is characterized by its velocity, volume, and variety.

Credit: Whish Works



As one New York Times writer puts it, "People think that data is in the cloud, but it's not. It's in the ocean." So much data infrastructure has been installed in the ocean that lined end-to-end, deep sea fiberoptic cables could wrap around the globe 22 times.

Using big data has largely become the responsibility of governments, companies, and research groups. These groups grapple with big data through innovative technologies of collecting, creating, analyzing, and storing data. Supercomputers, data centers, servers, algorithms, and internet cloud storage are a few examples of such innovations. By monopolizing digital technologies capable of manipulating big data, companies such as IBM, Facebook, Salesforce, and Google have built data empires worth billions. By generating consumer data, innovating new ways to use that data, and building new infrastructure to store it, tech companies enjoy seemingly infinite growth. In addition to topping the economic sector, some observers predict big data will provide "miraculous solutions to well-worn problems" such as climate change. In these terms, big data starts to seem like the modern messiah. Skeptics like Jefferson, however, warn us that data "... is only magical without problematizing it."

The problems with big data become apparent when you realize that the internet and its cloud are not just digital abstractions, but a material network of concrete components: thousands of miles of fiberoptic cables, added to the raw materials required to build them, the energy-intensive data centers they connect to, and the billions of electronic devices they power. With millions of iPhones touting wireless connections to the cloud, the physical reality of a world bound with industrial cables and wires goes unseen. This is particularly true when that industrial footprint is buried under the floor of the deep sea. As one *New York Times* writer put it, "People think that data is in the cloud, but it's not. It's in the ocean." So much data infrastructure has been installed in the ocean that lined end-to-end, deep sea fiberoptic cables could wrap around the globe 22 times. Imagine these cables crisscrossing the ocean floor, carrying infinite tidbits of data from mundane bank transactions to the President's tweets, to that often Googled question, how does the internet work? In all, 99 percent of the world's data travels through the ocean's trenches. Each byte of data rubs elbows with marine life we aren't even aware exists as it rides along a fiberoptic railway through the watery Wild West.

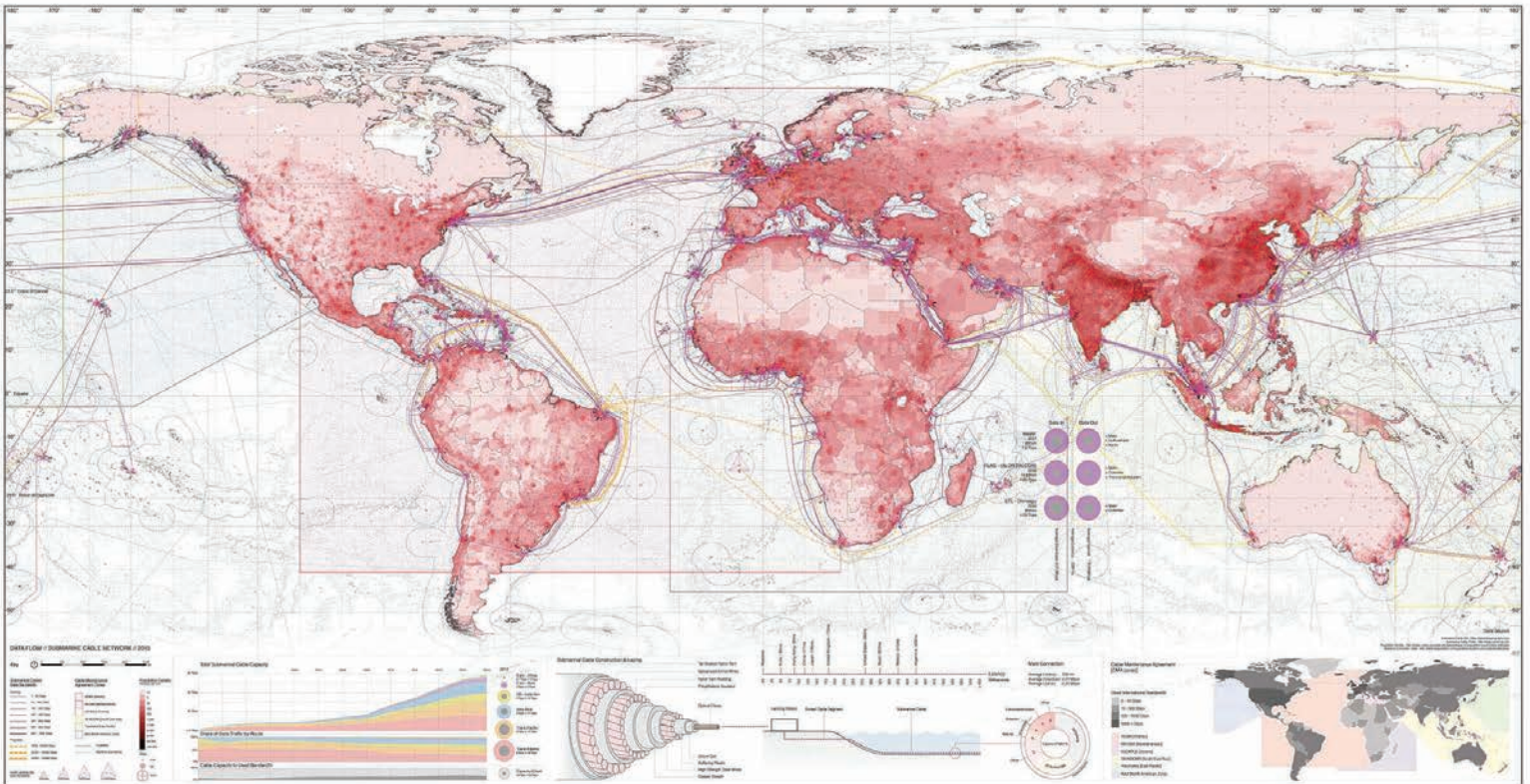
Strung across delicate and little-understood marine ecosystems, the massive undersea data industry is raising alarms. Environmental researchers such as Jean-Baptiste Jouffray, a graduate student at the Stockholm Resilience Centre, explain that “the extent, intensity, and diversity of today’s aspirations (in the ocean) are unprecedented.” Coining the term “blue acceleration” to describe industrialization of the sea floor, Jouffray and fellow researchers argue that the ocean has become the latest high-impact frontier of the Anthropocene. To what extent “blue acceleration” will damage marine ecosystems with noise, heat dissipation, and contamination is highly contentious. Minimal research has been done that might clarify the short- and long-term effects. In the absence of environmental research, cable companies have funded industry studies in support of their claims that cables are benign features of their underwater habitat.

These cable companies even go so far as to argue that it is the cable infrastructure itself that is under threat from marine life, specifically sharks. And indeed, there is evidence of sharks interfering with sub-cables. In the 1980s, cable companies reported that sharks were responsible for decommissioning the same cable line on four separate occasions, making sharks the original hackers. In 2010, video footage showing sharks’ antagonistic relationship with fiberoptic cables went viral on YouTube. Viewers expressed their amusement in the comments section,



Video footage of a shark biting an undersea cable. While sharks and other marine life can damage fiberoptic cables, incidents are rare. Credit: Michael Graham Richard, TreeHugger

making puns about the shark’s “megabyte” and blaming it for their subpar Internet connection. The increased publicity seemed to reflect an uptick in shark attacks, prompting Google to take action in 2014. The data giant announced that its new cables would don a Kevlar coating aimed at protecting the fiberoptic lines within from the jaws of, well, Jaws. Google’s statement mentioned little about the safety of the sharks. The report also fell short of providing a reason for sharks’ interest in data-laden cables. Cable companies suggest that sharks’ ability to sense the electro-magnetic field produced through the



Undersea cables, engine of the Internet, literally crisscross the globe. Credit: Nick Routley, Visual Capitalist

vibrations of suspended cables leads them to believe that the cables are food. Alternatively, shark specialists say not to underestimate the animals' curiosity. If you came across a cable in your backyard, you would probably check it out, too.

If sharks are a principal concern for cable companies, the ocean floor surrounding the Galápagos might not be the optimal place to sink a cable. What made the islands ideal for Darwin's scientific research — the variety and abundance of flora and fauna — make the islands a poor home for undersea data. Home to 32 species of cable predators, the area has "the highest abundance of sharks in the world." Nevertheless, plans to sink the America Movil-Telxius West Coast Cable just south of Isla Isabella in the Galápagos were made in 2019. Set to be operable sometime in 2020, the cable will run down the west coast of South America, from Puerto San José, Guatemala, to Valparaíso, Chile. The cable will represent a measly 0.01 percent of cables wrapped around the Earth's crust, but its impact is significant. Parts of South America previously bereft of data connection will now have command over 108 terabits of data per second. All of those 0s and 1s certainly outnumber their marine predators, but they're still no match against a shark attack.

Should sharks cut the connection to South American homes, it won't take long for cable companies to repair the damage. But will this same level of protection be extended to the marine life residing in some of the most biodiverse waters on the planet?

Jouffray and fellow researchers argue that the ocean has become the latest high-impact frontier of the Anthropocene. To what extent "blue acceleration" will damage marine ecosystems with noise, heat dissipation, and contamination is highly contentious. Minimal research has been done that might clarify the short- and long-term effects.

The sea floor is often imagined as a flat, watery desert, but ocean geographies and ecosystems are as diverse as those on land. Volcanoes, deep-sea geysers, and trenches are regular features. Natural disasters and "meteorological disturbances" sweep across the ocean like an indecisive artist's brush, reconfiguring the topography of the seabed regularly. Thus, cables are not sunk into a vacuum-like void, but are forced to interact with a "dynamic and fluid external environment." No larger than 0.08 of an inch, the fiberoptic cables that transmit bank transactions, research data, and everything else have no chance of surviving the hazards of life underwater. To give



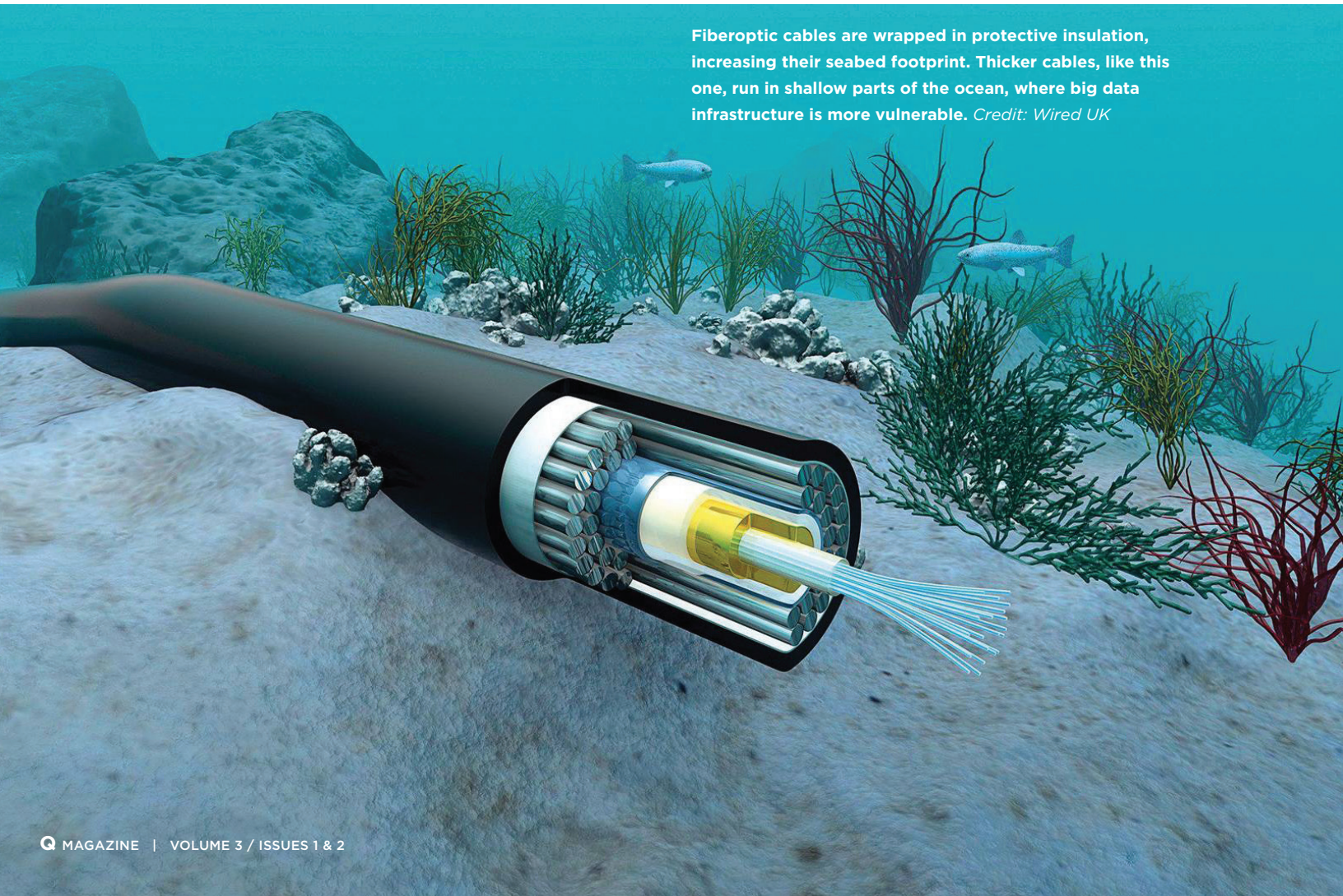
Manufactured by Royal IHC, this plow cuts the sea floor, making a trench for undersea cables. Credit: Royal IHC

the tiny cables extra protection, manufacturers retrofit fiberoptics with layers of hardy materials. The number of layers varies according to the depth at which the cable will rest. Deep-sea cables have less girth than those closer to shore, which use added layers as protection from human interference. The movement of sediment in tidal zones constitutes additional turbulence for coastal-dwelling cables. To mitigate the issue, the cables are suspended between rock formations causing them to “vibrate or strum” as they sway with the tide. The minuscule movements of the cable will strain the suspension system over time, wearing on the integrity of the supporting rocks and potentially disrupting rock-dwelling life.

Cables aren’t always homewreckers, however. Their hard, outer layer often makes a perfect underwater home on the otherwise soft, sedimentary ocean floors. Specifically, the cables attract “encrusting marine biota,” such as mollusks and anemones. While some adhesive creatures are lucky enough to find a forever home on cable lines, not all cable-dwelling creatures are so fortunate. Should the line become damaged or inoperable, repair or replacement will disturb the colony of life it has attracted. And for the mollusks and anemones that do remain, another

threat looms: The hard surface of the cables that the sea creatures prefer is often made of polyethylene, the most common type of plastic. Polyethylene is infamous for stirring up controversy; there have been many debates about whether the plastic leaches harmful chemicals when submerged in water. Initial studies suggest that polyethylene leaching is untraceable in the short term. Cables would need to be submerged for centuries before significant impacts due to leaching take place. This, in turn, raises a key question: With life spans of approximately 25 years, how long will cables actually be in our oceans?

Cables and data infrastructures might only be useful for a quarter century, but it has become common practice to leave them in place after they have stopped working. Senay Boztas, a writer for The Guardian, revealed that an estimated “94 percent of unused cables and 72,000 repeaters are abandoned on the seabed.” Having reached the end of their life cycle, the cables should be stripped of their expensive raw materials. But most data giants are choosing to leave the cables for dead. Owing to the lack of regulation over international waters, there is no hope of enforcing cable clean-up: “It is like the Wild West in the middle of the ocean,” according to one of Boztas’



Fiberoptic cables are wrapped in protective insulation, increasing their seabed footprint. Thicker cables, like this one, run in shallow parts of the ocean, where big data infrastructure is more vulnerable. Credit: Wired UK

informants. While some companies are beginning to take the initiative and extract their outdated cables from the ocean floor, there is disagreement on whether cable “recycling” is cost-effective or beneficial for the environment. Because cable extraction is a difficult task, companies must decide whether the energy and labor are worth a couple extra million dollars. Many cables can become biologically cemented to suspension points or buried under feet of sediment, which complicates the process of extraction and potentially disrupts marine life. Leagues above the site of extraction, the cable ship chugs along, burning hefty amounts of diesel fuel. For these reasons, some marine biologists suggest abandoning the cables in their underwater graves might be less damaging overall to marine life, especially those who have found a home on the cable. However, there is still significant controversy as researchers acknowledge “little is known about the long-term impacts of leaving the cable abandoned.” Scientists are asking what marine ecosystems will look like after centuries of absorbing polyethylene leached from undersea cables. Granted, it may so happen that no one is around to find out. In the meantime, I wonder, can we do better?

There is so much we don’t know about undersea cables and data networks: What are the short and long-term effects of cables on marine environments? How durable are fiberoptic cables in dynamic undersea environments? In spite of these uncertainties, data companies continue to move at full speed. In 2015, Microsoft launched Project Natick with the hopes of building a “standard, manufacturable, (and) deployable” underwater data center. Phase II of the project is now underway in Scotland, where the team is testing the data center’s capability to run unmanned on the ocean floor for a span of five years. Parsing through the project’s website, a sustainability agenda is at the forefront, with the vision of a fully recyclable facility that can be re-outfitted every five years and sunk back into the sea. Bathed in the cool waters of the ocean, Natick forgoes the need for energy intensive cooling systems. What little power the center does require is obtained from renewable energy sources, such as on- and off-shore wind farms. In all, the team is optimistic that Natick data centers can be “truly zero emission (with) no waste products ... (from) power generation, computers, or human maintainers.” Microsoft goes so far as to say that their underwater data center operates as a “shelter for local wildlife.” Regardless of the merit of this claim, the Natick is leagues ahead of land-based data centers that have carbon emissions on par with commercial airlines. In the mostly murky waters of the oceans’ future, Microsoft’s Natick is a glimmer of hope for sustainable data infrastructure.

Leagues below the ocean’s surface algal blooms and gyres of trash, data is coursing through fiberoptic cables.

There is so much we don’t know about undersea cables and data networks: What are the short and long-term effects of cables on marine environments? How durable are fiberoptic cables in dynamic undersea environments?

Some of this data is vital — spatial data on Arctic fires, satellite images of Earth’s thinning ozone, and statistics on the spread of COVID-19 — some, not so much (pet videos, anyone?). Ungoverned and unsupervised, it seems nothing can stop the data industry’s colonization of the sea bed — except, perhaps, the sharks. While cable companies assure us in soothing tones that the “impact ... is ... minor,” it becomes increasingly apparent that big data is hugely disruptive to global ecosystems, and to our vulnerable oceans especially.

Scientific research has never been without cost. In Darwin’s day, natural history research meant killing specimens in order to observe them. Some of the Galápagos tortoises Darwin studied ended up back in museum displays in London and even on Darwin’s dinner table. It remains to be seen if big data will be our saving grace or our damnation. For now, it’s hard not to be struck by the irony of the big data ocean grab. In 10 years’ time, will ocean researchers like Craig Venter still be storing their data on marine life in the very waters from which they collected it?



EDITOR’S NOTE: Since the original reporting of this article, Microsoft proudly announced that it has pulled its data center out of the water.



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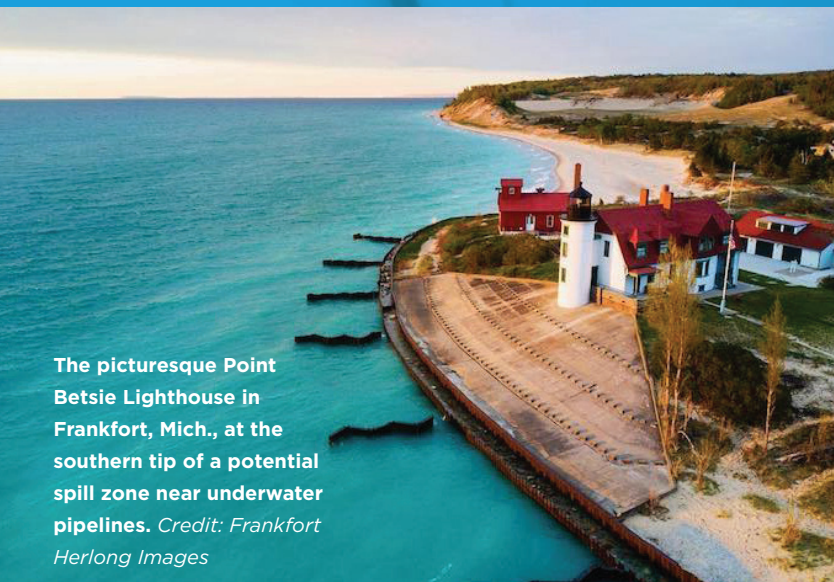


By Sarah Gediman

SAVE THE LAKES

Every summer, people across the country travel to freshwater beaches in northern Michigan to relax. They take hikes through the Sleeping Bear Dunes National Lakeshore, breathe in the scent of cedars and birch trees, and peer at the breeding grounds of endangered birds, the sandpipers and piping plovers. They eat local cherries, peaches, blueberries, and cheese, and watch sunsets from lakeside vineyards and historic lighthouses. The combination of sparsely populated beaches, breathtaking views of Lakes Michigan and Huron, and an increasingly popular food scene has earned the region generous coverage in prestige publications such as the *The New York Times* and *Vanity Fair*. But America's Third Coast is more than

the ideal vacation spot; together the five great lakes hold 20 percent of the world's freshwater. They support livelihoods, trade, and energy infrastructure — as well as drinking water for 40 million people. The lakes are fundamental to the ecological, economic, and public health security of the region. But Lake Michigan and Lake Huron together face a critical, imminent threat.



The picturesque Point Betsie Lighthouse in Frankfort, Mich., at the southern tip of a potential spill zone near underwater pipelines. Credit: Frankfort Herlong Images

Every day, 23 million gallons of crude oil and liquid natural gas, contained within twin 67-year-old pipelines, course below the Great Lakes. These structures have long been covered in rust. The original enamel meant to protect them from disintegrating has worn off. Nearly seven decades of powerful currents have swept their physical supports from the lake floor, and the pipelines have lost an average of 26 percent of their original wall thickness. Invasive species cling to the rusty pipes and add weight to these already crumbling pieces of post-war infrastructure — part of a pipeline known collectively as Line 5 — that has brought fossil fuels from Alberta to Sarnia, Ontario, since 1953.

A particularly fragile portion of Line 5 is positioned at the intersection of Lake Huron and Lake Michigan in a section of water known as the Straits of Mackinac, where the peninsula creates strong, unpredictable currents. Between the erratic currents and challenging topography of the peninsula, the Straits of Mackinac, in the words of University of Michigan researcher David Schwab, are arguably “the worst possible place for an oil spill.” A catastrophic Line 5 rupture would contaminate not one but two Great Lakes via currents that weave around the small gulfs and islands.

Simulating what a spill would look like under a variety of hydrological conditions, Schwab estimates that an oil spill in the Straits of Mackinac would affect between 150 and 700 miles of freshwater coastline. This shore is home to more than 1,870 species as well as scenic attractions vital to Michigan’s tourist industry. A study led by Michigan

State University ecologist Robert Richardson concludes that the average spill caused by a Line 5 rupture would lead to \$6.3 billion in damages to wildlife, municipal water systems, property values, and the tourist economy.

Many inland sections of Line 5 are in even worse shape than the sections that cross the Straits. According to Professor Jeffrey Insko, a member of the Pipeline Safety Trust, “there have been dozens and dozens of instances of leaks and spills and other things along the inland routes of (Line 5). So, Line 5 has in fact leaked in the past, it just so happens to not have leaked in the straits yet.” Nevertheless, some estimates report up to 1.1 million gallons of crude oil have already leaked from Line 5. The failure of the inland pipelines only makes the egregious state of the pipelines in the Straits more alarming.

Where Does It All Go?

In response to the concerns of the Pipeline Safety Trust and other environmental groups, Enbridge Energy, the company that owns Line 5 and the fossil fuel products that course through it, has argued that Michiganders depend on the pipeline for energy. But in fact, the vast majority of crude oil and natural gas pumped via Line 5 through the Straits of Mackinac is not used for domestic energy on either side of the border. It does not heat houses, power cars, or light classrooms and libraries. After crossing the Canadian border, Line 5 passes through Northern Wisconsin, and Northern and Western Michigan. It then merges with other pipelines just north



The beach on Mackinac Island, adjacent to Line 5. Credit: Jimmy Taylor Photograph

of Detroit, and its contents are finally emptied into oil refineries in Ontario. The majority of refined oil is then shipped to Asia where it is manufactured into plastic products. Because of this, it is impossible to tell exactly what percentage of the material that poses such a threat to the Great Lakes is converted into plastic in Asia and how much is used to heat homes in Michigan. What we do know is who, and what, would suffer from a massive oil spill.

The only people who definitively use energy from Line 5 to meet personal energy needs are residents in Michigan's Upper Peninsula who use propane from Line 5 to heat their homes. This is different from the energy they use for electricity, which is purchased through the power grid and can come from anywhere. But David Holtz, a representative from the environmental advocacy group Oil and Water Don't Mix, says that "it's really in the interest of people who heat their homes with propane in the Upper Peninsula not to be reliant on Line 5, to have other options if the line ruptures."

The enormous threat posed by Line 5 lies not only in the risk of a spill, but also in what the pipeline produces. Line 5 oil contributes significantly to climate change, increases disease as a result of both petroleum combustion and plastic exposure, and contributes to worldwide plastic pollution of oceans and waterways. A truly secure energy future would exclude conventional oil pipelines such as Line 5 for two reasons: because the physical pipelines inevitably deteriorate and pose a catastrophic environmental hazard, and because the fossil fuels they transport

are either burned or refined into materials that ultimately harm the well-being of the people the energy is intended to help in the first place.

Michigan's petroleum problem is even more alarming in light of Enbridge's dirty history of spills in the state — and the continuing risk for more spills. In 2010, an Enbridge pipeline called Line 6B spilled 1 million gallons of crude oil into the Kalamazoo River in Marshall, Mich. The disaster was one of the largest inland oil spills in U.S. history and cost Enbridge \$1.2 billion in cleanup and legal fees. In addition to the harm caused by the oil itself, unidentified chemicals that had been used to dilute the viscous bitumen were vaporized into toxic fumes upon contact with air, and caused numerous hospitalizations (Enbridge refused to tell doctors and patients what the chemicals causing extreme symptoms were, claiming it was a company secret). The oil left behind from the 2010 spill continues to tragically impact the region, devastating farmland, potable water springs, and wildlife habitat.

The Kalamazoo oil spill permanently affected Marshall, but also had the effect of drawing greater attention to Line 5. The risk of a spill of comparable or greater magnitude in the Straits of Mackinac has caused an increasingly vocal opposition to Line 5 and the oil it transports. As Holtz, the environmental advocate, recalls, "until that major catastrophe (in Marshall) most people in Michigan didn't even really know that those pipelines were in the Straits of Mackinac." Oil and Water Don't Mix formed shortly after the 2010 Kalamazoo spill. The group's anti-pipeline campaign has grown from the roughly 300 individuals who



Oil in the Kalamazoo River near Marshall, Mich., after a spill from Enbridge Line 6B.
Source: State of Michigan

“Simulating what a spill would look like under a variety of hydrological conditions, Schwab estimates that an oil spill in the Straits of Mackinac would affect between 150 and 700 miles of freshwater coastline. This shore is home to more than 1,870 species as well as scenic attractions vital to Michigan’s tourist industry.”

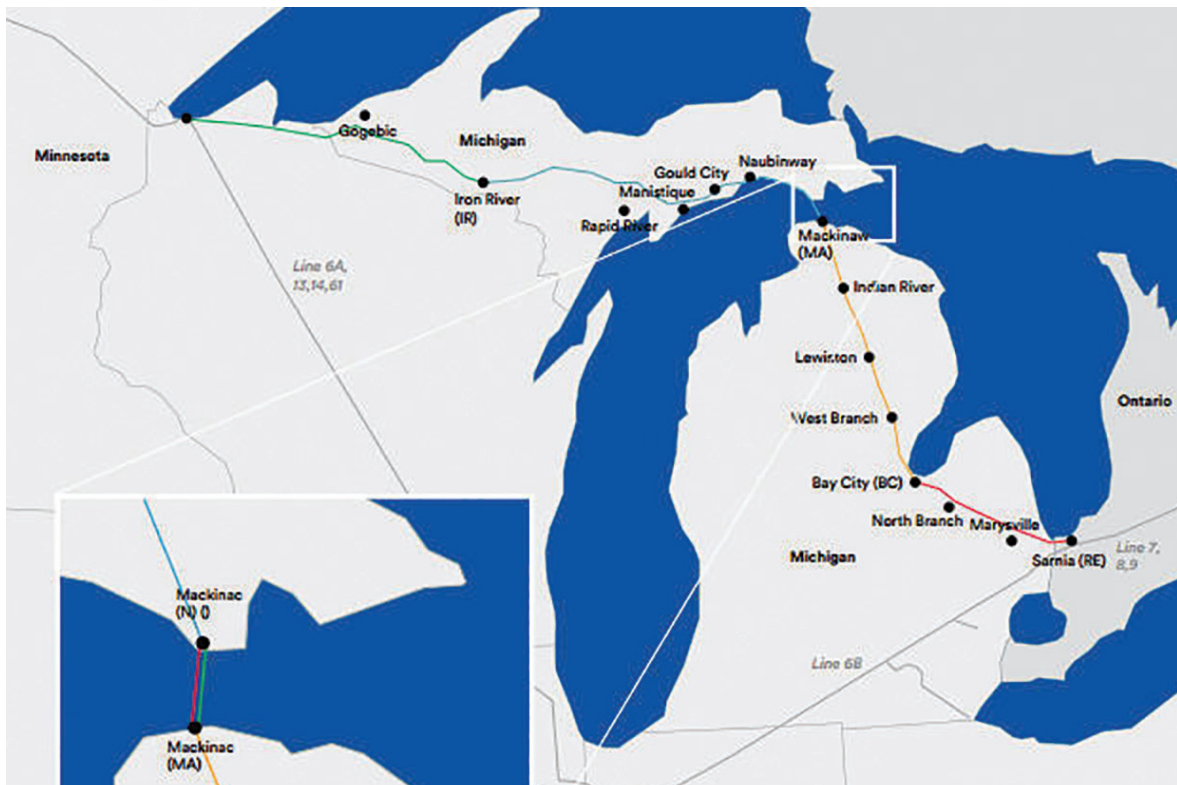
attended their first rally in 2013 to a network of over 250 indigenous nations, NGOs, local governments, faith-based organizations, and businesses. They advocate for the shutdown of Line 5 and an increase in renewable energy infrastructure, and they support politicians who align with these values. Their activism has drawn the attention of a number of national environmental groups, including the Sierra Club and Bill McKibben’s 350.

This wide-ranging network of anti-pipeline activists and politicians has also found sympathy among statewide elected officials. Michigan Attorney General Dana Nessel, elected in 2018, campaigned heavily on shutting down Line 5, which she deems a threat to the state. During her campaign, Nessel argued that it was “the responsibility of the attorney general to protect the state of Michigan and to protect the public against what I think will be the biggest economic and ecological catastrophe of our time.” Since her election, Nessel has acted on her commitment to protect Michigan’s natural resources. Insko is optimis-

tic that Nessel is “fully committed to the idea that the pipelines pose a real threat to the Straits and that a tunnel project is not viable because of the threat of climate change.” Gov. Gretchen Whitmer likewise included the issue in her campaign and is an outspoken advocate of shutting down Line 5.

What’s Next?

Meanwhile, however, Enbridge Energy has proposed its own substitute for the petrochemicals Line 5 supports: the company plans to decommission the current pipeline and replace it with a system that allows it to transport more oil through the Great Lakes system. Enbridge has proposed drilling a 10-foot-wide tunnel under the bedrock of the Straits of Mackinac over the course of 10 years. After construction, a new Line 5 would run through the tunnel, carrying a higher volume of oil under the Lakes than it does currently. The company has framed this



A map of the Line 5 area, with the Straits of Mackinac inset. Credit: michiganradio.org



Protestors from Oil and Water Don't Mix make their case in front of the Michigan Capitol building.
Credit: Oil and Water Don't Mix

tunnel project as a response to the risks posed by the current deteriorated state of Line 5. Drilling under two Great Lakes, however, would be unprecedented and extremely hazardous. It would also take about 10 years, during which time Line 5 is already expected to rupture. A spill is even more likely if the bedrock to which Line 5 is bound is gutted to make room for yet more crude oil.

Insko calls the new pipeline proposal “a distraction.” The tunnel will take many years to build, during which time the problems with Line 5 will worsen. This plan also depends on the responsible construction of and transition to a new piece of infrastructure, risky in light of Enbridge’s cavalier attitude toward pipeline security evidenced in the 2010 spill. Shortly before leaving office in 2019, Republican Gov. Rick Snyder’s administration gave Enbridge Energy the legal authority to proceed with the tunnel project. This is the latest in nearly 70 years of legislative and judicial accommodations between Enbridge and the State of Michigan. Nessel is currently pursuing a lawsuit that challenges the legality of the proposed tunnel.

Drilling for oil is dangerous, likewise transporting it. The aftermath of an oil spill is always accompanied by grieving communities, devastated wildlife, and contentious legal battles, but never by the full recovery of the spilled oil. “Cleaning up” an oil spill is a wishful way of describing a Sisyphean, often hopeless task. From the years-long battles between governments and the companies responsible for the spill, to the ineffective floating devices to skim oil once it has filtered through plant and animal material and risen to the surface, to dumping pollutants into water sources to cause the coagulation of oil to ease the removal process, “clean ups” can never remedy the catastrophe of a major oil spill. Once oil enters a body of water and shore ecosystem, the vast majority of it is never

recovered. Devastation of the environment, for hundreds of miles around, is effectively permanent.

We must save our Great Lakes. If Line 5 is not shut down very soon, the picturesque lighthouses of Lake Michigan and Lake Huron will be lighting the way not for tourists through a precious natural landscape, but for rescue boats through a sludge of crude oil. The soil that once supported award-winning wine and produce will be tainted, and the dunes that supported cedars, birches, and endangered species will shimmer with the purples, yellows, and blues of free-flowing oil. The sparkling waters that currently support a unique freshwater ecosystem, robust tourist economy, and 40 million human lives will be stained petroleum black.



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Sustainability, and hopes to pursue doctoral study in the history of climate science. She serves as the Volume 3 Student Editor for *Q Magazine*.



Q&A

By Anneli Cers

Protecting Our Water

A Q&A with Joan Rose



Credit: Tarasyuk Igor

Public health microbiologist Joan Rose has spent her career tracking pathogens in water, from *Escherichia coli* to the COVID-19 virus. The 2016 recipient of the prestigious Stockholm Water Prize took an interest in microbiology early in her undergraduate studies, completed her master's thesis at the University of Wyoming, and conducted her Ph.D. research at a drinking water plant in Arizona. Now Rose, the Homer Nowlin Chair in Water Research and Professor at Michigan State University, studies waterborne health threats by mapping the world's waterways.

Her experience in the world of water pollution microbiology with a public health slant has brought Rose to communities where waterborne disease outbreaks have forever altered lives.

"I realized that it wasn't just about running around and collecting water samples; it was really about a public health issue and protecting water for communities, the children, the elderly, and all of the people at risk," she said.

Her latest project: leading research on the Michigan State University campus and around the state of Michigan to track the COVID-19 virus in communities by collecting and tracing wastewater samples, so scientists can predict when and where outbreaks are likely to occur.

During Earth Week, Rose was a keynote speaker at the Spring 2021 iSEE Congress, "The Future of Water." Ahead of her virtual visit with the University of Illinois campus community, she talked in Fall 2020 with Q's Anneli Cers about mapping waterborne diseases, threats to water security, and addressing water quality through policy.

Q. Did you grow up near water?

I grew up in the Mojave Desert in Southern California, where water was scarce. Although the groundwater is stressed now, we had plenty of groundwater at that time. As a young kid, I did not worry about the quality of the tap water. I was excited to go to a little river, the mountain lakes, or to the ocean with my family. There is an appreciation of water when it's not around you. I did not think of groundwater as much until I got to Arizona and did my Ph.D. We sampled waters around the state to determine the water quality. I started thinking about whether the water was used for recreation or drinking water, and if it was coming off of our land, from our communities as wastewater, and how all this was impacting our water quality.

Q. How do you track pathogens in water?

It's not easy, but methods have evolved. The polymerase chain reaction (PCR) uses a kind of molecular tool to study pathogens, but these methods were not around

when I started my Ph.D. We used culture techniques and an old-school medium that we knew could specifically or differentially tell us which bacteria were present. For viruses, we had cell cultures. Often we knew a virus was there, but we did not know what kind. In 1985, PCR really started impacting the microbiology world and made things easier. It's no longer hunting for the needle in the haystack; we now have a magnet, so to speak, with which we can pull that needle out. We can look for any specific organism we want in the water with the new instruments and knowledge around DNA. PCR is basically a DNA copying machine, so we can look very specifically for pathogens like adenovirus, *Cryptosporidium*, or *Giardia*.

When the COVID-19 virus showed up in feces and sewage, scientists, including our lab, were able to quickly develop a method to look for that virus in the wastewater. We take the water sample, concentrate it, and sometimes actually use a magnet. We attach an antibody to our target organism with an iron molecule and pull it out of everything else with a magnet. Then, we use these molecular tools to identify the pathogen or even understand the source of the pollution, which could be coming from humans, birds, or cows.



Joan Rose

Q. Could you describe the complex process of mapping water diseases in just a few sentences?

We know we cannot sample every single water source every single day to understand the quality, so we strategically select our sampling sites to create a model. A watershed is a whole bunch of river systems that all come down to one spigot. A lot of times we'll sample at that spigot to try to collect what's in that watershed, and then we'll go upstream into that watershed. We try to understand what the land use is. How many wastewater plants are there? How many people are in that watershed? How many cows are in that watershed? Rain is a driver because it carries stuff off of the land and into our rivers, so we try to understand the transport. We try to study where the organisms come from, how fast they move, and where they go. We can determine if they are going to places where they are going to make people sick, like the beach or a drinking water source. We work with modelers, people who understand land use, and people who understand mapping. It's very much like a puzzle.

Q. What is the most notable or interesting outbreak that you have studied?

The *Cryptosporidium* outbreak in Milwaukee in 1993 was notable for many reasons. It was one of the largest outbreaks in terms of the number of people who got sick. Several sensitive populations were affected and immunocompromised individuals died. Suddenly people were like, "Wow, people are dying from our tap water!" In the United States, that shouldn't be happening. Another reason it was so notable is that the Safe Drinking Water Act was being reauthorized by Congress. The outbreak made an impact on the reauthorization because people realized that there are going to be emerging new microbes and contaminants that are going to cause a risk, so it got attention politically, scientifically, and in the public health arena.

One of the outbreaks that affected me more was a smaller outbreak associated with *E. coli* in a little town in Canada. I went to that community about five years after the outbreak and met people who were affected. Some had lost a child because of the contaminated tap water. People still



Joan Rose receives the 2016 Stockholm Water Prize from Carl XVI Gustaf, King of Sweden. The prize was awarded as a part of World Water Week. Credit: Stockholm International Water Institute (SIWI)

“Solutions include investments under the Clean Water Act, source-tracking methods, fixing impaired waterways, and looking at long-term solutions for treatment and infrastructure. As we build pipes or wastewater plants, we should be thinking that these should last 50 years.”

had reactive arthritis, which can be a chronic condition from some infections. People weren't affected for a short amount of time; this changed their lives for the long haul. It meant that we have to protect our drinking water and reduce those kinds of events.

Q. Why aren't people more aware of waterborne diseases?

Luckily, waterborne disease outbreaks are rare in the United States. When we mapped outbreaks over 50 years, we found that the same community rarely experienced two outbreaks. Once you have an outbreak, the infrastructure gets upgraded and a lot of attention is paid to the treatment conditions at the utility. We made a lot of changes to improve our drinking water after the *Cryptosporidium* outbreaks, and the new rules were implemented as part of the Safe Drinking Water Act.

A lot of things have to happen for an outbreak to occur. A pathogen has to hit a water plant, enter your well water, or enter the groundwater. It has to get through the treatment. Some water is quite susceptible because sometimes there's no treatment. Then, the outbreak has to be recognized. We believe that there are little outbreaks occurring, but they are not recognized because they're not big enough. The attack rate is the percentage of people in a community who actually get sick. Generally, the attack rate has to be above 20 percent to be recognized as an outbreak; 20 percent of the population is a lot. If the contamination is lower than that, and there are people getting sick, it's just not recognized.

Q. What is the biggest threat to water security? What kind of risk does climate change pose?

I think the biggest threat in terms of climate change is the

change in precipitation patterns, the intensity of rainfall events, and increased flooding. Analyses around the world reveal that a high percentage of outbreaks and dramatic disease events occur during these flood events because fecal pollution is spread by the floods. I think that this is a threat that overlays what we do on the land. We've got more people, we've got more animals, and we've got an aging infrastructure. So if we don't take care of the increased fecal pollution and aging infrastructure, the climate is going to exacerbate these issues.

Q. What do policy solutions for these threats look like at different levels of government?

At the state level, I think that solutions include investments under the Clean Water Act, source-tracking methods, fixing impaired waterways, and looking at long-term solutions for treatment and infrastructure. As we build pipes or wastewater plants, we should be thinking that these should last 50 years. Our clean water is going to be an asset and a driver of economic growth because people love to live around clean water. It drives economies in terms of tourism, fisheries, food, agriculture, and the manufacturing industry. At the federal level, we need to look at new emerging areas, such as plumbing systems in buildings. The few distribution system rules and federal programs that exist are not mandatory and are not cohesive to look at water quality in these buildings.

Our pipes are kind of out of sight, out of mind, and we don't think about them until something breaks. We really need a water infrastructure program that invests. We can't afford it if we ask the local ratepayer to pay for all of the upgrades for our water systems. The federal government and the state government need to partner with the local communities so that our taxes are actually going toward upgrading our infrastructure. This is going to protect our ambient waters, our lakes, our groundwaters, and the water that we drink.



A researcher takes a sample from a freshwater stream.

Credit: Wikimedia Commons

Q. Many people are currently affected by COVID-19. What might a pandemic caused by a waterborne pathogen look like?

We have seen it already to a certain extent with cholera. Cholera came over to the Americas in 1991 and spread to almost every country in South America. That was a big wakeup call because they did not have good wastewater treatment. We did not see it in North America because we have wastewater and drinking water treatment, which is a barrier to the spread of waterborne diseases. Cholera and *Salmonella*, the cause of typhoid, are still globally significant, but we know how to interrupt waterborne diseases for the most part. *Cryptosporidium* in emerging regions of the world, however, was so resistant to one of the most important barriers that we used, which was disinfection with chlorination, that we had to adjust to this new pathogen. We have seen these waterborne diseases spread around the world in a very short amount of time. A new genotype for norovirus, for example, can spread through food, people, water, and sewage. The main thing about these outbreaks in water is how many people are exposed at one time. Once the water is contaminated, you can have hundreds and thousands of people exposed at a

single period of time from their drinking water; that's why it's so dramatic. It's more like a plane crash than what we are seeing right now with the pandemic.

Q. Do we take water for granted? What are we risking by ignoring these issues?

Yes, I do think we take water for granted. I think most people don't know where their water comes from because they just turn on the tap. They don't know what's groundwater, surface water, and they don't know how it's treated. And they certainly don't know where their water goes when they flush their toilet. In some ways, that's kudos to the water profession for making it so seamless that we don't ever have to think about it. On the other side of that, the community gets upset if the city starts to raise water rates. It can be expensive, especially for poor income areas where they have to spend a high percentage of their income on water, which is a necessity. Globally there's been a declaration that water is a human right. In the United States we say that water is a human right, but you have to pay to access it. So how do we make sure that is reasonable and that, financially, we are doing the right thing for our communities as we install infrastructure?

Q. Where do you feel you've made the most impact, either through a specific project or overall?

I have never been my own lab. I work in collaboration, so I think I have had an impact on other fields by bringing microbiology into hydrology and working in the field. There's been an impact in developing, monitoring, and appreciating data. I've been a big supporter of monitoring, and not just compliance, where the law says you have to monitor for *E. coli* on a beach. I think that we need water diagnostics. When we find the pollution, how do we fix it? If we have water diagnostics, we can spend our dollars more wisely. And we've been able to create a global network where we can share knowledge. I think my impact has been in those areas.

Q. In 2016 you received the Stockholm Water Prize for your leadership in research on microbial threats to human health in water and translation of scientific findings to policy makers. What did that mean to you and to your work?

I was stunned! The recognition that the prize gave to our field of water quality and public health allows us to have a platform where we have more people calling and asking us to speak about this topic. It opens doors so that you meet more individuals who are working globally at the interfaces between disciplines. It's really humbling to be awarded something like that. You don't really think it's something that's going to happen in your career. It was an amazing week.

Q. What's next for you?

We are looking at taking everything we have learned and making it accessible on a global basis using the internet. We finished an online book about waterborne pathogens. We are creating a platform where we can share information so that people can make use of all of this knowledge that we have accumulated over the last 20 years, through both peer-reviewed publications and tools where you can access the actual data.

With COVID-19, I think that there is going to be even more attention to wastewater infrastructure and our ability to help with decisions about opening schools, the sports season, and the protection of nursing homes. I really think that the monitoring of wastewater systems is going to help us with this type of pandemic. As a vaccine becomes widely available, we will be able to support how this vaccine is administered, its uptake, and its protection of our communities by monitoring wastewater. Rather than having to sample each individual person, you can get a picture of the whole community with water samples. My public health colleagues are working so hard right now to fight this pandemic. It's just unbelievable.



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Environmental Law & Economics. She plans to pursue a J.D. in environmental law.



By Lindsay Albright

You're only 3 years old when you and your father pack up the car to go to the beach. You aren't quite sure what all this talk is about surf fishing, but you will soon find out it's a technique for catching fish by standing on the shoreline or wading in the surf. Your father meets up with his surf fishing friends and proudly introduces you. As the group walks along the shore searching for fish, your father gives you a very important task. He instructs you to flip those alien-like creatures on the sand who got stuck on their backs right-side up and float them back into the ocean. At the time it feels like you've been given a responsibility as big as holding the world itself together — and in a way you have been. One by one you begin flipping the mysterious horseshoe crabs over and watch them hurry back into the ocean — all the while imagining them giving you a little “thank you” before they leave. Your dad's friends tell you to do the opposite, to just kill them, or let them die. What do crabs matter anyway? But without hesitation your father says, “No. Put them back in the water.” From that day, you have never stopped working to save the horseshoe crabs, and you know better than anyone just how much this mysterious species matters to us all.

This unforgettable childhood experience is how Allen Burgenson was first introduced to the ancient world of horseshoe crabs, a 450-million-year-old species whose rare blue blood is used in the biomedical industry to test pharmaceutical products for safety. A species that, although vital to human health, is threatened with extinction. A species that Burgenson wants to make the world aware of, so we can work to protect and save them.

Now a global expert in biomedicine working for Lonza Pharma and Biotech, Burgenson agreed to an interview with *Q Magazine*. During the interview, Burgenson discussed how horseshoe crab blood is used, the vital importance of this species to biomedicine, and the serious environmental threats facing the species today.

Ancient Pedigree

In preparation for the interview, I tried to find out all I could about this extraordinary crab species, including how they're being used in the biomedical industry, and why their existence is threatened. What I found along the way is that horseshoe crabs may be crucial in developing a vaccine for the virus currently plaguing the world — COVID-19.

Prehistoric invertebrates, horseshoe crabs have crawled this planet since before the dinosaurs. They have survived three of Earth's five official extinctions, outlasting drastic environmental changes and volcanic eruptions largely thanks to their flexible diet and ability to tolerate different habitats.

Horseshoe crabs certainly look prehistoric, even alien. A horseshoe crab has 10 legs, nine eyes, and enjoys its own taxonomic class — Merostomata — which means "legs attached to the mouth." While their name and appearance suggest crab, they are actually closer relatives of scorpions and spiders.

Four species of the horseshoe crab exist today, one along the eastern coast of North and Central America, and the other three along Asian coasts in the Indian and Pacific Oceans. The American crab Allen Burgenson flipped over at age 3 is named *Limulus polyphemus*, which breeds along the East and Gulf coasts in late spring and early summer.

The crab's journey from the deep ocean begins with parent males arriving first, followed by the females. Breeding usually takes place during new and full moons, when the females lay their eggs on the beach in small holes they dig in the sand. The males then fertilize the eggs. The females can lay tens of thousands of eggs, most to be eaten by birds, reptiles, and fish. Those eggs not eaten will hatch in about two weeks and then move into ocean tidal flats for about a year until they mature and can migrate into

How is it that this odd creature, 450 million years old, could be of such importance not only to the red knot bird, but to medical researchers seeking a cure for COVID-19? Answer: It's all in their blood.

deeper waters. Juvenile horseshoe crabs will molt up to 17 times over the next 10 years until they reach adulthood, which can last another decade.

Horseshoe crabs play an important role in their ocean ecosystem, as a keystone species. They are a food source for many species of shore birds — many of which feed on horseshoe crab eggs during their migratory routes. Flocks of red knot birds, for example, migrate from southern South America all the way to the Arctic. During their journey they stop in the Delaware Bay area to gorge on horseshoe crab eggs, their last meal before the Arctic. In the past, the United States has used horseshoe crabs for fertilizer, resulting in a decline in horseshoe crab populations. When horseshoe crab populations began to decline, so did those of the red knot. Threats to the horseshoe crab ripple through the entire Atlantic seaboard ecosystem.

How is it that this odd creature, 450 million years old, could be of such importance not only to the red knot bird, but to medical researchers seeking a cure for COVID-19? Answer: It's all in their blood. Horseshoe crabs have blue blood, not red. This is unusual in and of itself, but it's what the crabs' blood can do that makes it so special.

Blood Bonds

If you've ever gotten a shot of any kind, you can be sure the drug was first tested for safety using the blood of horseshoe crabs. Every drug or medical device that comes into contact with our bloodstream must be tested for bacterial endotoxin, deadly to humans. The blue blood of horseshoe crabs is very sensitive to endotoxin, and thus a vital resource for drug testing.

The ingredient in the blood of horseshoe crabs used to test pharmaceutical products is called *Limulus amoebocyte lysate*, or LAL. Burgenson, who has worked with LAL for almost 40 years, explained to me the process of collecting and using horseshoe crab blood in the U.S.-based biomedical industry. First, fishermen collect the crabs and bring them to the bleeding facility where they



A horseshoe crab fossil.
Credit: blog.nature.org.



Credit: Shutterstock



Harvesting horseshoe crabs' distinctive blue blood.

Credit: National Geographic/Getty Images

are cleaned. Next, their blood is taken in a process not unlike when people donate blood. When a horseshoe crab is bent in half, a small membrane is exposed in the cardiac sinus. The lab tech wipes the area with iodine and inserts a clean needle, through which about three to six tablespoons of blood are removed from each horseshoe crab. After the bleeding process they are put into a return bin and checked, after which contracted fishermen restore them to the ocean within 24 hours. Although the Atlantic States Marine Fisheries Commission associates a 15% mortality rate with this process, Burgenson claims this rate is based on old data; today the bleeding practice mortality is reported to be more like 3-5%.

Back in the lab, technicians combine the extracted blood with anticoagulants so it doesn't clot, and put it into a centrifuge where the cells fall to the bottom. Although humans have many kinds of blood cells, horseshoe crabs only have one: amebocytes. The amebocytes are spun down, which separates the blue liquid — the blue hemolymph — which is then poured from the centrifuge. The remaining amebocyte cells are added to several other proprietary formulations, then freeze-dried and incubated at 37 degrees Celsius for one hour. This process results in the final LAL product: to test for endotoxins in injectable pharmaceuticals and medical devices.

The ability to test for endotoxins is critical to the past,

present, and future of human health. Endotoxins, which exist in bacteria, can be what medical professionals call "pyrogenic," which means they provoke a negative, toxic, usually feverish response in the body. Burgenson explains that there is a paradox here in that our guts are full of endotoxins, which are pyrogenic in nanogram amounts. One billionth of a gram of endotoxin is enough to cause a fever, and higher amounts will cause people to go into shock and potentially die. Pharmaceutical products can become contaminated with endotoxins from the water used to produce these products, and therefore all injectable drugs must be tested for endotoxins before being injected into patients. And what a successful system it is! Burgenson points out that in the 40 years LAL has been on the market, there's never been an instance where a product that tested negative for endotoxins using LAL turned out to be positive when the product was used out in the field.

"If you think of all the millions of product batches that have been manufactured around the world and tested with LAL it has never missed a bad batch of pharmaceutical products. Every person who has ever received an injection — whether it be a vaccination, whether it be IV fluids, whether it be vitamins — anything that's ever been injected into anybody in the world — everybody — that product that was injected into them has been tested using LAL. Every person in the world has been touched by the horseshoe crab. I think that's pretty amazing."

Every person who has ever received an injection — whether it be a vaccination, whether it be IV fluids, whether it be vitamins — anything that’s ever been injected into anybody in the world — everybody — that product that was injected into them has been tested using LAL. Every person in the world has been touched by the horseshoe crab.

Before LAL, hundreds of thousands of rabbits were used every year for pyrogen testing. Rabbit testing didn’t gain popularity until 1941, when injectable pharmaceutical drugs were being tested and used for World War II. Before then, anytime someone was injected they could expect something called “injection fever,” meaning that one time in 10 someone given an injection could expect to become sick, or possibly die, due to endotoxins.

In 2020, we are in a mad rush to find a vaccine, cure, or treatment for COVID-19 and to bring it to the market as

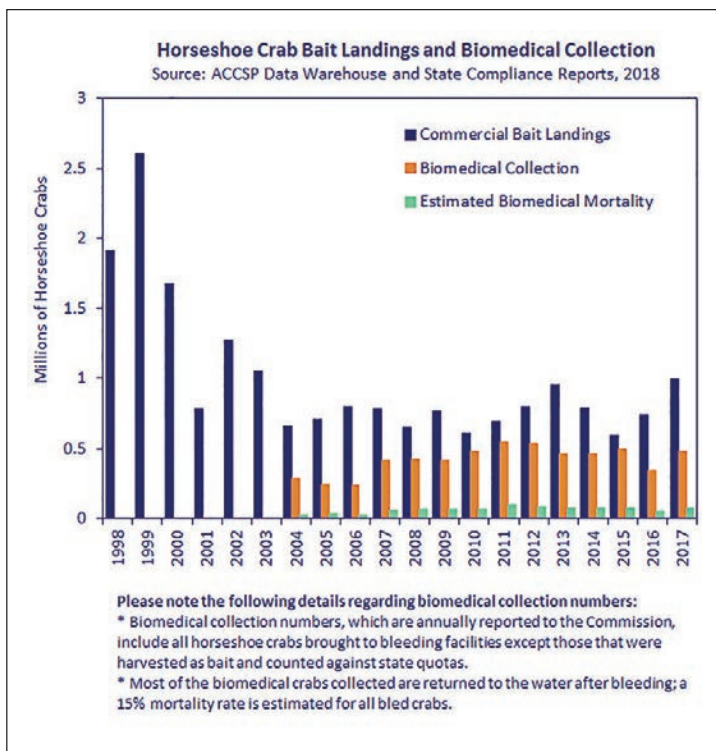
soon as possible. Any vaccine or injectable drug created in hopes of finding a cure or treatment will therefore be tested using the LAL product derived from the blood of horseshoe crabs, making this species crucial in our fight against this virus. The horseshoe crab has survived for more than 450 million years, and it’s truly incredible to think how a prehistoric species can be used in modern medicine to help us. Yet we who benefit most from the horseshoe crab also represent a direct threat to its existence. Can a species that survived for millions of years through multiple extinction events survive what is now known as the Anthropocene era?

Crabs on the Brink

Of the four species of horseshoe crabs, the three Asian varieties have been just about fished to extinction. The biomedical industry there is likewise dangerously careless. Horseshoe crabs are not bled minimally and returned to their natural habitat, but fully drained of blood, killed, and then ground up for fertilizer, used in traditional medicines or, occasionally, eaten for dinner (Burgenson described the amount of meat found on horseshoe crabs as “spider meat” because there really isn’t much to eat when you take into account a horseshoe crab’s physiology). Until countries such as China, Vietnam, Thailand, Malaysia, Singapore, and Indonesia come to some agreement, the black market in horseshoe crabs will continue to kill off and endanger this vital species.

By contrast, the United States has the Atlantic States Marine Fisheries Commission — Burgenson is the chairman of its Horseshoe Crab Advisory Panel — which regulates horseshoe crab fisheries by strictly enforcing quotas in the bait industry. If a fishery exceeds the quota it runs the risk of losing its license. Unlike the biomedical industry’s treatment of horseshoe crabs, mortality in the bait industry is 100% because the crabs are chopped up as bait to catch eels, conchs, and whelks.

The difference between how the two industries utilize horseshoe crabs is that the biomedical industry collects horseshoe crabs, whereas the bait industry harvests them. “When you harvest something, you kill it. We don’t kill. We take the blood and then we put it (the horseshoe crab) back,” Burgenson says. “Have you ever seen those big paper cutters that they used to have in schools?” I thought back to art class in high school where the teacher used one to cut stacks of paper and poster boards. “Well (bait fishermen) have those on their boat and then they put a horseshoe crab in this big paper cutter, and they cut it in half and cut it in quarters, and then they put it in their traps and let it go. A lot of times the horseshoe crabs are already dead ... sometimes they’re not.” A species whose



Credit: *asmfc.org*

blood is crucial in the testing of vaccine safety lives in a world where they are chopped up in quarters and thrown into the ocean to be used as bait.

The bait industry affects populations of horseshoe crabs, but so do other fisheries through bycatch. Thousands of horseshoe crabs are unintentionally caught up in nets designed for flounder and other marine staples. Too often commercial nets come up full of horseshoe crabs, half of which are destined to perish. The third major threat to horseshoe crabs, Burgenson says, is loss of habitat. Have you ever wondered what the newly arrived piles of rocks along your favorite beaches are for? Rock walls serve as erosion control in an age of rising seas, but in doing so cause devastating harm to horseshoe crab populations. When crabs come to the shore to spawn, they get stuck and die trying to climb over the rocks. An example of this is seen in Delaware Bay on Slaughter Beach where the

entire shoreline is lined with rocks to prevent beach erosion. If you visit this beach during their spawning season, you will find tens of thousands of stranded, dead horseshoe crabs.

The future for a species that's been around for more than 450 million years may seem bleak, but there is hope. Bad fishing practices are not without consequences. Southern states, such as South Carolina, have eliminated the bait industry by making it illegal to fish for horseshoe crabs with the intention of using them as bait. The only purpose of catching horseshoe crabs in these locations is to use them for the production of LAL, and because of this horseshoe crab populations are increasing along the southern East Coast. Populations of horseshoe crabs near Cape Hatteras and further south are actually doing quite well due to the elimination of this species by the bait industry. Likewise in Mid-Atlantic states, populations



Dead horseshoe crabs along Slaughter Beach in Delaware Bay.
Credit: Jessica Quinn



Credit: Amanda Sherman

of horseshoe crabs are stabilizing thanks to regulations put in place to reduce quotas. However, it's the New York Bight area — from the Delaware Bay to Montauk Point, Long Island — where the populations of horseshoe crabs are decreasing at an alarming rate due to illegal poaching.

Some eel and conch fisheries have also tried to work their way around the new protective regulations. A few years ago these fisheries began importing horseshoe crabs from Asia. In doing so they introduced an invasive species that posed a biological threat to native horseshoe crabs through exposure to foreign diseases. It wasn't long, however, before horseshoe crab advocates such as Burgenson stepped in and made it illegal to bring Asian crabs to the United States. Thanks to their actions this threat to *Limulus polyphemus* has subsided, but it goes to show how determined the bait industry is.

Nearing the end of our interview, I asked Burgenson what he would say if he could tell people just one thing about horseshoe crabs: "The one thing people have to know is that the horseshoe crab has touched everyone's life no matter where you live. They are responsible for maintaining human health around the world." His message to people in Asia: "Stop killing them."

The fact that a species — a species so resilient that it's survived major extinction events and has been around for more than 450 million years — can be at risk of extinction due to human actions goes to show just how much our

global civilization impacts the natural world. If we're capable of posing so big a threat to one of the world's most resilient species, what does that mean for species out there who aren't as tough?

Ask yourself: Who will you be? Will you be an Allen Burgenson who helps save the horseshoe crab and its habitat, or will you be like his father's thoughtless friends wanting him to kill them? The next time you get a vaccine, for COVID-19 or anything else, remember you owe the safety of that vaccine to a 450-million-year-old creature with precious stores of blue blood.



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Sustainability and received a minor in Creative Writing and the Certificate in Environmental Writing.



Memoir

BURN ZONE

By Andy Sima

Life abounds on Earth, from the boiling acid pools of Yellowstone to the pressure-cooked fish of the deep-sea Mariana Trench. But in my experience, there's one type of place devoid of all life, one that humanity creates. Burn zones. Flowers still grow in Chernobyl. But in a burn zone, everything is gone. These zones are spreading as the planet heats up and humanity's influence spreads tendrils-like deeper into the wilderness.

In the summer of 2019, I worked in New Mexico at a Boy Scout camp, Philmont Scout Ranch, in a place called Hunting Lodge, nestled in the pines near a manmade reservoir and about halfway up a river valley. On one side was a steep rockface leading up to a ridge, and on the other were more water-hewn gaps in the mountains. But just over the ridge behind my campsite was a burn zone: shell-shocked land left over from an out-of-control wildfire the previous summer. Years of fire suppression had built up a residual carpet of fallen wood and organic matter that fuels the worst sorts of blazes. An electrical box had shorted and sparks turned into flames that exploded into a raging wildfire. It lit up the night sky for a week across thousands of acres, almost all of it owned by Philmont. According to eyewitnesses, the fire was hot enough to cause trees 20 feet from the flames to spontaneously combust. It scorched a space right through the middle of my summer camp and left nothing behind. Even the dirt turned sterile.

We arrived at an eerie scene. Thousands of acres of land hung just north of us, out of sight behind the ridge. A corpse of earth, left behind by the fire, lay just on the other side of the cliff that had stopped the fire from reaching Hunting Lodge. The stone was too steep for the heat to consume its way across. That thin strip of projected rock marked a weird border: on one side stood a standard Southwestern alpine forest, tall trees and scrubby grasses; the other looked like death incarnate.

Officially, Philmont staff and campers were never allowed to go into the burn zone. Any trespassing by unauthorized persons over that very clear line was grounds for expulsion. There were good reasons for this. Once the plant roots have been burned, the soil is loose, and every hill is only a rainstorm away from sliding away. Without

tree cover, the sun beats down like an anvil and heat stroke becomes an ever more serious risk. The burned, blackened husks of trees can fall at the slightest wind, as their supports are no more than char. And stepping on the fragile ground diminishes the already slow process of natural remediation.

This is what the western American wilderness will increasingly come to resemble after 2020, a year of pandemic, racial reckonings, hurricanes, and out-of-control blazes. While I have not experienced all-consuming fire like that near Philmont firsthand, the aftermath was more than enough to make me stop in horror at the spectacle of unforgiving destruction. If one fire in a relatively out-of-the-way area could do so much damage, who can fathom the destruction caused by hundreds of these fires year after year across the West?

At Philmont, my coworkers, now my friends, and I walked into the burn zone in defiance of the rules. We had to see what it was like, how dangerous it was. We hiked up over the ridge to see the specter that had haunted us all summer, and we stood on the cusp between life and death. The burn was a sandy beige and not much else. Gnarled stumps of trees, blackened to a crisp, dotted the landscape. Everything else had been blown away in the wind.

And it was the wind that I remember hearing most clearly. On our hike up to the ridge, we had been greeted by the odd bird call from the brush and an incessant thrum of insects, but on reaching the burn, it all stopped. Not a single whistle. Just the wind, sighing ghost-like through the dead trees. Behind us, in the transition between trees and burn, the underlying drone was of the hardier bugs that could survive between worlds. But the burn zone had an empty, melancholy feeling. I'd never heard the wind so clearly.

We walked a little bit farther into the burn, testing our luck. The once much-traveled path was now indistinguishable from the miles of rocky emptiness between us and the horizon. The edges of the trail crumbled away beneath our feet, falling down the gentle slope into the valley below. The larger rocks thumped against the tree husks as they fell. Everything was dead. It was easy to imagine that it went on forever, that just over the next hill was more burned forest, that my friends and I had stepped back in time 2 billion years, before there was anything but rock and fire.

But a more apt analogy might be that I had stepped forward in time, if current trends continue. Millions of acres burned, burning, and destined to burn. Fire is natural, yes, and part of the reason things are so bad is because for generations the consensus among forest managers had been to suppress fire. But it's more than that. It's our planet's rising heat; incessant, unending, increasing heat. Maybe climate change will cause other places to become colder or wetter, but out west, it is going to get much hotter. We've been smoking in a house without windows for 300 years.

My friends and I sat for an hour or so on that New Mexican ridge, talking of what our workload might look like for the next day, discussing our performance review,

wondering when the next shipment of chocolate chip cookies would arrive. And we came up with new answers for when our campers asked about the burn. Usually, we guided them to the nearby forestry program that explained all about fire suppression and the difference between natural disturbance and unnatural extremes. As we talked, the energy of the sun blanketed us. Then the sun dipped behind the stone walls and we were in the cool shadow of the ridge. The burned valley below lay exposed to the wind and the dark.

We left, eventually. I felt much safer among the green pines, the bark that smelled like butterscotch and vanilla, and the birds that sang as they flitted between the branches. It was a peaceful, lively world on the other side of the ridge compared to that desolate loneliness just above us. And being back in the trees made it easy to practice a type of willful ignorance. To just pretend the burn wasn't there.

More than a year later, in September 2020, I was lucky enough to participate in a prescribed burn for a prairie plot in central Illinois. A friend of mine invited me along, and I was grateful for a different perspective on fire. Here fire was not a tool of destruction but of life, carefully managed to raze just the necessary zone and breathe new vigor into crowded grasses. But even in the context



From May 31 to June 19, 2019, the Ute Park Fire consumed 36,740 acres and burned 12 structures at Philmont Scout Ranch, N.M. Pictured: the wildfire as seen from the air.

Credit: U.S. Forest Service via Wikimedia Commons

The Earth mends on a scale of generations. Pictured: the Philmont Scout Ranch burn zone. Credit: Andy Sima





Pinyon pines make for magnificent high-altitude vistas, but can act as fuel when conditions become too dry. Pictured: Mexican pinyon evergreen bough.
Credit: Jasminka Kovačević via Pixabay

Fire is nature's refiner — but has humanity unleashed a force that can't be controlled? Pictured: the Philmont Scout Ranch burn zone. *Credit: Andy Sima*

“ **In a burn zone, nothing lives. The surrounding wilderness slowly creeps back into place, skin covering the wound, but healing takes years, even decades. The earth mends on a scale of generations, and the scar endures longer than humanity can even know.** ”

of fire as a useful, cleansing entity, its power was nearly unbearable.

I was given the opportunity to haul one of the water backpacks to keep the backburn under wraps. My responsibility was to stand by the edge of the flames and make sure nothing jumped the boundary. The flames were just a few inches high at a time, crawling along a dried-out, mowed-over road, but they were blindingly hot. I was sweating under my fire-retardant leggings and crying from the ash in my eyes. The smoke caused me to sneeze so many times my cloth virus mask became soggy. It was awful, and that was just the beginning of the burn.

I've heard of prairie flames reaching 30 feet in height, flying across grasses faster than you can run away. But as forceful as these Midwestern flames can be, what happens out to the west is much more intense. Entire trees ablaze, crowns of needles lit up to infinity, waves of heat intense enough to melt plastic and explode brick. The American West's burns are uncontrolled, chaotic, and destructive, the antonym to my controlled burn on the prairie. We're pumping the bellows of climate change ever stronger on these new flames. We're making more burn zones.

In a burn zone, nothing lives. The surrounding wilderness slowly creeps back into place, skin covering the wound, but healing takes years, even decades. The earth mends on a scale of generations, and the scar endures longer than humanity can even know.

At both Philmont and the Illinois prairie, I was grateful that I could leave the burn and go back to the regular world. But I wondered at the random chance of it. It was an accident of geology that had saved my small camp, and it was practical ecology that limited the spread of the prairie fire. I didn't realize it at the time, but Philmont's burn zone had scared me. A burn zone is no natural feature; it is devoid of life and growth, an alien space. Maybe prescribed burns are an antidote to that, a way to clear away the ground cover and channel our human need for control into something that won't blow up in our faces. But our grasp on such things is loose at best. Even prescribed fires are an exercise in limited control; managing fuel and planning for windspeed. Once a critical mass is reached, the fire itself is untouchable.

As the West Coast has gone up in smoke, it has become clear that, despite driving animals to extinction, despite converting the prairie and the tundra to agriculture, despite thinking that we are masters of this planet and everything on it, there are things we will never be able to control. There are things we are only able to try and guide. Do we pay attention to the warning signs? Take climate change as seriously as it needs to be taken? Or do we let it go and see what happens? Light a match and flick it into the grasses. Maybe it won't catch.

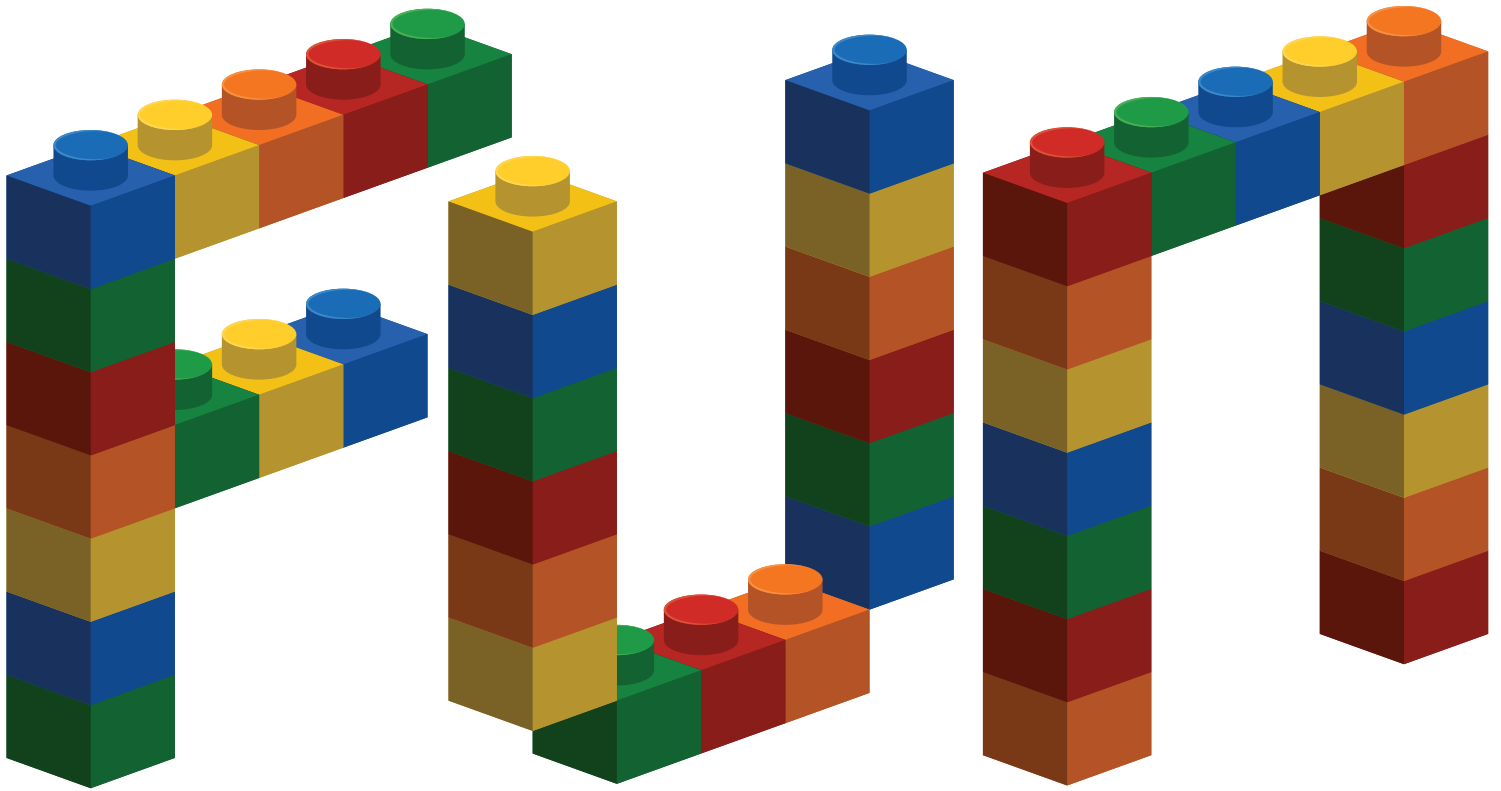
Perhaps that's our planet now. A lively space built atop a funeral pyre, waiting for any spark to ignite and devour it until nothing remains but the cold, ashy fingers of trees and shards of stone rising in the distance. Happenstance lights the spark, but humanity fuels the fire.



Andy Sima studies Environmental Sustainability and Creative Writing at Illinois, where he will graduate

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PLANT-BASED



By Brandon Hausser

I stared at the large, colorful box I held in my tiny, eager hands. I couldn't believe my eyes. My parents had given me "The Green Grocer," a massive LEGO project meant for someone seven years my senior, but I was determined to show the world that I could do it. It was just me and the thousands of beautifully colorful and incalculably craftable pieces against the world. I knew eventually one of the pieces would find its way to stab the most sensitive parts of my foot with one of its notoriously tough corners but, in that moment, I didn't care. I had a job that would last me endless fun-filled hours. Tearing through the crinkly, clear plastic packaging, I organized the pieces by color and size and crafted a mini, three-story building for my mini-people to call home — a journey in make-believe engineering I would repeat with a gift that kept on giving for more than a decade.

Now, however, I look back on that cherished childhood memory through the lens of a concerned environmentalist. I, like millions of people in the world, love the boundless creativity and fun that LEGO brings. But the packaging and plastic bricks themselves, precisely because of their material indestructibility, threaten long-term effects for the children of future generations. After decades with little concern for the environmental harms of their wildly popular product, will LEGO's recent promises of sustainability and corporate change be sincere enough to preserve my untainted memory of the beloved building blocks of my youth?

My concerns about LEGO are rooted in the company's use of petroleum-based plastics in the majority of their products and packaging. Nearly a tenth of the world's annual oil consumption can be traced to the plastics industry, of which the vast majority never gets recycled and repurposed. This demand is projected to more than double by the middle of the century. Today, we personally consume a credit card's worth of microplastic each week, while plastic chokes the oceans at the rate of one dump truck per minute.

Fortunately for LEGO lovers, the company has recently joined a cultural shift to contain the increasing hazards of our fossil fuel-based society. A wide-ranging transformation in values for a company as old and well-established as LEGO is quite remarkable. While the modern-day LEGO brick has existed since 1958, the company actually



The author's own LEGO 'Green Grocer' set represents cherished childhood memories and carries the hope of a sustainable future for children's toys.

Credit: Brandon Hausser

has roots predating the Great Depression. In the early decades of LEGO, the toys were made out of wood, but after multiple factory fires and resource scarcity following World War II, the company adopted the new and easy-to-mold acrylonitrile butadiene styrene — ABS for short — as its primary material for toys. Following the post-war switch to plastic, the company's financial and cultural success accelerated across the globe. By the 1980s, LEGO was a worldwide phenomenon; the company soon became one of the world's top 10 toy manufacturers. Now a brand with generations of recognition and an impressive presence in popular culture — including not only the toys themselves, but also movie and video game franchises, amusement parks, and apparel — LEGO continues to look toward the future of not just the company, but the planet.

In LEGO's latest Responsibility Report, the company outlines its vision for a sustainable future and its own role in it. The report emphasizes a well-rounded approach to becoming less dependent on environmentally intensive processes, from packaging, to the manufacturing of LEGO's famous bricks, to resource management and disposal.

As a company, LEGO has created its own environmental goals and seems sincerely motivated to meet them. In 2015, the family-owned holding group of LEGO, KIRKBI, bought a third of a wind farm in the North Sea that helps to balance its energy use for its offices and manufacturing plants. Its vision by 2030 is to implement environmentally friendly packaging in all of its products, lessen the resources it takes as a company to produce goods, and invest in renewable energies.

Yet the centerpiece of this transition is the iconic LEGO brick itself. While the company uses 20 kinds of plastic to fit the proper function of different types of bricks, ABS has been the main ingredient in the vast majority of LEGO pieces for almost 60 years. The unique chemical disposition of ABS is what makes it so attractive to LEGO. Once heated to at least 230°, the hard plastic pellet that originally arrives at the factory becomes a moldable liquid and susceptible to coloring by dyes. Due to its ability to retain its exact form forever once cooled, flexible strength, and capability to be remelted and recycled into the molds, it is the perfect chemical candidate for an indestructible child's toy. Any witness to a kid's playdate with LEGOs can attest that an unbreakable piece of plastic is an absolute must to withstand the creative, if sometimes clumsy and chaotic, forces of childhood imagination.

Unfortunately, though, the ingredients that give ABS plastic its name — acrylonitrile, butadiene, and styrene — are all fossil-fuel derived oils. While the company publicly claims its commitment to "finding sustainable materials to make our products," a complete shift away from ABS is a lofty challenge, especially when 80 percent of its product is made from the compound. Any possible alternative would have to meet the company's unwavering dedication

to rigorous quality and durability standards, leaving us to question: Can LEGO actually make the jump?

A breakthrough in one of the other 19 plastics used in LEGO production has made recent headlines. A total of 80 new LEGO pieces are now being produced using a different, more sustainable source. The new plant-based pieces are sourced from Brazilian sugarcane in partnership with the World Wildlife Fund (WWF). A first-time LEGO user would quickly perceive that the feel of the classic brick is different from that of a plant-based piece. A LEGO brick made of ABS feels rock solid, appears shiny and smooth, and is completely inflexible, while the polyethylene pieces from plants feel more textured, appear matte, and are much more bendable. The LEGO Responsibility Report prizes this transition to sustainable sourcing for 80 of its pieces in its “performance highlights” section, ensuring that the feel and quality of the sustainable pieces passes its rigorous standards for the “play value” of LEGO.

It is important to understand the negative externalities that this new approach to producing a bioplastic can create on the environment. Sugarcane requires large quantities of water. Growth in a sugarcane industry that is increasingly threatening the Amazon rainforest is — to say the least — an environmental alarm bell. Massive economic expansion fueled by the Brazilian government’s obliteration of environmental protections for one of the planet’s largest carbon sinks only exacerbates this crisis.

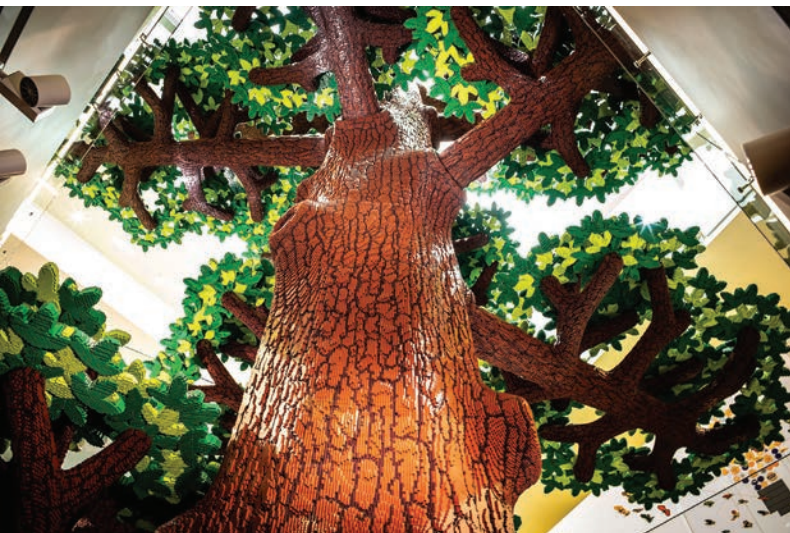
LEGO claims that its membership of the WWF’s Bio-

plastic Feedstock Alliance will ensure the protections for worker rights, community resilience, land and water stewardship, while making real a circular economy based on bioplastics. While these values are noble, a deeper look calls for a healthy dose of skepticism. According to BreakFreeFromPlastic, an environmental organization focused on eliminating plastic pollution, four of the 10 companies shown to be members of this alliance also land in the top 10 list of the world’s largest corporate plastic polluters. Additionally, several of those companies have directly contributed to environmental degradation like illegal deforestation and local water depletion in the past.

The decades-long efforts of corporations to greenwash their business practices — in an attempt to convince an environmentally conscious public that their motivation is not just for profit, but also for the environment’s health — are countless and all too familiar. The Keep America Beautiful campaign, most notable for the classic “Crying Indian” commercial, was an initiative backed by bottle companies such as Coca-Cola and the Dixie Cup Co. to shift the blame and responsibility for littering and its cleanup away from the companies producing single-use materials to the actions of individuals. In the 2015 Volkswagen emissions scandal, the car manufacturer rigged its diesel engine models’ emission control computers to display low, acceptable emission levels during testing — when in reality the cars emitted 40 times the acceptable rate set by the EPA. Just these few examples demonstrate that no matter how a company manufactures its goods,



Inside A LEGO factory in Monterey, Calif., 2011. Credit: LEGO



A four-story Lego tree at the Lego House in Billund, Denmark.
Credit: Carsten Snejbjerg for *The New York Times*

an outward show of environmental consciousness can be good for business, even if it is not good for the environment. This includes plastic toys like LEGO.

The Millennial and Gen Z generations now constitute the largest, most powerful consumer group in the United States, and corporations are beginning to prioritize the eco-consciousness that characterizes their consumer choices. According to data from Nielsen, a company that researches the preferences of consumers, the environmental consciousness of a company has never been more commercially important. Among millennials alone, 83 percent believe that it is imperative for a company to implement environmental programs. Three out of four say they would change consumption patterns to lessen their environmental impact. Because of this cultural shift in consumption from convenience to sustainability, it has never been more important to keep an eye out for dubious corporate claims.

LEGO and its publicized 2030 goals of sustainability shouldn't escape scrutiny and evaluation, especially at a time when a larger share of consumers is making the Earth's health a priority. Yet, it's not unreasonable to believe that LEGO is making an honest effort to better the company's use of natural resources and lower its environmental footprint. Although 15 billion of the bricks made each year are still formed with ABS, with no revolutionary bioplastic to replace it on the horizon, the steps LEGO has taken to transition to biopolyethylene are potentially significant.

LEGO claims it is aware of greenwashing's pitfalls. The company doesn't specify biodegradability as a goal since doing so would conflict with the durability their bricks are known for, especially when studies show that it could take 1,300 years to break down in the ocean. This type of transparency with regard to environmental initiatives is a path that more global companies should strive for, as opposed to the greenwashing deceptions many have practiced for much too long. LEGO's multifaceted approach to sustainability, which includes using renewable energy sources to power offices and manufacturing plants, the



LEGO's plant-based pieces differ from their traditional bricks in composition and style. Credit: LEGO

introduction of biodegradable packaging, and a near 100 percent recycling rate within the company, shows LEGO is at least making a commitment to today's children and those of the future, albeit within the framework of "green capitalism."

But in the bigger picture, LEGO's business model still depends on a model of infinite growth and exploitation of our planet's natural resources, perpetuating increased levels of both plastic waste and greenhouse gas emissions. No matter how carefully actions are taken to sidestep the inevitable environmental consequences, ultimate sustainability — setting a specific limit of resource extraction for the planet to healthily replenish itself each year — will be out of reach in the pursuit of ever-enlarging production and consumption.

It will take the critical attention of young consumers and their parents to determine if LEGO really means what it says. I hope environmentally concerned LEGO aficionados like me keep pressure on the company to stick to the promises it made to us and to the planet. I want a future where my own 8-year-old can eagerly tear through paper packaging to build their own beautiful, plant-based monument to creativity and joy. I'll happily tread on the corner of a brick buried in the carpet and smile through the pain, if I can be sure the toy I've loved since my childhood is no longer so painful to the planet.



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Urban and Regional Planning. He hopes to work in environmental preservation and conservation.



“Gnocchi al pesto for the table, per favore.” My three roommates and I sit under a yellow umbrella at Ristorante Bar La Torre, a touristy spot along Italy’s Vernazza Beach. Our table overlooks the sparkling Ligurian Sea. Belonging to a cluster of five towns along the Italian Riviera, Vernazza is also known as Cinque Terre: the birthplace of pesto. The hot Mediterranean sun tingles on my bare arms as I watch waves crash against the rocks. The charming Italian waiter smiles as he pours four glasses of pinot and sets a vibrant green dish of pasta in the middle of the table. Never have I ever tasted anything so fresh! I can taste the earth in the pesto, in the best way. Sitting along the coast, eating authentic cuisine and sipping a glass of crisp white wine, I’ve never felt so lucky. I savor every bite, sip, and spray of saltwater. I could sit here all day — and we just might!

Clearly, they don’t call it “slow food” for nothing.

ROMAN HOLIDAY



The fresh lunch plate at Il Casale di Marignano.
Credit: Nicole Pinsky

Even after studying in Italy for three months, I was still pleasantly surprised by every dish I ordered. Why? The food itself is only the beginning. It's all about the culture behind the food — the generations of practice and perfection behind every dish, drink, and dessert. The Italian people treasure every meal ...

Italy is one of 160 countries that are part of the international slow food movement. Slow food became a hot topic in the 1990s to promote human health and combat environmental degradation. It aims, moreover, to "prevent the disappearance of local food cultures and traditions, counteract the rise of fast life and combat people's dwindling interest in the food they eat, where it comes from and how our food choices affect the world around us." Throughout my semester in Rome, slow food was a phenomenon my friends and I relished daily. But on my return home, the stark contrast hit me between Italian eating culture and the United States, where food is anything but slow.

The United States is not part of the slow food movement. As Americans, we are always looking toward the next thing. In a country reliant on efficiency and multi-tasking,

food often becomes an afterthought. Italians simply cannot fathom such ideas as scarfing down McDonald's in the car between meetings or skipping breakfast because there just isn't enough time. However, as we all know, from the first day McDonald's opened in the U.S., it has built an enormous, loyal market. The number of franchises climbed to 1,000 in the first decade. For all the countries where McDonald's has spread, the company still makes the majority of its revenue from the United States. Our reliance on fast food, most obviously symbolized by the famous "golden arches," has negative health impacts that are felt nationwide. For example, 37% of adults and 17% of children in the U.S. are considered obese. American eating habits are making an impact on the country's overall health, with diet-related heart disease, stroke, and diabetes ranking as our top health concerns.

With numbers like these, we could take a few pages from Italy's cookbook. In recent years, more Americans are starting to realize the importance of healthy and sustainable dining. The number of U.S. farmers markets increased by 300% between 1994 and 2008, and farm-to-table restaurants are emerging across the country. As



“going green” becomes a much-needed trend, restaurant owners and chefs are looking to countries like Italy for slow food and sustainability inspiration.

Slow Food 101

During my four months in Rome, I learned quickly why Italians hold daily meals so dear to their hearts. I was able to witness firsthand the traditional farm-to-table process. I had the pleasure of visiting many people in the food industry to hear their testimonials about why slow food is essential to quality of life.

One day, we were dropped off on the side of a dirt road and told to follow the signs for “Il Casale di Martignano.” The air was clean and crisp an hour outside of Rome. It was so quiet and peaceful, surrounded by vineyards and rolling green hills. I made my way down a winding path toward an agritourism farmhouse (*agriturismo vicino*). According to the business’s webpage, “The philosophy that distinguishes the farm is linked to sustainability and respect for nature.” The estate doubles as a farm and a venue, hosting weddings, events, and educational classes using foods they grow right there on the farm. The kind-eyed owner guided us on a tour with what little English she knew. Our language barrier did not detract from the obvious pride she had for her business. We fed the pigs and cows as we walked through the grounds to the top of a hill overlooking acres of crops. We made our way into the kitchen, where we learned how to make ricotta cheese — and tips on how to make a sustainable business flourish. We ate a lunch of Italian meats, cheeses, vegetables, and homemade wine. I was surprised by how different everything tasted when it is truly fresh and nutrient-rich, and felt envious of the luxury of enjoying a food culture like this every day.

My next stop was Tenuta Vannulo, a certified organic buffalo mozzarella farm. The husband-and-wife team talked us through their journey of becoming certified organic by the Environmental and Ethical Certification Institute (ICEA). The ICEA certificate means they promote the development of organic farming and “work with respect for people and the environment, protecting the dignity of workers and the rights of consumers.” The buffalo at Tenuta Vannulo are treated in the most humane way possible, living long and healthy lives. The farm produces mozzarella, milk, yogurt, and gelato that is distributed locally and sold at the farm. Locals arrive at dawn every morning to buy fresh products for their restaurants and homes. I asked the owners why they decided to open a buffalo farm. They smiled and explained that they wanted to create a place for these buffalo to live happily while supplying the community with good, clean food products.

Each stop on my slow food Italian tour was better than

the last. These businesses make their living promoting slow food’s two most important goals: tradition and sustainability. In their own ways, they all do their part to reduce emissions and maintain traditions. Almost every restaurant I went to was family-owned and offered deliciously limited menus consisting of only local and fresh ingredients. People spent hours eating meals together and enjoying every minute.

Even outside the focus on farm-to-table dining, I quickly learned that the Italian restaurant culture was very different from the United States. For example, Italians do not believe in to-go boxes, and it was considered rude to leave food on your plate. This means you stay at the restaurant until you finish everything, no matter how long it takes — giving “slow food” a new meaning! Servers would never ask if you are ready for the check, and families and friends sit at the table for hours, talking, laughing, and enjoying each other’s company (and, of course, the food). Some say the slow food movement is a big part of Italian culture, but I would say it was their culture long before it became a movement. Their main goal has been and always will be to ensure that everyone has access to tasty, sustainable food imbued with love of family and tradition.

I remember thinking to myself, “I wish we had places like this back home.” So, when I returned to Chicago last summer, I embarked on a research project to find local restaurants that use farm-to-table to promote sustainability and the slow food movement. I was pleasantly surprised by what I found ...

From Italy to Illinois

Today, Chicago is filled with neighborhood restaurants that do their part to buy locally. These neighborhoods are usually up-to-date with the recent trends, including environmentally conscious dining.

First stop: Publican Quality Bread in Chicago’s Fulton Market area. Fulton Market, located on the city’s West Side, is an up-and-coming neighborhood filled with unique restaurants and businesses, very different from the Roman neighborhoods I knew. However, many of these restaurants share values with traditional establishments in Rome. Publican Quality Bread and its sister restaurant, Publican Quality Meats, know the value of local farming to source ingredients.

I sat down with head baker Greg Wade to better understand his views on sustainability and farm-to-table dining. Early on in his career, Wade realized the importance of using local food — and having a strong relationship with local farmers. He came to this realization while working at Girl & the Goat under Chef Stephanie Izard, the first female winner of Bravo’s “Top Chef.” As head baker,

“ During my four months in Rome, I learned quickly why Italians hold daily meals so dear to their hearts. I was able to witness firsthand the traditional farm-to-table process. I had the pleasure of visiting many people in the food industry to hear their testimonials about why slow food is essential to quality of life. ”



The author and her fellow travelers learn to make ricotta cheese at Il Casale di Martignano. Credit: Nicole Pinsky



The view from the table at Ristorante Bar La Torre. Credit: Nicole Pinsky

“After exploring sustainable cuisine in my hometown, I was surprised to find so many examples of the slow food culture I had only associated with Italy! Restaurants like these are increasing awareness of the importance of the slow food movement and sustainable farming. Beyond Chicago, chefs throughout the country see the Italian way of slow food and farm-to-table as a cure for the American fast food mindset.”

Wade has developed an entire wholesale wing of Publican restaurants. His bakery specializes in “using ancient and whole grains farmed sustainably and locally.” Produce comes from a farm in central Illinois — Spence Farms — that practices sustainable agriculture by “using chemical-free or certified organic practices, pastured livestock, and non-GMO seed.” Wade connected with sustainable farmer Marty Spence while working at Girl & the Goat. When Wade moved to work at Publican, he brought Marty with him. Wade now receives deliveries from Spence every Wednesday with products for his bakery (and his own groceries as well!).

Wade is passionate about building up farmer support and using products derived from sustainable agriculture. So passionate, he founded the Artisan Grain Collaborative to create a community of chefs and farmers to work together to achieve sustainability goals like creating regenerative agricultural practices (“farming and grazing practices that ... reverse climate change by rebuilding soil organic matter

and restoring degraded soil biodiversity”) and improving the health of communities and local economies — goals very much in alignment with the slow food movement.

Publican Restaurants aren’t the only Chicago eateries participating in the farm-to-table phenomenon. Located in the West Loop, not too far from Fulton Market, is another trendy restaurant called Eden. The inside is decorated cleanly and simply, with greenery scattered throughout — a fitting décor choice to match the eatery’s eco-conscious values. As stated on the website, “Eden, located in the West Loop, is a contemporary restaurant focused on new American and fresh cuisine. With emphasis placed on clean cooking and sustainability, Eden sources the majority of its ingredients from an on-site greenhouse or local farms and purveyors.”

Homestead on the Roof is another “green” restaurant located in Chicago’s Ukrainian Village neighborhood. Homestead is a rooftop venue boasting 7,000 square



Samples of artisan creations at Publican Quality Bread in Chicago. Credit: publicanqualitybread.com

Credit: Shutterstock

feet of garden space. The owners describe their planting process on their website: “Our first planting begins in early April, typically with hearty greens and durable produce, and we plant three more times until early autumn. We write our menus based around our planting schedule allowing the chef’s complete freedom to let the season’s bounty dictate the direction they take their food.” Rooftop gardening certainly follows the goals of the slow food movement. It showcases the restaurateurs’ interest in the food they serve and their pride in serving fresh and nutritional ingredients.

After exploring sustainable cuisine in my hometown, I was surprised to find so many examples of the slow food culture I had only associated with Italy! Restaurants like these are increasing awareness of the importance of the slow food movement and sustainable farming. Beyond Chicago, chefs throughout the country see the Italian way of slow food and farm-to-table as a cure for the American fast food mindset. These chefs expose our unhealthy American food culture for all to see — but is it enough?

New Menu Options

The U.S. population is more than five times greater than Italy’s, with many different traditions and cultures. Is the Italian way of living realistic for the U.S.? According to the World Health Organization, Italy’s average life expectancy is five to 10 years higher than the United States, while its obesity rate is significantly lower (21% versus 33% in the U.S.). There is no question that we live unhealthier lives compared to the Italians, but it may not be completely our fault. Therootastes.com explains that “industrialization came with advances in agriculture and a shift in the demographic from rural to urban settings. Not only did the population boom, food had to travel farther than it used to, many times arriving past its peak of freshness.”

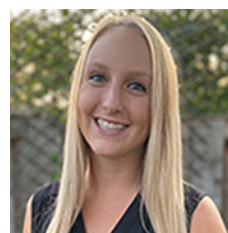
In other words, our food culture is based on how to generate the highest yields and ship it all over the country. When produce is out of season, we get it from other countries. We always look for the most efficient and convenient way of feeding our 327 million people (compared to Italy’s 60 million). This brings us face-to-face with the question of whether more people necessarily equals compromised health.

One challenge to building a more sustainable and healthy food culture in the United States is the widespread existence of so-called food deserts. Medical News Today defines food deserts as “... areas where people have limited access to a variety of healthful foods. This may be due to having a limited income or living far away from sources of healthful and affordable food.” According to a Tulane University infographic, 23.5 million Americans live in food deserts. In a country where millions of people lack access

to fresh foods and grocery stores, the farm-to-table style of eating might seem unreachable. With race and income greatly affecting one’s diet, how can everyone in the U.S. benefit from farm-to-table ingredients? Government initiatives like the Healthy Food Financing Initiative (HFFI) and Michelle Obama’s “Let’s Move!” campaign are helping solve this problem. Both “Let’s Move!” and HFFI share the goal of bringing healthier alternatives to underserved communities across the U.S. With the help of these initiatives and many nonprofits around the country, the U.S. is slowly working toward a healthier relationship with food.

There are many differences between American and Italian food culture. Italian food culture might be healthier and more environmentally friendly, but I believe that the U.S. can work its way up to those standards. As more farmers, chefs, and advocates make their mark on cities like Chicago, word is spreading of the importance of slow food. Wade’s goals for the future are to increase food production in a healthy way and promote regenerative soil with low fertilizer inputs. Ultimately, he’s looking for a radical change in how the United States views its agricultural production, system wide.

My hope for the future is to have the same experience in Chicago — or anywhere in the U.S. — as I had that golden afternoon in Cinque Terre. I want to be as food fulfilled as I was on the coast of the Italian Riviera, eating dishes so fresh I could taste the earth. These are reachable goals with progressive food programs and a holistic slow food philosophy. Also essential? Our support, as consumers, for farmers and chefs who are making a difference, making us healthier, and delighting our palettes.



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Sustainability with a minor in Public Relations and the Certificate in Environmental Writing. She recently began working in a human resources role for W.W. Grainger, an industrial supply company in Lake Forest, Ill., and hopes to move into the company’s sustainability division.



HERE COMES THE SUN

By Brooke Witkins

Science fiction movies have entertained us with plentiful far-fetched predictions about the future. While many of the more eccentric “futuristic” technologies have been left in the past, more realistic energy options have been introduced in recent films. First seen powering Tony Stark’s Iron Man suits, the Arc Reactor has become one of the most recognized energy sources of the modern sci-fi genre. Although it was originally created to save him from a heart injury, Tony continues to improve on the suit until he’s made something with the power to save the world. But what could sustain such a powerful device? Iron Man’s answer is nuclear fusion (not to be confused with nuclear fission, the foundation of our real-world nuclear energy industry).

Fusion is what creates the massive amounts of energy we see in the stars every night. It is literally a universal power source. Beyond Iron Man, we've watched the dream of fusion mature from a science fiction fantasy to a potential Earth-saving fuel source. Frustratingly, however, time after time fusion seems to fall short of its eternal promise.

But with recent exciting developments in Europe and elsewhere, could fusion's moment have finally arrived?

Everyday nuclear fission, in a working reactor, throws neutrons at incredibly high speeds toward a heavy atom such as uranium to break it into lighter atoms, releasing neutrons, lighter elements, and a tremendous amount of energy during the split. Currently, roughly 20% of the electricity in America is generated by these fission power plants. The energy created from traditional nuclear plants is massive and relatively clean as they don't produce CO₂ or airborne pollutants in the way of fossil fuel emissions. However, operating a fission reactor requires a delicate balance between keeping reactivity high enough to allow chain reactions to occur but low enough to prevent a meltdown. This balancing act means that design flaws or poor management can result in catastrophe. Examples of this flawed management are notorious — notably the Chernobyl disaster of 1986 and, more recently, the 2011 accident at Fukushima in Japan.

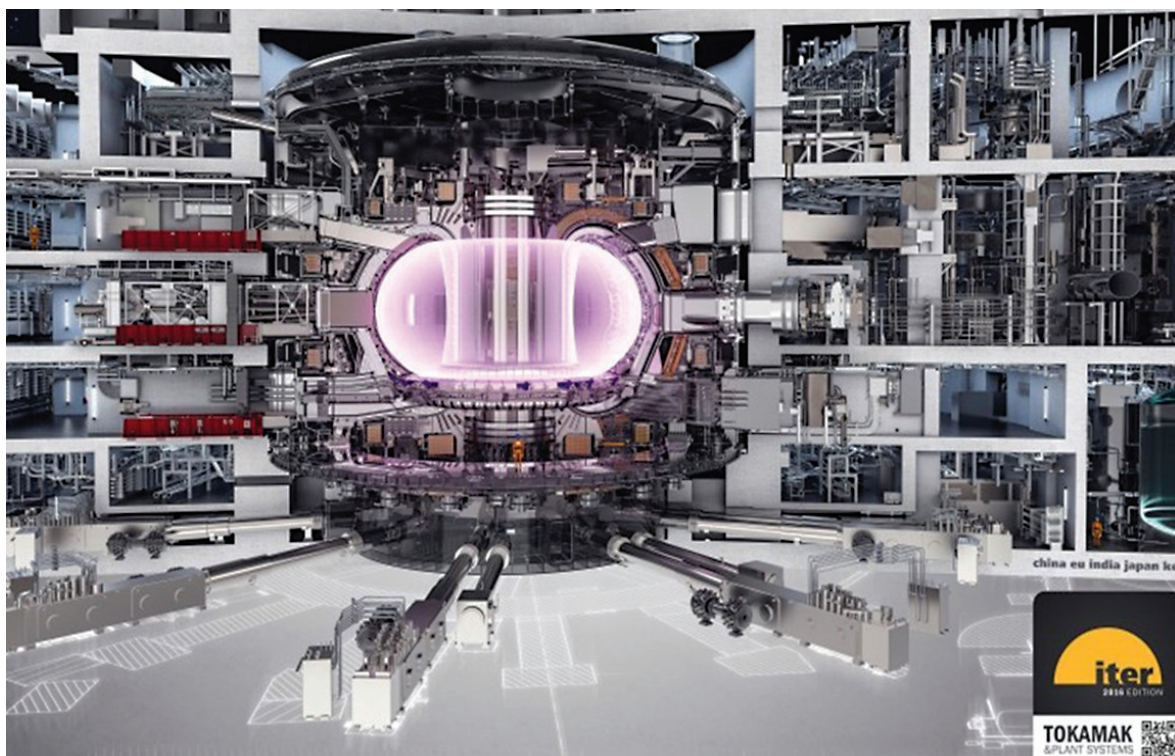
So, how does fusion compare to traditional fission power, and what are its advantages, particularly regarding safety? Fusion is the exact opposite of fission: Rather

than splitting the atoms, small hydrogen atoms are fused together. The reward? Per gram of fuel, fusion releases four times more energy than fission. The downside is how incredibly difficult this process is to achieve here on Earth. The hydrogen atoms naturally repel each other so, in order to get them to combine, temperatures need to be extreme. As atoms are heated, they move faster and faster until they inevitably collide. The speed of the crash is so intense it overcomes the natural repulsion between the atoms, causing them to fuse and form one helium atom and one energetic neutron per interaction.

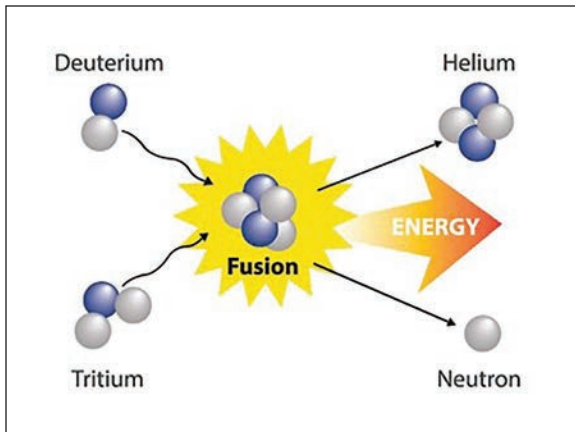
Fusion power has been notoriously difficult to realize, but the solution may be here at last, in the form of a 60-meter-tall high-tech machine located in the French countryside called the International Thermonuclear Experimental Reactor — or ITER for short. This massive fusion chamber is bringing the stars to France through the collaboration of 35 countries that design, build, and transport each massive industrial element of the ITER puzzle to the 180-hectare build-site.

"This arrangement was made in order to support each partner advancing fusion technology and manufacturing within their own nation," says Lynne Degitz, senior communications specialist for the United States branch of ITER at Oak Ridge National Laboratory.

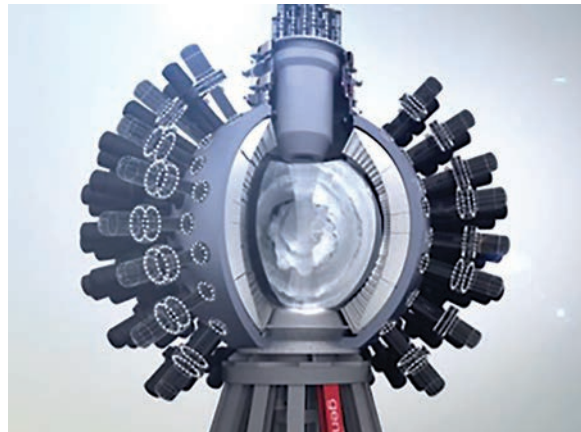
ITER's main goal is to create a self-heating plasma, which is considered a critical step in the development of fusion energy. This plasma would be heated from outside



A digital model of the International Thermonuclear Experimental Reactor facility. Credit: ITER.org



How nuclear fusion works. Credit: BBC



Artist's impression of a magnetized fusion reactor. Credit: General Fusion

“ Fusion is the exact opposite of fission: Rather than splitting the atoms, small hydrogen atoms are fused together. The reward? Per gram of fuel, fusion releases four times more energy than fission. ”

sources and house the hydrogen atoms that will fuse together and eventually stay heated from the continuous fusion interactions within the plasma. The success of this plasma will allow the fusion process to finally create a net-positive energy output. When operational, ITER is expected to be able to produce 500 megawatts for every 50 megawatts inputted.

If nuclear plants can melt like Chernobyl did, what about ITER? As difficult as it is to get a fusion reaction going, this also means that it's easy to stop a fusion reaction. Unlike fission, if something goes awry in a fusion reactor, the reaction will simply stop rather than spiral out of control and cause a meltdown.

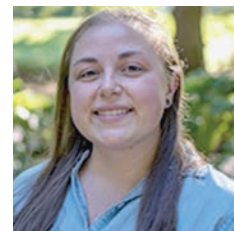
In even better news, it turns out ITER isn't the only organization working on finally harnessing fusion. Multiple small, private organizations around the globe are working on their own technologies, some using a completely different process than ITER. One company, General Fusion in Canada, is working on a nuclear fusion process called magnetized target fusion, in which hydrogen plasma is injected into a sphere of liquid metal and then compressed by several pistons at the same time. The pressure increases the temperature to fusion conditions, and the heat generated by the reactions is captured in the metal and turned into steam, which creates electricity.

Competition is there, of course, but fusion researchers still work together. "The success of any one team gener-

ally is a good thing for us all," says Michael Delage, Chief Technology Officer at General Fusion.

Fusion has always been an entertaining fantasy, as Iron Man exemplifies. But it might yet be the serious, real-world answer to the environmental issues that plague us from our addiction to carbon-spewing fossil fuels. Though ITER is an experimental facility, not a power plant, many smaller companies continue to research and build prototypes of different fusion devices that might one day soon be used across the globe. ITER spokeswoman Lynne Degitz puts it best:

"Fusion is hard — but it is also worth pursuing."



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as well as a certificate in GIS and the Certificate in Environmental Writing. Her future plans include relocating to Utah and working in restoration.

S U P E R C A R B O N

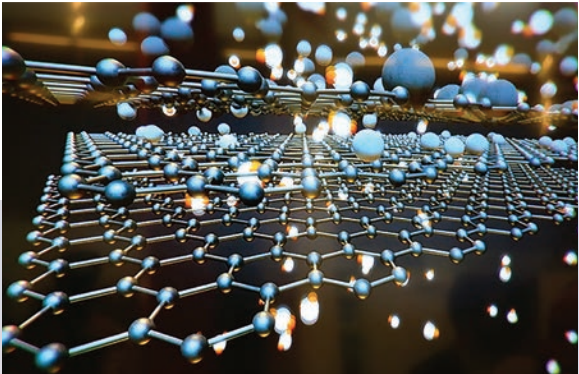
By Joshua Reed

Global society is being held hostage. Humanity continues to spew carbon into the atmosphere because we are told we have no other options. Since the industrial revolution, roughly 375 billion tons of carbon have been emitted into the atmosphere we breathe and sucked into the oceans. For those who worry that this carbon addiction will lead to catastrophe for our planet, be hopeful — a hero might just be on its way. While carbon in the form of CO_2 has long been cast as the villain of this story, there is another, “green” form of carbon that could yet save us all: *graphene*.

Credit: Shutterstock

When graphene was discovered in 2004 by Andre Geim and Kostya Novoselov, two professors at the University of Manchester, it was hailed as a wonder material with applications that could save the world. It's easy to see why: Although a sheet of graphene is only a single atom thick, it's proven to be 200 times stronger than steel and can carry 1,000 times more electricity than copper.

Admittedly, the early hype around graphene may have been a little premature, as there are still limitations on feasible implementation. At the time of its discovery, graphene had inconsistencies in its form between each sample, it wasn't cheap to produce, and scientists weren't sure how to best apply this new wonder technology. It's been a little over 15 years and, in that time, researchers have come a long way in working out the kinks in graphene and branching out to more inventive production methods and applications.



Graphene is super thin, modeled here at the molecular level. *Credit: Pixabay*

My investigations into graphene took me across the ocean, where an astonishingly elegant technique to produce this magical material has been developed. At Karlsruhe Institute of Technology in Germany, a team of researchers has discovered a method to use carbon capture to produce graphene. With the help of specially prepared, catalytically active metal surfaces, graphene can be formed by heating CO₂ and hydrogen gas to 1,000 degrees Celsius. This essentially allows us to cycle carbon out of the atmosphere and convert it into graphene parts for green technologies.

To understand more about the applications of graphene, I spent some time with SungWoo Nam, a nanoscale materials and devices researcher who is an Assistant Professor of Mechanical Science and Engineering at the University of Illinois Urbana-Champaign. When I asked him about the new material's uses, he told me "graphene is better than traditional additives. In tires for example, instead of using black carbon and rubber, mixing in graphene will get better performance out of the composite product." Everyday products that are traditional carbon composites can be improved hugely by replacing them with graphene,

Scientists continue to explore the properties and potential uses of graphene. *Credit: Shutterstock*





Graphene might just be the answer to toxic battery waste.

Credit: Shutterstock

ensuring a longer life — and meaning that smaller amount of carbon, if any at all, will be consumed.

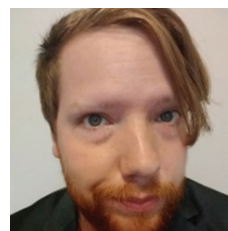
How else might graphene feature in our low-carbon future? One of the most well-known green energies is solar power. For all its hype, solar only accounts for 1.8% of all energy generated in the United States. As Karl Mathiesen of *The Guardian* writes, "... solar is held back by its 'capacity factor,' essentially how often it is producing electricity. A coal power station runs at 70-80% capacity. In northern Europe, solar panel capacity factor is just 15%." A solution to this "capacity factor" issue could be graphene, which has been proven to be a supercapacitor. If we were able to supplement traditional solar panels with graphene, or even completely manufacture them out of graphene, solar energy would become much more efficient, reducing the need to burn fossil fuels.

Like solar energy, the electric car was hailed as an innovation that would propel us into a carbon-free future. But as with many similar technologies, it is not without its shortcomings. The batteries used in these cars are dependent on materials like cobalt that are scarce, and too often extracted using exploited or slave labor. BBC reports that, "Apple, Google, Tesla, and Microsoft are among firms named in a lawsuit seeking damages over deaths and injuries of child miners in the Democratic Republic of Congo," where 60% of the world's cobalt is mined. For an alternative to the unethically sourced lithium and cobalt used in our electrovoltaic batteries, look no further than graphene, a promising replacement due to its great efficiency in conducting heat and electricity.

Graphene can now be cheaply and more easily produced in the lab, so why hasn't it yet lived up to expectations? One reason is funding. Currently, a large amount of research and development is done by universities, with their long turnaround and highly competitive funding streams. Nam explained just how complicated it is to get funding, but he also informed me that, "(They're) seeing

more interest from startups or the tech industry in trying to make graphene more marketable." With interest from the private sector, the implementation of graphene could arrive soon. This would weaken the stronghold that fossil fuels have had on us for the last century and counting.

Simply by living in an advanced industrial society like the United States, I was born effectively shoveling carbon into the fires that would ultimately burn that society down. So were my parents, and their parents. The Industrial Revolution began with the promise of "advancing" humanity, but doing so meant having to sacrifice the only home we know: Earth's climate, forests, and seas. With graphene's discovery, we now have the opportunity to use carbon in a different way. There may have been some roadblocks initially, but graphene is becoming much easier and cheaper to produce, and has potentially game-changing applications for a green energy economy. If our carbon future is graphene, we might finally breathe a deep sigh of relief — and this time, it will be clean.



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BLAME GAMES

For two nights in August 2020, rolling blackouts shut off electricity to hundreds of thousands of California residents against the backdrop of a dreaded pandemic, a blistering heatwave, and a horrendous forest fire season that devastated the state. Many were quick to pin the blame on renewable energy, making unfounded judgments about what took place, who was at fault, and prescriptions that fit their ideological interests. Rolling blackouts are unacceptable, but it is essential that technical analysis, not ideology, guide our understanding of what happened and, more importantly, solutions to prevent rolling blackouts in the future.

What Happened?

At 6:38 p.m. on Friday, Aug. 14, 2020, the California Independent Systems Operator (CAISO) — the operator for roughly 80 percent of the state’s electric grid — issued a Stage 3 Emergency and instructed Utility Distribution Companies to cut power to more than 400,000 customers for an hour to an hour-and-a-half by evening’s end. The next day, CAISO again ordered rolling blackouts, this time at 6:28 p.m., affecting roughly 200,000 customers and lasting for 30 minutes.

These rotating blackouts were controlled and notably different from outages caused by storms or, as California has become all too familiar with, intentional shutoffs to prevent forest fires. Rather, they were a preventative measure, employed by CAISO to lower power consumption on the grid and avoid cascading, uncontrolled outages across the western United States and Canada. On electric grids, supply must equal demand exactly. If supply trails demand, electric frequency on the grid drops and can cause widespread blackouts that take days to resolve. This worst-case scenario materialized in 2003 when 50 million people on the East Coast lost power in an outage caused by several damaged power lines in Ohio and amplified by subsequent human and software errors. Protocols established by the North American Electric Reliability Corporation (NERC) govern when rolling blackouts are required to maintain grid reliability.

A year ago, CAISO issued a report warning of generation capacity shortfalls for 2020 summer evening demand peaks. The report cited three concerns: the anticipated retirement of 4,000 megawatts (MWs) of power plants in California; reduced availability of imported electricity from neighboring states due to large coal-fired power plant closures; and diminished hydropower capacity due to drier conditions caused by climate change. More concerning than the demand peak is what is known as the “net demand” peak. Simply put, net demand is load minus solar and wind power output. High solar power penetration results in a large and temporally narrow peak in net demand known as the “duck curve,” after the sun goes down and before the wind picks up in the evening. CAISO has traditionally relied on expensive “peaker” plants — natural gas-fired power plants that quickly ramp up output during periods of high demand — and imports from neighboring states to address this net demand peak.

Prior to Aug. 14, CAISO anticipated supply issues. A sweltering once-in-a-generation heat wave prompted Californians to crank up their air conditioners, pumping up electricity demand. The state wasn’t equipped to handle it. According to a recent post-mortem report from energy regulators, California’s resource adequacy is only designed to withstand a 1-in-2-year peak demand with an additional 15 percent planning reserve margin. And

since the heat wave smothered the entire West, many neighboring states were unwilling to sell power to CAISO. Furthermore, as NERC anticipated in a June 2020 report, “below-normal hydro conditions” limited availability of hydropower imports, a major component of system reliability. On Wednesday, Aug. 12, in anticipation of the supply scarcity and demand surge, CAISO restricted scheduled power plant maintenance for that Friday. On Thursday, Aug. 13, CAISO issued an alert for insufficient resources for the next evening. In addition to the anticipated stresses on the grid, the 495 MW gas-fired Blythe Power Facility unexpectedly tripped offline due to “plant trouble” a few minutes before 3 p.m. that Friday, while an unknown 750 MW gas-fired power plant was also unexpectedly inactive that day. All of this, compounded by a lower-than-usual evening output of wind power, only made matters worse. As Steve Berberich, former CEO of CAISO, put it: “We have a perfect storm going on right here.”

The next day, Aug. 15, the net demand peak was lower than that for Aug. 14. However, shortly after 5 p.m., roughly 1,000 MW of wind power went offline, followed by a 248 MW loss of gas-fired power from the Panoche Energy Center — which, according to reporting from the *San Francisco Chronicle*, was the result of erroneous instructions from a PG&E grid operator. A short time later CAISO initiated rotating blackouts, based on the detailed timeline it released on Aug. 17.

After the back-to-back days of rotating blackouts, California had several close calls. Fortunately, a combination of energy conservation and power imports kept the lights on. Case in point: On Aug. 18, CAISO was again worried about inadequate supply, but its unprecedented energy conservation alerts yielded an astounding ~4,000 MW of demand reduction by consumers.

Wrong Diagnoses and Faulty Prescriptions

Almost immediately after California’s blackouts, political pundits, provocateurs, and others were quick to share hot takes and silver-bullet solutions. Only one day after the blackouts, the *Wall Street Journal* Editorial Board argued that “heavily subsidized green energy” was to blame, contrary to analysis showing that on a levelized cost of energy basis, unsubsidized solar and wind are cheaper than nuclear and fossil fuel power. Three days after the editorial, CAISO, the California Public Utilities Commission (CPUC), and the California Energy Commission wrote an open letter to Gov. Gavin Newsom, unequivocally stating that “renewable energy did not cause the rotating outages.” There is an unavoidable irony in proposing to stunt the transition to clean energy

“ The California Energy Commission wrote an open letter to Gov. Gavin Newsom, unequivocally stating that ‘renewable energy did not cause the rotating outages.’ There is an unavoidable irony in proposing to stunt the transition to clean energy as a result of power outages that were, among other things, due to high temperatures, a known consequence of climate change. ”

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Even a prominent former energy regulator argued, with seemingly no evidence, that the rotating outages were the result of the “sons of Enron,” a reference to the infamous California energy crisis of 2001 in which Enron Corp. manipulated California’s newly deregulated electricity markets, sending prices soaring. However, high prices alone are certainly not sufficient evidence of market manipulation. And if systematic and suspicious unscheduled outages attempting to increase prices did occur, CAISO would surely have been able to identify such manipulation.

To add to the confusion, reporting from *The New York Times* suggested that the short-term rolling blackouts on Aug. 15 were overly cautious and perhaps even unnecessary. Specifically, that CAISO’s operating reserves — surplus generation capacity — were sufficient to meet demand. However, it is important to note that CAISO must watch trends and, above all else, ensure the reliability of the macro electric grid. Furthermore, as of December the Federal Energy Regulatory Commission had decided against launching an independent probe of CAISO’s handling of the rolling blackouts, opting for a more collaborative role and organizing a technical conference.

So, how can California avoid crippling blackouts in the future?

Power lines in California.

Credit: jonasschloegljs via Pixabay



Solutions and Outlook

In a webinar hosted by the University of California Berkeley's Energy Institute shortly after the rolling blackouts, Professor Severin Borenstein, who also serves on CAISO's Board of Governors, remarked that "we've actually gotten off pretty easy so far," and future outages could be worse. He went on to highlight that California's grid is classified as a 1-in-10 system, meaning that rotating outages should occur no more than once in a 10-year period. Sure enough, it was almost 20 years since California last had rotating outages, for 38 days, during the state's 2001 energy crisis.

Certainly, a shortfall of power supply is highly problematic and especially so during a heat wave and global pandemic. Power plant failures and errors were simply the straw that broke the camel's back in the lead-up to California's rotating 2020 outages. More crucial are broader systemic issues that allowed for such a situation to occur at all. These four strategies, including market and hardware solutions, could address systemic issues in California's electricity system.

Expand regional wholesale electricity markets — Unlike regional ISOs, CAISO operates largely within California. Generally, CAISO is able to purchase surplus hydropower or thermal generation from neighboring states. However, in high regional demand scenarios, these states cannot dependably export power to California because they need to ensure reliability. A regional ISO could more effectively meet demand across state lines. Currently, CAISO's Energy Imbalance Market (EIM), a real-time Western electricity market, has demonstrated the potential benefits of regional wholesale electricity markets and should be expanded.

Increase long-term contracts — After the 2001 California energy crisis, state regulators instructed utilities to procure a greater proportion of electricity via long-term contracts as opposed to the wholesale market. Executives of these entities will be quick to point out that prior to the crisis, they were required to rely on the state's deregulated electricity market to source much of their load. Nevertheless, long-term contracts can help hedge against unexpected shortfalls in capacity.

Improve demand response capacity regulations — The most immediate solution to California's capacity shortfall is to improve its demand response regulatory policies. For example, California could employ variable electricity rates, encouraging consumers to reduce consumption during peaks in net demand. Furthermore, companies such as OhmConnect, which can reduce demand from an astounding 150,000 homeowners by marginally lowering consumption from thermostats, can bid this demand reduction into wholesale markets and help reduce load during net demand peaks. However, the CPUC calculates

the capacity of such offerings via a black-box approach that lacks transparency. And it evaluates aggregated capacity of demand response assets on an annual basis as opposed to a rolling one — so if a California resident signs up for a firm's demand response program, their capacity cannot be bid into the state's electricity market until the following year. Moreover, the CPUC calculates load reduction from demand response relative to average loads instead of in real-time, which discounts load reduction during the days like Aug. 14 and 15 when they are most needed. These arcane regulations can be easily amended and immediately help CAISO manage future net demand peaks.

Add more capacity resources to meet evening net demand peaks — Energy storage is an obvious choice. Battery storage costs continue to fall, and adding capacity is increasingly favored over natural gas peaker plants to address evening demand peaks. California is on the right track in this regard and has mandated that investor-owned utilities deploy 1,325 MW of energy storage by 2024. However, until these storage resources come online, California should be cautious about future thermal power plant closures. Over the past three years, 5,000 MW of gas-fired power plants were shuttered while only 2,200 MW of dispatchable (not intermittent) generation resources were added. Furthermore, 3,000 MW of anticipated battery storage is not yet operational. Still, low-cost solar and wind power should and will continue to be mainstays in California's energy plans. Gov. Newsom rightly doubled down on renewable energy last summer, declaring that the heat waves, fires, and power outages "highlighted the urgent need to quickly transition to a renewable energy system."

While observers look to score points and make questionable judgments about the causes and implications of the 2019 power outages, California should stay focused on the bigger picture. Quickly and swiftly decarbonizing the power sector is a major priority. It requires intelligent resource adequacy planning, a supporting cast of demand reduction tools, and better market mechanisms for CAISO to maintain grid reliability in the future.



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Memoir

By Maria Maring

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Credit: Shutterstock

After the passing of legendary folk singer/songwriter John Prine in April 2020, I found myself revisiting his songs in memoriam. Prine's music was the soundtrack of my childhood. My entire family are musicians, and they played Prine classics like "Long Monday" and "Angel from Montgomery" at every family gathering. Now, as a young adult and aspiring environmentalist, I've discovered new meaning in his lyrics: profound ecological consciousness.

"Paradise," from his 1971 self-titled debut album, particularly caught my attention. In the song, Prine expresses a deep longing to revisit a fond place from his youth — Muhlenburg County, Kentucky — only to be informed that the whole town has been demolished for mining operations.

... Then the coal company came with the world's largest shovel,

And they tortured the timber and stripped all the land.

Well, they dug for the coal 'til the land was forsaken.

Then they wrote it all down as the progress of man.

*"And daddy, won't you take me back to Muhlenburg County,
Down by the Green River where Paradise lay?"*

"Well, I'm sorry my son, but you're too late in asking:

Mr. Peabody's coal train has hauled it away."

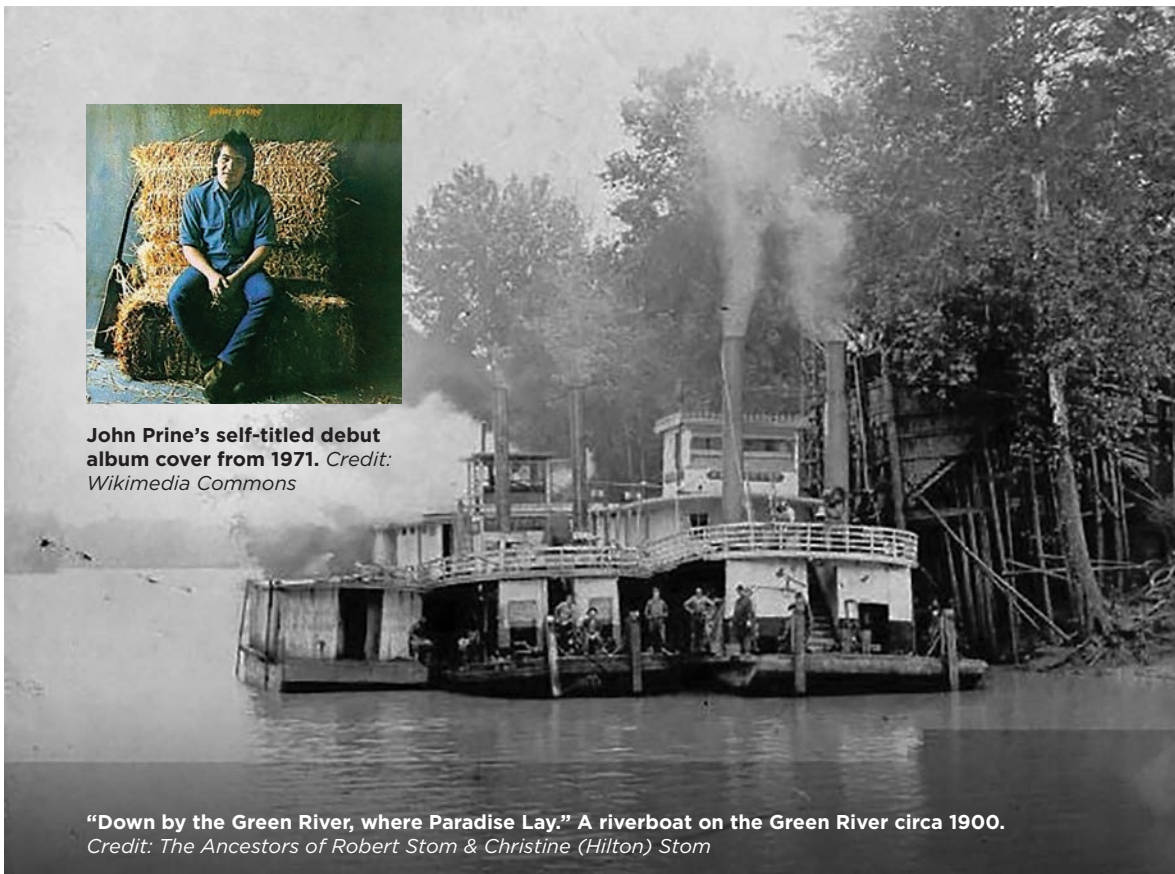
This 1971 song describes what would be coined in 2003 as solastalgia. A combination of the words "solace" and "nostalgia," solastalgia is the distress one feels at environmental degradation of one's home place. Although the term has existed for less than two decades, the feeling of solastalgia has been around for much longer, and its tendrils have quietly crept around the globe. Too often, climate change is regarded strictly as an ecological, economic, or human rights issue; we have been slow to acknowledge that it also has emotional implications. The effects of climate change are hitting closer and closer to home. While many of us have come to expect the ecological consequences of climate change, very few of us have begun to acknowledge, much less openly discuss, its impact on mental health and emotional well-being.

Over the years, Prine's lyrics have taught us that emotions are beautiful and necessary, even in the realm of environmentalism. To move forward as a climate activist, I must first feel the emotional toll of the drastic changes happening to our homelands.

Prine was writing about very real experiences in "Paradise." The song refers not necessarily to an imaginary paradise-like place, but to an actual small town in Muhlenburg County that sat on the banks of the Green River. And the Peabody Coal Co., now known as Peabody Energy, really did conduct mass strip mining operations in



John Prine's self-titled debut album cover from 1971. Credit: Wikimedia Commons



"Down by the Green River, where Paradise Lay." A riverboat on the Green River circa 1900. Credit: The Ancestors of Robert Stom & Christine (Hilton) Stom



“Paradise and the Highway Thereto.” Credit: *The Ancestors of Robert Stom & Christine (Hilton) Stom*

Paradise, as well as across Kentucky and other Midwestern states. Furthermore, “the world’s largest shovel” was no metaphor; it referenced the Bucyrus Erie 3850-B Power Shovel, which lumbered into Paradise in 1962.

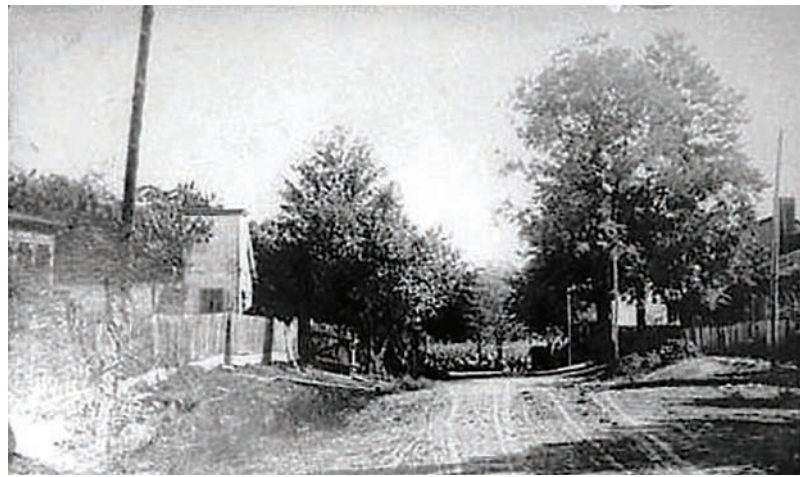
When the song debuted in 1971, Prine’s lyrics immediately caused outrage at Peabody, and the controversy persists today. In 1973, the company published a fiery rebuttal to the song, titled “Facts vs. Prine.” And during a lawsuit 40 years later involving the wrongful arrest of environmental demonstrators, Peabody requested that Prine’s lyrics finally be struck down for tarnishing its name. That request was denied.

Today, Paradise no longer exists. Strip mining polluted the land, water, and air, leading to outbreaks of cancer and heart disease. The town was abandoned in 1967, its destitute residents forced to begin new lives elsewhere. All of the town’s buildings were bulldozed and replaced by the Tennessee Valley Authority Fossil Plant, the largest coal power plant in the world at that time. That facility was retired in February 2020 due to noncompliance with the Clean Air Act. All that remains today is the Paradise Cemetery.

Prine’s story is merely one example of the environmental atrocities that have destroyed beloved places and driven people from their homes. There are lost paradises all over the world. For example, the 2018 climate change-driven “Camp Fire” destroyed Paradise, Calif.

Glenn Albrecht, Professor of Sustainability at Murdoch University in Western Australia, has long investigated the connection between mental illness and environmental degradation. It was after studying areas affected by strip mining and interviewing displaced inhabitants that Albrecht coined the term solastalgia. In the paper that introduced his term to the world, he concluded:

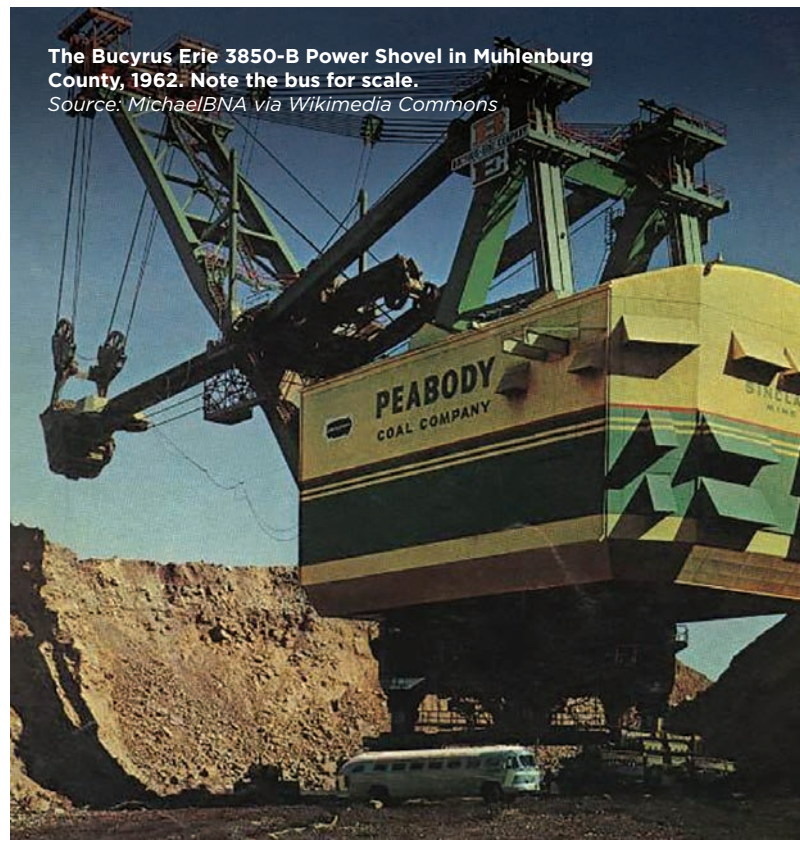
There are complex relationships between environmental or ecosystem stressors and human distress. ... A psychoterratic (related to the earth) syndrome such as solastalgia captures the essence of the relationship between ecosystem health, human health and control (hopelessness and powerlessness)



Downtown Paradise, Ky., circa 1898.
Credit: *Wikimedia Commons*

and negative psychological outcomes. While the preliminary research on mining ... has produced promising new insights into psychoterratic illness, there are many more environmental contexts where chronic environmental stressors negatively affect human health and wellbeing. Climate change (will) be a globally significant source of psychoterratic distress expressed as nostalgia and solastalgia.

In 2020, we witnessed a multitude of these chronic environmental stressors — and likely, a host of unnamed psychoterratic syndromes. For example, wildfires uncontrollably raged in the West, while hurricanes relentlessly demolished eastern communities. In total more than 9,900 fires burned over 4.2 million acres in California. Meanwhile, Louisiana residents have been losing hope for their flood-drenched coastal homes, many surrendering and moving inland after Hurricane Laura. Events like these will become normalized in our changing climate; the degradation of more paradises is impending.



The Bucyrus Erie 3850-B Power Shovel in Muhlenburg County, 1962. Note the bus for scale.
Source: *MichaelBNA via Wikimedia Commons*

As climate change continues, solastalgia will become more widespread, and we must acknowledge it. Although there may be no steadfast cure for environmental distress, the first step to approaching any issue is recognizing its existence. As we take steps to mitigate and adapt to global changes, it is imperative that we also allow ourselves the time and space necessary to process these changes. Staring climate change in the face is no easy feat.

Arguably the most inspiring solastalgia-recovery story is famous Swedish climate activist Greta Thunberg. At 11 years old, Thunberg watched a video about the bleak effects of climate change, featuring starving polar bears and severe weather events. Thunberg was so intensely affected, knowing that her home country would not be excluded from such horrors, that she fell into a deep depression. She stopped speaking and even eating, weakened nearly to the point of hospitalization. Yet, out of this depression emerged the relentless Greta we know today. One Friday afternoon, she sat on the steps of Swedish Parliament with a sign that read “School Strike for Climate.” Although she protested alone on Day 1, she has mobilized millions in one of the largest political movements sweeping the globe. Thunberg told *Time Magazine* in her 2019 Person of the Year interview: “Learning about climate change triggered my depression in the first place. But it was also what got me out of my depression, because there were things I could do to improve the situation. I don’t have time to be depressed anymore.”

As with all issues that affect our mental well-being, we will cope with climate change in numerous unique ways. Greta channeled her solastalgia into activism, quickly becoming the face of the environmental movement. Prine used his songwriting gifts to cope with solastalgia, which brought national attention to strip mining’s devastation. My own avenue for solastalgic expression is writing.

I have witnessed ongoing damage to my home environment of Southern Illinois. Fall and spring now span only a couple of weeks, giving way to more intense summers and winters. The white noise of humming insects and singing birds has largely faded over the past decade as their populations plummet on a local and global scale; the retired farmstead that I call home is now dead quiet. An otherwise healthy individual, I have developed asthma as a result of declining air quality. The streams, rivers, and lakes I’ve been romping in since I was a kid — Hutchins Creek, Cedar Lake, and others — are now tainted green and orange due to nitrogen runoff from agricultural fields and coal ash from leaky mines, respectively. Both prairie and forest ecosystems have been demolished for housing units and strip malls. Our uniquely hilly and biodiverse Southern Illinois lands have been reduced to parking lots and artificial grass. More frequent flooding from the Ohio, Mississippi, and Big Muddy rivers have cursed local farmers, ravaging local economies and food systems. My

community and I are forced to reckon with these myriad symptoms of climate change just as communities around the globe reckon with theirs.

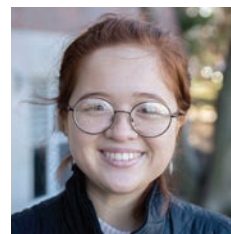
In every piece I write, I contemplate the effects of environmental degradation, thoroughly dissect how I feel about it, and synthesize those feelings carefully. Everyone has an individual responsibility to contribute to collective climate action, so I write to implore others to make small changes in their life or start a climate conversation with their friends and family.

I also write to say this: It is OK to be angry and sad and confused about the state of the world. It is only when we acknowledge our solastalgia that we can act upon it, striving toward a more sustainable home, community, and world. For one person, coping with solastalgia might manifest as joining an environmental organization; for another, keeping a weather journal. For someone else, it might mean showing up to the polls.

As the last verse of “Paradise” requested, John Prine’s ashes were spread on the Green River after he passed on April 7, 2020. While we mourn his loss, we are also mourning the slow death of our homes. Let us not ignore this mounting grief; let’s turn the pain of solastalgia into personal songs of climate action.

EDITOR’S NOTE: You may view a video of Prine playing “Paradise” on Season 3, Episode 17 of Bobby Bare and Friends, a talk show that hosted country and folk musicians for performances and interviews from 1983 to 1988. The author’s uncle, Robert Bowlin, was the fiddle player for Bare’s house band at the time. Mr. Bowlin plays a lovely solo in this version of “Paradise.”

View the video on YouTube at https://www.youtube.com/watch?v=HDEjL3_j2XU.



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